カンボジア王国
環境省

カンボジア国
環境影響評価を含む環境公害管理
能力向上プロジェクト

添付資料 I

2021 年 12 月

独立行政法人
国際協力機構（JICA）
株式会社建設技研インターナショナル
環境社会基盤コンサルタント株式会社
株式会社 エックス都市研究所

環境
JR
21-077

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株式会社 エックス都市研究所

添付資料 1　Minutes of the Meeting and Record of Discussion

RECORD OF DISCUSSIONS

ON

THE PROJECT

FOR

EFFECTIVE IMPLEMENTATION OF EIA AND POLLUTION CONTROL THROUGH THE CAPACITY DEVELOPMENT OF MOE

IN

THE KINGDOM OF CAMBODIA

AGREED UPON BETWEEN

MINISTRY OF ENVIRONMENT

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Phnom Penh, 06 March 2017

for

Mr. Yuichi Sugano	H.E. EANG Sophalleth
Chief Representative	Under Secretary of State
JICA Cambodia Office	Ministry of Environment
Japan International Cooperation Agency	The Kingdom of Cambodia

Based on the minutes of meetings on the Detailed Design Survey on the Technical Cooperation Project for Effective Implementation of EIA and Pollution Control through the Capacity Development of MoE(hereinafter referred to as "the Project") signed on 15 December, 2016 between the Ministry of Environment (hereinafter referred to as "MoE") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with MoE and relevant organizations to develop a detailed design of the Project.

Both sides agreed the detailed design of the Project and the main points discussed as described in Appendix 1 and Appendix 2 respectively.

Both sides also agreed that General Directorate of Environmental Protection (hereinafter referred to as "GDEP"), the counterpart to JICA, will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant ministries, institutions and organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward sustainable (environmental, social and economic) development of Cambodia.

The Project will be implemented within the framework of the the Agreement on Technical Cooperation signed on 17 June, 2003 (hereinafter referred to as "the Agreement") and the Note Verbales exchanged on 8 June, 2016 between the Government of Japan (hereinafter referred to as "GOJ") and Government of Cambodia.

Appendix 1: Project Description
Appendix 2: Main Points Discussed
Appendix 3: Minutes of Meetings on the Detailed Design Survey

Appendix 1

PROJECT DESCRIPTION

I. BACKGROUND

Cambodia has experienced rapid economic growth along with drastic urbanization and industrialization. Together with activities related to the development, environmental degradation has become a serious issue for the country and there is a need to take an appropriate action accordingly.

As guided by the Rectangular Strategy Phase III, the National Strategic Development Plan 2014-2018 and recent Industrial Development Policy 2015-2025, the Government of Cambodia has given priorities to maintain environmental quality and assess environmental impacts of development projects through regular and effective monitoring of water and pollution sources.

MoE is mandated environmental protection, bio-diversity conservation and sustainable development by the Government of Cambodia. However MoE has been facing with the difficulty to handle the situation due to the lack of institutional capacity to conduct environmental management effectively and efficiently. In addition to this, the absence of appropriate policies, legal frameworks and technical guidelines is one of the obstacles for smooth implementation of the given mandates of GDEP, MoE.

Under such background and circumstances, the Government of Cambodia requested technical cooperation to the GOJ.

II. TENTATIVE OUTLINE OF THE PROJECT

1. Title of the Project

The Project for Effective Implementation of EIA and Pollution Control through the Capacity Development of MoE

2. Expected Goals which will be attained after implementing the Proposed Plan.

<Overall Goal>

MoE's institutional and technical capacity is developed to implement the mission of ensuring environmental protection and natural resources management effectively and efficiently.

<Project Purpose>

GDEP capacity to prevent, reduce and mitigate environmental pollution focusing on EIA and water is strengthened.

3. Outputs

Output 1: Legal documents related to EIA and pollution control focusing on water are revised and processed for approval.

Output 2: Technical issues and procedures related to EIA and pollution control focusing on water are clarified and shared with GDEP staff as well as other stakeholders.

Output 3: Capacity of GDEP as whole and related departments under GDEP to implement EIA and pollution control is enhanced.

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Details of the Project activities are described in the Logical Framework (Project Design Matrix: PDM) (Annex I) and the Plan of Operation (Annex II).

4. Input

(1) Input by JICA

(a) Dispatch of Experts

JICA will provide the service of Japanese experts in following areas;

Short term experts

- Environmental Management
- EIA
- Pollution control
- Water quality monitoring and pollution modeling
- Wastewater treatment
- Environmental laws and regulations

JICA experts will be added as the need arises for smooth and effective implementation of the Project.

(b) Training

Training of counterpart personnel in third countries and/or Japan

(c) Machinery and Equipment

-Portable water monitoring equipment
-Portable PM detector
-Basic laboratory apparatus (hot plate, water bath and pH meter)
-Equipment for lecture training
-Reagents and consumables required for the machinery and equipment above

In case of importation, the machinery, equipment and other materials under II-4 (c) above will become the property of the MoE upon being delivered C.I.F. (cost, insurance and freight) to MoE at the ports and/or airports of disembarkation.

Input other than indicated above will be determined through mutual consultations between JICA and MoE during the implementation of the Project, as necessary.

(2) Input by MoE

MoE will take necessary measures to provide at its own expense:

(a) Services of MoE counterpart personnel and administrative personnel as referred to in II-5;
(b) Suitable office space with necessary equipment;
(c) Supply or replacement of machinery, equipment, instruments, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than the equipment provided by JICA;
(d) Transport and travel expenses for MoE counterpart personnel and administrative personnel for official travel in Cambodia;
(e) Information and support in obtaining medical service;

(f) Credentials or identification cards;
(g) Available data (including maps and photographs) and information related to the Project;
(h) Running expenses necessary for the implementation of the Project, such as electricity, internet connection, water and telephone;
(i) Expenses necessary for transportation within Cambodia of the equipment referred to in II-4(1) as well as for the installation, operation and maintenance thereof; and
(j) Necessary facilitations to the JICA experts for the remittance as well as utilization of the funds introduced into Cambodia from Japan in connection with the implementation of the Project.

5. Implementation Structure
The project organization chart and related members list are given in the Annex III, IV and V. The roles and assignments of relevant organizations are as follows:

(1) MoE
(a) Project Director
General Director of General Directorate of Environmental Protection will be responsible for overall administration and implementation of the Project.

(b) Project Manager
Deputy General Director of General Directorate of Environmental Protection will be responsible for the managerial and technical matters of the Project as the Project Manager.

(2) JICA Experts
The JICA experts will give necessary technical guidance, advice and recommendations to the counterparts on any matters pertaining to the implementation of the Project.

(3) Joint Coordinating Committee
Joint Coordinating Committee (hereinafter referred to as "JCC") will be established in order to facilitate inter-organizational coordination. JCC will be held at least once a year and whenever deems it necessary. JCC will review the progress, revise the overall plan when necessary, approve an annual work plan, conduct evaluation of the Project, and exchange opinions on major issues that arise during the implementation of the Project. A list of proposed members of JCC is shown in the Annex IV.

6. Project Site and Beneficiaries
(1) Project Site
Phnom Penh

(2) Beneficiaries
Key staff members of GDEP, MoE

7. Duration
Three (3) and half years from the arrival of the first expert in Cambodia.

8. Environmental and Social Considerations

Cambodia agreed to abiding by 'JICA Guidelines for Environmental and Social Considerations' and Cambodia's EIA regulations in order to ensure that appropriate considerations will be made for the environmental and social impacts of the Project.

III. UNDERTAKINGS OF MoE

1. MoE will take necessary measures to:

(1) ensure that the technologies and knowledge acquired by the Cambodian nationals as a result of Japanese technical cooperation contributes to sustainable economic and social development of Cambodia, and that the knowledge and experience acquired by the personnel of Cambodia from technical training as well as the equipment provided by JICA will be utilized effectively in the implementation of the Project; and

(2) grant privileges, exemptions and benefits to the JICA experts referred to in II-4 above and their families, which are no less favorable than those granted to experts and members of the missions and their families of third countries or international organizations performing similar missions in Cambodia.

2. MoE will take necessary measures to:

(1) provide security-related information as well as measures to ensure the safety of the JICA experts;
(2) permit the JICA experts to enter, leave and sojourn in Cambodia for the duration of their assignments therein and exempt them from foreign registration requirements and consular fees.
(3) exempt the JICA experts from taxes and any other charges on the equipment, machinery and other material necessary for the implementation of the Project;
(4) exempt the JICA experts from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to them and/or remitted to them from abroad for their services in connection with the implementation of the Project; and
(5) meet taxes and any other charges on the equipment, machinery and other material, referred to in II-4 above, necessary for the implementation of the Project.

3. MoE will bear claims, if any arises, against the JICA experts resulting from, occurring in the course of, or otherwise connected with, the discharge of their duties in the implementation of the Project, except when such claims arise from gross negligence or willful misconduct on the part of the JICA experts.

IV. MONITORING AND EVALUATION

JICA and MoE will jointly and regularly monitor the progress of the Project through the Monitoring Sheets based on the Project Design Matrix (PDM) and Plan of Operation

(PO). The Monitoring Sheets will be reviewed every six (6) months. Authorized Monitoring Sheet shall be sent to JICA.

Also, Project Completion Report will be drawn up one (1) month before the termination of the Project.

JICA will conduct the following evaluations and surveys to verify sustainability and impact of the Project. MoE is required to provide necessary support for them.

1. Ex-post evaluation three (3) years after the project completion, in principle.
2. Follow-up surveys on necessity basis.

V. PROMOTION OF PUBLIC SUPPORT

For the purpose of promoting support for the Project, MoE will take appropriate measures to make the Project widely known to the public.

VI. MISCONDUCT

If JICA receives information related to suspected corrupt or fraudulent practices in the implementation of the Project, MoE and relevant organizations will provide JICA with such information as JICA may reasonably request, including information related to any concerned official of the government and/or public organizations of the Cambodia.

MoE and relevant organizations will not, unfairly or unfavorably treat the person and/or company which provided the information related to suspected corrupt or fraudulent practices in the implementation of the Project.

VII. MUTUAL CONSULTATION

JICA and MoE will consult each other whenever any major issues arise in the course of Project implementation.

VIII. AMENDMENTS

The Record of Discussions may be amended by the minutes of meetings between JICA and MoE. However, PO may be amended in the Monitoring Sheets.

The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the record of discussions.

Annex I	Logical Framework (Project Design Matrix: PDM)
Annex II	Plan of Operation (PO)
Annex III	Project Organization Chart
Annex IV	A List of Proposed Members of Joint Coordinating Committee
Annex V	A List of Counterpart Members

Project Design Matrix (2016/12/15) Ver.1.0
Project Name: Technical Cooperation Project for Better Implementation of EIA and Pollution Control through the Capacity Development of MoE
Duration of Project: 3 years
Target Group: GDEP (General Department of Environmental Protection), Ministry of Environment
Target area: Phnom Penh

Narrative Summary	Verifiable Indicators	Means of Verification	Important assumption
[Overall goal] **MoE's institutional and technical capacity is developed to implement the mission of ensuring environmental protection effectively and efficiently.**	**MoE's work on environmental protection received better evaluation from related stakeholders, compared to the level that of the starting point of the project.**	**Organizing a seminar to report the progress after the project and obtaining questionnaire answer from related stakeholders.**	Present national policy and environment regulation in Cambodia is maintained and improved. Manpower and budget to be provided by the government,
[Project purpose] **GDEP capacity to prevent, reduce and mitigate environmental pollution focusing on EIA and water is strengthened.**	**GDEP's work on EIA received more confidence from government offices related to EIA, compared to the level that of the starting point of the project.** **Transparency of GDEP is increased through information disclosure.**	**Questionnaire answer from the related government offices** **Website that contains information related to EIA and environmental pollution**	Present national policy and environment regulation in Cambodia is maintained and improved. Manpower and budget to be provided by the government,
[Output] **1. Legal documents related to EIA and pollution control focusing on water are revised and processed for approval.**	**● Prakas/Joint Prakas : Documents submitted to Minister(s) for approval** **● Sub-decrees : Document submitted to the Prime Minister's office for approval**	**Legal documents under approval process**	.
2. Technical issues and procedures related to EIA and pollution control focusing on water are clarified and shared with GDEP staff as well as other stakeholders.	**● Technical guidelines and procedures developed**	**● Printed Technical guidelines and procedures** **● Minutes of consultation meetings**	
3. Capacity of GDEP as a whole and related departments under GDEP is enhanced.	**● Enhanced EIA review** **-Review and comment on EIA reports of 70 investment projects in 2017 and increase by 10% every year onward** **- Collect data and related information of EIA/IEIA/EPA reports of 140 investment projects in 2017 and increase by 10% every year onward** **- Monitor environmental EPA and EMP (written in IEIA/EIA reports) of 322 investment projects for 644 times in 2017 and increase by 10% every year onward** **● Water quality monitoring** **- Pollution source mapping in PP area** **-Increased coverage of pollution source/waste water monitoring in PP**	**- Internal reports** **- Water pollution mapping report** **- Monitoring data compiled** **-**	

	area (100% coverage by 2020) **- An increased number of sites for ambient water monitoring (50% increase from 2016)**		
[Activity of the project] Output 1 Law and regulation revised and updated 1.1 Develop task force to review law and regulation 1.2 Finalize items for output 1 1.3 Review and draft revised law and regulation 1.4 Consultation with stakeholders 1.5 Finalize draft revised law and regulation 1.6 Prepare summary report for output 1 Output 2 Technical guideline and procedure developed 2.1 Develop task force to develop guideline and procedure 2.2 Finalize items for output 2 2.3 Develop draft guideline and procedures 2.4 Consultation with stakeholders 2.5 Finalize draft guideline and procedure 2.6 Prepare summary report for output 2 Output 3 Capacity development of MoE staff 3.1 Finalize content/subject of training program 3.2 Organize seminar 3.3 study tour 3.4 Develop training program and implement 3.5 Prepare summary report of output 3	[Input] .Japanese Side (1) Japanese Experts 7-10 short term expert (2)Training Study tour to Japan and other countries (3)Local Cost Local costs for experts' activities Sub-contract for EIA Sub-contract for data collection and Database input Local consultant to assist legal document drafting Small funding for research (4)Machinery, Equipment and Materials Portable water quality monitoring unit and accessory, reagent Portable air quality monitoring unit (PM) Laboratory common apparatus (hot plate, water bath, pH meter) Cambodia side (1)Counterpart personnel including administrator (2)Office space, meeting room (3)Local costs (see Minutes of Meeting)"		

Note:

- "Task force" mentioned in activity 1.1 and 2,1 means working team within GDEP and JICA team for respective task, i.e, preparation of legal document, technical guideline and materials. Persons from outside may be selected to join the team.
- "Summary report" mentioned in activity 1.6, 2.6 and 3.6 means reports to be prepared by GDEP and JICA team to summarize the activity/achievement in each output area, and will be used to report to others in GDEP, JICA and other stakeholders.

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Annex II

Plan of Operation (as of 15December 2016)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Output 1 Law and regulation revised and updated																																										
1.1 Develop task force to review law and regulation																																										
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1.3 Review and draft revised law and regulation																																										
1.4 Consultation with stakeholders																																										
1.5 Finalize drfat revised law and regulation																																										
1.6 Prepare summary report for output 1																																										
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3.2 Organize seminar																																										
3.3 study tour																																										
3.4 Develop training program and implement																																										
3.5 Prepare summary report of output 3																																										

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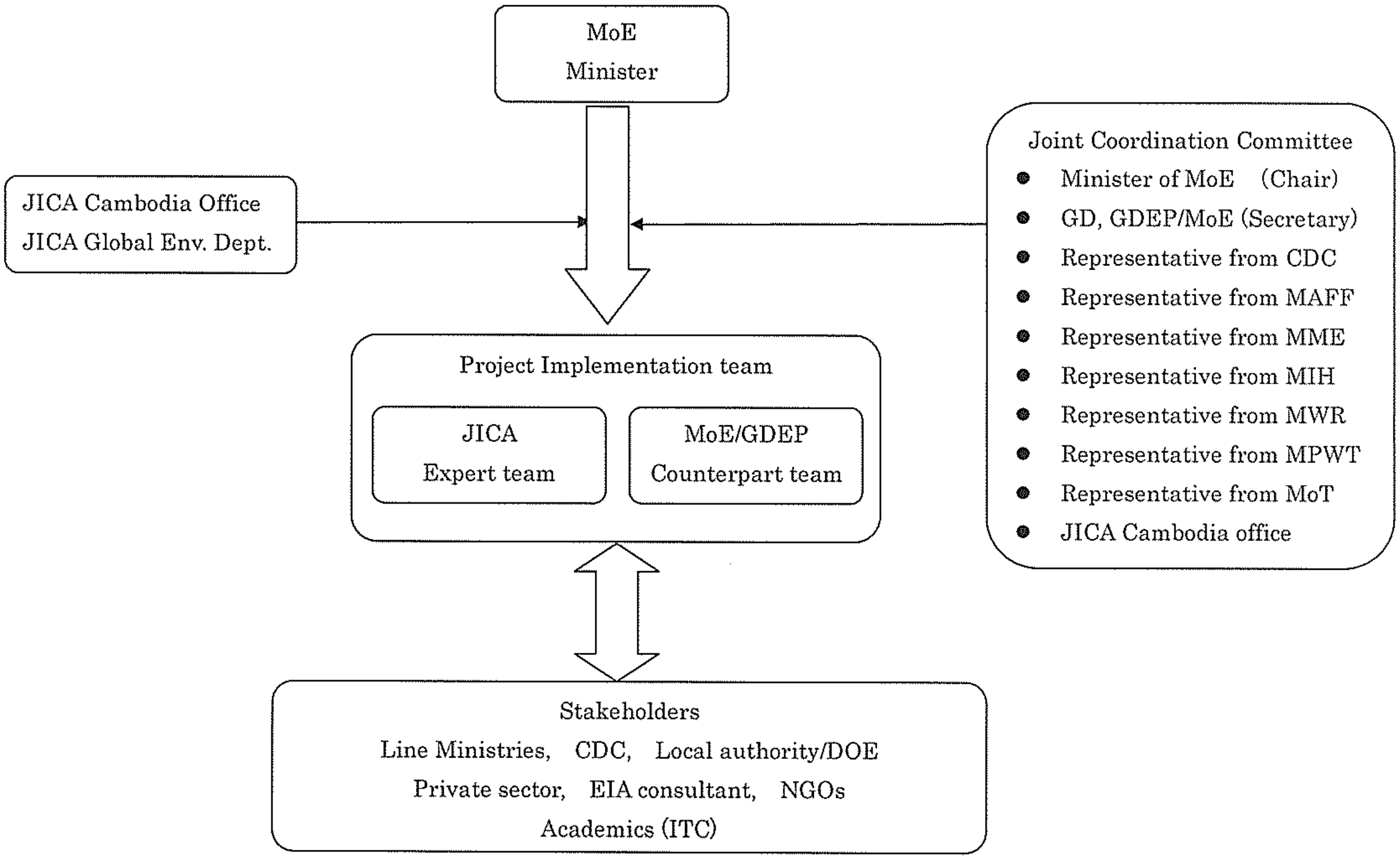
Annex III


MoE
Minister
JICA Cambodia Office
JICA Global Env. Dept.
Joint Coordination Committee
Minister of MoE (Chair)
GD, GDEP/MoE (Secretary)
Representative from CDC
Representative from MAFF
Representative from MME
Representative from MIH
Representative from MWR
Representative from MPWT
Representative from MoT
JICA Cambodia office
Project Implementation team
JICA
Expert team
MoE/GDEP
Counterpart team
Stakeholders
Line Ministries, CDC, Local authority/DOE
Private sector, EIA consultant, NGOs
Academics (ITC)

JOINT COORDINATING COMMITTEE (JCC)

1. Functions

The Joint Coordinating Committee (hereinafter referred to as "JCC") will meet at least once a year or whenever the necessity arises, in order to fulfill the following functions:

(1) To approve an annual work plan of the Project based on the Plan of Operation within the framework of the Record of Discussions;
(2) To monitor and review the overall progress of the Project carried out under the above-mentioned annual work plan; and
(3) To exchange views and ideas on major issues those arise during the implementation of the Project.

2. Members of the JCC

The JCC will be composed of the chair, the members and the observers. The chair may declare closed sessions against the observers. The rules and guidelines for the management of the JCC will be determined at the initial stage of the Project.

(1) Chairperson: Minister, Ministry of Environment
(2) Cambodian side:
-Representative from the Council for the Development of Cambodia
-Representative from Ministry of Agriculture, Forestry and Fishery
-Representative from Ministry of Mining and Energy
-Representative from Ministry of Industry and Handicraft
-Representative from Ministry of Water Resources
-Representative from Ministry of Public Work and Transportation
-Representative from Ministry of Land Management, Urbanization and Construction
-Representative from Ministry of Tourism
-Counterparts
(3) Japanese side
-JICA Expert(s) of the Project
-Representative from JICA Cambodia Office
(4) Other member(s)

Note: Official(s) of Embassy of Japan may attend the JCC meeting as observer(s). The chairperson can name new members or request the attendance of other participants, as necessary, upon mutual consent by both sides, when necessary.

Annex V

A LIST OF COUNTERPART PERSONNEL OF CAMBODIA

No.	Project Position	Position	Organization	Related Output
1.	Project Director	General Director	General Directorate of Environmental Protection	All
2.	Project Manager	Deputy General Director	General Directorate of Environmental Protection	All
3.	Project Assistant	Director	Department of Administration Planning and Finance	All
4.	Project Assistant	Director	Department of Air and Noise Quality Management	Output 3
5.	Project Assistant	Director	Department of Solid Waste Management	Output 3
6.	Project Assistant	Director	Department of Water Quality Management	All
7.	Project Assistant	Director	Department of Hazardous substance Management	Output 3
8.	Project Assistant	Director	Department of Environmental Impact Assessment	All
9.	Project Assistant	Director	Department of Law Enforcement and Inspection	All
10.	Counterpart	Staff	Department of Administration Planning and Finance	All
11.	Counterpart	Staff	Department of Air and Noise Quality Management	Output 3
12.	Counterpart	Staff	Department of Solid Waste Management	Output 3
13.	Counterpart	Staff	Department of Water	All

			Quality Management	
14.	Counterpart	Staff	Department of Hazardous substance Management	Output 3
15.	Counterpart	Staff	Department of Environmental Impact Assessment	All
16.	Counterpart	Staff	Department of Law Enforcement and Inspection	All
17.	Counterpart	Staff	Laboratory	Output 3

Note:
Counterpart personnel will be added as the need arises for the smooth and effective implementation of the Project.

Appendix 2

MAIN POINTS DISCUSSED

Project policy for transportation and travel expenses for the Project counterparts is to be considered once the Project starts.

Appendix 3

MINUTES OF MEETINGS
BETWEEN
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
MINISTRY OF ENVIRONMENT OF THE KINGDOM OF CAMBODIA
ON
JAPANESE TECHNICAL COOPERATION PROJECT FOR CAPACITY BUILDING OF THE MOE STAFF TO IMPROVE THE IMPLEMENTATION OF EIA AND POLLUTION CONTROL LAW AND REGULATION

In response to the request made by the Royal Government of Cambodia for the Japanese Technical Cooperation Project for "Capacity building of the MoE staff to improve the implementation of EIA and pollution control law and regulations"(hereinafter referred to as " the Project"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") has dispatched the Detailed Design Survey Team to the Kingdom of Cambodia (hereinafter referred to as "the Team") headed by Dr. Mimpei Ito, Director of Global Environment Department, JICA, from 22 November to 15 December, 2016.

During its stay, both the Team and MoE had a series of discussions and exchanged views for the purpose of working out the framework and contents of the Project.

As a result of the discussions, both sides agreed to recommend to their respective organizations the matters referred to in the documents attached hereto.

Phnom Penh, Cambodia, 15 December, 2016

伊藤民平

Dr. Mimpei Ito
Leader,
Detailed Design Survey Team
Japan International Cooperation Agency

Mr. Sao Sopheap
Advisor and Director of Cabinet
Ministry of Environment
The Kingdom of Cambodia

ATTACHED DOCUMENT

1. Comments and/or advice on Environmental Code

MoE requested JICA to make comments or give advice on Environmental Code which is currently at the stage of drafting. JICA agreed once the Project has started, JICA experts will provide MoE with comments and advice upon request.

2. Coordination among development partners

As there are several development partners working in the area of environmental management in Cambodia, both sides recognized the necessity of coordinating activities among such organizations to maximize the effectiveness of each project and avoid duplication of the activities. MoE will play a role as the coordinator among the related partners.

3. Title of the Project

Both sides agreed on changing the title of the Project to "Technical Cooperation Project for Effective Implementation of EIA and Pollution Control through the Capacity Development of MoE".

4. Draft Record of Discussions

Both sides agreed on the contents of the Project framework, as attached in the Appendix I, II, and III, as well as draft version of Record of Discussion which will be signed by both sides early next year after the approval of the contents of the document at JICA headquarters in Tokyo and MoE's management later. Both sides agreed that there will be a possibility of minor modification on the document during the approval process, in which case both sides will keep each other informed.

5. Provisional schedule until the Project commencement

5.1 Signing of Record of Discussions in February, 2017

5.2 Commencement of the Project in June, 2017

6. Undertaking of MoE

6.1 Allocation of Personnel

MoE confirmed to allocate counterpart personnel to the Project in order to ensure the effective implementation of the Project.

6.2 Working Space

MoE has confirmed to secure the working space for JICA experts during the project cooperation period.

6.3 Monitoring

JICA and MoE will jointly and regularly monitor the progress of the Project through the Monitoring Sheets based on the Project Design Matrix (PDM) and Plan of Operation (PO). The Monitoring Sheets will be reviewed every six (6) months.

7. Other relevant issues for implementation of the Project

7.1 Allocation of budget and personnel to extend cooperation of the Project to local governments regarding EIA

MoE requested to involve local governments in the project scope. The Team explained that allocation of budget and personnel to handle the EIA related work in local governments is the key to sustain the quality of EIA review.

MoE has started the implementation of program-based budgeting and MoE has the intention to allocate some of the ministry's budget for this purpose during and after the Project.

7.2 Information disclosure

The Team explained that to enable sound environmental management, involvement of four actors (Government, private sectors, citizens, and academics) is indispensable. In this regard, the Team shared its view that information disclosure to the public would be an important aspect to be tackled through the Project, with step by step approach.

Appendix I : Tentative Project Design Matrix
Appendix II: Tentative Plan of Operation
Appendix III: Tentative framework of project Output relations
Appendix IV: Draft Record of Discussion

Appendix :I

Tentative Project Design Matrix (2016/12/15) Ver.1.0

Project Name: Technical Cooperation Project for Better Implementation of EIA and Pollution Control through the Capacity Development of MoE

Duration of Project: 3 years

Target Group: GDEP (General Department of Environmental Protection), Ministry of Environment

Target area: Phnom Penh

Narrative Summary	Verifiable Indicators	Means of Verification	Important assumption
[Overall goal] MoE's institutional and technical capacity is developed to implement the mission of ensuring environmental protection effectively and efficiently.	MoE's work on environmental protection received better evaluation from related stakeholders, compared to the level that of the starting point of the project.	Organizing a seminar to report the progress after the project and obtaining questionnaire answer from related stakeholders.	Present national policy and environment regulation in Cambodia is maintained and improved. Manpower and budget to be provided by the government.
[Project purpose] GDEP capacity to prevent, reduce and mitigate environmental pollution focusing on EIA and water is strengthened.	GDEP's work on EIA received more confidence from government offices related to EIA, compared to the level that of the starting point of the project. Transparency of GDEP is increased through information disclosure.	Questionnaire answer from the related government offices Website that contains information related to EIA and environmental pollution	Present national policy and environment regulation in Cambodia is maintained and improved. Manpower and budget to be provided by the government.
[Output] 1. Legal documents related to EIA and pollution control focusing on water are revised and processed for approval.	● Prakas/Joint Prakas : Documents submitted to Minister(s) for approval ● Sub-decrees : Document submitted to the Prime Minister's office for approval	Legal documents under approval process	.
2. Technical issues and procedures related to EIA and pollution control focusing on water are clarified and shared with GDEP staff as well as other stakeholders.	● Technical guidelines and procedures developed	● Printed Technical guidelines and procedures ● Minutes of consultation meetings	
3. Capacity of GDEP as a whole and related departments under GDEP is enhanced.	● Enhanced EIA review -Review and comment on EIA reports of 70 investment projects in 2017 and increase by 10% every year onward - Collect data and related information of EIA/IEIA/EPA reports of 140 investment projects in 2017 and increase by 10% every year onward - Monitor environmental EPA and EMP (written in IEIA/EIA reports) of 322 investment projects for 644 times in 2017 and increase by 10% every year onward ● Water quality monitoring - Pollution source mapping in PP area -Increased coverage of pollution source/waste water monitoring in PP	- Internal reports - Water pollution mapping report - Monitoring data compiled -	

	area (100% coverage by 2020) - An increased number of sites for ambient water monitoring (50% increase from 2016)		
[Activity of the project] Output 1 Law and regulation revised and updated 1.1 Develop task force to review law and regulation 1.2 Finalize items for output 1 1.3 Review and draft revised law and regulation 1.4 Consultation with stakeholders 1.5 Finalize draft revised law and regulation 1.6 Prepare summary report for output 1 Output 2 Technical guideline and procedure developed 2.1 Develop task force to develop guideline and procedure 2.2 Finalize items for output 2 2.3 Develop draft guideline and procedures 2.4 Consultation with stakeholders 2.5 Finalize draft guideline and procedure 2.6 Prepare summary report for output 2 Output 3 Capacity development of MoE staff 3.1 Finalize content/subject of training program 3.2 Organize seminar 3.3 study tour 3.4 Develop training program and implement 3.5 Prepare summary report of output 3	[Input] .Japanese Side (1) Japanese Experts 7-10 short term expert (2)Training Study tour to Japan and other countries (3)Local Cost Local costs for experts' activities Sub-contract for EIA Sub-contract for data collection and Database input Local consultant to assist legal document drafting Small funding for research (4)Machinery, Equipment and Materials Portable water quality monitoring unit and accessory, reagent Portable air quality monitoring unit (PM) Laboratory common apparatus (hot plate, water bath, pH meter) Cambodia side (1)Counterpart personnel including administrator (2)Office space, meeting room (3)Local costs (see Minutes of Meeting)*		

Note:

- "Task force" mentioned in activity 1.1 and 2,1 means working team within GDEP and JICA team for respective task, i.e, preparation of legal document, technical guideline and materials. Persons from outside may be selected to join the team.
- "Summary report" mentioned in activity 1.6, 2.6 and 3.6 means reports to be prepared by GDEP and JICA team to summarize the activity/achievement in each output area, and will be used to report to others in GDEP, JICA and other stakeholders.

Appendix: II

Tentative Plan of Operation (draft version as of 15December 2016)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
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1.1 Develop task force to review law and regulation																																										
1.2 Fianlize items for output 1																																										
1.3 Review and draft revised law and regulation																																										
1.4 Consultation with stakeholders																																										
1.5 Finalize drfat revised law and regulation																																										
1.6 Prepare summary report for output 1																																										
Output 2 Technical guideline and procedure developed																																										
2.1 Develop task force to develop guideline and procedure																																										
2.2 Fianlize items for output 2																																										
2.3 Develop draft guideline and procedures																																										
2.4 Organization of consultation with stakeholders																																										
2.5 Finalize drfat guideline and procedure																																										
2.6 Prepare summary report for output 2																																										
Output 3 Capacity development of MoE staff																																										
3.1 Fianlaize content/subject of training program																																										
3.2 Organize seminar																																										
3.3 study tour																																										
3.4 Develop training program and implement																																										
3.5 Prepare summary report of output 3																																										

Tentative framework of project Output relations(as of 15 December 2016)

Output 1 (Law & regulation)	Output 2 (Guideline and procedure)	Output 3 (Training) Lecture	Output 3 (Training) Practice/Pilot	JICA Provision	Dept. inside GDEP	Stakeholders relation
Sub-Decree and Prakas on Industrial Wastewater management		Industrial Wastewater management (Introduction of Japanese case – Law and Practice)	Stakeholder consultation	Study tour to Japan Local assistant for drafting	WQM	
Note: Lecture content can be used to draft various sub decree related to the topics, but will not be included as official output of the project.		Industrial Waste Management (Introduction of Japanese case – Law and Practice)			SWM	MIH, Private sector (including JBAC), NGO, Local authority
		Hazardous Waste Management (Introduction of Japanese case –Law and Practice)			SWM, HSM	MIH, Private sector (including JBAC), NGO, Local authority
		Air Pollution Management (Introduction of Japanese case – Law and Practice)			AQNM	MIH, Private sector (including JBAC), NGO, Local authority
	• EIA General Guideline • Guideline of EIA criteria	• EIA General • EIA review method • EMP/EPA monitoring	• EIA awareness raising seminar (1^{st}, 2^{nd} year) • Trainer's training + Training for local officers (3^{rd} year) • Preparation and dissemination of awareness raising	• Seminar, Training expenses • Study tour to Japan	EIA	MAFF, MIH, MME, Local officers Private sectors(including JBAC) General public (materials dissemination)

			materials			
	EIA sector specific technical reference	● Environment impact/loading process by specific sector (Agriculture, Water Resource, Industry, Health, Energy, Infrastructure, Tourism, etc.) Including building construction, river-bank collapse prevention during sand mining, pollution control of stone and cement mining	● EIA real practice ● EIA review practice ● Preparation of technical reference materials and leafletsto be shared among ministries and local governments	Sub-contract to local consultants (EIA)	EIA	MAFF, MIH, MME, Local officers Private sectors(including JBAC)
	Factory inspection manual	Factory inspection	On-site practice (focusing on water) including use of portable monitoring unit	● Portable water monitoring equipment ● Laboratory supply (hot plate, water bath, and pH meter)	ILE, WQM	Private sectors (including JBAC)
	Guideline /manual for waste water treatment facility	Water quality management	● Training on portable monitoring unit ● Water quality monitoring around Phnom Penh area ● Evaluation of monitoring data ● Application of pollution modeling		WQM	Local officers
		Application of GIS and database	● Pollution source (water) mapping	Sub-contract to local consultant (Data	WQM, HSM	General public through web site and

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			around Phnom Penh area ● Data disclosure with monitoring data to public	collection survey and Database input)		publication
		Emerging issue in environment and promotion of collaboration with other institutes	● Develop collaboration framework with other institutes (such as ITC) ● PM 10 and 2.5 fact finding survey	● Research funding to ITC ? (small scale) ● Portable PM detector	All (AQM as focus on PM10 and 2.5)	General public and political level through fact paper
		● PRTR, EMS and promotion of voluntary management by industry ● Promotion of Eco-business	● Pilot self–monitoring by power plant or other facility ● Eco business forum	● Technical expense for data connection ● Study tour to Thailand	All	Private sector (power plant, or other facility) Private sector (Eco business promoters)

Remarks:

1. Number of law and regulation to be supported as output1 depends on effort to draft them at GDEP side (at this moment JICA side propose to limit output 1 just for "industrial wastewater management"). JICA team will provide technical substance such as those regulatory system in Japanese case and will answer specific question from GDEP, however will NOT draft the legal document. JICA team may assist such drafting work by engaging local law firm or consultant to support GDEP staff, if requested so.
2. To tackle new issue in environment such as PM10 and 2.5 pollution, it is suggested GDEP to collaborate with other institutes. ITC (Institute of Technology of Cambodia) who is under JICA support can be a good candidate.

Appendix: IV

RECORD OF DISCUSSIONS

ON

JAPANESE TECHNICAL COOPERATION PROJECT

FOR

EFFECTIVE IMPLEMENTATION OF EIA AND POLLUTION CONTROL THROUGH THE CAPACITY DEVELOPMENT OF MOE

IN

THE KINGDOM OF CAMBODIA

AGREED UPON BETWEEN

MINISTRY OF ENVIRONMENT

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Phnom Penh, XX Month,2017

Mr. Itsu ADACHI Chief Representative JICA Cambodia Office Japan International Cooperation Agency	Mr. Say Samal Minister Ministry of Environment The Kingdom of Cambodia

Based on the minutes of meetings on the Detailed Design Survey on the Technical Cooperation Project for Effective Implementation of EIA and Pollution Control through the Capacity Development of MoE(hereinafter referred to as "the Project") signed on 15 December, 2016 between the Ministry of Environment (hereinafter referred to as "MoE") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with MoE and relevant organizations to develop a detailed design of the Project.

Both sides agreed the detailed design of the Project and the main points discussed as described in Appendix 1 and Appendix 2 respectively.

Both sides also agreed that General Directorate of Environmental Protection (hereinafter referred to as "GDEP"), the counterpart to JICA, will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant ministries, institutions and organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward sustainable (environmental, social and economic) development of Cambodia.

The Project will be implemented within the framework of the the Agreement on Technical Cooperation signed on 17 June, 2003 (hereinafter referred to as "the Agreement") and the Note Verbales exchanged on 6 May, 2016 between the Government of Japan (hereinafter referred to as "GOJ") and Government of Cambodia.

Appendix 1: Project Description
Appendix 2: Main Points Discussed
Appendix 3: Minutes of Meetings on the Detailed Design Survey

Appendix 1

PROJECT DESCRIPTION

I. BACKGROUND

Cambodia has experienced rapid economic growth along with drastic urbanization and industrialization. Together with activities related to the development, environmental degradation has become a serious issue for the country and there is a need to take an appropriate action accordingly.

As guided by the Rectangular Strategy Phase III, the National Strategic Development Plan 2014-2018 and recent Industrial Development Policy 2015-2025, the Government of Cambodia has given priorities to maintain environmental quality and assess environmental impacts of development projects through regular and effective monitoring of water and pollution sources.

MoE is mandated environmental protection, bio-diversity conservation and sustainable development by the Government of Cambodia. However MoE has been facing with the difficulty to handle the situation due to the lack of institutional capacity to conduct environmental management effectively and efficiently. In addition to this, the absence of appropriate policies, legal frameworks and technical guidelines is one of the obstacles for smooth implementation of the given mandates of GDEP, MoE.

Under such background and circumstances, the Government of Cambodia requested technical cooperation to the Japanese Government.

II. TENTATIVE OUTLINE OF THE PROJECT

1. Title of the Project

Technical Cooperation Project for Effective Implementation of EIA and Pollution Control through the Capacity Development of MoE

2. Expected Goals which will be attained after implementing the Proposed Plan.

<Overall Goal>

MoE's institutional and technical capacity is developed to implement the mission of ensuring environmental protection and natural resources management effectively and efficiently.

<Project Purpose>

GDEP capacity to prevent, reduce and mitigate environmental pollution focusing on EIA and water is strengthened.

3. Outputs

Output 1: Legal documents related to EIA and pollution control focusing on water are revised and processed for approval.

Output 2: Technical issues and procedures related to EIA and pollution control focusing on water are clarified and shared with GDEP staff as well as other stakeholders.

Output 3: Capacity of GDEP as a whole and related departments under GDEP to implement EIA and pollution control is enhanced.

Details of the Project activities are described in the Logical Framework (Project Design Matrix: PDM) (Annex I) and the Plan of Operation (Annex II).

4. Input

(1) Input by JICA

(a) Dispatch of Experts

JICA will provide the service of Japanese experts in following areas;

Short term experts

- Environmental Management
- EIA
- Pollution control
- Water quality monitoring and pollution modeling
- Wastewater treatment
- Environmental laws and regulations

JICA experts will be added as the need arises for smooth and effective implementation of the Project.

(b) Training

Training of counterpart personnel in third countries and/or Japan

(c) Machinery and Equipment

-Portable water monitoring equipment
-Portable PM detector
-Basic laboratory apparatus (hot plate, water bath and pH meter)
-Equipment for lecture training
-Reagents and consumables required for the machinery and equipment above

In case of importation, the machinery, equipment and other materials under II-4 (c) above will become the property of the MoE upon being delivered C.I.F. (cost, insurance and freight) to MoE at the ports and/or airports of disembarkation.

Input other than indicated above will be determined through mutual consultations between JICA and MoE during the implementation of the Project, as necessary.

(2) Input by MoE

MoE will take necessary measures to provide at its own expense:

(a) Services of MoE counterpart personnel and administrative personnel as referred to in II-5;
(b) Suitable office space with necessary equipment;
(c) Supply or replacement of machinery, equipment, instruments, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than the equipment provided by JICA;
(d) Transport and travel expenses for MoE counterpart personnel and administrative personnel for official travel in Cambodia;
(e) Information and support in obtaining medical service;

(f) Credentials or identification cards;
(g) Available data (including maps and photographs) and information related to the Project;
(h) Running expenses necessary for the implementation of the Project, such as electricity, internet connection, water and telephone;
(i) Expenses necessary for transportation within Cambodia of the equipment referred to in II-4(1) as well as for the installation, operation and maintenance thereof; and
(j) Necessary facilitations to the JICA experts for the remittance as well as utilization of the funds introduced into Cambodia from Japan in connection with the implementation of the Project.

5. Implementation Structure

The project organization chart and related members list are given in the Annex III, IV and V. The roles and assignments of relevant organizations are as follows:

(1) MoE

(a) Project Director

General Director of General Directorate of Environmental Protection will be responsible for overall administration and implementation of the Project.

(b) Project Manager

Deputy General Director will be responsible for the managerial and technical matters of the Project as the Project Manager.

(2) JICA Experts

The JICA experts will give necessary technical guidance, advice and recommendations to the counterparts on any matters pertaining to the implementation of the Project.

(3) Joint Coordinating Committee

Joint Coordinating Committee (hereinafter referred to as "JCC") will be established in order to facilitate inter-organizational coordination. JCC will be held at least once a year and whenever deems it necessary. JCC will review the progress, revise the overall plan when necessary, approve an annual work plan, conduct evaluation of the Project, and exchange opinions on major issues that arise during the implementation of the Project. A list of proposed members of JCC is shown in the Annex IV.

6. Project Site and Beneficiaries

(1) Project Site

Phnom Penh

(2) Beneficiaries

Key staff members of GDEP, MoE

7. Duration

Three (3) and half years from the arrival of the first expert in Cambodia.

8. Environmental and Social Considerations

Cambodia agreed to abiding by 'JICA Guidelines for Environmental and Social Considerations' and Cambodia's EIA regulations in order to ensure that appropriate considerations will be made for the environmental and social impacts of the Project.

III. UNDERTAKINGS OF MoE

1. MoE will take necessary measures to:

(1) ensure that the technologies and knowledge acquired by the Cambodian nationals as a result of Japanese technical cooperation contributes to sustainable economic and social development of Cambodia, and that the knowledge and experience acquired by the personnel of Cambodia from technical training as well as the equipment provided by JICA will be utilized effectively in the implementation of the Project; and

(2) grant privileges, exemptions and benefits to the JICA experts referred to in II-4 above and their families, which are no less favorable than those granted to experts and members of the missions and their families of third countries or international organizations performing similar missions in Cambodia.

2. MoE will take necessary measures to:

(1) provide security-related information as well as measures to ensure the safety of the JICA experts;
(2) permit the JICA experts to enter, leave and sojourn in Cambodia for the duration of their assignments therein and exempt them from foreign registration requirements and consular fees.
(3) exempt the JICA experts from taxes and any other charges on the equipment, machinery and other material necessary for the implementation of the Project;
(4) exempt the JICA experts from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to them and/or remitted to them from abroad for their services in connection with the implementation of the Project; and
(5) meet taxes and any other charges on the equipment, machinery and other material, referred to in II-4 above, necessary for the implementation of the Project.

3. MoE will bear claims, if any arises, against the JICA experts resulting from, occurring in the course of, or otherwise connected with, the discharge of their duties in the implementation of the Project, except when such claims arise from gross negligence or willful misconduct on the part of the JICA experts.

IV. MONITORING AND EVALUATION

JICA and MoE will jointly and regularly monitor the progress of the Project through the Monitoring Sheets based on the Project Design Matrix (PDM) and Plan of Operation (PO). The Monitoring Sheets will be reviewed every six (6) months. Authorized

Monitoring Sheet shall be sent to JICA.

Also, Project Completion Report will be drawn up one (1) month before the termination of the Project.

JICA will conduct the following evaluations and surveys to verify sustainability and impact of the Project. MoE is required to provide necessary support for them.

1. Ex-post evaluation three (3) years after the project completion, in principle.
2. Follow-up surveys on necessity basis.

V. PROMOTION OF PUBLIC SUPPORT

For the purpose of promoting support for the Project, MoE will take appropriate measures to make the Project widely known to the public.

VI. MISCONDUCT

If JICA receives information related to suspected corrupt or fraudulent practices in the implementation of the Project, MoE and relevant organizations will provide JICA with such information as JICA may reasonably request, including information related to any concerned official of the government and/or public organizations of the Cambodia.

MoE and relevant organizations will not, unfairly or unfavorably treat the person and/or company which provided the information related to suspected corrupt or fraudulent practices in the implementation of the Project.

VII. MUTUAL CONSULTATION

JICA and MoE will consult each other whenever any major issues arise in the course of Project implementation.

VIII. AMENDMENTS

The Record of Discussions may be amended by the minutes of meetings between JICA and MoE. However, PO may be amended in the Monitoring Sheets.

The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the record of discussions.

Annex I	Logical Framework (Project Design Matrix: PDM)
Annex II	Plan of Operation (PO)
Annex III	Project Organization Chart
Annex IV	A List of Proposed Members of Joint Coordinating Committee
Annex V	A List of Counterpart Members

Appendix 2

MAIN POINTS DISCUSSED

Project policy for transportation and travel expenses for the Project counterparts is to be considered once the Project starts.

Annex I

Tentative Project Design Matrix (2016/12/15) Ver.1.0

Project Name: Technical Cooperation Project for Better Implementation of EIA and Pollution Control through the Capacity Development of MoE

Duration of Project: 3 years

Target Group: GDEP (General Department of Environmental Protection), Ministry of Environment

Target area: Phnom Penh

Narrative Summary	Verifiable Indicators	Means of Verification	Important assumption
[Overall goal] MoE's institutional and technical capacity is developed to implement the mission of ensuring environmental protection effectively and efficiently.	MoE's work on environmental protection received better evaluation from related stakeholders, compared to the level that of the starting point of the project.	Organizing a seminar to report the progress after the project and obtaining questionnaire answer from related stakeholders.	Present national policy and environment regulation in Cambodia is maintained and improved. Manpower and budget to be provided by the government.
[Project purpose] GDEP capacity to prevent, reduce and mitigate environmental pollution focusing on EIA and water is strengthened.	GDEP's work on EIA received more confidence from government offices related to EIA, compared to the level that of the starting point of the project. Transparency of GDEP is increased through information disclosure.	Questionnaire answer from the related government offices Website that contains information related to EIA and environmental pollution	Present national policy and environment regulation in Cambodia is maintained and improved. Manpower and budget to be provided by the government,
[Output] 1. Legal documents related to EIA and pollution control focusing on water are revised and processed for approval.	• Prakas/Joint Prakas : Documents submitted to Minister(s) for approval • Sub-decrees : Document submitted to the Prime Minister's office for approval	Legal documents under approval process	.
2. Technical issues and procedures related to EIA and pollution control focusing on water are clarified and shared with GDEP staff as well as other stakeholders.	• Technical guidelines and procedures developed	• Printed Technical guidelines and procedures • Minutes of consultation meetings	
3. Capacity of GDEP as a whole and related departments under GDEP is enhanced.	• Enhanced EIA review -Review and comment on EIA reports of 70 investment projects in 2017 and increase by 10% every year onward - Collect data and related information of EIA/IEIA/EPA reports of 140 investment projects in 2017 and increase by 10% every year onward - Monitor environmental EPA and EMP (written in IEIA/EIA reports) of 322 investment projects for 644 times in 2017 and increase by 10% every year onward • Water quality monitoring - Pollution source mapping in PP area -Increased coverage of pollution source/waste water monitoring in PP	- Internal reports - Water pollution mapping report - Monitoring data compiled -	

	area (100% coverage by 2020) - An increased number of sites for ambient water monitoring (50% increase from 2016)		
[Activity of the project] Output 1 Law and regulation revised and updated 1.1 Develop task force to review law and regulation 1.2 Finalize items for output 1 1.3 Review and draft revised law and regulation 1.4 Consultation with stakeholders 1.5 Finalize draft revised law and regulation 1.6 Prepare summary report for output 1 Output 2 Technical guideline and procedure developed 2.1 Develop task force to develop guideline and procedure 2.2 Finalize items for output 2 2.3 Develop draft guideline and procedures 2.4 Consultation with stakeholders 2.5 Finalize draft guideline and procedure 2.6 Prepare summary report for output 2 Output 3 Capacity development of MoE staff 3.1 Finalize content/subject of training program 3.2 Organize seminar 3.3 study tour 3.4 Develop training program and implement 3.5 Prepare summary report of output 3	[Input] .Japanese Side (1) Japanese Experts 7-10 short term expert (2)Training Study tour to Japan and other countries (3)Local Cost Local costs for experts' activities Sub-contract for EIA Sub-contract for data collection and Database input Local consultant to assist legal document drafting Small funding for research (4)Machinery, Equipment and Materials Portable water quality monitoring unit and accessory, reagent Portable air quality monitoring unit (PM) Laboratory common apparatus (hot plate, water bath, pH meter) Cambodia side (1)Counterpart personnel including administrator (2)Office space, meeting room (3)Local costs (see Minutes of Meeting)"		

Note:

- "Task force" mentioned in activity 1.1 and 2,1 means working team within GDEP and JICA team for respective task, i.e, preparation of legal document, technical guideline and materials. Persons from outside may be selected to join the team.
- "Summary report" mentioned in activity 1.6, 2.6 and 3.6 means reports to be prepared by GDEP and JICA team to summarize the activity/achievement in each output area, and will be used to report to others in GDEP, JICA and other stakeholders.

Annex II

Tentative Plan of Operation (draft version as of 15December 2016)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Output 1 Law and regulation revised and updated																																										
1.1 Develop task force to review law and regulation																																										
1.2 Fianlize items for output 1																																										
1.3 Review and draft revised law and regulation																																										
1.4 Consultation with stakeholders																																										
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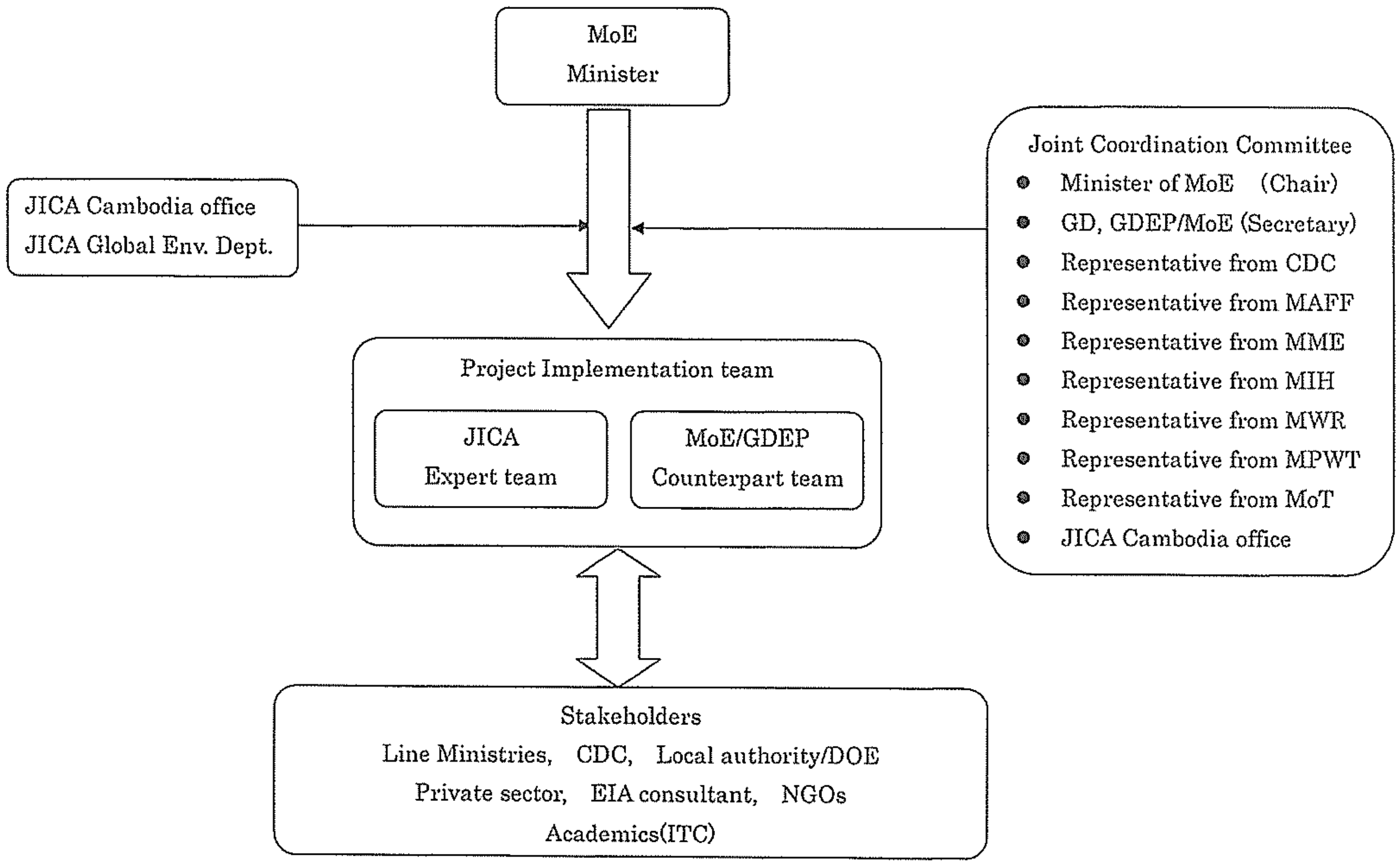
3.1 Fianlaize content/subject of training program																																										
3.2 Organize seminar																																										
3.3 study tour																																										
3.4 Develop training program and implement																																										
3.5 Prepare summary report of output 3																																										

Annex III


MoE
Minister
JICA Cambodia office
JICA Global Env. Dept.
Joint Coordination Committee
Minister of MoE (Chair)
GD, GDEP/MoE (Secretary)
Representative from CDC
Representative from MAFF
Representative from MME
Representative from MIH
Representative from MWR
Representative from MPWT
Representative from MoT
JICA Cambodia office
Project Implementation team
JICA
Expert team
MoE/GDEP
Counterpart team
Stakeholders
Line Ministries, CDC, Local authority/DOE
Private sector, EIA consultant, NGOs
Academics(ITC)

Annex IV

JOINT COORDINATING COMMITTEE (JCC)

1. Functions

The Joint Coordinating Committee (hereinafter referred to as "JCC") will meet at least once a year or whenever the necessity arises, in order to fulfill the following functions:

(1) To approve an annual work plan of the Project based on the Plan of Operation within the framework of the Record of Discussions;
(2) To monitor and review the overall progress of the Project carried out under the above-mentioned annual work plan; and
(3) To exchange views and ideas on major issues those arise during the implementation of the Project.

2. Members of the JCC

The JCC will be composed of the chair, the members and the observers. The chair may declare closed sessions against the observers. The rules and guidelines for the management of the JCC will be determined at the initial stage of the Project.

(1) Chairperson: Minister, Ministry of Environment
(2) Cambodian side:
-Representative from the Council for the Development of Cambodia
-Representative from Ministry of Agriculture, Forestry and Fishery
-Representative from Ministry of Mining and Energy
-Representative from Ministry of Industry and Handicraft
-Representative from Ministry of Water Resources
-Representative from Ministry of Public Work and Transportation
-Representative from Ministry of Land Management, Urbanization and Construction
-Representative from Ministry of Tourism
-Counterparts
(3) Japanese side
-JICA Expert(s) of the Project
-Representative from JICA Cambodia Office
(4) Other member(s)

Note: Official(s) of Embassy of Japan may attend the JCC meeting as observer(s). The chairperson can name new members or request the attendance of other participants, as necessary, upon mutual consent by both sides, when necessary.

Annex V

A LIST OF COUNTERPART PERSONNEL OF CAMBODIA

No.	Project Position	Position	Organization	Related Output
1.	Project Director	General Director	General Department of Environmental Protection	All
2.	Project Manager	Deputy General Director	General Department of Environmental Protection	All
3.	Project Assistant	Director	Department of Administration Planning and Finance	All
4.	Project Assistant	Director	Department of Air and Noise Quality Management	Output 3
5.	Project Assistant	Director	Department of Solid Waste Management	Output 3
6.	Project Assistant	Director	Department of Water Quality Management	All
7.	Project Assistant	Director	Department of Hazardous substance Management	Output 3
8.	Project Assistant	Director	Department of Environmental Impact Assessment	All
9.	Project Assistant	Director	Department of Law Enforcement and Inspection	All
10.	Counterpart	Staff	Department of Administration Planning and Finance	All
11.	Counterpart	Staff	Department of Air and Noise Quality Management	Output 3
12.	Counterpart	Staff	Department of Solid Waste Management	Output 3
13.	Counterpart	Staff	Department of Water	All

			Quality Management	
14.	Counterpart	Staff	Department of Hazardous substance Management	Output 3
15.	Counterpart	Staff	Department of Environmental Impact Assessment	All
16.	Counterpart	Staff	Department of Law Enforcement and Inspection	All
17.	Counterpart	Staff	Laboratory	Output 3

Note:
Counterpart personnel will be added as the need arises for the smooth and effective implementation of the Project.

添付資料 2　Project Design Matrix

Project Design Matrix (2016/12/15) Ver.1.0

Project Name: Technical Cooperation Project for Better Implementation of EIA and Pollution Control through the Capacity Development of MoE

Duration of Project: 3 years

Target Group: GDEP (General Department of Environmental Protection), Ministry of Environment

Target area: Phnom Penh

Narrative Summary	Verifiable Indicators	Means of Verification	Important assumption
[Overall goal] **MoE's institutional and technical capacity is developed to implement the mission of ensuring environmental protection effectively and efficiently.**	**MoE's work on environmental protection received better evaluation from related stakeholders, compared to the level that of the starting point of the project.**	**Organizing a seminar to report the progress after the project and obtaining questionnaire answer from related stakeholders.**	Present national policy and environment regulation in Cambodia is maintained and improved. Manpower and budget to be provided by the government,
[Project purpose] **GDEP capacity to prevent, reduce and mitigate environmental pollution focusing on EIA and water is strengthened.**	**GDEP's work on EIA received more confidence from government offices related to EIA, compared to the level that of the starting point of the project.** **Transparency of GDEP is increased through information disclosure.**	**Questionnaire answer from the related government offices** **Website that contains information related to EIA and environmental pollution**	Present national policy and environment regulation in Cambodia is maintained and improved. Manpower and budget to be provided by the government,
[Output] **1. Legal documents related to EIA and pollution control focusing on water are revised and processed for approval.**	● **Prakas/Joint Prakas : Documents submitted to Minister(s) for approval** ● **Sub-decrees : Document submitted to the Prime Minister's office for approval**	**Legal documents under approval process**	.
2. Technical issues and procedures related to EIA and pollution control focusing on water are clarified and shared with GDEP staff as well as other stakeholders.	● **Technical guidelines and procedures developed**	● **Printed Technical guidelines and procedures** ● **Minutes of consultation meetings**	
3. Capacity of GDEP as a whole and related departments under GDEP is enhanced.	● **Enhanced EIA review** **-Review and comment on EIA reports of 70 investment projects in 2017 and increase by 10% every year onward** **- Collect data and related information of EIA/IEIA/EPA reports of 140 investment projects in 2017 and increase by 10% every year onward** **- Monitor environmental EPA and EMP (written in IEIA/EIA reports) of 322 investment projects for 644 times in 2017 and increase by 10% every year onward** ● **Water quality monitoring** **- Pollution source mapping in PP area** **-Increased coverage of pollution source/waste water monitoring in PP**	**- Internal reports** **- Water pollution mapping report** **- Monitoring data compiled** **-**	

	area (100% coverage by 2020) **- An increased number of sites for ambient water monitoring (50% increase from 2016)**		
[Activity of the project] Output 1 Law and regulation revised and updated 1.1 Develop task force to review law and regulation 1.2 Finalize items for output 1 1.3 Review and draft revised law and regulation 1.4 Consultation with stakeholders 1.5 Finalize draft revised law and regulation 1.6 Prepare summary report for output 1 Output 2 Technical guideline and procedure developed 2.1 Develop task force to develop guideline and procedure 2.2 Finalize items for output 2 2.3 Develop draft guideline and procedures 2.4 Consultation with stakeholders 2.5 Finalize draft guideline and procedure 2.6 Prepare summary report for output 2 Output 3 Capacity development of MoE staff 3.1 Finalize content/subject of training program 3.2 Organize seminar 3.3 study tour 3.4 Develop training program and implement 3.5 Prepare summary report of output 3	[Input] .Japanese Side (1) Japanese Experts 7-10 short term expert (2)Training Study tour to Japan and other countries (3)Local Cost Local costs for experts' activities Sub-contract for EIA Sub-contract for data collection and Database input Local consultant to assist legal document drafting Small funding for research (4)Machinery, Equipment and Materials Portable water quality monitoring unit and accessory, reagent Portable air quality monitoring unit (PM) Laboratory common apparatus (hot plate, water bath, pH meter) Cambodia side (1)Counterpart personnel including administrator (2)Office space, meeting room (3)Local costs (see Minutes of Meeting)"		

Note:

- “Task force” mentioned in activity 1.1 and 2,1 means working team within GDEP and JICA team for respective task, i.e, preparation of legal document, technical guideline and materials. Persons from outside may be selected to join the team.
- “Summary report” mentioned in activity 1.6, 2.6 and 3.6 means reports to be prepared by GDEP and JICA team to summarize the activity/achievement in each output area, and will be used to report to others in GDEP, JICA and other stakeholders.

Project Design Matrix (2018/1/10) Ver.2.0
Project Name: Technical Cooperation Project for Better Implementation of EIA and Pollution Control through the Capacity Development of MoE
Duration of Project: 3 years
Target Group: GDEP (General Department of Environmental Protection), Ministry of Environment
Target area: Phnom Penh

Narrative Summary	Verifiable Indicators	Means of Verification	Important assumption
[Overall goal] MoE's institutional and technical capacity is developed to implement the mission of ensuring environmental protection effectively and efficiently.	MoE's work on environmental protection received better evaluation from related stakeholders, compared to the level that of the starting point of the project.	Organizing a seminar to report the progress after the project and obtaining questionnaire answer from related participated stakeholders.	Present national policy and environment regulation in Cambodia is maintained and improved. Manpower and budget to be provided by the government,
[Project purpose] GDEP capacity to prevent, reduce and mitigate environmental pollution focusing on EIA and water is strengthened.	1. GDEP's work on EIA and water pollution control received 20 percent increased confidence from government offices related to the above mentioned fields compared to the level that of the starting point of the project 2. Transparency of GDEP is increased through regular information disclosure 3. EIA review and water pollution control related works are carried out in accordance with the development of technical guidelines and procedures	1. Questionnaire answer from the related government offices 2. Information disclosure materials such as Annual report of MoE, Website that contains information related to EIA and environmental pollution 3. Result of the interview 4. Work record	Present national policy and environment regulation in Cambodia is maintained and improved. Manpower and budget to be provided by the government,
[Output] 1. Legal documents related to EIA and pollution control focusing on water are organized	1-1 Prakas/Joint Prakas : Documents are submitted to Minister(s) for approval 1-2 Sub-decrees:Documents are submitted to the Council of Ministers for approval	1. Copy of legal documents approved or under approval process	.
2. Technical issues and procedures related to EIA and pollution control focusing on water are clarified and shared with GDEP staff as well as other stakeholders.	2-1 Developed technical guidelines and procedures are understood by the stakeholders	2-1 Printed Technical guidelines and procedures 2-2 Minutes of consultation meetings 2-3 Questionnaire answer of the stakeholders	
3. Capacity of GDEP and related departments under GDEP in the field of Environmental Management is enhanced	3-1 Result of water quality monitoring is opened to the public by GDEP 3-2 Quality of the comments on EIA/IEIA reports made by staffs of EIA Department and other members of EIA review committee is improved compared to the level at the starting point of the Project.	3-1 Water quality monitoring reports 3-2 Compiled water quality monitoring data 3-3 Compiled comments on EIA reports 3-4 Interview results	

	3-3 Pollution source mapping in PP area	from staffs of EIA Department and EIA review committee	
[Activity of the project] <u>Output 1: Law and regulation revised and updated</u> 1.1 Develop task force to review laws and regulations 1.2 Finalize items for output 1 1.3 Review and draft revised laws and regulations 1.4 Consultation with stakeholders 1.5 Finalize draft revised laws and regulations 1.6 Prepare summary report for output 1 <u>Output 2 : Technical guideline and procedure developed</u> 2.1 Develop task force to develop guideline and procedure 2.2 Finalize items for output 2 2.3 Develop draft guidelines and procedures 2.4 Consultation with stakeholders 2.5 Finalize draft guidelines and procedures 2.6 Disseminate the finalized and/or draft guideline and procedure to stakeholders 2.7 Prepare summary report for output 2 <u>Output 3: Capacity development of MoE staff</u> 3.1 Review the institutional arrangements of GDEP to clarify the scope of the training 3.2 Prepare the syllabus including contents/subjects of training program 3.3 Organize seminars 3.4 Conduct study tours 3.5 Develop training programs reflecting the obtained results from seminars and study tours 3.6 Implement the developed training program 3.7 Evaluate the implemented training program and prepare the next training 3.8 Prepare summary report of output 3	[Input] .<u>Japanese Side</u> Japanese Experts 7-10 short term expert (2)Training Study tour to Japan and other countries (3)Local Cost Local costs for experts' activities Sub-contract for EIA Sub-contract for data collection and Database input Local consultant to assist legal document drafting Small funding for research (4)Machinery, Equipment and Materials Portable water quality monitoring unit and accessory, reagent Portable air quality monitoring unit (PM) Laboratory common apparatus (hot plate, water bath, pH meter) <u>Cambodia side</u> (1)Counterpart personnel including administrator (2)Office space, meeting room (3)Local costs (see Minutes of Meeting)"		

Note:

- "Task force" mentioned in activity 1.1 and 2.1 means working team within GDEP and JICA team for respective task, i.e, preparation of legal document, technical guideline and materials. Persons from outside may be selected to join the team.
- "Summary report" mentioned in activity 1.6, 2.6 and 3.8 means reports to be prepared by GDEP and JICA team to summarize the activity/achievement in each output area, and will be used to report to others in GDEP, JICA and other stakeholders.

添付資料 3　　ESIA Report Review Manual (4th Edition)

ESIA Report Review Manual

2021

Ministry of Environment
Kingdom of Cambodia

ESIA Report Review Manual

(as of 25 Aug 2021)

Table of Contents

Definition of Terms

Alternatives
Options, choices, or courses of action; they are means to accomplish ends. From the perspective of ESIA, these ends include not just a particular agency's or developers goals, but also broader societal goals such as the protection and promotion of environmental quality.

Baseline Information
Information derived from data which:
- Records the existing elements and trends in the environment; and
- Records the characteristics of a given project proposal

Checklist
A list of special biophysical, social and economic factors that may be affected by specific types of activities. Sectoral checklists are available for application to particular types of projects and categories of impacts (such as dams or road building).

Consultation
A process with decision-makers, key stakeholders affected communities, environmental interest groups to ensure that all potential impacts are detected.

Decision-maker
The person(s) entrusted with the responsibility for allocating resources or granting approval to a project proposal.

Decision-making
The sequence of steps, actions or procedures that result in decisions, at any stage of a proposal.

Environment
The surroundings within which humans exist and that are made up of:
i. land, water and atmosphere of the earth;
ii. micro-organisms, plant and animal life;
iii. any part or combination of (i) and (ii) and the interrelationships among and between them; and
iv. the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being. This includes the economic, cultural, historical, and political circumstances, conditions and objects that affect the existence and development of an individual, organism or group.

Environmental Consultant
Individuals or firms who act in an independent and unbiased manner to provide information for decision-making.

Environmental and Social Impact Assessment (ESIA)
A public process, which is used to identify, predict and assess the potential environmental and social impacts of a proposed project on the environment. ESIA is used to inform decision-making. In this manual, IEIA and EIA are inclusively referred to as ESIA.

Environmental Management Plan (EMP)
A plan stipulated in the ESIA report on assessment of impacts on environmental and social aspects which define environmental protection measures and impact mitigation; responsibility and schedule for implementation of environmental management plan; monitoring plan and assessment of impacts on the environment from the project that must be done including sufficient budget planning for environmental activities required during the design/construction and operation periods and project termination.

Project
The execution of construction works or of other installations or schemes and other interventions in the natural surroundings and landscape including those involving the extraction of mineral resources.

Project Proponent
Any individual, government department, authority, industry or association proposing a project.

Public
Ordinary citizens who have diverse cultural, educational, political and socio-economic characteristics. The public is not a homogeneous and unified group

	of people with a set of agreed common interests and aims. There is no single public. There are a number of publics, some of whom may emerge at any time during the process depending on their particular concerns and the issues involved.
Public Participation	It consists of public consultation and involvement in the ESIA process of discussion, exchange and hearing of opinions, access to information on all parties of direct and indirect impact from the project development, and settlement of grievance issues from the period of planning formulation, implementation and environmental maintenance and restoration period to project termination.
Review	The process of establishing whether an ESIA report is adequate for the Competent Authority to use it to inform the decision on Development Consent. It is important to note that the decision will usually involve consideration of other information in addition to the environmental information, but the aim of review is to check that the environmental information is adequate.
Scoping	The process of identifying the content and extent of the Environmental and Social Information to be submitted to the Competent Authority under the ESIA procedure.
Screening	The process by which a decision is taken on whether or not ESIA is required for a particular Project.
Stakeholder	A sub-group of the public whose interests may be positively or negatively affected by a proposal or activity and/or who are concerned with a proposal or activity and its consequences. The term therefore includes the proponent, authorities (both the lead authority and other authorities) and all interested and affected parties (I&APs). The principle that environmental consultants and stakeholder engagement practitioners should be independent and unbiased excludes these groups from being considered stakeholders.
Stakeholder Engagement	The process of engagement between stakeholders (the proponent, authorities and I&APs) during the planning, assessment, implementation and/or management of proposals or activities. The level of stakeholder engagement varies depending on the nature of the proposal or activity as well as the level of commitment by stakeholders to the process. Stakeholder engagement can therefore be described by a spectrum or continuum of increasing levels of engagement in the decision-making process. The term is considered to be more appropriate than the term "public participation".
Terms of Reference (ToR)	A document produced by the authority conducting the ESIA study. It is formed normally during scoping - the second stage in the ESIA process.

0. Preface

Introduction

An Environmental and Social Impact Assessment (ESIA) essentially provides information on the environmental and social consequences of given activities of a project in order to inform decision-making. Such information needs to be accessible to a wide range of users including decision-makers and stakeholders. Note in this manual ESIA refers to IEIA and EIA which are commonly used in Cambodia as well.

ESIA Report

The final product of an ESIA is an Environmental and Social Statement or Report. The ESIA report provides information to decision makers prior to issuing an operating license so they can properly assess the project's impacts on both the environment and people. Therefore, the report should to be based on accurate and relevant information that accounts for diverse impacts and cumulative effects of the planned project's life cycle. The ultimate audience of the ESIA report is the decision makers: it aims to help them decide whether to accept the project as it is, ask for revisions in the project or reject it.

Aspects of a good ESIA report include:

- Is well-structured and uses non-technical language supported by data and well-executed analyses.
- Provides information that is helpful and relevant to decision making.
- Results in the satisfactory prediction of the adverse effects of proposed actions and their mitigation using conventional and customized techniques.

After the ESIA report is completed, the review process is conducted by the responsible agencies (e.g. Department of EIA).

Challenges of an ESIA

Overall there are often many challenges in putting together a comprehensive ESIA. These challenges include:

- The description of the proposal does not cover key features.
- Key problems affected by the proposal are not described.
- Sensitive elements in the affected environment are overlooked.
- Alternatives do not comply with environmental regulations and standards.
- Appropriate mitigating measures are not considered.
- Serious environmental impacts or risks are not described or incorrectly described.
- Insufficient or inaccurate data/information.

There are also wider outcomes associated with an ESIA. It should lead to better standards of development, and in some cases, limit development completely in sensitive areas. Where developments do go ahead, environmental assessments should help propose proper mitigation measures. When done well, an EIA can help stimulate growth and production in the local economy while promoting sustainability. In this context the specific contributions of the ESIA can be listed as follows):

- Ensure that environmental and social considerations are explicitly addressed and incorporated into the development decision-making process.
- Anticipate and avoid, minimize or offset the adverse significant biophysical, social and other relevant effects of development proposals.
- Protect the productivity and capacity of natural systems and the ecological processes which maintain their functions.
- Promote development that is sustainable, optimizing resource use and management opportunities

An ESIA should allow decision makers to understand a project's impacts in all its phases. It should also allow the public and other stakeholders to present their views and inputs on the planned development. Furthermore, to be truly effective, an ESIA must contribute to and improve the project design, so that environmental as well as socioeconomic measures are core parts of it. Information used in the ESIA needs to be based on good data, use accepted methodological approaches and be summarized in plain language that is understandable for decision makers.

ESIA Review

An ESIA review attempts to ensure the presented information is accurate, comprehensive and comprehensible, as well as to assess the adequacy and quality of ESIA reports ensuring reference to legal conformity and good practice. In summary an ESIA review is an instrument for quality control.

This manual aims to describe the function of review in ESIA, more specifically the manual serves to address the following items:

- The role and purpose of persons in charge of reviewing.
- The reviewer's roles and responsibilities in the overall ESIA process.
- The critical information required for informed decision-making.

This manual is structured to describe the review process, why it is important to present a series of review principles and to describe an approach to conducting a comprehensive review.

1. Introduction

1.1 What is Review in ESIA?

Review can be referred to as the practice of having an independent party to assess work submitted in EIA reports make sure it is accurate, comprehensive and clearly presented. Review is not only an integral part of the ESIA process, but also serves to provide comments and opinions on the quality of the ESIA from a range of stakeholder perspectives. ESIA review acts as a tool to improve the quality of an ESIA.

The ultimate purpose of the ESIA is to provide critical inputs for decision making about the planned development. The review is carried out to confirm the quality of the information and methods used in the ESIA, and that the ESIA report addresses all the critical and cumulative impacts as well as the relevant mitigation measures.

The review will determine whether or not the project adequately addresses major environmental and social impacts and other risks, and whether or not to grant a license to the project proponents (or perhaps to request changes). This means that a good quality ESIA might still lead to the planned development not being permitted to go ahead based on the identified impacts.

1.2 Purpose and Objectives of ESIA Review

1.2.1 General Information

Project owners are directed to conduct simultaneously the environmental and social impact study. The purpose of ESIA review is to assure the completeness and quality of the information presented in the ESIA report. The key objectives of ESIA report review include:

- Assessing the validity, adequacy and quality of an ESIA report;
- Considering public comments;
- Determining if the provided information is sufficient for a final decision;
- Identifying the deficiencies in the ESIA report; and
- Providing quality comments and recommendations for a better ESIA report.

1.2.2 Stages of ESIA Process

The ESIA process can be divided into six (6) stages. Simple explanations of the purpose of each stage are shown in Table 1.

Table 1 The Purpose of Review at Each Stage of the ESIA Process

No.	Stage in EIA Process	Purpose
1	Screening	Determine the extent to which a full environmental impact study is required or not
2	Scoping[1]	Define the scope and TOR of the assessment
3	Assessment	Conduct the assessment as defined by scoping stage, including baseline and impact assessment, mitigation measures, EMP and EMoP
4	Decision	Decide the project to be authorized or declined
5	Implementation	Implement the ESIA recommendations and conditions of authorization
6	Stakeholder Engagement	Demonstrate opportunity for stakeholders to participate in the ESIA process. Keep in mind this stage shall be considered at an earlier time of and thru the project.

Source: South African DEAT (2004)

Box 1: Questions to help reviewers assess project proposals and to determine

These questions are designed so that a "Yes" answer will generally point toward the need for ESIA and a "No" answer to one not being required:

1. Will there be a large change in environmental conditions?
2. Will new features be out-of-scale with the existing environment?
3. Will the effect be unusual in the area or particularly complex?
4. Will the effect extend over a large area?
5. Will there be any potential for transboundary impact?
6. Will many people be affected?
7. Will many receptors of other types (fauna and flora, businesses, facilities) be affected?
8. Will valuable or scarce features or resources be affected?
9. Is there a risk that environmental standards will be breached?
10. Is there a risk that protected sites, areas, and features will be affected?
11. Is there a high probability of the effect occurring?
12. Will the effect continue for a long time?
13. Will the effect be permanent rather than temporary?
14. Will the impact be continuous rather than intermittent?
15. If it is intermittent will it be frequent rather than rare?
16. Will the impact be irreversible?
17. Will it be difficult to avoid, or reduce or repair or compensate for the effect?

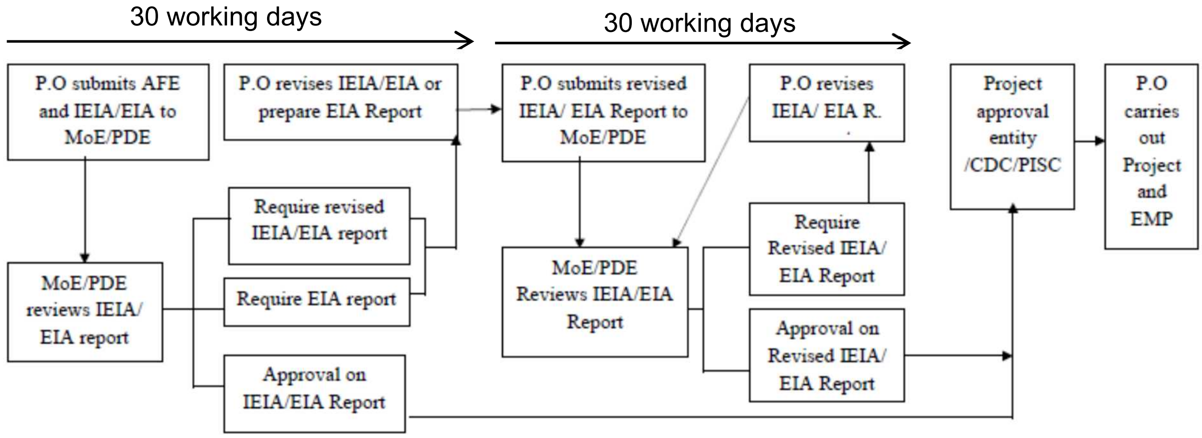
Source: European Commission (2001)

[1] Scoping is a critical step in the preparation of an ESIA, as it identifies the issues that are likely to be of most importance during the ESIA and eliminates those that are of little concern. Scoping is a systematic exercise that establishes the boundaries of your ESIA and sets the basis of the analyses you will conduct at each stage. A quality scoping study reduces the risk of including inappropriate components or excluding components that should be addressed:
- Identifying all relevant issues and factors, including cumulative effects, social impacts, and health risks.
- Facilitating meaningful public engagement and review in at least two stages of the process: once when scoping the impacts and issues to be considered, and again during the presentation of initial findings of the ESIA, including a non-technical summary.
- Determining the appropriate time and space boundaries of the ESIA.
- Identifying the important issues to be considered in an ESIA, such as setting the baseline and including alternatives

2. ESIA Report Review Process and Principles in Cambodia

2.1 Process Review

Figure 1 illustrates the official ESIA review scheme in Cambodia.



Abbreviations:

IEIA: Initial Environmental Impact Assessment, **EIA**: Full Environmental Impact Assessment, **CDC**: Council for Development of Cambodia, **EMP**: Environmental Management Plan, **MoE**: Ministry of Environment, **PISC**: Provincial Investment Sub-committee, **PDE**: Provincial Department of Environment, **AFE**: Application Form of Environment, **P.O**: Project Owner

Source: MoE's Prakas No.376 on General Guidelines for Developing Initial and Environmental Impact Assessment Report (2009)

Figure 1 Process for ESIA Clearance for Proposals with Endorsement from Project Approval Entity/ CDC or by Provincial Investment Sub-committee

According to Prakas No. 376 (2009), review of an ESIA (IEIA or EIA) report needs 30 working days from the date on which MoE receives the Application Form of Environment (AFE) and ESIA report from the project owner (Article 10).

The review and clearance of ESI report at the ministerial level is subject to the following manner (Article 11):

- Visit and collect comments made by technical officials of Department of Environmental Impact Assessment at the project site (within 10 working days);
- Comments made by relevant departments of MoE (within 5 working days);
- Comments by the management of MoE (within 5 working days);
- Comments at multi-stakeholder meeting chaired by the Minister of MoE with representation from relevant government ministries/ agencies, local authorities, non-governmental organizations, and other stakeholders concerned with the investment project (within 5 working days).

After a request of any additional ESIA revision by the reviewing authority, the MoE will make additional review(s) within 30 working days upon the official receipt of the revised report (Article 13).

2.2 ESIA Review Principles

The ESIA review process generally has the following five principles which should be ensure the review process is constructive and sound. Table 2 describes the five principles.

Table 2 The Review Principles and Descriptions

No.	Principle	Description
1	Assumption	When considering the assumptions that have been used, two aspects should be addressed including: 1) reasonability and validity, and 2) degree of affection to the conclusions and findings.
2	Consistency	Spreading a broad range of items from writing and presentation style through to the more complex challenge of ensuring that the information provided is consistent or coherent.
3	Efficiency	Efficiency can be evaluated by the adequacy of the particular information to the issues that need to be addressed.
4	Logic	Making deductions and conclusions based on the acquired information.
5	Sufficiency	Often becoming a major problem in EIA because of insufficient information to address all the issues at the required level of data. To compensate such weakness, it can be used to make assumptions and specify the argument behind those assumptions.

Source: South African DEAT (2004)

Table 3 shows generic concepts that can be applied to all stages of the ESIA process. These concepts should be the basis for the review process

Table 3 Review Concepts.

Concept	Description
Adaptive	The process should be adjusted to the realities, issues and circumstances of the proposals under review without compromising the integrity of the process, and be iterative, incorporating lessons learned throughout the proposal's life cycle.
Cost-effective	The process should achieve the objectives of ESIA within the limits of available information, time, resources and methodology.
Credible	The process should be carried out with professionalism, rigor, fairness, objectivity, impartiality and balance, and be subject to independent checks and verification.
Efficient	The process should impose the minimum cost burdens in terms of time and finance on proponents and participants consistent with meeting accepted requirements and objectives of ESIA.
Focused	The process should concentrate on significant environmental effects and key issues; i.e., the matters that need to be taken into account in making decisions.
Integrated	The process should address the interrelationships of social, economic and biophysical aspects.
Participative	The process should provide appropriate opportunities to inform and involve the interested and affected publics, and their inputs and concerns should be addressed explicitly in the documentation and decision making.
Practical	The process should result in information and outputs which assist with problem solving and are acceptable to and able to be implemented by proponents.
Purposive	The process should inform decision making and result in appropriate levels of environmental protection and community well-being.
Relevant	The process should provide sufficient, reliable and usable information for development planning and decision making.
Rigorous	The process should apply “best practicable” science, employing methodologies and techniques appropriate to address the problems being investigated.

Concept	Description
Systematic	The process should result in full consideration of all relevant information on the affected environment, of proposed alternatives and their impacts, and of the measures necessary to monitor and investigate residual effects.
Transparent	The process should have clear, easily understood requirements for ESIA content; ensure public access to information; identify the factors that are to be taken into account in decision making; and acknowledge limitations and difficulties.

Source: South African DEAT (2004)

2.3 Content of ESIA reports

Although ESIA is a technical process and the outputs can be complex, the report must be written in a non-technical manner where possible to facilitate comprehension by a distance of readers, such as some of whom have little technical or engineering knowledge.

The ESIA report fundamentally follows the requirements of the ToR and should therefore have the following sections as shown in Table 4 below.

Table 4 Generic Sections of an ESIA Report

Section	Key Contents
Justification for the project	- The report shall begin with a clear statement regarding the need for the project and how it relates to national policies and plans. - Reference can be made to the demands and issues that the proposal is intended to address, the purpose that will be achieved, and the impacts that are anticipated.
Legal and policy framework	- The report shall include a discussion of all laws or policies that apply to the project. - This can set the basis for determining that the project will be compliant with the national and international jurisdiction.
Terms of Reference (ToR)	- The ToR for the ESIA shall be summarized in the report in order to allow the reader to check the report against the ToR requirements.
Description of the proposal and its alternatives	- The report shall have a comprehensive description of the proposal and the alternatives, including maps and diagrams displaying the location of the project and its various components. - The description must address all project phases such as design/construction, operation and decommissioning. - Alternatives of the project shall be selected taking into account its feasibility, advantages of natural/ socio- economic aspects, including zero-option (no project implementation).
Description of the affected environment	- The report shall contain a description of the biophysical and socio-economic conditions of the environment that could be affected by the project. - It is essentially a presentation of the baseline information that was collected and this is the point of reference against which the impacts will be predicted. - Such information includes: · spatial and temporal boundaries; · biophysical, land use and socio-economic conditions; · major trends and anticipated future conditions which may intercept the project going ahead; and · environmentally sensitive areas and valued resources that may need special protection.
Public consultation and inputs	- The summary and results of the public consultations shall be presented in the report. - It will include a description of who were consulted, how they were informed, a full analysis of the perspectives and indicate how these have been addressed in the proposal.

Section	Key Contents
	- Any outstanding issues which may give impacts on the project should also be indicated.
Environmental impacts, their evaluation and mitigation	-This section is one of the most critical one to present potential positive and negative impacts by each component of the environment identified as important to the proposed project. - Possible information contained in this section includes: · prediction of each major impact, its characteristics and likely consequences; · consideration of their compliance with environmental standards and policy objectives; · recommended measures for avoiding, minimizing and remedying the impact; · evaluation of significance of the residual impacts which should be avoidable or considered critical (e.g. stating the standards or criteria used); and · limitations associated with impact prediction and evaluation, as indicated by the assumptions made, gaps in knowledge and uncertainties encountered when appropriate.
Environmental Management Plan (EMP)	- An EMP describes actions that will be taken to monitor and manage project related impacts during implementation and operation. - The EMP summarizes recommended mitigation measures (and any opportunities for environmental enhancement) and describes how they will be implemented. - The plan should also include: · recommended mitigation measures; · assignment of responsibilities for plan implementation; · schedule of the actions to be taken; · programs for surveillance and monitoring against agreed targets; · an impact management strategy to correct larger than predicted changes; · contingency and emergency response plans, where necessary; and · reporting, audit and review procedures. - The EMP can also contain any institutional strengthening, capacity building and training requirements that are necessary to implement the components of the plans.
Appendices	- This section contains the information that may be needed for reference or for detailed review by technical experts. - Baseline data, technical information and description of methodologies can be included in appendices when they are important to an understanding of the basis of the ESIA report but are not suitable for the main text. - Appendices can contain some or all of the following information: · glossary and explanation of acronyms; · listings of individuals and agencies consulted during the ESIA; · sources of data and information and a list of all reference material used; and · terms of reference for the ESIA.

Source: IAIA (1999)

The qualities expected to be inclusive within an ESIA report are discussed in Box 2 below. The reviewer should use this list of qualities as a guide to ensure the ESIA has been produced to the expected standards and contains information will enable a decision maker to make a clear and informed decision of the said project.

Box 2: Examples of qualities of a good ESIA report

- A clear structure with a logical sequence describing: existing baseline conditions, predicted impacts and mitigation measures;
- A table of contents at the beginning of the document;

- A clear description of the development consent procedure and how ESIA fits within it;
- Reads as a single document with appropriate cross-referencing;
- Is concise, comprehensive and objective;
- Is written in an impartial manner without bias;
- Includes a full description of the development proposals;
- Makes effective use of diagrams, illustrations, photographs etc. to support the text;
- Uses consistent terminology with a glossary;
- References all information sources used;
- Contains a good description of the methods used for the studies of each environmental topic;
- Covers each environmental topic in a way which is proportionate to its importance;
- Provides evidence of good consultations;
- Includes a clear discussion of alternatives;
- Has a non-technical summary which avoids technical jargon;

Source: European Commission (2001)

3. Conducting an ESIA Review

In general, a key consideration in conducting a review is ensuring that it enhances the ESIA. There are three steps which are recommended in conducting a review.

Step 1: **Identify the deficiencies in the ESIA report.**

- Read the contents of the analysis included in the qualification list, study them, and reflect on the information requirements and qualification criteria.
- Identify the information required. If the communication of results and fulfillment of formal and administrative aspects are not adequate, the reviewer should request the project coordinator to rewrite the study report and explain its deficiencies. If the communication of results is appropriate and the study provides the necessary information, the review team should continue with the analysis.

Step 2: **Focus on shortcomings /imperfections in the report. Separate crucial deficiencies, which may directly impede decision- making from less important one.**

- Study the specific tasks that should have been carried out to comply fully with the requirements described.
- Seek answers to the questions in the tables. The information required can be found in the study itself; it may be necessary to look for it - *do not presume that it is implicit*.
- The study can be qualified negatively if information is repeatedly found to be lacking. Carefully review the qualification system to understand its logic, since this system will be used to deal with each review criterion.

Step 3: **Recommend how short-comings are to be remedied to facilitate informed decision-making.**

- Decide on the appropriate qualification and record it in the qualification summary list.
- Decide if the ESIA is acceptable and the license to operate can be awarded, if the ESIA needs improvements or shows that the planned

development could have impacts to the area that are too severe.

3.1 Review Checklist

The review is based on the ToR and in most cases aided by the use of a review checklist, which is the simplest and most effective review technique containing pre-defined questions. Checklists are most useful for reviewing the completeness of an ESIA, but are far less effective in checking the quality of information that is presented. Checklists are aimed at helping reviewers decide whether the provided information meets the objective of:

- providing the necessary information to authorities for decision-making; and
- communicating with stakeholders so that they can comment in an informed manner.

An example of generic checklist is attached in Appendix.

3.2 Selecting Reviewers

The predominant requirement for a reviewer is that the person should have a level of expertise and knowledge similar to, or greater than, that of the specialist/ practitioner who compiled the report and should be well versed in the requirements of EISA. Experience, competence and reputation are as important as academic qualifications.

Reviewers should consist of a review team that understands how the project intends to operate; therefore operating procedures and rules should be known in advance. The lead reviewer (DEIA or its representative) should ensure that the process is managed in a timely manner, and is responsible for developing final recommendations. The review team should also comprise independent experts who can verify technical accuracy and completeness. They should have no vested interest in promoting the development or withholding approval. The team should also reflect the technical expertise required by the development, i.e. agriculture, ecosystem, engineering etc.

3.3 Responding to Review Comments

The review process is generally perceived to be a key in deciding whether an ESIA (or particular findings within the ESIA) is acceptable or not. Reviews tend to provide new insight on the information that is being presented.

If a reviewer expresses a divergent opinion, a useful mechanism to clarify issues is to provide an opportunity for dialogue. The discussion between the two parties should focus on the reasoning behind the findings rather than on the findings themselves. Again, the review criteria should employ the principles set out earlier in this Manual: consistency, logic, sufficiency, efficiency and assumptions. Box 3 presents advice for ESIA report reviewers in Japan

Box 3: Tips for ESIA Report Review in Japan

General

- Reviewers shall fully understand the ESIA system including its historical background, contents of related laws/regulations.
- Reviewers shall make comments/recommendations from a broad viewpoint, not from specific or self-satisfactory ones.
- The review shall be carried out fairly based on the environmental conservation and safety principles such as related law/ regulations and national/ international standards, and avoid being fixed on the past cases.
- When selecting experts who are familiar with the project area or local conditions, databases provided by the authorities including such information should be utilized, for instance.

Project Description and Methodology

- Parameters shall be derived from the project characteristics taking account of the type of the project area from scientific, engineering and objective viewpoints.

- The specifications of the project such as background, validity and necessity shall be described in accordance with the related laws and regulations.
- The survey methods and parameters shall be selected considering characteristics of the project and region, in order to enhance a best-driven ESIA.

Water Quality

- The method employed to predict impacts should be based on scientific practices
- Baseline data shall be collected to ensure that analysis is statistically significant.
- Models used shall set suitable parameters under a proper condition, and hopefully be one which is authorized or widely-employed by users.

Air Quality/ Noise

- For vehicle emission, parameters used for prediction shall be updated and proper (e.g. diffusion space, emission coefficients by vehicle type, vehicle volume in the future etc.)
- For vehicle noise, pre-set conditions shall be proper such as traffic condition, acoustic power levels of driving vehicles, pavement condition etc.

Fauna/Flora/Ecosytem

- Methods shall be appropriate for survey routes, survey point selection, timing and frequency of survey.
- Adaptive management shall be employed unless there are proper guidelines based on scientific perspective.

Ueda (2009), JAIA (2014)

References

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Appendix 1: EIA Report Review Checklist (Draft)

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
Section 1. DESCRIPTION OF THE PROJECT				
The Objectives and Physical Characteristics of the Project				
1.1	Are the need for and objectives of the project explained?			
1.2	Is the program for implementation of the Project described, detailing the estimated length of time and start and Finnish dates for construction, operation and decommissioning? (this should include any phases of different activity within the main phases of the Project, for example extraction phases for mining operations)			
1.3	Are all the main components of the project described?			
1.4	Is the location of each Project component identified, using maps, plans and diagrams as necessary?			
1.5	Is the layout of the site (or sites) occupied by the project described? (including ground levels, buildings, other physical structures, underground works, coastal works, storage facilities, water features, planting, access corridors, boundaries)			
1.6	For linear projects, are the route corridor, the vertical and horizontal alignment and any tunneling and earthworks described?			
1.7	Are the activities involved in construction of the project all described?			
1.8	Are the activities involved in operation of the project all described?			
1.9	Are the activities involved in decommissioning the project all described? (e.g. closure, dismantling, demolition, clearance, site restoration, site re-use etc)			
1.10	Are any additional services required for the project all described? (e.g. transport access, water, sewerage, waste disposal, electricity, telecoms) or developments (e.g. roads, harbors, powerlines, pipelines)			
1.11	Are any developments likely to occur as a consequence of the Project identified? (e.g. new housing, roads, water or sewerage infrastructure, aggregate extraction)			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
1.12	Are any existing activities which will alter or cease as a consequence of the Project identified?			
1.13	Are any other existing or planned developments with which the Project could have cumulative effects identified?			
The Size of the Project				
1.14	Is the area of land occupied by each of the permanent project components quantified and shown on a scaled map? (including any associated access arrangements, and escaping and ancillary facilities)			
1.15	Is the area of land required temporarily for construction quantified and mapped?			
1.16	Is the reinstatement and after use of land occupied temporarily for operation of the Project described? (e.g. land used for mining or quarrying)			
1.17	Is the size of any structures or other works developed as part of the Project identified? (e.g. the floor area and height of buildings, the size of excavations, the area or height of planting, the height of structures such as embankments, bridges of chimneys, the flow or depth of water)			
1.18	Is the form and appearance of any structures or other works developed as part of the Project described? (e.g. the type, finish and color of materials, the architectural design of buildings and structures, plant species, ground surfaces, etc)			
1.19	For urban or similar development projects, are the numbers and other characteristics of new populations or business communities described?			
1.20	For projects involving the displacement of people or businesses, are the numbers and other characteristics of those displaced described?			
1.21	For new transport infrastructure or projectsgenerating substantial traffic flows, is the type, volume, temporal pattern and geographical distribution of new traffic generated or diverted as a consequence of the Project described?			
Production Processes and Resources Used				
1.22	Are all the processes involved in			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
	operating the Project described? (e.g. manufacturing or engineering processes, primary raw material production, agricultural or forestry production methods, extraction processes)			
1.23	Are the types and quantities of outputs produced by the Project described? (these could be primary or manufactured products, goods such as power or water or services such as homes, transport, retailing, recreation, education, municipal services (water, waste, etc))			
1.24	Are the types and quantities of raw materials and energy needed for construction and operation discussed?			
1.25	Are the environmental implications of the sourcing of raw materials discussed?			
1.26	Is efficiency in use of energy and raw materials discussed?			
1.27	Are any hazardous materials used, stored, handled or produced by the Project identified and quantified? · during construction · during operation · during decommissioning			
1.28	Are the transport of raw materials to the Project and the number of traffic movements involved discussed? (including road, rail and sea transport) · during construction · during operation · during decommissioning			
1.29	Is employment created or lost as a result of the Project discussed? · during construction · during operation · during decommissioning			
1.30	Are the access arrangements and the number of traffic movements involved in bringing workers and visitors to the Project estimated? · during construction · during operation · during decommissioning			
1.31	Is the housing and provision of services for any temporary or permanent employees for the Project discussed? (relevant for Projects requiring migration of a substantial new workforce into the area for either construction or the long term)			
Residues and Emissions				

No.	Review Question	Relevant	Judgment	What further information is needed?
		Yes/No	C/A/I	
1.32	Are the types and quantities of solid waste generated by the Project identified? (including construction or demolition wastes, surplus spoil, process wastes, by-products, surplus or reject products, hazardous wastes, household or commercial wastes, agricultural or forestry wastes, site clean-up wastes, mining wastes, decommissioning wastes) · during construction · during operation · during decommissioning			
1.33	Are the composition and toxicity or other hazards of all solid wastes produced by the Project discussed?			
1.34	Are the methods for collecting, storing, treating, transporting and finally disposing of these solid wastes described?			
1.35	Are the locations for final disposal of all solid wastes discussed?			
1.36	Are the types and quantities of liquid effluents generated by the Project identified? (including site drainage and run-off, process wastes, cooling water, treated effluents, sewage) · during construction · during operation · during decommissioning			
1.37	Are the composition and toxicity or other hazards of all liquid effluents produced by the Project discussed?			
1.38	Are the methods for collecting, storing, treating, transporting and finally disposing of these liquid effluents described?			
1.39	Are the locations for final disposal of all liquid effluents discussed?			
1.40	Are the types and quantities of gaseous and particulate emissions generated by the Project identified? (including process emissions, fugitive emissions, emissions from combustion of fossil fuels in stationary and mobile plant, emissions from traffic, dust from materials handling, odors) · during construction · during operation · during decommissioning			
1.41	Are the composition and toxicity or other hazards of all emissions to air produce by the Project discussed?			
1.42	Are the methods for collecting, treating and finally discharging these			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
	emissions to air described?			
1.43	Are the locations for discharge of all emissions to air identified and the characteristics of the discharges identified? (e.g. height of stack, velocity and temperature of release)			
1.44	Is the potential for resource recovery from wastes and residues discussed? (including re-use, recycling or energy recovery from solid waste and liquid effluents)			
1.45	Are any sources of noise, heat, light or electromagnetic radiation from the Project identified and quantified? (including equipment, processes, construction works, traffic, lighting, etc)			
1.46	Are the methods for estimating the quantities and composition of all residues and emissions identified and any difficulties discussed?			
1.47	Is the uncertainty attached to estimates of residues and emissions discussed?			
Risks of Accidents and Hazards				
1.48	Are any risks associated with the Project discussed? · risks from handling of hazardous materials · risks from spills fire, explosion · risks of traffic accidents · risks from breakdown or failure of processes or facilities · risks from exposure of the Project to natural disasters (earthquake, flood, landslip, etc)			
1.49	Are measures to prevent and respond to accidents and abnormal events described? (preventive measures, training, contingency plans, emergency plans, etc)			
Other Questions on Description of the Project				
SECTION 2. CONSIDERATION OF ALTERNATIVES				
2.1	Is the process by which the Project was developed described and are alternatives considered during this process described?			
2.2	Is the baseline situation in the No Project situation described?			
2.3	Are the alternatives realistic and genuine alternatives to the Project?			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
2.4	Are the main reasons for choice of the proposed Project explained, including any environmental reasons for the choice?			
2.5	Are the main environmental effects of the alternatives compared with those of the proposed Project?			
Other Questions on Consideration of Alternatives				
SECTION 3. DESCRIPTION OF ENVIRONMENT LIKELY TO BE AFFECTED BY THE PROJECT				
Aspects of the Environment				
3.1	Are the existing land uses of the land to be occupied by the Project and the surrounding area described and are any people living on or using the land identified? (including residential, commercial, industrial, agricultural, recreational and amenity land uses and any buildings, structures or other property)			
3.2	Are the topography, geology and soils of the land to be occupied by the Project and the surrounding area described?			
3.3	Are any significant features of the topography or geology of the area described and are the conditions and use of soils described? (including soil quality stability and erosion, agricultural use and agricultural land quality)			
3.4	Are the fauna and flora and habitats of the land to be occupied by the Project and the surrounding area described and illustrated on appropriate maps?			
3.5	Are species populations and characteristics of habitats that may be affected by the Project described and are any designated or protected species or areas defined?			
3.6	Is the water environment of the area described? (including running and static surface waters, groundwaters, estuaries, coastal wasters and the sea and including run off and drainage)			
3.7	Are the hydrology, water quality and use of any water resources that may be affected by the Project described? (including use for water supply, fisheries, angling, bathing, amenity, navigation, effluent disposal)			
3.8	Are local climatic and meteorological conditions and			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
	existing air quality in the area described?			
3.9	Is the existing noise climate described?			
3.10	Is the existing situation regarding light, heat and electromagnetic radiation described?			
3.11	Are any material assets in the area that may be affected by the Project described? (including buildings, other structures, mineral resources, water resources)			
3.12	Are any locations or features of archaeological, historic, architectural or other community or cultural importance in the area that may be bisected the Project described, including any designated or protected sites?			
3.13	Is the landscape or townscape of the area that may be affected by the Project described, including any designated or protected landscapes and any important views or viewpoints?			
3.14	Are demographic, social and socio-economic conditions (e.g. employment) in the area described?			
3.15	Are any future changes in any of the above aspects of the environment that may occur in the absence of the project, described? (the so-called Moving Baseline or No Project situation)			
Data Collection and Survey Methods				
3.16	Has the study area been defined widely enough to include all the area likely to be significantly affected by the Project?			
3.17	Have all relevant national and local agencies been contacted to collect information on the baseline environment?			
3.18	Have sources of data and information on the existing environment been adequately referenced?			
3.19	Where surveys have been undertaken as part of the Environmental Studies to characterize the baseline environment are the methods used, any difficulties encountered and any uncertainties in the data described?			
3.20	Were the methods used appropriate for the purpose?			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
3.21	Are any important gaps in the data on the existing environment identified and the means used to deal with these gaps during the assessment explained?			
3.22	If surveys would be required to adequately characterize the baseline environment but they have not been practicable for any reason, are the reasons explained and proposals set out for the surveys to be undertaken at a later stage?			
Other Questions on the Description of the Environment				
SECTION 4. DESCRIPTION OF THE LIKELY SIGNIFICANT EFFECTS OF THE PROJECT				
Scoping of Effects				
4.1	Is the process by which the scope of the Environmental Studies was defined described? (for assistance, see the Scoping Guide in this series)			
4.2	Is it evident that a systematic approach to scoping was adopted?			
4.3	Is it evident that full consultation was carried out during scoping?			
4.4	Are the comments and views of consultees presented?			
Prediction of Direct Effects				
4.5	Are direct, primary effects on land uses, people and property described and where appropriate quantified?			
4.6	Are direct, primary effects on geological features and characteristics of soils described and where appropriate quantified?			
4.7	Are direct, primary effects on fauna and flora and habitats described and where appropriate quantified?			
4.8	Are direct, primary effects on the hydrology and water quality of water features described and where appropriate quantified?			
4.9	Are direct, primary effects on uses of the water environment described and where appropriate quantified?			
4.10	Are direct, primary effects on air quality and climatic conditions described and where appropriate quantified?			
4.11	Are direct, primary effects on the acoustic environment (noise or vibration) described and where			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
	appropriate quantified?			
4.12	Are direct, primary effects on heat, light or electromagnetic radiation described and where appropriate quantified?			
4.13	Are direct, primary effects on material assets and depletion of non-renewable natural resources (e.g. fossil fuels, minerals) described?			
4.14	Are direct, primary effects on locations or features of cultural importance described?			
4.15	Are direct, primary effects on the quality of the landscape and on views and viewpoints described and where appropriate illustrated?			
4.16	Are direct, primary effects on demography, social and socio-economic condition in the area described and where appropriate quantified?			
Prediction of Secondary, Temporary, Short Term, Permanent, Long Term, Accidental, Indirect, Cumulative Effects				
4.17	Are secondary effects on any of the above aspects of the environment caused by primary effects on other aspects described and where appropriate quantified? (e.g. effects on fauna, flora or habitats caused by soil, air or water pollution or noise; effects on uses of water caused by changes in hydrology or water quality; effects on archaeological remains caused by desiccation of soils)			
4.18	Are temporary, short term effects caused during construction or during time limited phases of project operation or commissioning described?			
4.19	Are permanent effects on the environment caused by construction, operation or decommissioning of the Project described?			
4.20	Are long term effects on the environment caused over the lifetime of Project operations or caused by build up of pollutants in the environment described?			
4.21	Are effects which could result from accidents, abnormal events or exposure of the Project to natural or man-made disasters described and where appropriate quantified?			
4.22	Are effects on the environment caused by activities ancillary to the main project described? (ancillary			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
	activities are part of the project but usually take place distant from the main Project location e.g. construction of access routes and infrastructure, traffic movements, sourcing of aggregates or other raw materials, generation and supply of power, disposal of effluents or wastes)			
4.23	Are indirect effects on the environment caused by consequential development described? (consequential development is other projects, not part of the main Project, stimulated to take place by implementation of the Project e.g. to provide new goods or services needed for the Project, to house new populations or businesses stimulated by the Project)			
4.24	Are cumulative effects on the environment off the Project together with other existing or planned developments in the locality described? (different future scenarios including a worst case scenario should be described)			
4.25	Are the geographic extent, duration, frequency, reversibility and probability of occurrence of each effect identified as appropriate?			
Prediction of Effects on Human Health and Sustainable Development Issues				
4.26	Are primary and secondary effects on human health and welfare described and where appropriate quantified? (e.g. health effects caused by release of toxic substances to the environment, health risks arising from major hazards associated with the Project, effects caused by changes in disease vectors caused by the project, changes in living conditions, effects on vulnerable groups)			
4.27	Are impacts on issues such as biodiversity, global climate change and sustainable development discussed where appropriate?			
Evaluation of the Significance of Effects				
4.28	Is the significance or importance of each predicted effect discussed in terms of its compliance with legal requirement and the number, importance and sensitivity of people, resources or other receptors affected?			
4.29	Where effects are evaluated against legal standards or requirements are			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
	appropriate local, national or international standards used and relevant guidance followed?			
4.30	Are positive effects on the environment described as well as negative effects?			
4.31	Is the significance of each effect clearly explained?			
Impact Assessment Methods				
4.32	Are methods used to predict effects described and are the reasons for their choice, any difficulties encountered and uncertainties in the results discussed?			
4.33	Where there is uncertainty about the precise details of the Project and its impact on the environment are worst case predictions described?			
4.34	Where there have been difficulties in compiling the data needed to predict or evaluate effects are these difficulties acknowledged and their implications for the results discussed?			
4.35	Is the basis for evaluating the significance or importance of impacts clearly described?			
4.36	Are impacts described on the basis that all proposed mitigation has been implemented i.e. are residual impacts described?			
4.37	Is the level of treatment of each effect appropriate to its importance for the development consent decision? Does the discussion focus on the key issues and avoid irrelevant or unnecessary information?			
4.38	Is appropriate emphasis given to the most severe, adverse effects of the Project with lesser emphasis given to less significant effects?			
Other Questions relevant to Description of Effects				
SECTION 5. DESCRIPTION OF MITIGATION				
5.1	Where there are significant adverse effects on any aspect of the environment is the potential for mitigation of these effects discussed?			
5.2	Are any measures which the developer proposes to implement to mitigate effects clearly described and their effect on the magnitude and			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
	significance of impacts clearly explained?			
5.3	If the effect of mitigation measures on the magnitude and significance of impacts is uncertain is this explained?			
5.4	Is it clear whether the Developer has made a binding commitment to implement the proposed mitigation or that the mitigation measures are just suggestions or recommendations?			
5.5	Are the Developer's reasons for choosing the proposed mitigation explained?			
5.6	Are responsibilities for implementation of mitigation including funding clearly defined?			
5.7	Where mitigation of significant adverse effects is not practicable or the developer has chosen not to propose any mitigation are the reasons for this clearly explained?			
5.8	Is it evident that the EIA Team and the Developer have considered the full range of possible approaches to mitigation including measures to reduce or avoid impacts by alternative strategies or locations, changes to the project design and layout, changes to methods and processes, "end of pipe" treatment, changes to implementation plans and management practices, measures to repair or remedy impacts and measures to compensate impacts?			
5.9	Are arrangements proposed to monitor and manage residual impacts?			
5.10	Are any negative effects of the proposed mitigation described?			
Other Questions relevant to Description of Effects				
SECTION 5. DESCRIPTION OF MITIGATION				
6.1	Does the Environmental information include a Non-Technical Summary?			
6.2	Does the Summary provide a concise but comprehensive description of the Project, its environment, the effects of the Project on the environment and the proposed mitigation?			
6.3	Does the Summary highlight any significant uncertainties about the			

No.	Review Question	Relevant Yes/No	Judgment C/A/I	What further information is needed?
	Project and its environmental effects?			
6.4	Does the Summary explain the development consent process for the Project and the role of EIA in this process?			
6.5	Does the Summary provide an overview of the approach to the assessment?			
6.6	Is the Summary written in non-technical language, avoiding technical terms, detailed data and scientific discussion?			
6.7	Would it be comprehensible to a lay member of the public?			
Other Questions on Non-Technical Summary				
SECTION 7. QUALITY OF PRESENTATION				
7.1	Is the Environmental Information available in one or more clearly defined documents?			
7.2	Is the document(s) logically organized and clearly structured so that the reader can locate information easily?			
7.3	Is there a table of contents at the beginning of the document(s)?			
7.4	Is there a clear description of the process which has been followed?			
7.5	Is the presentation comprehensive but concise, avoiding irrelevant data and information?			
7.6	Does the presentation make effective use of tables, figures, maps, photographs and other graphics?			
7.7	Does the presentation make effective use of annexes or appendices to present detailed data not essential to understanding the main text?			
7.8	Are all analyses and conclusions adequately supported with data and evidence?			
7.9	Are all sources of data properly referenced?			
7.10	Is consistent terminology used throughout the document(s)?			
7.11	Does it read as a single document with cross referencing between sections used to help the reader navigate through the document(s)?			

No.	Review Question	Relevant	Judgment	What further information is needed?
		Yes/No	C/A/I	
7.12	Is the presentation demonstrably fair and as far as possible impartial and objective?			
Other Questions on Quality of Presentation				

Note:

Complete (C): all information required for decision-making is available. No additional information is required even though more information might exist.

Acceptable (A): the information presented is incomplete, but the omissions do not prevent the decision-making process from proceeding.

Inadequate (I): the information presented contains major omissions. Additional information is necessary before the decision-making process can proceed.

OVERALL APPRAISAL OF THE EIA REPORT			
If the reviewer wishes to use the Review Checklist to make an overall appraisal of the quality of Environmental Information, this can be done using the table below.			
No.	**Review Topic**	**Judgement (C/A/I)**	**Comment**
1	DESCRIPTION OF THE PROJECT		
2	CONSIDERATION OF ALTERNATIVES		
3	DESCRIPTION OF ENVIRONMENT LIKELY TO BE AFFECTED BY THE PROJECT		
4	DESCRIPTION OF THE LIKELY SIGNIFICANT EFFECTS OF THE PROJECT		
5	DESCRIPTION OF MITIGATION		
6	NON-TECHNICAL SUMMARY		
7	QUALITY OF PRESENTATION		

Complete (C): all information required for decision-making is available. No additional information is required even though more information might exist.
Acceptable (A): the information presented is incomplete, but the omissions do not prevent the decision-making process from proceeding.
Inadequate (I): the information presented contains major omissions. Additional information is necessary before the decision-making process can proceed.

The overall report is graded as follows (tick one box)

☐ **Excellent**: The EIA report contains everything required for decision-making on the project. There are no gaps.

☐ **Good**: The EIA report contains most of the information required as far as it is relevant in the particular circumstances of the project; any gaps are relatively minor.

☐ **Satisfactory**: The information presented is not complete; there are significant omissions but in the context of the proposed project, these are not so great as to prevent a decision being made on whether the project should be allowed to proceed.

☐ **Inadequate**: Some of the information has been provided, but there are major omissions; in the context of the proposed project these must be addressed before a decision on whether the project should be allowed to proceed can be taken.

☐ **Poor**: The information required has not been provided or is far from complete and, in the context of the proposed project, the omissions must be addressed before a decision on whether the project should be allowed to proceed can be taken.

In your opinion (tick one box):

	Yes	**Don't' know**	**No**
- Did the EIA process include genuine public participation?	☐	☐	☐
- Were the consultants unduly influenced by the proponent or the Authorities?	☐	☐	☐
- Did the EIA report consider critical issues to the project?	☐	☐	☐
- Is the EIA report of acceptable quality?	☐	☐	☐
- Will the EIA report help to make a more informed decision about the project?	☐	☐	☐

Appendix 2: Summary for EIA Review Practice (Khmer version)

ការបណ្តុះបណ្តាល ការត្រួតពិនិត្យឡើងវិញ ការប្រើប្រាស់ គម្រូ របាយការការណ៍EIA
(Training H8)

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JICA Expert Team/ EIA

Project for Effective Implementation of EIA and Pollution Control through the Capacity Development of MOE - PEPC

03 June 2021

CTi

មាតិកា

I. ចំណេះដឹងមូលដ្ឋាននៃការត្រួតពិនិត្យឡើងវិញ EIA (Already Presented)

1. គោលបំណងនៃការត្រួតពិនិត្យវាយតម្លៃរបាយការណ៍ EIA និងលក្ខណៈវិនិច្ឆ័យ ទូទៅ
2. ដំណាក់កាលចំនួន៥ ដែលការពិនិត្យវាយតម្លៃអាចត្រូវបានអនុវត្ត
3. គោលបំណងនៃការត្រួតពិនិត្យវាយតម្លៃនៅដំណាក់កាលនីមួយៗ
4. លក្ខណៈវិនិច្ឆ័យប្រកបដោយប្រសិទ្ធិភាពសម្រាប់ការត្រួតពិនិត្យវាយតម្លៃដំណើរការ EIA
5. គោលការណ៍ត្រួតពិនិត្យវាយតម្លៃទូទៅ

II. ពិនិត្យការអនុវត្តឡើងវិញ (Main Topic)

6. វិធីធ្វើការត្រួតពិនិត្យឡើងវិញEIA
7. របាយការណ៍EIA ប្រកបដោយគុណភាព(ឧទាហរណ៍)
8. ដំណើរការនៃការត្រួតពិនិត្យឡើងវិញEIA
9. ការអនុវត្តន៍
10. វង្វាយតម្លៃផ្ទាល់ខ្លួនចំពោះការបណ្តុះបណ្តាល

CTi 2

I. ចំណេះដឹងមូលដ្ឋាននៃការត្រួតពិនិត្យឡើងវិញ EIA (Already Presented)

CTi 3

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1. គោលបំណងនៃការត្រួតពិនិត្យវាយតម្លៃរបាយការណ៍ EIA និងលក្ខណៈវិនិច្ឆ័យទូទៅ

គោលបំណងចំបងៗគឺ:

1) ទទួលបាន ភាពគ្រប់គ្រាន់ និងប្រកបដោយគុណភាព នៃរបាយការណ៍ EIA
2) យក មតិយោបល់ជាសាធារណៈ
3) កំណត់ថាព័ត៌មានគឺ គ្រប់គ្រាប់ សម្រាប់ការសម្រេចចិត្តចុងក្រោយ
4) កំណត់ពី កង្វះខាត នៅក្នុងរបាយការណ៍ EIA

លក្ខណៈវិនិច្ឆ័យទូទៅ (ដោយ UNEP)

1) តម្រូវការ បទដ្ឋានគតិយុទ្ធសំរាប់ EIA
2) ស្តង់ដារ ឬគោលការណ៍ណែនាំបរិស្ថាន
3) គោលការណ៍ណែនាំនៃ ការអនុវត្ត EIA បានល្អ
4) ចំណេះដឹង នៃគម្រោង និងផលប៉ះពាល់របស់

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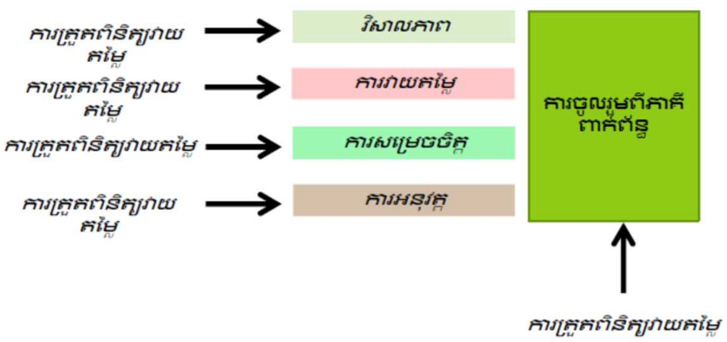
2. ដំណាក់កាលចំនួន៥ ដែលការពិនិត្យវាយតម្លៃអាចត្រូវបានអនុវត្ត



3. គោលបំណងនៃការត្រួតពិនិត្យវាយតម្លៃនៅដំណាក់កាលនីមួយៗ

ដំណាក់កាល	គោលបំណង	លក្ខណៈវិនិច្ឆ័យសម្រាប់ការត្រួតពិនិត្យវាយតម្លៃ
1. វិសាលភាព	កំណត់ដែនកំណត់នៃការវាយតម្លៃ	- តើបញ្ហាទាំងអស់បានលើកយកមកបង្ហាញដែរឬទេ? - តើមានភាពខុសគ្នាសមហេតុផលដែរឬទេ រវាងបញ្ហាដែលត្រូវវាយតម្លៃ និងមិនត្រូវវាយតម្លៃ? - តើមានទំនាក់ទំនងសមហេតុផលដែរឬទេ រវាងបញ្ហាដែលបានកំណត់ និងលក្ខខ័ណ្ឌការងារ (ToR) សម្រាប់ការវាយតម្លៃ?
2. ការវាយតម្លៃ	ធ្វើការវាយតម្លៃ ដែលបានកំណត់ដោយវិសាលភាព	- តើបញ្ហាទាំងអស់មានលើកឡើងកំឡុងពេលកំណត់ដែនកំណត់ឬទេ? តើមានទំនាក់ទំនងសមហេតុផលដែរឬទេ រវាងបញ្ហា និងការវាយតម្លៃ? - តើមានការវាយតម្លៃផលក្ខណៈបច្ចេកទេស និងវិទ្យាសាស្ត្រត្រឹមត្រូវដែរឬទេ? - តើការវាយតម្លៃបានបង្ហាញអំពីលក្ខខ័ណ្ឌការងារ (ToR) ដែរឬទេ? - តើការវាយតម្លៃមានភាពច្បាស់លាស់ និងងាយស្រួលធ្វើតាមដែរឬទេ?
3. ការសម្រេចចិត្ត	ការអនុញ្ញាត ឬបដិសេធគម្រោង	- តើមានការសម្រេចចិត្តសមហេតុផលដែរឬទេ ផ្អែកលើមាតិកានៃ EIA? - តើមានហេតុផលច្បាស់លាស់ដែរឬទេ សម្រាប់ការសម្រេចចិត្ត? - តើលក្ខខ័ណ្ឌនៃការសម្រេចចិត្តសមហេតុផល និងអាចអនុវត្តបានដែរឬទេ?

3. គោលបំណងនៃការត្រួតពិនិត្យវាយតម្លៃនៅដំណាក់កាលនីមួយៗ

ដំណាក់កាល	គោលបំណង	លក្ខណៈវិនិច្ឆ័យសម្រាប់ការត្រួតពិនិត្យវាយតម្លៃ
4. ការអនុវត្ត	ការអនុវត្តនៃការផ្តល់យោបល់ EIA និងលក្ខខ័ណ្ឌនៃការអនុញ្ញាត	- តើមានការផ្តល់បទបញ្ញត្តិត្រឹមត្រូវសម្រាប់ការអនុវត្តនៃការផ្តល់យោបល់/ លក្ខខ័ណ្ឌក្នុងទម្រង់នៃផែនការគ្រប់គ្រងបរិស្ថានដែរ ឬទេ? - តើមានអនុសាសន៍/លក្ខខ័ណ្ឌត្រូវអនុវត្តដែរ ឬទេ?
5. ការចូលរួមពីភាគីពាក់ព័ន្ធ	ធ្វើបទបង្ហាញអំពីឱកាសសម្រាប់ភាគីពាក់ព័ន្ធដើម្បីចូលរួមដំណើរការ EIA	- តើភាគីពាក់ព័ន្ធទាំងអស់បានចូលរួមដែរ ឬទេ? - តើមានឱកាសស្មើគ្នាដែរឬទេ សម្រាប់អ្នកចូលរួម រួមទាំងឯកសារច្បាស់លាស់ និងឱកាសគ្រប់គ្រាន់សំរាប់ផ្តល់យោបល់? - តើមានយន្តការសមហេតុផលដែរឬទេ សម្រាប់រួមបញ្ចូលទាំងបញ្ហាដែលលើកឡើងនៅក្នុងការវាយតម្លៃ និងផ្តល់ដំណោះស្រាយនៃបញ្ហា?

អ្នកត្រួតពិនិត្យការវាយតម្លៃសំខាន់ៗមាន:

1) អ្នកធ្វើសេចក្តីសម្រេចចិត្ត 2) អង្គាធរជំនាញ, 3) អ្នកគាំទ្រគម្រោង, 4) ហិរញ្ញឹក

4. លក្ខណៈវិនិច្ឆ័យប្រកបដោយប្រសិទ្ធិភាពសម្រាប់ការត្រួតពិនិត្យវាយតម្លៃនៃដំណើការ EIA

ដំណើរការ	លក្ខណៈវិនិច្ឆ័យប្រកបដោយប្រសិទ្ធិភាព
1. Screening	សំណើរត្រូវបានចាត់ថ្នាក់អោយបានត្រឹមត្រូវទៅតាមកម្រិត និងតម្រូវការសម្រាប់ការវាយតម្លៃ
2. Scoping	ដំណើរការត្រូវបានបញ្ចប់ និងទទួលលទ្ធផល: *i. បញ្ហាអាទិភាព និងទាក់ទងនឹងផលប៉ះពាល់* *ii. ចំនុចសំខាន់ៗពាក់ព័ន្ធ* *iii. ជម្រើសថ្មីត្រូវបានបង្កើតឡើង និង* *iv. លក្ខខ័ណ្ឌការងារ គោលការណ៍ណែនាំត្រូវបានរៀបចំឡើង*
3. Impact Analysis ការវិភាគផលប៉ះពាល់	ដំណើរការបញ្ចប់នៅក្នុង scope និងតម្រូវការស៊ីជម្រៅ *i. ផលប៉ះពាល់បរិស្ថាន (baseline) បង្ហាញពីស្ថានភាព និង* *ii. ជាន់ប្រមាណ និងទស្សន៍ទាយនូវប្រភេទផលប៉ះពាល់សំខាន់ៗ រួមទាំង* *- ផលប៉ះពាល់ដោយប្រយោល និងគរៗគ្នា* *- កត្តាដែលពាក់ព័ន្ធផ្សេងៗ*
4. Mitigationការកាត់បន្ថយ	វិធានការចាំបាច់ ឬផែនការគ្រប់គ្រងបរិស្ថាន រួមបញ្ចូល: *i. Follow up និងរៀបចំការតាមដាន* *ii. បញ្ជាក់ពីផែនការប្រថុយប្រថាន ឬការប្រតិបត្តិមិនមានស្តង់ដារ*
5. Significance សារៈសំខាន់	ផលប៉ះពាល់អវិជ្ជមានត្រូវបានវាយតម្លៃទៅលើភាពធ្ងន់ធ្ងរ រួមទាំង: *i. ដែនកំណត់ ពេលវេលា និងភាពមិនអាចប្រែប្រួល* *ii. សារសំខាន់ទៅនឹងសហគមន៍ ឬមុខងារអេកូឡូស៊ី និង* *iii. ការទូទាត់សងដែលអាចធ្វើទៅបាន*

5. គោលការណ៍ត្រួតពិនិត្យវាយតម្លៃទូទៅ

គោលការណ៍	ការពិពណ៌នា
1. ភាពស៊ីចង្វាក់គ្នា (Consistency)	ភាពប្រទាក់គ្នាសម្រាប់បែបបទនៃការសរសេរធ្វើបទបង្ហាញ
2. ឡូស៊ីក (logic)	វិធីពិភាក្សាវែកញែកត្រូវបានបង្កើតឡើង និងធ្វើការកាត់ចេញ និងសន្និដ្ឋានផ្អែកទៅលើព័ត៌មានដំណើរការ
3. ភាពគ្រប់គ្រាន់ (Sufficiency)	បញ្ហាចំបងនៅក្នុង EIA ដោយសារការខ្វះខាតព័ត៌មានដើម្បីដោះស្រាយបញ្ហាទាំងអស់
4. ប្រសិទ្ធិភាព (Efficiency)	ប្រសិទ្ធភាព គឺត្រូវបានវាយតម្លៃដោយការសាកសួរព័ត៌មានដែលទាក់ទងទៅនឹងបញ្ហាដែលចាំបាច់ត្រូវដោះស្រាយ។
5. ការសន្មត់ (Assumption)	អនុវត្តការសន្មត់គឺមានសារសំខាន់សម្រាប់ការត្រួតពិនិត្យវាយតម្លៃ EIA និងគួរត្រូវបានយកចិត្តទុកដាក់លើ: 1) សមហេតុផល និងមានសុពលភាព 2) កម្រិតនៃការសន្មត់អាចកាត់បន្ថយទំនុកចិត្តនៅក្នុងការលទ្ធផលរកឃើញ

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5. គោលការណ៍ត្រួតពិនិត្យវាយតម្លៃទូទៅ

គោលការណ៍អនុវត្តល្អបំផុត (ដោយ IAIA)

1. ភាពផ្លាស់ប្តូរបាន (Adaptive)
2. ចំណាយមានប្រសិទ្ធភាព (Cost-effective)
3. ជឿជាក់បាន (Credible)
4. ប្រសិទ្ធភាព (Efficient)
5. យកចិត្តទុកដាក់ (Focused)
6. សមាហរណកម្ម (Integrated)
7. អន្តរវិន័យ (Interdisciplinary)
8. ការចូលរួម (Participative)
9. អនុវត្តបាន (Practical)
10. តាមគោលបំណង (Purposive)
11. ភាពទាក់ទង (Relevant)
12. ហ្មត់ចត់ (Rigorous)
13. ជាប្រព័ន្ធ (Systematic)
14. តម្លាភាព (Transparent)

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II. ពិនិត្យការអនុវត្តឡើងវិញ (Main Topic)

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6. វិធីធ្វើការត្រួតពិនិត្យឡើងវិញEIA

បានផ្តល់អនុសាសន៍ ៣ជំហាន (ដោយ UNEP)

ជំហាន	មាតិកា
1	កំណត់ភាពខ្វះខាតនៅក្នុងរបាយការណ៍ EIA
2	ផ្តោតលើកំហុស/ភាពមិនល្អឥតខ្ចោះនៅក្នុងរបាយការណ៍ ញែកចេញពីគ្នានូវភាពខ្វះខាតសំខាន់ៗ ដែលអាចរារាំងដោយផ្ទាល់នៃការសម្រេចចិត្តពីអ្នកដែលមិនសូវសំខាន់
3	ផ្តល់អនុសាសន៍ថាតើកំហុសត្រូវបានដោះស្រាយដោយរបៀបណាក្នុងការធ្វើសេចក្តីសម្រេចចិត្ត

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6. វិធីធ្វើការត្រួតពិនិត្យឡើងវិញEIA

ការត្រួតពិនិត្យវាយតម្លៃដោយប្រើ Checklist

- បច្ចេកទេសក្នុងការត្រួតពិនិត្យវាយតម្លៃមានភាពសាមញ្ញ និងប្រសិទ្ធភាព
- ព័ត៌មានគួរតែត្រូវនឹងគោលបំណង:
  * ការផ្តល់ព័ត៌មានចាំបាច់ដល់អ្នកធ្វើការសម្រេចចិត្ត
  * ទំនាក់ទំនងជាមួយភាគីពាក់ព័ន្ធ ដូច្នេះពួកគេអាចជួយផ្តល់យោបល់

TOR for អ្នកត្រួតពិនិត្យវាយតម្លៃ (recommended)

- វាយតម្លៃមាតិកាបច្ចេកទេស និងវិធីសាស្ត្រវាយតម្លៃនៅក្នុង EIA, យកចិត្តទុកដាក់លើពេលវេលា និងថវិកាដែលបម្រុងទុកសម្រាប់ការសិក្សានេះ
- កំណត់ថាតើមានព័ត៌មាននៅខ្វះចន្លោះ ដែលភ្លេច ឬគិតមិនបានដល់ដែលអាចត្រូវការដើម្បីដោះស្រាយ
- វាយតម្លៃពីកម្រិតដែលការវាយតម្លៃបានបំពេញតាម ToR ច្បាប់ដើម
- វាយតម្លៃថាតើអនុសាសន៍ណាមួយនៅក្នុងការសិក្សាអាចអនុវត្តបាន និងជាជម្រើសដ៏ល្អបំផុត
- បញ្ជាក់ពីទស្សនៈផ្សេងៗដែលពាក់ព័ន្ធនឹងបញ្ហានៅក្នុងរបាយការណ៍ ប្រសិនបើមាន

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7. ការធ្វើរបាយការណ៍ត្រួតពិនិត្យវាយតម្លៃ EIA

របាយការណ៍EIA ប្រកបដោយគុណភាព (examples)

- រចនាសម្ព័ន្ធច្បាស់លាស់ ជាមួយនឹងការពិពណ៌នាតាមលំដាប់: ទិន្នន័យមូលដ្ឋានដែលមាន ស្រាប់ព្យាករណ៍ផលប៉ះពាល់ និងវិធានការកាត់បន្ថយ
- តារាងមាតិកានៅទំព័រដើមឯកសារ
- ការពិពណ៌នាច្បាស់លាស់ អំពីនីតិវិធីនៃការអនុវត្តដំណើរការព្រមព្រៀង
- អានជាឯកសារតែមួយដែលមានឯកសារយោងត្រូវសមស្របគ្នា
- សង្ខេបខ្លី ងាយយល់ និងមានគោលបំណង
- សរសេរដោយមិនលំអៀង
- រួមបញ្ចូលទាំងការពិពណ៌នាពេញលេញនៃសំណើរអភិវឌ្ឍន៍
- ប្រើប្រាស់ផ្សាក្រាម រូបភាព និង illustration ប្រកបដោយប្រសិទ្ធភាព ដើម្បីគាំទ្រអត្ថបទ

Source: European Communities (2001)

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៧. របាយការណ៍EIA ប្រកបដោយគុណភាព (examples)

- ប្រើពាក្យបច្ចេកទេសអោយត្រូវគ្នាជាមួយនឹងសទ្ទានុក្រម
- ផ្តល់ឯកសារយោងសម្រាប់ប្រភពព័ត៌មានទាំងអស់ដែលបានប្រើ
- មានការពិពណ៌នាល្អអំពីវិធីសាស្ត្រដែលបានប្រើសម្រាប់ការសិក្សាលើប្រធានបទបរិស្ថាននីមួយៗ
- គ្របដណ្តប់លើប្រធានបទបរិស្ថាននីមួយៗតាមរបៀបដែលសមាមាត្រទៅនឹងសារៈសំខាន់របស់វា
- ផ្តល់នូវភ័ស្តុតាងនៃការពិគ្រោះយោបល់ល្អៗ
- រួមបញ្ចូលការពិភាក្សាច្បាស់លាស់នៃជម្រើសផ្សេងៗ
- មិនមានការសង្ខេបបច្ចេកទេស ដែលចៀសវាងប្រើភាសាបច្ចេកទេសមិនត្រឹមត្រូវ

Source: European Communities (2001)

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8. ដំណើរការនៃការត្រួតពិនិត្យឡើងវិញEIA

អ្នកត្រួតពិនិត្យឡើងវិញEIA

1. ត្រូវមានក្រុមត្រួតពិនិត្យឡើងវិញ ដោយយល់អំពីគម្រោងដែលនឹងត្រូវដាក់ឱ្យដំណើរ
2. ត្រូវមានក្រុមត្រួតពិនិត្យឡើងវិញ គួរតែមានអ្នកជំនាញឯករាជ្យ ដែលអាចបញ្ជាក់ពីភាពច្បាស់លាស់នៃបច្ចេកទេស និងភាពពេញលេញ
3. ក្រុមនេះក៏គួរតែមានជំនាញបច្ចេកទេសផងដែរ សម្រាប់ការអភិវឌ្ឍ ដូចជា កសិកម្ម អេកូស៊ីស្តែម និងវិស្វករជាដើម៕

ការឆ្លើយតបលើមតិយោបល់

1. ប្រសិនបើអ្នកត្រួតពិនិត្យ បង្ហាញពីកំនិតថ្មយ វាមានសារសំខាន់ក្នុងការប្រើប្រាស់យន្តការ ដើម្បីបញ្ជាក់ពីបញ្ហា ដើម្បីផ្តល់ឱកាសក្នុងការពិភាក្សា។
2. ការសម្រេចចិត្តរវាង ភាគីទាំងពីរ ត្រូវផ្តោតលើអំណះអំណាងសមហេតុផល នៅពីក្រោយលទ្ធផលដែលរកឃើញ។
3. ជាថ្មីម្តងទៀតលក្ខណៈវិនិច្ឆ័យពិនិត្យឡើងវិញគួរតែប្រើប្រាស់គោលការណ៍ដែលបានចែងមុននៅក្នុងសៀវភៅណែនាំ៖ ភាពស៊ីសង្វាក់គ្នា តក្កភាព គ្រប់គ្រាន់ ប្រសិទ្ធភាព និងការសន្ទត។

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8. ដំណើរការនៃការត្រួតពិនិត្យឡើងវិញEIA

ការត្រួតពិនិត្យវាយតម្លៃ EIA ដោយបញ្ជីផ្ទៀងផ្ទាត់ Checklist:

1. ដើរតួជាឧបករណ៍សម្រាប់ការត្រួតពិនិត្យវាយតម្លៃពីភាពគ្រប់គ្រាន់នៃរបាយការណ៍ EIA
2. ជួយអ្នកត្រួតពិនិត្យវាយតម្លៃសម្រេចចិត្តថាតើព័ត៌មានឆ្លើយតបទៅនឹងគោលបំណងខាងក្រោម

   i) ផ្តល់អោយអ្នកសម្រេចចិត្តជាមួយនឹងព័ត៌មានបរិស្ថានចាំបាច់សម្រាប់ការសម្រេចចិត្ត

   ii) ទំនាក់ទំនងប្រកបដោយប្រសិទ្ធភ
   យោបល់ដែលមានប្រយោជន៍ទៅព
3. ជួយអ្នកត្រួតពិនិត្យតាមដានធ្វើការ

EIA Report Review Check List (Draft)

No.	Review Question	Relevant Yes/No	Judgement C/A/I	What further information is needed?
SECTION 1. DESCRIPTION OF THE PROJECT				
The Objectives and Physical Characteristics of the Project				
1.1	Are the need for and objectives of the project explained?			
1.2	Is the programme for implementation of the Project described, detailing the estimated length of time and start and finish dates for construction, operation and decommissioning? (this should include any phases of different activity within the main phases of the Project, for example extraction phases for mining operations)			
1.3	Are all the main components of the project described?			
1.4	Is the location of each Project component identified, using maps, plans and diagrams as necessary?			
1.5	Is the layout of the site (or sites) occupied by the project described? (including ground levels, buildings, other physical structures, underground works, coastal works, storage facilities, water features, planting, access corridors, boundaries)			
1.6	For linear projects, are the route corridor, the vertical and horizontal alignment and any tunnelling and earthworks described?			

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8. ដំណើរការនៃការត្រួតពិនិត្យឡើងវិញEIA

ទម្រង់បញ្ជីផ្ទៀងផ្ទាត់ នៃការត្រួតពិនិត្យឡើងវិញEIA

1. មាន៧ផ្នែក
   1- ការពិពណ៌នាពីគម្រោង
   2- ការពិចារណាលើជម្រើស
   3- ការពិពណ៌នាពីបរិស្ថាន ដែលទំនងរងហេតុប៉ះពាល់ពីគម្រោង
   4- ការពិពណ៌នាពី ឥទ្ធិពលដែលមានសារសំខាន់របស់គម្រោង
   5- ការពិពណ៌នាពី វិធានការកាត់បន្ថយ
   6- ការសង្ខេបមិនមែនបច្ចេកទេស
   7- គុណភាពនៃបទបង្ហាញ
2. លក្ខខណ្ឌវាយតម្លៃចំនួន២ សម្រាប់ធាតុ(item) នីមួយៗ
   1- ទាក់ទង៖ បាទ/ចាស ឬទេ (Yes or No)
   2- ការវិនិច្ឆ័យ: បានបញ្ចប់ (Complete) (C), អាចទទួលយកបាន (Acceptable) (A) or មិនទាន់គ្រប់គ្រាន់ (Inadequate) (I)
3. ចំណុចគោលដៅចំនួន៥ នៃរបាយការណ៍ EIA

ល្អប្រសើរ ល្អ ពេញចិត្ត មិនគ្រប់គ្រាន់ មិនល្អ

ខ្ពស់ ទាប

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9. ការអនុវត្តន៍

ការអនុវត្តន៍ 1

គោលបំណង និងភាពចាំបាច់នៃគម្រោង

ការកែលម្អផ្លូវថ្នល់នេះ គឺដើម្បីធានាសុវត្ថិភាពនៃការធ្វើដំណើរ និងកាត់បន្ថយការកកស្ទះ ជាមួយការរួមចំណែកកាត់បន្ថយការបំពុលខ្យល់ គ្រោះថ្នាក់ចរាចរណ៍ និងអភិវឌ្ឍសេដ្ឋកិច្ចក្នុងតំបន់។

ធាតុផ្សំនៃគម្រោង

គម្រោងមាន៖ 1) កែលម្អផ្លូវថ្នល់ (បេតុង), 2) ប្រព័ន្ធបង្ហូរទឹកសងខាង និង 3) ផ្លូវសម្រាប់អ្នកថ្មើរជើង

No.	Review Question	Relevant Yes/No	Judgement C/A/I	What further information needed of comment
ផ្នែកទី 1. ការពិពណ៌នាពីគម្រោង				
1.1	តើគម្រូវឱ្យមានការពន្យល់ពីគោលបំណងនៃគម្រោងដែរឬទេ?			
1.3	តើធាតុសំខាន់ៗរបស់គម្រោងត្រូវបានពិពណ៌នាដែរ?			

បញ្ចូលការវាយតម្លៃរបស់អ្នក នៅក្នុង
[Relevant] [Judgement] and
[What further information needed or comment]

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9. ការអនុវត្តន៍

ការអនុវត្តន៍ 1

គោលបំណង និងភាពចាំបាច់នៃគម្រោង

ការកែលម្អផ្លូវថ្នល់នេះ គឺដើម្បីធានាសុវត្ថិភាពនៃការធ្វើដំណើរ និងកាត់បន្ថយការកកស្ទះ ជាមួយការរួមចំណែកកាត់បន្ថយការបំពុលខ្យល់ គ្រោះថ្នាក់ចរាចរណ៍ និងអភិវឌ្ឍសេដ្ឋកិច្ចក្នុងតំបន់។

ធាតុផ្សំនៃគម្រោង

គម្រោងមាន៖ 1) កែលម្អផ្លូវថ្នល់ (បេតុង), 2) ប្រព័ន្ធបង្ហូរទឹកសងខាង និង 3) ផ្លូវសម្រាប់អ្នកថ្មើរជើ

No.	Review Question	Relevant Yes/No	Judgement C/A/I	What further information needed of comment
ផ្នែកទី 1. ការពិពណ៌នាពីគម្រោង				
1.1	តើគម្រូវឱ្យមានការពន្យល់ពីគោលបំណងនៃគម្រោងដែរឬទេ?	No	I	គោលបំណងត្រូវបានបញ្ជាក់ ប៉ុន្តែភាពចាំបាច់នៅមិនទាន់ច្បាស់ឡ
1.3	តើធាតុសំខាន់ៗរបស់គម្រោងត្រូវបានពិពណ៌នាដែរ?	Yes	C	ការពិពណ៌នាពីធាតុសំខាន់ដោយសាមញ្ញ ។ គួរបន្ថែមការពន្យល់នៅក្នុងធាតុនីមួយៗ ឱ្យបានច្បាស់លាស់ ក្នុងផ្នែកនីមួយៗ

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9. ការអនុវត្តន៍

ការអនុវត្តន៍2

ការសង្ខេបមិនមែនបច្ចេកទេស(**NTS**)

ឯកសារច្បាស់លាស់ ដែលផ្តល់ពីការពិពណ៌នា ដំណើរការ EIA process និងការរកឃើញនេះ នៅក្នុងទម្រង់ដែលងាយស្រួលយល់ក្នុងចំណោម សាធារណ:ជន។

No.	Review Question	Relevant Yes/No	Judgement C/A/I	What further information needed of comment
ផ្នែកទី 6. ការសង្ខេបមិនមែនបច្ចេកទេស				
6.1	តើព័ត៌មានបរិស្ថានមានបញ្ចូលការសង្ខេបមិនមែនបច្ចេកទេស?			
6.2	តើការសង្ខេបផ្តល់ភាពច្បាស់លាស់ និងពិពណ៌នាគ្រប់ជ្រុងជ្រោយ នៃគម្រោង ទាំងផ្នែកបរិស្ថាន ហេតុប៉ះពាល់លើបរិស្ថាន និងសំណើវិធានការកាត់បន្ថយ?			
6.3	តើការសង្ខេបបានបង្ហាញសារសំខាន់ដែលមិនប្រាកដ ក្នុងគម្រោង និងហេតុប៉ះពាល់របស់វា?			ដកស្រង់ខ្លឹមសារ ការសង្ខេបមិនមែនបច្ចេកទេស (NTS)
6.4	តើការសង្ខេបបាន ពន្យល់ពីដំណើរការយល់ព្រមការអភិវឌ្ឍសម្រាប់គម្រោង និងតួនាទីរបស់ EIA ក្នុងដំណើរការនេះ			
6.5	តើសេចក្តីសង្ខេបផ្តល់នូវទិដ្ឋភាពទូទៅនៃវិធីសាស្ត្រក្នុងការវាយតម្លៃដែរឬទេ?			
6.6	តើសេចក្តីសង្ខេបត្រូវបានសរសេរជាភាសាមិនមែនបច្ចេកទេសដើម្បីជៀសវាងពាក្យបច្ចេកទេស ទិន្នន័យលម្អិត និងការពិភាក្សាបែបវិទ្យាសាស្ត្រដែរឬទេ?			
6.7	តើវាអាចយល់បានចំពោះសាធារណ:ជន ដែរឬទេ?			

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9. ការអនុវត្តន៍

ការអនុវត្តន៍2

ការសង្ខេបមិនមែនបច្ចេកទេស(**NTS**)

ឯកសារច្បាស់លាស់ ដែលផ្តល់ពីការពិពណ៌នា ដំណើរការ EIA process និងការរកឃើញនេះ នៅក្នុងទម្រង់ដែលងាយស្រួលយល់ក្នុងចំណោម សាធារណ:ជន។.

ការដកស្រង់ខ្លឹមសារ ការសង្ខេបមិនមែនបច្ចេកទេស (NTS)អាចមាន៖

1) រាយការណ៍រាល់សេចក្តីសន្និដ្ឋាននៃការវាយតំលៃ

2) មានបច្ចុប្បន្នភាពនិងស្របតាមសេចក្តីថ្លែងការណ៍ស្តីពីបរិស្ថានជាពិសេស ផលប៉ះពាល់សំខាន់ៗ

3) គ្របដណ្តប់បញ្ហាដែលពាក់ព័ន្ធនៅក្នុងកម្រិតសមស្របនៃព័ត៌មានលម្អិតដោយផ្អែកលើ សារ:សំខាន់របស់វា

4) ប្រើប្រាស់ឯកសារយោង ឱ្យស៊ីសង្វាក់គ្នា ជាមួយសេចក្តីថ្លែងការណ៍បរិស្ថាន

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9. References

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添付資料 4　Guidelines on Environmental Impact Assessment for Road Sector Projects (Full EIA case)

Guideline on Environmental Impact Assessment

for

Road Sector Projects (Full EIA case)

Table of Contents

Abbreviation

CARDI	Cambodian Agricultural Research and Development Institute
CI	Conservation International
dB	Decibel
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FAO	Food and Agriculture Organization
GIS	Geological Information System
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
PM	Particulate Matter
RoW	Right of Way
TOR	Terms of Reference
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund

I. Preface

This guideline is to provide a guidance on contents of EIA (Environmental Impact Assessment) study process and EIA reports by showing what is to be described in EIA report in road sector for the full EIA project. This guideline covers road projects including highways and bridges.

In the EIA report, reference data/information source is to be provided.

(Reference)

- Sub-decree on Environmental Impact Assessment Process, 1999
- Prakas on General Guidelines for Initial and Full Environmental Impact Assessment Reports, 2009

II. The Guideline

0. Executive Summary

A general summary of the EIA report is provided (within 15-20 pages recommended). It includes at least the following information from the EIA report:

- Objectives of the EIA
- Project Owner
- Project Description including project site
- Other Project Alternatives
- Existing Environmental Resources
- Public Participation including issues raised by stakeholders and any outstanding issues
- Impacts and Mitigation Measures
- Environmental Management Plan
- Economic analysis and environmental value
- Conclusion and recommendation

1. Introduction

This chapter provides the introductory part of the EIA report.

1.1 Project overview

Summary of the project background, the rationale for development of the project, and general situation on the project site are described.

The nature of the project such as new, extension, widening, rehabilitation or combination of these is described.

The summary of the railway structure such as number of lanes is described.

1.2 Objectives of the EIA

The reason and timing that the EIA is prepared and the consultant who prepares the EIA report are described.

2. Scope and Methods of the Study

This chapter provides points related to the Terms of Reference of the EIA study including stipulations in the relevant Prakas and Sub-decree in Cambodia.

2.1 Scope of the Study

Scope of the study including covered area by the study is described.

2.2 Data source

The items to be described include how data source is clarified, including how the data is collected such as the measurement and data from existing document is described. For example, in the case of air quality measurement by the project owner, selection of the sampling date and point, measurement method of pollutants and method of compiling data is described. In the case of data from existing document, justification/relevance of the referred document is described.

Also, when data is described, it is clarified whether the data is primary data (data from the field, observation at/around the project site) or secondary data (collected and quoted data from existing technical document).

2.3 Methods of the study

How the impacts in each project phase is predicted/estimated is described.

Appropriate methods of dada collection are included in this section. Method of the data analysis is described. For example, in air quality case, how the expected air quality is derived, how the expected impact in air quality is derived and compared with the air quality standard in Cambodia is described. When non-Cambodian standards/guidelines are used, justification/relevance of the referred document is described.

Also, basic and common methods for understanding physical resources, biological resources and social and economic resources is described in this section and the detail in individual resource is described in the individual sections.

For example, the methods on social and economic study is described including following.

- The area covered such as length from the right of way
- Selection of targeted villages/communities
- Sample size compared with the population/number of household
- Items surveyed. Survey material such as questionnaire and photograph is attached in the Annex.
- (if included) The replacement cost policy and methods to identify the ownership of assets

Further, methods for public participation is described (The detail is described in 6. Public Participation).

The EIA preparer describes the time table of the EIA survey and team composition including name and work role.

3. Legal Framework

In this chapter, legal setting is described by clarifying related legal and policy document.

Legal and policy documents related to the project is described. This includes the title, issued year and explanation of laws, sub-decrees and policies which are related to the project.

The donor policies in donor supported project case is described, if any.

(Reference)

Table 1 An example of related Laws and Sub-decrees

Title	Year	Explanation
Law on Constitution of Kingdom of Cambodia	1993	
Law on Environmental Protection and Natural Resources Management	1996	
Law on Road	2014	
Law on Road Traffic	2006	
Law on Expropriation	2010	
Law on Water Resource Management	2007	
Law on Forestry	2002	
Law on Fishery	2006	
Law on Protected Area	2008	
Law on Land	2001	
Law on Labor	1997	
Law on the Protection of Cultural Heritage	1996	
Law on Land Management, Urban Planning and Constructions	1994	
Law on Management and Exploitation of Mineral Resources	2001	
Royal-Decree on establishment and management of Tonle Sap Biosphere Reserve (In Tonle Sap area case)	2001	
Sub-Decree on Environmental Impact Assessment Process	1999	
Sub-Decree on the Establishment of Environmental and Social Fund	2016	
Sub-Decree on the Air Pollution and Noise Disturbance Control,	2000	
Sub-Decree on Water Pollution Control	1999	
Sub-Decree on Solid Waste Management	1999	
Sub-decree on Management of Garbage and Solid	2015	

Waste of Downton		
Sub-Decree on Right of Way of National Road Channels and Railroads	2009	
Sub-decree on Land Acquisition and Involuntary Resettlement	2018	

Note 1: The consultant can add or delete laws for suitable tabulation to the concerned project.

Note 2: Input essential but simple descriptions in Explanation columns.

4. Project Description

This chapter provides what is the project and related information.

4.1 Background and experiences of the project owner/company

Following items are described.

- The background of the project,
- The project owner/company including registration information and address,
- The construction company (if it is already decided)
- The capital of construction and operation including the financer.
- The experiences of the project owners/company in the sector are described. If there is a background study such as feasibility survey, it is in introduced.

4.2 Project site

Following items are described.

1) Location of the project on the map (1:10,000) with GPS coordinates
2) Description on the alignment by section with pictures and general condition for bridges and tunnels, if any
3) Broad geology, topography
4) Villages, settlements and land use including demographic, socio, cultural and economic aspects
5) Environmentally sensitive places such as the protected area and land acquisition
6) Case specific information, if any

Case	Information
The proposed alignment is passing through any hilly area or rock falling area.	The details of the area such as landslides and erosion.
The proposed alignment involves tunneling.	The details of the tunnel and locations of tunneling with geological structural fraction

The proposed project involves any land reclamation.	The details of reclamation and the area of land to be reclaimed.
The proposed project involves heavy volume of dredging.	The details of dredging and the river/channel to be dredged.

4.3 Project types

1) Project specification

The specification of the project is described. It includes length and width of the alignment, number of bridges to be constructed/implemented etc. The table below is an example of specification.

Table 2 Example of project specification in road projects

no	Description	Quantity(unit)
	Length of the alignment (in extension case, new and existing)	(km)
	Width of the alignment (in widening case, new and existing)	(m)
	Number of bridges	
	Length and width of major bridge	(m)
	Number of culverts	
	Number of underpasses	
	Number of intersections	
	Number of railway crossings	

2) Structure of road by section is described. The structure could be plane, canal, elevated, semi-underground or underground (tunnel) (typical cross section figure is useful).

3) Technologies involved for design and construction are described.

4) Procedures and criteria adopted for selection of the alignment of right of way is described.

5) Activities for site preparation are described.

(Reference)

- Width of Right of Way (ROW) is specified by the Sub-decree on Right of Way of National Road Channels and Railroads, 2009.
- Ministry of Public Works and Transport sets several roads and bridges standards/guidelines such as Bridge Design Standard (2003).

4.4 Alternatives

The project alternatives are described. For example, alternatives can be described in option 1, option 2 and zero-option (the case without project), with the reason on the selection of the project among the alternatives and the selection of alternatives. For example, the alternative can be the project with a route bypassing populated area, different alignment case with shorter route passing populated area and without project case.

The comparison of alternatives is described by a table.

These details are comprised of:

- Description of various alternatives by locations, layouts or technologies studied
- Description of each alternative
- Summary of adverse and positive impact of each alternative
- Procedures and criteria adopted for selection of alternative
- Comparison of alternatives in table.
- Selection of the alternative which is the best with respect to use of resources and adverse environmental impact

4.5 Activities of the project

Project activities are described. For example;

- Administration (management) of the project
- Sources and quantity of input to be used including water, energy and machinery requirements
- Local and foreign workforce requirements including their housing
- Quantity of final output/products: If it is described in the project overview, refer to it.
- Income and expenditure (Revenue and cost)
- Overall waste management plan: To describe what waste is generated and how waste is collected and disposed by project phase.
- Risk management policy: To describe policy to respond to natural hazards and to secure safety.

4.6 Work plan/ schedule

1) Project phasing.

The phasing of the project is described, if any.

2) Project implementation schedule.

The project implementation schedule is shown by bar chart.

5. Description of Existing Environment

This chapter provides the condition of existing environment by type of resources.

5.1 Natural Environment

Natural environment feature on project area and surroundings is described by the items in 5.1.1 and 5.1.2.

5.1.1 Physical Resources

1) Soil

Soil profile of the alignment such as geological data, topology, soil type, slope condition, soil mechanic and watershed is described. A detailed seismology and geology study is provided, if available.

If the alignment runs mineral resource area, mineral resource is clarified.

The history on landslide is provided, if any.

(Reference)

- CARDI (Cambodian Agricultural Research and Development Institute) soil type can be used to describe using ArcGIS software.
- Topographic information can be used from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Global Soil Organic Carbon Map, FAO, 2017

2) Climate

The items to be described include the following.

- Affecting weather information is described. The information could be temperature, rain fall, wind speed and pattern, wind direction, relative humidity and sea level (in coastal area) for several years (average data for at least last 5 years).
- The history on storm surge and earthquake, if any.
- Information on climate change such as adaptation study, if any.

(Reference)

- Information by Department of Meteorology, Ministry of Water Resources and Meteorology
- UNDP Climate Change Country Profiles, UNDP

3) Air quality

Air quality situation is described by pollutants major pollutants source and weather condition. Dust fall is included when traffic of truck is expected to be heavy.

Baseline data is described. At least 2 samples (one at the project site and another in the community near the project site considering wind direction and geography) are measured, while more samples can be measured when necessary. The description includes method, period and location with its characteristics such as distance from the sensitive area (community, hospital, school, temple/pagoda, etc.) and map.

While the area under expected impact depends on the natural and social conditions, 150m from the edge of alignment can be referred for the area under expected impact.

When site sampling is conducted, sampling sites are recommended at least at the project site and at the sensitive receptors site.

Table 3 Example of data on air quality situation

No	Parameter	Unit	Average time	Observed	Standards	Method
1	Carbon monoxide (CO)	mg/m^3	8 hours		20	
2	Nitrogen dioxide (NO_2)	mg/m^3	24 hours		0.1	
3	Sulfur dioxide (SO_2)	mg/m^3	24 hours		0.3	
4	Ozone (O_3)	mg/m^3	1 hour		0.2	
5	Lead (Pb)	mg/m^3	24 hours		0.005	
6	Total Suspended Particulate (TSP)	mg/m^3	24 hours		0.33	
7	PM10	mg/m^3	24 hours		0.05	
8	PM2.5	mg/m^3	24 hours		0.025	

(Source) Sub-decree on Air Pollution and Noise Disturbance and Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Ambient Air Quality Standard.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project
- Environmental Impact Assessment Technique for Road Project, National Institute for Land and Infrastructure Management, Japan, 2013(on the area under expected impact)

4) Noise and Vibration

Noise and vibration situation is described.

Baseline data is described. At least 2 samples (one at the project site and another in the public building/area) are measured, while more samples can be measured when necessary. The description includes method, period and location with its characteristics such as distance from the sensitive area (community, hospital, school, temple/pagoda, etc.) and map. While the area under expected noise impact depends on the natural and social conditions, 200m for noise, 100m for vibration from the edge of alignment can be referred for the area under expected impact.

Table 4 Example of data on noise

<table>
<tr><th rowspan="3">No</th><th rowspan="3">Area</th><th colspan="6">Period of time</th></tr>
<tr><th colspan="2">From 6 to 18</th><th colspan="2">From 18 to 22</th><th colspan="2">from 22 to 6</th></tr>
<tr><th>Observed</th><th>Standard (dB(A))</th><th>Observed</th><th>Standard (dB(A))</th><th>Observed</th><th>Standard (dB(A))</th></tr>
<tr><td>1</td><td>Quiet areas
- Hospitals
- Libraries
- School
- Kindergarten</td><td></td><td>45</td><td></td><td>40</td><td></td><td>35</td></tr>
<tr><td>2</td><td>Residential area:
- Hotels
- Administration offices
- House</td><td></td><td>60</td><td></td><td>50</td><td></td><td>45</td></tr>
<tr><td>3</td><td>Commercial and service areas and mix</td><td></td><td>70</td><td></td><td>65</td><td></td><td>50</td></tr>
<tr><td>4</td><td>Small industrial factories intermingling in residential areas</td><td></td><td>75</td><td></td><td>70</td><td></td><td>50</td></tr>
</table>

(Source) Sub-decree on Air Pollution and Noise Disturbance

Table 5 Example of data on vibration

Daytime (from 06to 18)		Nighttime (from 18 to 06)	
Observed	Standard	Observed	Standard
	65 dB		60 dB

(Source) Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Maximum permitted noise level.

- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project
- Environmental Impact Assessment Technique for Road Project, National Institute for Land and Infrastructure Management, Japan, 2013 (on the area under expected impact)

5) Water quality

Water quality situation is described by pollutants and pollutants source.

Baseline data is described. At least 2 samples (one at the project site (downstream side) and another at the natural water area) are measured, while more samples can be measured when necessary. It includes method, period and location with its characteristics and map. When site sampling is conducted, sampling sites are recommended at the project site and at the important water user site such as water supply source.

If the road has a tunnel section, the groundwater quality is described.

Table 6 Example of data on water quality

No	Parameters	Unit	Observed	Standards*1	Method
1	pH	-			
2	Total Dissolved Solid (TDS)	mg/l			
3	Total Suspended Solid (TSS)	mg/l			
4	Dissolved Oxygen (DO)	mg/l			
5	Biological Oxygen Demand (BOD5)	mg/l			
6	Chemical Oxygen Demand (COD)	mg/l			
7	Oil and Grease	mg/l			
8	Detergent	mg/l			
9	Total Nitrogen (TN)	mg/l			
10	Total Phosphorous (TP)	mg/l			
11	Lead (Pb)	mg/l			
12	Arsenic (As)	mg/l			
13	Cadmium (Cd)	mg/l			
14	Iron (Fe)	mg/l			
15	Total Coliform	NPN/100ml			

*1 Apply appropriate standard values in accordance with the tested water source (e.g. river, lake/ reservoir or marine)

(note) When consideration for aquatic organism is needed, Linear Alkyl Benzene Sulfonic Acid and its salts (LAS) which is used in detergent can be set as a parameter.

(Reference)

- Sub-decree on Water Pollution Control, 1999 prescribes Water Quality Standard in public water areas.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

Table 7 Parameters and standard for surface water quality

No	Parameters	Unit	River water	Lake and reservoir	Marine
1	Acid or Base (pH)	-	6.5 – 8.5	6.5 - 8.5	7.0 – 8.3
2	Total Dissolved Solid (TDS)	mg/l	<1000	<1000	<1000
3	Total Suspended Solid (TSS)	mg/l	25-100	1-15	<60
4	Dissolved Oxygen (DO)	mg/l	7.5-2.0	7.5-2.0	7.5-2.0
5	Biological Oxygen Demand (BOD_5)	mg/l	1-10	<30	<30
6	Chemical Oxygen Demand (COD)	mg/l	<50	1-8	2-8
7	Oil and Grease	mg/l	<5.0	<5.0	0
8	Detergent	mg/l	<5.0	<5.0	0
9	Total Nitrogen (TN)	mg/l	0.1-0.6	0.1-0.6	0.2-1.0
10	Total Phosphorus (TP)	mg/l	0.005-0.05	0.005-0.05	0.02-0.09
11	Lead (Pb)	mg/l	<0.01	<0.01	<0.01
12	Arsenic (As)	mg/l	<0.01	<0.01	<0.01
13	Cadmium (Cd)	mg/l	<0.001	<0.001	<0.001
14	Iron (Fe)	mg/l	<1	<1	<1
15	Total Coliform	NPN/ 100ml	<5000	<5000	<5000

(Source) Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

Table 8 Parameters and standard for groundwater quality when required

No	Parameters	Unit	Standards
1	pH	-	6.5-8.5
2	Turbidity	NTU	5
3	Electrode Conductivity (EC)	NTU	500-1500
4	Total Dissolved Solid (TDS)	mg/l	800
5	Total Hardness (as $CaCO_3$)	mg/l	300
6	Chloride	mg/l	250
7	Fluoride (F)	mg/l	1.5
8	Nitrate (NO_3)	mg/l	50
9	Sulfate (SO_4)	mg/l	250
10	Iron (Fe)	mg/l	0.3
11	Arsenic (As)	mg/l	0.05

12	Mercury (Hg)	mg/l	0.001
13	Chromium (Cr)	mg/l	0.05
14	Manganese (Mn)	mg/l	0.1
15	Aluminum (Al)	mg/l	0.2
16	Benzene (C_6H_6)	mg/l	0.01
17	Dichloromethane (CH_2Cl_2)	mg/l	-
18	Cadmium (Cd)	mg/l	0.003
19	Total coliform	MPN/100ml	0
20	E-coli	MPN/100ml	0

(note) Parameters are selected depending on the geology and the tunnel structure/construction work

(Source) Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

6) Hydrology

River, lake, reservoir, wetland and drainage system is described with map.

The items to be described include the following.

- Water level (with warning water level, if any) and flow rate of river/lake by table.
- Run-off characteristics of watersheds is described. Delineation of watersheds and drainage pattern in the area of influence using aerial/remote sensing images is recommended.
- The history on flood and storm surge, if any.
- If the railway has a tunnel section, the groundwater situation.

(Reference)

- The Study on Hydro-Meteorological Monitoring for Water Quantity Rules in Mekong River Basin (JICA, 2004) (for hydrologic information)
- Department of Hydrology and River Works, Ministry of Water Resources and Meteorology (for hydrologic information)
- Mekong River Commission website

5.1.2 Biological Resources

1) Forest

The items to be described include the following.

- Situation on forest area such as vegetation and forest cover with map
- The designated protected area (especially Core zone and Conservation zone) on forest, if there is in proximity of the project site. Clarification on zoning is important.

- The methodologies for the study, such as direct observation (with map on location), local interview, analysis of reference documents.

(Reference)

- The Law on Forestry (Royal Kram) prescribes permanent forest reserve, production forest, protection forest and community forest. Also the Law has provisions on environmental and social impact assessment.
- The Protected Areas Law
- Cambodia Forest Cover, 2014 (Forestry Administration, 2016)

2) Protected area

The items to be described include the following.

- The designated protected area concerning biological resources, especially Core zone and Conservation zone, if there is in proximity of the project site.
- Clarification on zoning is important and zoning information could be collected from the Sub-decree on individual Protected area, related Ministry or local government.
- The methodologies for the study, such as direct observation (with map on location), local interview, analysis of reference documents.

(Reference)

- Protected Areas Law prescribes the category of the protected areas and zoning (Core zone, Conservation zone, Sustainable use zone and Community zone) of the protected areas
- Sub-decree on individual Protected area

3) Wildlife species and habitats

Wildlife species and their habitats are described, especially endangered species. This includes rare species, endemic species and movement (corridor and migratory pattern). The methods for the study is described such as direct observation (with map on location), local interview and analysis of reference documents.

(Reference)

- WWF (World Wide Fund for Nature) (https://www.worldwildlife.org), CI (Conservation International) (https://www.conservation.org) and WCS (Wildlife Conservation Society) (https://www.wcs.org) website on endangered species.

4) Biodiversity and ecological systems

The items to be described include the following.

- Situation on biodiversity and ecological system, including endangered species and important biological corridor, if there is in proximity of the project site.
- The designated protected area and sensitive area.

- The ecology resources function (forest/ecology system situation and function) with the result of 1), 2) and 3).
- The methodologies for the study, such as direct observation, local interview, or analysis of reference documents.

5) Aquatic resources

The items to be described include the following.

- Situation on aquatic resources. It can be inland resources and/or marine resources in the case the project site is in coastal or sea area. Fishery is important resource in both food and employment in Cambodia.
- The methodologies for the study, such as direct observation, local interview, or analysis of reference documents.

(Reference)

Reports of Ministry of Agriculture, Forest and Fishery

5) Wetland systems, if related

Situation on wetland is described, if there is crossing in or near designated wetland site such as by the Ramsar Convention (Boeng Chhmar and Associated River System and Flood Plain, Prek Toal Ramsar Site, Koh Kapik and Associated Islets, and Middle Stretches of Mekong River North of Stoeng Treng).

5.2 Social and Economic Resources

1) Social and economic study method

The method of social and economic study is described including following.

- The area covered such as length from the right of way
- Selection of targeted villages/communities among the total alignment
- Sampling method and sample size compared with the population/number of household
- Items surveyed.
- (if included) The replacement cost policy including eligibility and method to identify the ownership/occupancy of assets

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

2) Demography and settlement

Population, villages and settlements is described.

(Reference)

- General Population Census by National Institute of Statistics

3) Economic status

Economic situation is described such as economic growth, income (primary and secondary) level, major industry/product and major employment.

(Reference)

- Economic Census of Cambodia by National Institute of Statistics

4) Land use and land registration

Land use is described such as industrial area, forest area, city area and agriculture area. Also the land use master plan is described, if any.

In the case land acquisition is planned, land ownership and occupancy with the relation with the Right-of-way is described.

(Reference)

- Land use information can be used by revised information from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Land law (2001)
- Expropriation Law (2010)
- Sub-Decree on Right of Way of National Road Channels and Railroads (2009)
- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

5) Water use

Water resources and water s use including water source and purpose is described.

6) Energy use

Major energy source is described.

7) Infrastructure

Major public infrastructure conditions in the area (e.x. major roads/traffic, irrigation, parks, water supply and sewerage etc.) are described.

8) Education

Situation on education is described such as literacy rate and school enrollment rate.

The crossing of the alignment and school routes is described, if any.

9) Public health and well-being

Situation on public health and well-being is described.

(Reference)

- Cambodia Demographic and Health Survey by National Institute of Statistics

10) Heritage/culture

Heritage (cultural heritage, historical monuments, landscape, ancient temples, pagodas and customs/traditions) is described, especially ones designated/listed by the Protected Area Law and UNESCO/Government, if any.

Cultural characteristics and important cultural/traditional sites are also described.

(Reference)

- Law on Protection of Cultural Heritage prescribes protected sites and inventory on cultural property.
- Information by Ministry of Culture and Fine Arts

11) Marginal group

The poor, ethnic minority and indigenous people is identified.

Situation on the poor, ethnic minority and indigenous people is described such as by specific socio-economic survey and the latest National Census Reports.

(Reference)

- Sub-Decree on Procedures of Registration of Land of Indigenous Communities
- Information by local government

12) Tourism destinations

Situation on tourism resources and their use is described, if any.

(Reference)

- Tourism Development Strategic Plan 2012-2020

13) Others

The result of the social and economic study such as replacement cost study is described if it is not covered in the above.

The presence of unexploded weapons is described when there is possibility.

6. Public Participation

The items to be described include the following.

- The public participation process, especially the process to provide project affected people and other stakeholders the opportunities to be informed and consulted, to express an opinion about projects including activities, and to allow effective involvement.
- The methodology and procedure of public participation such as identification of project affected people and other stakeholders, how to inform including access to the information and how to consult including feedback.

The plan of public participation has 3 phases following the Term of Reference on Infrastructure and Tourism Development Project (Prakas No.120, 2018):

Table 9 Phases of public participation

Phases		Outline
1	Information dissemination at project site	The project owner and consultant company disseminates information to stakeholders in order to inform them about the project inception, scope, impact exposure as well as preliminary information and people who get impact from the project.
2	Interviewing the authorities, involved departments	The project owner and consultant company interviews with authorities, involved departments and stakeholders, and/or prepares the Focus Group discussion in order to get the opinion and comments on the project.
3	Dissemination Workshop	The project and consultant company prepares the public disseminationworkshop in order to show the result of Environmental Impact Assessment Report and stakeholders interview

Following points are also described.

- Dissemination by the project owner with local authorities and local communities of the development project
- Feedback from relevant provincial departments/ agencies and relevant local authorities
- Comments from relevant non-government organizations (NGOs);
- Consultation with affected local communities
- Conclusions on results of the public consultation

Also, the project owner establishes and informs the grievance redress mechanism which deals with complaints and grievances.

7. Environmental Impacts and Mitigation Measures

This chapter provides information on impacts and mitigation measures by project phase.

7.1 A summary of impacts and mitigation measures

The view on determination of impacts and mitigation measures are described. The project phase is covered from design to closure. The following points are included.

- Matrix to show the relation between the project activities and impact on environmental resources for determining the potential of impact level
- Geographic Information System (GIS) by using Tool Overlay to identify an area where the projects impact on environment
- Check list for identifying the impact level by the summary table below

The summary of 7.2 is shown by such as following table.

Table 10 Summary of impacts and mitigation

Environmental and Socio-Economic Aspects	Negative Impacts	Scope of Impacts			Mitigation Measure	Remark
		Low	Moderate	High		
1. Negative impacts of design and construction phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
2. Negative impacts of operation phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
3. Negative impacts of closure phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						

7.2 Impacts and mitigation measures by project phase

In this section, the contents and degree of impacts is described by project phase. , It includes method for estimating/forecasting impacts and evaluation of estimated/forecasted impacts.

Mitigation measures on the expected impact are described with the description how and what level the expected impacts are mitigated.

Following is the example for listed possible impacts and mitigation measures by impact items. When describing the expected impact, not only describing the expected impact but also how the expected impact is derived and evaluation of the impact (for example, comparison with the environmental standard) is described. Also, when describing the mitigation measures, not only the measure itself but also how the measure mitigates the impact and how much impact is mitigated is described.

(Reference)

Environmental, Health, and Safety Guidelines for Toll Roads, IFC, 2007

7.2.1 Impacts and mitigation measures during design and construction phase

Physical Resources

1) Soil erosion/quality

(Design and construction phase)

- Impact due to the removal of topsoil
- Impact due to erosion and consequent modification of natural conditions
- Impact due to destabilization of slopes
- Impact due to usage of heavy machinery for material transportation
- Impact on subsidence by drainage change and additional weight to the soil in subsidence prone area
- Impact of bridge construction due to crossing a river or stream

【Mitigation measures】

(Design and construction phase)

- Engineering measures for slope protection and erosion prevention
- Drainage improvements for prevention of soil erosion and siltation of water course. Also, drainage and curtain covering the pathway to prevent erosion in the bridge construction case.
- Slope stabilization techniques and erosion control measures

(Design phase)

- While selecting road alignment, avoiding areas prone to landslides, soil erosion and subsidence
- The erosion potential of construction alternatives is carefully examined and selecting the one involving least disturbance to the natural ground

(Construction phase)

- Reduction of the need for borrow pits and minimization of excess spoil material generation
- Restoration, revegetation and rehabilitation measures
- Construction of drainage ensuring the stability of the slope

2) Air quality

(Construction phase)

- Impact due to vehicular emissions from vehicles including heavy vehicles used for construction
- Impact due to dust generation from material handling, storage, operation of crushers and hot mix plants, movement of construction vehicles, construction activities, excavation of soil and cutting of embankment near to habitation,

hospitals, schools and sanctuaries etc.

【Mitigation measures】

(Design phase)

- Selecting alignment which avoids passing close to housing, schools and hospitals etc.
- Providing sufficient capacity to avoid traffic congestion, even with projected increase in traffic flow
- Ensuring buffer area with planting tall leafy vegetation between roads and human settlements

(Construction phase)

- Periodical watering and transporting construction materials with tarpaulin coverage during the construction phase
- Provision of air pollution control systems in stone crushers and hot mix units to meet the emission regulation

3) Noise & vibration

(Design and construction phase)

- Impact of noise on the surrounding community due to vehicle movement
- Impact of noise on wildlife from crossing road corridors and becoming the project corridor a barrier to regular wild life travel routes
- Impact of noise and vibration during construction activity including operation of various equipment
- Impact of vibrations during blasting activity, if any

【Mitigation measures】

(Design phase)

- Avoiding alignment through noise sensitive areas
- Provision for machines and equipment with acoustic enclosures and silencers.
- Provision of noise barriers
- Ensuring buffer area with planting tall leafy and dense vegetation between roads and noise sensitive areas

(Construction phase)

- Provision of mandatory acoustic enclosure /acoustic treatment of room for stationary generator sets
- Avoiding or minimizing stone quarrying and blasting activity

4) Water quality

(Design and construction phase)

- Impact due to drain from construction site
- Impact due to wastewater generated from the temporary project offices and temporary workers housing area
- Impacts caused by oil leaks from machinery, changing machinery or pollution caused from unsuitable storage conditions and location

【Mitigation measures】

(Design and construction phase)

- Measures to minimize sedimentation, erosion and wastewater run-off such as basins, artificial wetlands, grass filter strips and buffer zones
- Silt screens and sediment traps to be made before out-letting to water bodies to minimize turbidity and silting in local water bodies
- Wastewater treatment for domestic wastewater
- Storing broken machinery and equipment adequately in a warehouse

5) Hydrology/ groundwater and water use/rights

(Design and construction phase)

- Impact due to surface water flow modifications such as potential flooding and decrease of water supply. Because road construction that intersect drainage basins, generally modify the natural flow of surface water by concentrating flows at certain points and in many cases, increasing the speed of flow, result in flooding, soil erosion, channel modification and siltation of streams
- Impact on channel capacities and existing floodways
- Impact on water facilities such as, wells, hand pumps and tube wells etc. along the alignment
- Coordination with provincial department of water resources and meteorology (DoWRM) and other agricultural groups to collect information and discuss mitigation measures
- If the road has a tunnel section, impact on groundwater

【Mitigation measures】

(Design phase)

- While selecting road alignment, avoiding the location of cutting significant water flows
- In case of flood prone areas and/or areas with very flat slopes, hydrological surveys are conducted before alignment finalization. Inputs derived from these surveys such as the need for provision of culverts/bridges or other cross/roadside drainage structures is considered in the alignment finalization.
- Drainage improvements to avoid water logging and flooding due to disturbance of

natural drainage pattern are considered

- Water flow speed control is exercised to check surface runoff's and silt loads during construction activities
- Design and construct a detour while constructing a bridge across a canal, stream or on any irrigation project
- In dry areas, road drainage can be designed to retain water in small dams or maintain a high water table.
- Rehabilitation of water flows and provision of alternative water supplies

6) Waste management

(Construction phase)

- Impacts by construction & demolition waste
- Impacts by dust and particulate matter from construction waste including its storage
- Impacts on waste landfill site by accumulating construction waste

【Mitigation measures】

(Construction phase)

- Control of dust and particulate matter by water spraying
- Designating appropriate landfill site for disposal of waste

<u>Biological Resources</u>

7) Protected areas

(Design and construction phase)

- Impact due to the passage of alignment in and next to the protected area
- Impact due to the disturbance to the access to the protected area
- Impact due to changes in land profile

【Mitigation measures】

(Design and construction phase)

- Selecting alignment which avoids passing through or close to the sensitive area.
- Providing new location for rehabilitating/compensating, if potential impacts are unavoidable

8) Ecosystem including biodiversity such as forest and wildlife

(Design and construction phase)

- Impact due to removal of trees in the alignment
- Impact on forest resources, economically important plants including medicinal plants and threat to endangered species

- Impact on wildlife habitat including wildlife corridors and biodiversity due to change in land use
- Impact due to fragmentation of wildlife habitat and territories
- Pressure on habitats of wildlife as a result of increased access provided by roads
- Impact due to changes in water quality, soil profile, noise, light and air pollution, which may affect the nature and character of habitats
- Impact on food chain, if the project may destruct the food chain of the ecosystem

【Mitigation measures】

(Design phase)

- Selecting alignment which avoids passing through or close to biodiversity sensitive area
- Providing new habitats for rehabilitating/compensating
- Providing road crossing structures such as underpass for passage of wildlife and non-structural measure such as ultrasound

(Construction phase)

- Prohibit workers to set an animal trap, hunt or kill the wildlife
- Prohibit logging outside of the road boundary for the purpose of construction

<u>Social and Economic Resources</u>

9) Resettlement and decent livelihood

In principle, resettlement including livelihood restoration is managed by resettlement plan/framework) prepared by the project owner and approved by Inter-Ministerial Resettlement Committee (IRC). The summary and data from resettlement plan/framework is described. Social and economic survey on potential project affected people provides an important basis to prepare the resettlement plan/framework.

(Design phase)

- Describe land acquisition including ownership of land, land use and population
- Clarifying the procedure and institutional setting on land acquisition and resettlement, considering vulnerable people and marginal groups
- Clarifying the policy on compensation and livelihood restoration
- Impacts due to the land acquisition on residence, land and living measures

【Mitigation measures】

(Design phase)

- Selecting alignment which minimizes the resettlement and impacts by land acquisition and resettlement
- Careful plan and study on land acquisition and resettlement

(Construction phase)

- Implement land acquisition and resettlement as RAP
- Monitor the progress of the process and the situation after the resettlement

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

10) Land use

Adverse land use impacts may arise from the displacement of existing uses, preventing access across it or new land use. Indirect impacts may arise on the natural resources of the area. Identification and assessment of land use, ownership, property values and economic activities is important.

In urban areas, the principal impacts arise from the dislocation of urban activities.

In rural areas, the principal impacts arise from the acquisition and severance of rural holdings. High quality of agricultural land may be lessened by severance.

Natural systems, visual amenity and historic/cultural resources may be disturbed.

【Mitigation measures】

(Design phase)

- While selecting road alignment, avoiding areas of productive lands such as fertile agriculture lands
- Provision of access or alternative routes
- Economic compensation

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

11) Heritage/culture

(Design and construction phase)

- Impact on the heritage/cultural site itself and access to the heritage/cultural site through the identification of the heritage/cultural site
- Coordination with Ministry of Culture and Fine Arts to collect information and discuss mitigation measures

【Mitigation measures】

(Design and construction phase)

- Selecting alignment which avoids passing through or close to the heritage/cultural site
- In case avoidance is not possible, providing new location or rehabilitating/compensating heritage/cultural site

12) Infrastructure

(Design and construction phase)

- Impact on existing infrastructure, such as traffic disturbance on other roads
- Impact on existing infrastructure by change of existing road such as diversion and closure of lane for the construction work
- Impact on existing infrastructure by cutting existing infrastructure such as communication, power and water

【Mitigation measures】

(Design and construction phase)

- Provision of local access roads where access to main arteries has been restricted for the purpose of promoting traffic efficiency and safety
- Provision of alternative routes during construction if existing traffic is much disrupted
- Re-installation of existing infrastructure

13) Landscape

(Design phase)

- Impact on the significant landscape by the project such as major land clearing and tree cutting

【Mitigation measures】

(Design and construction phase)

- Landscaping, rehabilitation and compensation

14) Marginal group

(Design and construction phase)

- Impacts on the poor, ethnic minorities & indigenous people
- Collect information from the latest National Census

【Mitigation measures】

(Design and construction phase)

- Planning and implementing indigenous peoples plan
- Provision of livelihood program

15) Working condition

(Construction phase)

- Impacts on working condition (condition on how the work is done), accidents, health and safety of construction workers
- Coordination with Ministry of Labor and Vocational Training to collect information and discuss mitigation measures

【Mitigation measures】

(Construction phase)

- Complying with Labor Law and Law on Social Security Schemes
- Providing safety measures such as mandatory helmet and health check

16) Public health

(Construction phase)

- Potential of occurrence of species communicating diseases such as mosquito by pooling of water
- Potential of occurrence of communicable diseases through workers
- Impact on pneumonia/respiratory disease is caused by dust

【Mitigation measures】

(Construction phase)

- Provision of drainage at the project site including borrow pits
- Routine watering and reducing the dust that leads to pneumonia occurrence
- Appropriate waste management to avoid waste disposal at the project site
- Provision of health education/training program for the construction workers by the contactor

17) Risks (man-made risks)

(Construction phase)

- Impact due to spillages and accidents of vehicles/storage with chemicals and fuels
- Potential impact on the increase of traffic accident

【Mitigation measures】

(Construction phase)

- Appropriate drainage arrangements with catch drains and catch pits is planned to prevent the spillage of chemicals and fuels reaching the water bodies.
- Provision of signs and safe crossings.

(Reference)

National Road Safety Policy, 2014

18) Climate change

(Design phase)

- Impacts and mitigation measures are described in qualitative way when the project increases the emission of climate change gas significantly

7.2.2 Impacts and mitigation measures during operation phase

Physical Resources

1) Soil erosion/quality

- Impact due to erosion and consequent modification of natural conditions
- Impact due to destabilization of slopes
- Impact due to traffic
- Impact on subsidence by drainage change and additional weight to the soil in subsidence prone area

【Mitigation measures】

- Maintenance program for all erosion control works

2) Air quality and noise & vibration

- Impact due to vehicular emissions and dust caused by vehicles
- Emission levels are expected to increase with the increase in vehicle numbers. Quantitative analysis is better in future while qualitative analysis is acceptable with well-planned mitigation measures.
- Clarifying the method to explain the expected impact
- Impact of noise on the surrounding community due to vehicle movement
- Impact of noise on wild life from crossing road corridors and becoming the project corridor a barrier to regular wild life travel routes
- If the road has the elevated section, the road height is considered.

【Mitigation measures】

- Increase of energy efficiency of the railway system to reduce fuel consumption
- Ensuring buffer area with planting tall leafy vegetation between roads and human settlements
- Preventing encroachment to the buffer area
- Setting noise barrier
- Appropriate road maintenance to prevent potholed road
- Keeping smooth traffic by preventing congestion
- Monitoring on air quality and noise

3) Water quality

- Impacts by drain with sedimentation and increased turbidity
- Run-off such as oils, greases and waste water from roadside, fuel storage and establishment along the road station

【Mitigation measures】

- Maintenance program for controlling run-off and waste water
- Monitoring on water quality

4) Hydrology/ groundwater and water use/rights

- Impact due to surface water flow modifications such as potential flooding and decrease of water supply
- Impact on channel capacities and existing floodways
- Impact on water facilities such as, wells, hand pumps, tube wells etc. falling along the alignment is assessed
- If the road has a tunnel section, impact on groundwater

【Mitigation measures】

- Maintenance program for controlling water flow change and water use
- Monitoring on hydrology and water use

5) Waste management

- Impact from waste from road sweeping, shops and restaurants and gas stations

【Mitigation measures】

- Appropriate waste management plan by kind of source of waste

<u>Biological Resources</u>

6) Protected areas

- Impact on the protected objects under the protected area
- Impact due to the disturbance to the access to the protected area
- Impact due to changes in land profile

【Mitigation measures】

- Maintenance program for controlling measures
- Monitoring on the situation of the protected area

7) Ecosystem including biodiversity

- Impact on forest resources, economically important plants including medicinal plants and threat to endangered species
- Impact on wildlife habitat and biodiversity due to change in land use
- Impact due to fragmentation of wildlife habitat and territories
- Pressure on habitats of wildlife as a result of increased access provided by roads such as collision with vehicle
- Impact due to changes in water quality, soil profile, noise, light and air pollution, which may affect the nature and character of habitats
- Impact on food chain, if the project may destruct the food chain of the ecosystem

【Mitigation measures】

- Warning and speed control to prevent collision with wildlife
- Maintenance program for controlling measures
- Monitoring on the situation of the ecosystem

<u>Social and Economic Resources</u>

8) Involuntary resettlement and livelihood

【Mitigation measures】

- Maintenance and operating program as planned in the resettlement planning
- Monitoring on the situation after the land acquisition and resettlement

9) Land use

【Mitigation measures】

- Maintenance program as planned in the planning
- Monitoring on the situation after the land use change

10) Heritage/culture

- Impact on the heritage/cultural site itself and access to the heritage/cultural site by the traffic caused by the project

【Mitigation measures】

- Maintenance program as planned
- Monitoring on the situation during the operation

11) Infrastructure

- Impact on existing infrastructure through the induced traffic by the project

【Mitigation measures】

- Planning and constructing additional structure, if needed
- Monitoring on the situation during the operation

12) Landscape

【Mitigation measures】

- Monitoring on the situation during the operation

13) Marginal group

【Mitigation measures】

- Implementing indigenous peoples plan
- Provision of livelihood program
- Monitoring on the situation during the operation

14) Working condition

- Impacts on working condition, accidents, health and safety of operation and maintenance workers

【Mitigation measures】

- Complying with Labor Law and Law on Social Security Schemes

15) Public health

- Potential of occurrence of species communicating diseases such as mosquito by pooling of water

【Mitigation measures】

- Appropriate water management generated at the road establishments
- Provision of health program for the workers

16) Risks (man-made risks)

- Impact due to spillages and accidents of vehicles/storage with chemicals and fuels
- Potential impact on the increase of traffic accident

【Mitigation measures】

- Appropriate drainage arrangements with catch drains and catch pits is planned to prevent the spillage of chemicals and fuels reaching the water bodies.
- Provision of safe crossings
- Safety education/training to the residents
- Contingency plan to prepare for accidents.

(Reference)

National Road Safety Policy, 2014

17) Cumulative impacts

Cumulative impacts are described with focus on combination with other projects, with map of other project site. Cumulative impacts can be the case when other major road or major area development project in the same project site. Methods could include following:

- Rough estimation of cumulative pollution loads
- Matrix list for identifying the relation between project activities and impact
- Showing Geographic Information System (GIS) by Tool Overlay to identify an area on the projects impact
- Check list for identifying the impact level

7.2.3 Impacts and mitigation measures during closure phase

How the environmental management plan is continued when change of project owner is described.

Also how the environmental and social condition is transferred/ maintained when part or whole project is closed is described.

7.3 Description of the positive environmental and socio-economic impacts

Positive impacts for both environmental and socio-economic impacts are described.

8. Environmental Management Plan (EMP)

This chapter provides points to clarify the management of the environmental measures planned.

1) Agency

Agency/institution responsible for project implementation and monitoring is described. Also, supervising (control) institution is described.

2) Institutional arrangement

Institutional set-up such as procedures and organization to manage each impacts and mitigation measures is described.

3) Trainings

Training programs for staffs for environmentally and socially sound performance is described.

4) Monitoring plan including method

The plan to monitor impact and mitigation measures is shown. Also, following points are described.

- Baseline conditions before construction through the analysis of existing conditions
- Monitoring plan including parameters, method, monitoring points and frequency, by impact
- Environmental standards or guidelines for monitoring
- Progress/situation on mitigation measures by impact
- Quarterly monitoring report to be submitted to the Ministry of Environment and relevant ministries/agencies
- Emergency response plan for emergency case such as serious accident

5) Assessment of monitoring results
Criteria to assess monitoring results is described.

6) Budget plan for EMP
The budget plan to implement EMP is described. The contribution to the Social and Environmental Fund is described.
(Reference)
- Sub-decree on the Establishment of Social and Environmental Fund
- Joint Prakas on the Provision of Public Services of the Ministry of Environment
- (under draft) Joint Prakas on Social and Environmental Fund by the Ministry of Environment and the Ministry of Economy and Finance.

7) Monitoring report
The above points are compiled to the monitoring report by the agency/institution responsible for project implementation and monitoring. The monitoring report is submitted to the Ministry of Environment and if necessary, to relevant ministries.

9. Economic Analysis and Environmental Value
This chapter provides the economic analysis.
1) Project benefit
Project benefits are described such as improvements in the physical infrastructure and access, improvements in social services by better transport, development of economy including tourism development and improvements in life style.

2) Economic analysis
Cost benefit analysis of the project is described with method and indicators/parameters including valuation methods including adverse environmental and social impact. Following points are shown with sources and references.
- Financial analysis: base on profit and loss of the project
- Economic analysis: economic valuation of cost and benefit
- Environmental damage analysis: direct and indirect cost analysis on individual resources

https://wedocs.unep.org/bitstream/handle/20.500.11822/28857/EIA_Operational_CBA.pdf?sequence=1&isAllowed=y

10. Conclusions and Recommendations

This chapter provides the conclusions and recommendations.

The conclusion is described with the justification, mitigation of major impacts and overall benefits of the project including promotion of local livelihood.

Also, the project owner's assurance and responsibility for the environmental impact assessment is clarified.

The recommendation to the project owner and, if any, to the stakeholders shall be described.

11. References

Reference documents quoted are written down with the author/institution, title of the document, name of the journal, if any and year published.

12. Annex

Attached documents such as maps and figures are shown as Annex.

添付資料 5　Guidelines on Environmental Impact Assessment for Road Sector Projects (IEIA case)

Guideline on Environmental Impact Assessment

for

Road Sector Projects (IEIA case)

Table of Contents

Abbreviation

CARDI	Cambodian Agricultural Research and Development Institute
CI	Conservation International
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FAO	Food and Agriculture Organization
GIS	Geological Information System
GPS	Global Positioning System
IEIA	Initial Environmental Impact Assessment
JICA	Japan International Cooperation Agency
RoW	Right of Way
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund

I. Preface

This guideline is to provide a guidance on contents of IEIA ((Initial Environmental Impact Assessment) study process and IEIA reports by showing what is to be described in IEIA report in road sector for the IEIA project. This guideline covers road projects including highways and bridges.

In the IEIA report, reference data/information source is to be provided.

(IEIA is the preliminary assessment of primarily secondary data of physical, biological and socio-economic environment and resources on the area within or in the surrounding the project site. It forms basis for identification, prediction and analysis of potential adverse environmental and social impacts by project activities, aiming to identify actions to minimize negative impacts and maximize positive impacts.)

(Reference)

- Sub-decree on Environmental Impact Assessment Process, 1999
- Prakas on General Guidelines for Initial and Full Environmental Impact Assessment Reports, 2009

II. The Guideline

0. Executive Summary

A general summary of the IEIA report is provided (within 5-10 pages recommended). It includes at least the following information from the IEIA report:

- Objectives of the IEIA
- Project Owner
- Project description including project site
- Existing Environmental Resources
- Public Participation
- Impacts and Mitigation Measures
- Environmental Management Plan
- Economic analysis and environmental value
- Conclusions and Recommendations

1. Introduction

This chapter provides the introductory part of the IEIA report.

1.1 Project overview

The items to be described include the following.

- Summary of the project background, the rationale for development of the project, and general situation on the project site are described.
- The nature of the project such as new, extension, widening, rehabilitation or combination of these is described.

The summary of the railway structure such as number of lanes is described.

1.2 Objectives of the IEIA

The reason and timing that the IEIA is prepared and the name of consultant who prepares the IEIA report are described.

1.3 Scope and Method

Scope of the study including covered area by the study is described.

Method of the study is described on the following points.

- How the impacts are predicted/estimated.
- Clarification on data source and how the data is measured
- How the data is analyzed
- Basic and common method for understanding existing environmental resources

2. Legal Framework

In this chapter, legal setting is described by clarifying related legal and policy document.

Important legal and policy documents related to the project is described. This includes the title, issued year and explanation of laws, sub-decrees and policies which are much related to the project.

3. Project Description

This chapter provides what is the project and related information.

3.1 Background and experiences of the project owner/company

Following items are described:

- The background of the project,
- The project owner/company including registration information and address,
- The construction company (if it is already decided)
- The capital of construction and operation including the financer.
- If there is a background study such as feasibility survey, it is in introduced.

3.2 Project site, project activities and schedule

1) Project site

Following items are described.

- Location of the project on the map (1:10,000) with administrative boundaries and GPS coordinates
- Description on the alignment by section with pictures and general condition for bridges and tunnels, if any
- Broad geology, topography
- Environmentally sensitive places such as the protected area and land acquisition

2) Project activities

Following is described.

- The specification of the project: It includes length and width of the alignment, number of bridges to be constructed/implemented etc.
- Structure of road by section: The structure could be plane, canal, elevated, semi-underground or underground (tunnel) (typical cross section figure is useful).
- Project alternative
- Technologies involved for design and construction
- Views/priorities adopted for selection of the alignment of right of way with the reason of the selection among the alternatives.

- Waste management, what waste is generated and how waste is collected and disposed
- The project implementation schedule is shown by bar chart.

(Reference)

- Width of Right of Way (ROW) is specified by the Sub-decree on Right of Way of National Roads and Railways, 1999.
- Ministry of Public Works and Transport sets several road and bridges standards/guidelines such as Bridge Design Standard (2003).

4. Description of Existing Environment

This chapter provides the condition of existing environment by type of resources.

4.1 Natural Environment

Natural environment features on project area and surroundings is described by the items in 5.1.1 and 5.1.2.

4.1.1 Physical Resources

1) Soil

Soil profile of the alignment such as geological data is described.

(Reference)

- CARDI (Cambodian Agricultural Research and Development Institute).
- Topographic information can be used from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Global Soil Organic Carbon Map, FAO, 2017

2) Climate

Affecting weather information is described. The information could be temperature (maximum and minimum), rain fall, wind speed and wind direction, for a few years.

(Reference)

- Information by Department of Meteorology, Ministry of Water Resources and Meteorology
- UNDP Climate Change Country Profiles, UNDP

3) Air quality

Air quality situation is described by selected pollutants with comparison of data observed/referred and standard value. Dust fall is included when traffic of truck is expected to be heavy.

If data is taken by sampling, describe method, period and location.

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Ambient Air Quality Standard.

4) Noise and Vibration

Noise and vibration situation is described.

If data is taken by sampling, describe method, period and location.

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Maximum permitted noise level.

5) Water quality

Water quality situation is described by selected pollutants with comparison of data observed/referred and standard value.

If data is taken by sampling, describe period and location.

If the road has a tunnel section, the groundwater quality is described.

(Reference)

- Sub-decree on Water Pollution Control, 1999 prescribes Water Quality Standard in public water areas.

6) Hydrology

River, lake, reservoir, wetland and drainage system is described with map.

Run-off characteristics of watersheds are described. When data is described, whether data source is on-site measurement or quoted data clarified.

(Reference)

- The Study on Hydro-Meteorological Monitoring for Water Quantity Rules in Mekong River Basin (JICA, 2004) (for hydrologic information)
- Department of Hydrology and River Works, Ministry of Water Resources and Meteorology (for hydrologic information)
- Mekong River Commission website

4.1.2 Biological Resources

1) Forest

Situation on forest area such as forest cover with map is described.

The designated protected area (especially Core zone and Conservation zone) on forest is described, if there is in proximity of the project site.

(Reference)

- The Law on Forestry (Royal Kram)

- The Protected Areas Law
- Cambodia Forest Cover, 2014 (Forestry Administration, 2016)

2) Protected area

The designated protected area concerning biological resources is described, especially Core zone and Conservation zone, if there is in proximity of the project site.

(Reference)
- Protected Areas Law
- Sub-decree on individual protected area

3) Biodiversity and ecological systems

Situation on biodiversity (aquatic resources included) and ecological system (wetland system included) is described, especially endangered species and important ecological system, if there is in proximity of the project site.

The designated protected area and sensitive area is described.

(Reference)
- WWF (World Wide Fund for Nature) (https://www.worldwildlife.org), CI (Conservation International) (https://www.conservation.org) and WCS (Wildlife Conservation Society) (https://www.wcs.org) website on endangered species.

4.2 Social and Economic Resources

1) Demography and economic status

Population, public health and economic situation is described such as economic growth, income level, major industry/product.

(Reference)
- Economic Census of Cambodia by National Institute of Statistics

2) Land use and land registration

Land use is described.

In the case land acquisition is planned, land ownership and occupancy with the relation with the Right-of-way is described.

(Reference)
- Land use information can be used by revised information from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Land law (2001)
- Expropriation Law (2010)
- Sub-Decree on Right of Way of National Road Channels and Railroads

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

3) Infrastructure

Major public infrastructures in the area such as roads, irrigation, and water supply are described.

4) Heritage/culture

Heritage (cultural heritage, historical monuments, landscape, ancient temples, pagodas and customs/traditions) is described, especially ones designated/listed by the Protected Area Law and UNESCO/Government, if any.

(Reference)

- Law on Protection of Cultural Heritage prescribes protected sites and inventory on cultural property.

5) Marginal group

Situation on the poor, ethnic minority and indigenous people is described such as by the latest National Census Reports.

(Reference)

- Information by local government

6) Others

The important result of the social and economic study such as replacement cost study is described if it is not covered in the above.

The presence of unexploded weapons is described when there is possibility.

5. Public Participation

This chapter provides the public participation process, especially the process to involve project affected people and other stakeholders. Refer to the Guideline on Public Participation in Environmental Impact Process, 2016 for detail.

The plan of public participation has 3 stages following the Prakas on the Enforcement of Term of Reference on Infrastructure and Tourism Development Project.

Table 1 Stages of public participation

Stages		Outline
1	Information dissemination at project site	The project owner and consultant company disseminates information to stakeholders in order to inform them about the project inception, scope, impact exposure as well as

		preliminary information and people who get impact from the project.
2	Interviewing the authorities, involved departments	The project owner and consultant company interviews with authorities, involved departments and stakeholders, and/or prepares the Focus Group discussion in order to get the opinion and comments on the project.
3	Consultation Workshop	The project and consultant company prepares the public consultation workshop in order to show the result of Environmental Impact Assessment Report and stakeholders interview

Also, the project owner establishes and informs the grievance redress mechanism which deals with complaints and grievances.

6. Environmental Impacts and Mitigation Measures

This chapter provides information on impacts and mitigation measures.

6.1 A summary of impacts and mitigation measures

- The view on determination of impacts and mitigation measures are described. The project stage is covered from design to closure.

The summary of 6.2 is shown by such as following table.

Table 2 Summary of impacts and mitigation

Environmental and Socio-Economic Aspects	Negative Impacts	Scope of Impacts			Mitigation Measure	Remark
		Low	Moderate	High		
1. Negative impacts of design and construction stage						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
2. Negative impacts of operation stage						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
3. Negative impacts of closure stage						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						

6.2 Impacts and mitigation measures

In this section, the contents and degree of impacts is described. It includes method for estimating impacts and evaluation of estimated/forecasted impacts. Also mitigation measures on the expected impact is described with the description how the expected impacts are mitigated. When individual impact and mitigation measure is a stage specific one, the corresponding stage is clarified.

Following is the example for listed possible impacts and mitigation measures by impact items.

<u>Physical Resources</u>

1) Soil erosion/quality

- Impact due to erosion and consequent modification of natural conditions.
- Impact on subsidence by drainage change and additional weight to the soil in subsidence prone area.
- Impact of bridge construction due to crossing a river or stream
- Impact due to traffic (operation stage)

【Mitigation measures】

- Engineering measures for slope protection and erosion prevention/control.
- Drainage improvements for prevention of soil erosion and siltation of water course.
- While selecting road alignment, avoiding areas prone to landslides, soil erosion, and subsidence.(design stage)
- Reduction of the need for borrow pits and minimization of excess spoil material generation. (construction stage)
- Restoration, revegetation and rehabilitation measures.
- Construction of drainage ensuring the stability of the slope. (construction stage)
- Maintenance program for erosion control works (operation stage)

2) Air quality and noise

- Impact on air due to vehicular emissions from vehicles including heavy vehicles used for construction.
- Impact on noise on the surrounding community due to vehicles.
- Impact due to dust generation from material handling, storage, equipment and vehicles, construction activities, excavation of soil and cutting of embankment near to habitation, hospitals, schools, sanctuaries etc. (construction stage)

【Mitigation measures】

- Selecting alignment which avoids passing close to housing, schools, hospitals etc.

(design stage)

- Providing sufficient capacity to avoid traffic congestion, even with projected increase in traffic flow. (design stage)
- Ensuring buffer area with planting tall leafy vegetation between roads and human settlements.
- Provision of noise barrier, if needed.
- Periodical watering.
- Road maintenance and keeping smooth traffic. (operation phase)

3) Water quality

- Impact due to drain.
- Impact due to oil leaks, greases, waste water generated.

【Mitigation measures】

- Measures to minimize sedimentation, erosion and wastewater run-off such as basins, artificial wetlands, grass filter strips and buffer zones.
- Silt screens and sediment traps.
- Maintenance program for controlling run-off and monitoring. (operation phase)

4) Hydrology

- Impact due to surface water flow modifications such as potential flooding and decrease of water supply. Because road construction that intersect drainage basins, generally modify the natural flow of surface water by concentrating flows at certain points and in many cases, increasing the speed of flow, result in flooding, soil erosion, channel modification and siltation of streams.
- Impact on channel capacities and existing floodways.
- If the road has a tunnel section, impact on groundwater.

【Mitigation measures】

- While selecting road alignment, avoiding the location of cutting significant water flows.(design stage)
- Drainage improvements to avoid water logging and flooding due to disturbance of natural drainage pattern are considered.
- Water flow speed control.

<u>Biological Resources</u>

5) Protected areas

- Impact due to the passage of alignment in and next to the protected area.
- Impact due to the disturbance to the access to the protected area.

- Impact due to changes in land profile.

【Mitigation measures】

- Selecting alignment which avoids passing through or close to the sensitive area.(design stage)
- Maintenance program for controlling and monitoring.(operation phase)
- Providing new location for rehabilitating/compensating, if needed.

6) Ecosystem including biodiversity such as forest and wildlife

- Impact on forest resources and biodiversity, and threat to endangered species including their habitat.
- Pressure on habitats of wildlife as a result of increased access provided by roads.

【Mitigation measures】

- Selecting alignment which avoids passing through or close to biodiversity sensitive area.(design stage)
- Providing new habitats for rehabilitating/compensating.
- Providing road crossing structures such as underpass for passage of wildlife and non-structural measure such as ultrasound.
- Prohibit workers to set an animal trap, hunt or kill the wildlife.
- Warning and speed control measures to prevent collision with wildlife.(operation phase)
- Maintenance program for controlling and monitoring.(operation phase)

<u>Social and Economic Resources</u>

7) Resettlement and decent livelihood

In principle, resettlement including livelihood restoration is managed by resettlement plan/framework) prepared by the project owner and approved by Inter-Ministerial Resettlement Committee (IRC). The summary and data from resettlement plan/framework is described. Social and economic survey on potential project affected people provides an important basis to prepare the resettlement plan/framework.

【Mitigation measures】

- Selecting alignment which minimizes the resettlement and impacts by land acquisition and resettlement.(design stage)
- Implement land acquisition and resettlement as RAP (construction stage)
- Monitor the progress of the process and the situation after the resettlement.

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

8) Land use

Adverse land use impacts may arise from the displacement of existing uses, preventing access across it or new land use. Indirect impacts may arise on the natural resources of the area. Identification and assessment of land use, ownership, property values and economic activities is important.

【Mitigation measures】

- While selecting road alignment, avoiding areas of productive lands such as fertile agriculture lands.(design stage)
- Economic compensation.

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

9) Heritage/culture

- Impact on the heritage/cultural site itself and access to the heritage/cultural site through the identification of the heritage/cultural site.

【Mitigation measures】

- Selecting alignment which avoids passing through or close to the heritage/cultural site.(design stage)
- In case avoidance is not possible, providing new location or rehabilitating/compensating heritage/cultural site.

10) Infrastructure

- Impact on existing infrastructure, such as traffic disturbance, diversion or closure.
- Impact on existing infrastructure by cutting existing infrastructure such as communication, power and water

【Mitigation measures】

- Provision of alternative routes if existing infrastructure is much disrupted.

11) Marginal group

- Impacts on the poor, ethnic minorities & indigenous people.

【Mitigation measures】

- Planning and implementing indigenous peoples plan.
- Provision of livelihood program when needed.

12) Public health and working condition

- Potential of occurrence of communicable diseases through pooling of water and workers.

- Impacts on working condition, accidents, health and safety of construction workers.(construction stage)

【Mitigation measures】

- Providing education/training program and safety measure.

13) Risks (man-made risks)

- Impact due to spillages and accidents of vehicles/storage with chemicals and fuels.
- Potential impact on the increase of traffic accident.

【Mitigation measures】

- Appropriate drainage arrangements.
- Provision of signs and safe crossings.

(Reference)

- National Road Safety Policy, 2014

7. Environmental Management Plan (EMP)

This chapter provides points to clarify the management of the environmental measures planned.

1) Agency

Agency/institution responsible for project implementation and monitoring is described. Also, supervising (control) institution is described.

2) Trainings

Training programs for staffs for environmentally and socially sound performance is described.

3) Monitoring plan including method

The plan to monitor impact and mitigation measures is shown. Also, following points are described.

- Monitoring plan including parameters, method, monitoring points and frequency, by impact.
- Method of monitoring includes parameters of impact and schedule.
- Semi-annual monitoring report to be submitted to the Ministry of Environment and relevant ministries/agencies.
- Budget plan for EMP

(Reference)

- Sub-decree on the Establishment of Social and Environmental Fund (2016)

4) Assessment of monitoring results

Criteria to assess monitoring results is described.

8. Economic Analysis and Environmental Value

Project benefits are described such as improvements in the physical infrastructure and access.

9. Conclusions and Recommendations

The conclusion is described with the justification, mitigation of major impacts and overall benefits of the project.

Also, the project owner’s assurance and responsibility for the environmental impact assessment is clarified.

10. References

Reference documents quoted are written down with the author/institution, title of the document, name of the journal, if any and year published.

11. Annex

Attached documents such as maps and figures are shown in Annex.

添付資料 6　　Guidelines on Environmental Impact Assessment for Railway Sector Projects (Full EIA case)

Guideline on Environmental Impact Assessment

for

Railway Sector Projects (Full EIA case)

Table of Contents

Abbreviation

CARDI	Cambodian Agricultural Research and Development Institute
CI	Conservation International
dB	Decibel
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FAO	Food and Agriculture Organization
GIS	Geological Information System
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
PM	Particulate Matter
RoW	Right of Way
TOR	Terms of Reference
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund

I. Preface

This guideline is to provide a guidance on contents of EIA (Environmental Impact Assessment) study process and EIA reports by showing what is to be described in EIA report in railway sector for the full EIA project. This guideline covers railway projects including bridges.

In the EIA report, reference data/information source is to be provided.

(Reference)

Sub-decree on Environmental Impact Assessment Process, 1999

Prakas on General Guidelines for Initial and Full Environmental Impact Assessment Reports, 2009

II. The Guideline

0. Executive Summary

A general summary of the EIA report is provided (within 15-20 pages recommended). It includes at least the following information from the EIA report:

- Objectives of the EIA
- Project Owner/Proponents
- Project Description including project site
- Other Project Alternatives
- Existing Environmental Resources
- Public Participation including issues raised by stakeholders and any outstanding issues
- Impacts and Mitigation Measures
- Environmental Management Plan
- Economic analysis and environmental value
- Conclusion and recommendation

1. Introduction

This chapter provides the introductory part of the EIA report.

1.1 Project overview

Summary of the project background, the rationale for development of the project, and general situation on the project site are described.

The nature of the project such as new, extension, widening, rehabilitation or combination of these is described.

The summary of the railway structure such as number of lanes is described.

1.2 Objectives of the EIA

The reason and timing that the EIA is prepared and the consultant who prepares the EIA report are described.

2. Scope and Methodologies of the Study

This chapter provides points related to the Terms of Reference of the EIA study including stipulations in the relevant Prakas and Sub-decree in Cambodia.

2.1 Scope of the Study

Scope of the study including covered area by the study is described.

2.2 Data source

The items to be described include how the data is collected such as the measurement and data from existing document is described. For example, in the case of air quality measurement by the project owner, how the sampling date and point is selected and measurement method of pollutants is described. In the case of data from existing document, justification/relevance of the referred document is described.

Also, when data is described, it is clarified whether primary data (data from the field, observation at and around the project site) or secondary data (collected and quoted data from technical document).

2.3 Methodologies of the study

How the impacts in each project stage is predicted/estimated is described.

Appropriate methods of dada collection are included in this section. Method of the data analysis is described. For example, how the expected impact in air quality is compared with the air quality standard in Cambodia is described. When non-Cambodian standards/guidelines are used, justification/relevance of the referred document is described.

Also, basic and common methodologies for understanding physical resources, biological resources and social and economic resources is described in this section and the detail in individual resource is described in the individual sections.

For example, the methodologies on social and economic study is described including following.

- The area covered such as length from the right of way
- Selection of targeted villages/communities
- Sample size compared with the population/number of household
- Items surveyed.
- (if included) The replacement cost policy and methodologies to identify the

ownership of assets

Further, methodologies for public participation is described (The detail is described in 6. Public Participation).

The EIA preparer describes the time table of the EIA survey and team composition including name and work role.

3. Legal Framework

In this chapter, legal setting is described by clarifying related legal and policy document.

Legal and policy documents related to the project is described. This includes the title, issued year and explanation of laws, sub-decrees and policies which are related to the project.

The donor policies in donor supported project case is described, if any.

(Reference)

Table 1 An example of related Laws and Sub-decrees

Title	Year	Explanation
Law on Constitution of Kingdom of Cambodia	1993	
Law on Environmental Protection and Natural Resources Management	1996	
Law on Expropriation	2010	
Law on Water Resource Management	2007	
Law on Forestry	2002	
Law on Fishery	2006	
Law on Protected Area	2008	
Law on Land	2001	
Law on Labour	1997	
Law on the Protection of Cultural Heritage	1996	
Law on Land Management, Urban Planning and Constructions	1994	
Law on Management and Exploitation of Mineral Resources	2001	
Royal-Decree on establishment and	2001	

management of Tonle Sap Biosphere Reserve (In Tonle Sap area case)		
Sub-Decrees on Environmental Impact Assessment Process	1999	
Sub-Decree on the Establishment of Environmental and Social Fund	2016	
Sub-Decrees on the Air Pollution and Noise Disturbance Control,	2000	
Sub-Decrees on Water Pollution Control	1999	
Sub-Decrees on Solid Waste Management	1999	
Sub-decree on Management of Garbage and Solid Waste of Downtown	2015	
Sub-Decrees on the Management the Reserved Land along the National Road and Railroad	2009	
Sub-decree on Land Acquisition and Involuntary Resettlement	2018	

Note 1: The consultant can add or delete laws for suitable tabulation to the concerned project.

Note 2: Input essential but simple descriptions in Explanation columns.

4. Project Description

This chapter provides what is the project and related information.

4.1 Background and experiences of the project owner/company

Following items are described.

- The background of the project,
- The project owner/company including registration information and address,
- The construction company (if it is already decided)
- The capital of construction and operation including the financer.
- The experiences of the project owners/company in the sector are described. If there is a background study such as feasibility survey, it is in introduced.

4.2 Project site

Following items are described.

1) Location of the project on the map (1:10,000) with GPS coordinates
2) Description on the alignment by section, station and rail yard with pictures and general condition for bridges and tunnels, if any
3) Broad geology, and topography
4) Villages, settlements and land use including demographic, socio, cultural and economic aspects
5) Environmentally sensitive places such as the protected area and land acquisition
6) Case specific information, if any

Case	Information
The proposed alignment is passing through any hilly area or rock falling area.	The details of such area such as landslides and erosion.
The proposed alignment involves tunneling.	The details of the tunnel and locations of tunneling with geological structural fraction
The proposed project involves any land reclamation.	The details of reclamation and the area of land to be reclaimed.
The proposed project involves heavy volume of dredging.	The details of dredging and the river/channel to be dredged.

4.3 Project types

1) Project specification

The specification of the project is described. It includes length and width of the alignment, station, rail yard and number of bridges to be constructed/implemented etc. The table below is an example of specification.

Table 2 Example of project specification in railway projects

no	Description	Quantity(unit)
	Length of the alignment (in extension case, new and existing)	(km)
	Width of the alignment (in widening case, new and existing)	(m)
	Number of stations	
	Area of rail yard/cargo yard	(m^2)
	Number of bridges	
	Length and width of major bridge	(m)

	Number of culverts	
	Number of underpasses	
	Number of intersections	
	Number of railway crossings	

2) Structure of railway by section is described. The structure could be plane, canal, elevated, semi-underground or underground (tunnel) (typical cross section figure is useful).

3) Technologies involved for design and construction are described, including power for train vehicle.

4) Procedures and criteria adopted for selection of the alignment of right of way is described.

5) Activities for site preparation are described.

(Reference)

- Width of Right of Way (ROW) is specified by the Sub-decree on Right of Way of National Road Channels and Railways, 2009.
- Ministry of Public Works and Transport sets several roads and bridges standards/guidelines such as Bridge Design Standard (2003).

4.4 Alternatives

The project alternatives are described. For example, alternatives can be described in option 1, option 2, option 3 and zero-option (the case without project), with the reason on the selection of the project among the alternatives and the selection of alternatives. For example, the alternative can be the project with a route bypassing populated area, different alignment case with shorter route passing populated area and without project case.

The comparison of alternatives is described by a table.

These details are comprised of:

- Description of various alternatives by locations, layouts or technologies studied
- Description of each alternative
- Summary of adverse and positive impact of each alternative
- Procedures and criteria adopted for selection of alternative

  Selection of the alternative which is the best with respect to use of resources and adverse environmental impact

4.5 Activities of the project

Project activities are described. For example;

- Administration (management) of the project
- Sources and quantity of input to be used including water, energy and machinery requirements
- Local and foreign workforce requirements including their housing
- Quantity of final output/products: If it is described in the project overview, refer to it.
- Income and expenditure (Revenue and cost)
- Overall waste management plan: To describe what waste is generated and how waste is collected and disposed by project phase.
- Risk management policy: To describe policy to respond to natural hazards and to secure safety.

4.6 Work plan/ schedule

1) Project phasing.

The phasing of the project is described, if any.

2) Project implementation schedule.

The project implementation schedule is shown by bar chart.

5. Description of Existing Environment

This chapter provides the condition of existing environment by type of resources.

5.1 Natural Environment

Natural environment features on project area and surroundings is described by the items in 5.1.1 and 5.1.2.

5.1.1 Physical Resources

1) Soil

Soil profile of the alignment such as geological data, topology, soil type, slope condition, soil mechanic and watershed is described. A detailed seismology and geology study is provided, if available.

If the alignment runs mineral resource area, mineral resource is clarified

The history on land slide is provided, if any.

(Reference)

- CARDI (Cambodian Agricultural Research and Development Institute) soil type can be

used to describe using ArcGIS software.
- Topographic information can be used from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Global Soil Organic Carbon Map, FAO, 2017

2) Climate

The items to be described include the following.

- Affecting weather information is described. The information could be temperature, rain fall, wind speed and pattern, wind direction, relative humidity and sea level (in coastal area) for several years (average data for at least last 5 years).
- The history on storm surge and earthquake, if any.
- Information on climate change such as adaptation study, if any.

(Reference)
- Information by Department of Meteorology, Ministry of Water Resources and Meteorology
- UNDP Climate Change Country Profiles, UNDP

3) Air quality

Power source of train is clarified. If the power source is oil/coal engine, there is a potential of impact on air quality, while if the power source is electricity, there is no potential impact on air quality from train in operation phase. Also, it is clarified whether there is a power generator at the yard as potential impact source.

Air quality situation is described by pollutants, major pollutants source and weather condition.

Baseline data is described. At least 2 samples (one at the project site and another in the community near the project site considering wind direction and geography) are measured, while more samples can be measured when necessary. The description includes methodology, period and location with its characteristics such as distance from the sensitive area (community, hospital, school, temple/pagoda, etc.) and map.

While the area under expected impact depends on the natural and social conditions, 150m from the edge of alignment can be referred for the area under expected impact.

When site sampling is conducted, sampling sites are recommended at least at the project site and at the sensitive receptors site.

Table 3 Example of data on air quality situation

No	Parameter	Unit	Average time	Observed	Standards	Method
1	Carbon monoxide (CO)	mg/m³	8 hours		20	
2	Nitrogen dioxide (NO_2)	mg/m³	24 hours		0.1	
3	Sulfur dioxide (SO_2)	mg/m³	24 hours		0.3	
4	Ozone (O_3)	mg/m³	1 hour		0.2	
5	Lead (Pb)	mg/m³	24 hours		0.005	
6	Total Suspended Particulate (TSP)	mg/m³	24 hours		0.33	
7	PM10	mg/m³	24 hours		0.05	
8	PM2.5	mg/m³	24 hours		0.025	

(Source) Sub-decree on Air Pollution and Noise Disturbance and Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Ambient Air Quality Standard.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project
- Environmental Impact Assessment Technique for Road Project, National Institute for Land and Infrastructure Management, Japan, 2013.(on the area under expected impact)

4) Noise and Vibration

Noise and vibration situation is described. As a train is composed of heavy vehicles, there is a potential impact on noise and vibration.

Baseline data is described. At least 2 samples (one at the project site and another in the public building/area) are measured, while more samples can be measured when necessary. The description includes methodology, period and location with its characteristics such as distance from the sensitive area (community, hospital, school, temple/pagoda, etc.) and map. While the area under expected noise impact depends on the natural and social conditions, 200m for noise, 100m for vibration from the edge of alignment can be referred for the area under expected impact.

Table 4 Example of data on noise

No	Area	Period of time					
		From 6 to 18		From 18 to 22		from 22 to 6	
		Observed	Standard (dB(A))	Observed	Standard (dB(A))	Observed	Standard (dB(A))
1	Quiet areas - Hospitals - Libraries - School - Kindergarten		45		40		35
2	Residential area: - Hotels - Administration offices - House		60		50		45
3	Commercial and service areas and mix		70		65		50
4	Small industrial factories intermingling in residential areas		75		70		50

(Source) Sub-decree on Air Pollution and Noise Disturbance

Table 5 Example of data on vibration

Daytime (From 06to 18)		Nighttime (From 18 to 06)	
Observed	Standard	Observed	Standard
	65 dB		60 dB

(Source) Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Maximum permitted noise level.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project
- Environmental Impact Assessment Technique for Road Project, National Institute for Land and Infrastructure Management, Japan, 2013.(on the area under expected impact)

5) Water quality

It is clarified what is potential water pollution source in operation phase, such as toilet with open bottom, cleaning/maintenance of train at the yard and oil tanks.

Water quality situation is described by pollutants and pollutants source.

Baseline data is described. At least 2 samples (one at the project site (downstream side) and another at the natural water area) are measured, while more samples can be measured when necessary. It includes methodology, period and location with its characteristics and map. When site sampling is conducted, sampling sites are recommended at the project site and at the important water user site such as water supply source.

If the railway has a tunnel section, the groundwater quality is described.

Table 6 Example of data on water quality

No	Parameters	Unit	Observed	Standards	Method
1	pH	-			
2	Total Dissolved Solid (TDS)	mg/l			
3	Total Suspended Solid (TSS)	mg/l			
4	Dissolved Oxygen (DO)	mg/l			
5	Biological Oxygen Demand (BOD5)	mg/l			
6	Chemical Oxygen Demand (COD)	mg/l			
7	Oil and Grease	mg/l			
8	Detergent	mg/l			
9	Sulfate (SO4)	mg/l			
10	Total Nitrogen (TN)	mg/l			
11	Total Phosphorous (TP)	mg/l			
12	Lead (Pb)	mg/l			
13	Arsenic (As)	mg/l			
14	Cadmium (Cd)	mg/l			
15	Iron (Fe)	mg/l			
16	Mercury (Hg)	mg/l			
17	Total Coliform	NPN/100ml			

*1 Apply appropriate standard values in accordance with the tested water source (e.g. river, lake/reservoir or marine)

(note) When consideration for aquatic organism is needed, Linear Alkyl Benzene Sulfonic Acid and its salts (LAS) which is used in detergent can be set as a parameter.

(Reference)

- Sub-decree on Water Pollution Control, 1999 prescribes Water Quality Standard in public water areas.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

Table 7 Parameters and standard for surface water quality

No	Parameters	Unit	River water	Lake and reservoir	Marine
1	Acid or Base (pH)	-	6.5 – 8.5	6.5 - 8.5	7.0 – 8.3
2	Total Dissolved Solid (TDS)	mg/l	<1000	<1000	<1000
3	Total Suspended Solid (TSS)	mg/l	25-100	1-15	<60
4	Dissolved Oxygen (DO)	mg/l	7.5-2.0	7.5-2.0	7.5-2.0
5	Biological Oxygen Demand (BOD_5)	mg/l	1-10	<30	<30
6	Chemical Oxygen Demand (COD)	mg/l	<50	1-8	2-8
7	Oil and Grease	mg/l	<5.0	<5.0	0
8	Detergent	mg/l	<5.0	<5.0	0
9	Sulfate (SO_4)	mg/l	<300	<300	<300
10	Total Nitrogen (TN)	mg/l	0.1-0.6	0.1-0.6	0.2-1.0
11	Total Phosphorus (TP)	mg/l	0.005-0.05	0.005-0.05	0.02-0.09
12	Lead (Pb)	mg/l	<0.01	<0.01	<0.01
13	Arsenic (As)	mg/l	<0.01	<0.01	<0.01
14	Cadmium (Cd)	mg/l	<0.001	<0.001	<0.001
15	Iron (Fe)	mg/l	<1	<1	<1
16	Mercury (Hg)	mg/l	<0.0005	<0.0005	<0.0005
17	Total Coliform	NPN/ 100ml	<5000	<5000	<5000

(Source) Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

Table 8 Parameters and standard for groundwater quality when required

No	Parameters	Unit	Standards
1	pH	-	6.5-8.5
2	Turbidity	NTU	5
3	Electrode Conductivity (EC)	NTU	500-1500
4	Total Dissolved Solid (TDS)	mg/l	800
5	Total Hardness (as $CaCO_3$)	mg/l	300
6	Chloride	mg/l	250
7	Fluoride (F)	mg/l	1.5
8	Nitrate (NO_3)	mg/l	50

9	Sulfate (SO_4)	mg/l	250
10	Iron (Fe)	mg/l	0.3
11	Arsenic (As)	mg/l	0.05
12	Mercury (Hg)	mg/l	0.001
13	Chromium (Cr)	mg/l	0.05
14	Manganese (Mn)	mg/l	0.1
15	Aluminum (Al)	mg/l	0.2
16	Benzene (C_6H_6)	mg/l	0.01
17	Dichloromethane (CH_2Cl_2)	mg/l	-
18	Cadmium (Cd)	mg/l	0.003
19	Total coliform	MPN/100ml	0
20	E-coli	MPN/100ml	0

(note) Parameters are selected depending on the geology and the tunnel structure/construction work

(Source) Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

6) Hydrology

River, lake, reservoir, wetland and drainage system is described with map.

The items to be described include the following.

- Water level (with warning water level, if any) and flow rate of river/lake by table.
- Run-off characteristics of watersheds is described. Delineation of watersheds and drainage pattern in the area of influence using aerial/remote sensing images is recommended.
- The history on flood and storm surge, if any.
- If the railway has a tunnel section, the groundwater situation.

(Reference)

- The Study on Hydro-Meteorological Monitoring for Water Quantity Rules in Mekong River Basin (JICA, 2004) (for hydrologic information)
- Department of Hydrology and River Works, Ministry of Water Resources and Meteorology (for hydrologic information)
- Mekong River Commission website

5.1.2 Biological Resources

1) Forest

The items to be described include the following.

- Situation on forest area such as vegetation and forest cover with map
- The designated protected area (especially Core zone and Conservation zone) on forest, if there is in proximity of the project site. Clarification on zoning is important.
- The methodologies for the study, such as direct observation (with map on location), local interview, analysis of reference documents.

(Reference)

- The Law on Forestry (Royal Kram) prescribes permanent forest reserve, production forest, protection forest and community forest. Also the Law has provisions on environmental and social impact assessment.
- The Protected Areas Law
- Cambodia Forest Cover, 2014 (Forestry Administration, 2016)

2) Protected area

The items to be described include the following.

- The designated protected area concerning biological resources, especially Core zone and Conservation zone, if there is in proximity of the project site.
- Clarification on zoning is important and zoning information could be collected from the Sub-decree on individual Protected area, related Ministry or local government.
- The methodologies for the study, such as direct observation (with map on location), local interview, analysis of reference documents.

(Reference)

- Protected Areas Law prescribes the category of the protected areas and zoning (Core zone, Conservation zone, Sustainable use zone and Community zone) of the protected areas
- Sub-decree on individual Protected area

3) Wildlife species and habitats

Wildlife species and their habitats are described, especially endangered species. This includes rare species, endemic species and movement (corridor and migratory pattern). The methodologies for the study is described such as direct observation (with map on location), local interview and analysis of reference documents.

(Reference)

- WWF (World Wide Fund for Nature) (https://www.worldwildlife.org), CI (Conservation International) (https://www.conservation.org) and WCS (Wildlife Conservation Society) (https://www.wcs.org) website on endangered species.

4) Biodiversity and ecological systems

The items to be described include the following.

- Situation on biodiversity and ecological system, including endangered species and important biological corridor, if there is in proximity of the project site.
- The designated protected area and sensitive area.
- The ecology resources function (forest/ecology system situation and function) with the result of 1), 2) and 3).
- The methodologies for the study, such as direct observation, local interview, or analysis of reference documents.

5) Aquatic resources

The items to be described include the following.

- Situation on aquatic resources. It can be inland resources and/or marine resources in the case the project site is in coastal or sea area. Fishery is important resource in both food and employment in Cambodia.
- The methodologies for the study, such as direct observation, local interview, or analysis of reference documents.

(Reference)

Reports of Ministry of Agriculture, Forest and Fishery

5) Wetland systems, if related

Situation on wetland is described, if there is crossing in or near designated wetland site such as by the Ramsar Convention (Boeng Chhmar and Associated River System and Flood Plain, Prek Toal Ramsar Site, Koh Kapik and Associated Islets, and Middle Stretches of Mekong River North of Stoeng Treng).

5.2 Social and Economic Resources

1) Social and economic study methodologies

The methodologies of social and economic study is described including following.

- The area covered such as length from the right of way
- Selection of targeted villages/communities among the total alignment
- Sampling method and sample size compared with the population/number of household
- Items surveyed.
- (if included) The replacement cost policy including eligibility and methodologies to identify the ownership/occupancy of assets

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

2) Demography and settlement

Population, villages and settlements is described.

(Reference)

- General Population Census by National Institute of Statistics

3) Economic status

Economic situation is described such as economic growth, income (primary and secondary) level, major industry/product and major employment.

(Reference)

- Economic Census of Cambodia by National Institute of Statistics

4) Land use and land registration

Land use is described such as industrial area, forest area, city area and agriculture area. Also the land use master plan is described, if any.

In the case land acquisition is planned, land ownership and occupancy with the relation with the Right-of-way is described.

(Reference)

- Land use information can be used by revised information from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Land law (2001)
- Expropriation Law (2010)
- Sub-Decree on Right of Way of National Road Channels and Railroads of the Kingdom of Cambodia (2009)
- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

5) Water use

Water resources and water s use including water source and purpose is described.

6) Energy use

Major energy source is described.

7) Infrastructure

Major public infrastructures in the area (e.x. roads, irrigation, parks, water supply and sewerage etc.) are described.

8) Education

Situation on education is described such as literacy rate and school enrollment rate.

The crossing of the alignment and school routes is described, if any.

9) Public health and well-being

Situation on public health and well-being is described.

(Reference)

- Cambodia Demographic and Health Survey by National Institute of Statistics

10) Heritage/culture

Heritage (cultural heritage, historical monuments, landscape, ancient temples, pagodas and customs/traditions) is described, especially ones designated/listed by the Protected Area Law and UNESCO/Government, if any.

Cultural characteristics and important cultural/traditional sites are also described.

(Reference)

- Law on Protection of Cultural Heritage prescribes protected sites and inventory on cultural property.
- Information by Ministry of Culture and Fine Arts

11) Marginal group

The poor, ethnic minority and indigenous people is identified.

Situation on the poor, ethnic minority and indigenous people is described such as by specific socio-economic survey and the latest National Census Reports.

(Reference)

- Sub-Decree on Procedures of Registration of Land of Indigenous Communities
- Information by local government

12) Tourism destinations

Situation on tourism resources and their use is described, if any.

(Reference)

- Tourism Development Strategic Plan 2012-2020

13) Others

The result of the social and economic study such as replacement cost study is described if it is not covered in the above.

The presence of unexploded weapons is described when there is possibility.

6. Public Participation

The items to be described include the following.

- The public participation process, especially the process to provide project affected people and other stakeholders the opportunities to be informed and consulted, to express an opinion about projects including activities, and to allow effective involvement.
- The methodology and procedure of public participation such as identification of project affected people and other stakeholders, how to inform including access to the information and how to consult including feedback.

The plan of public participation has 3 stages following the Term of Reference on Infrastructure and Tourism Development Project (Prakas No.120, 2018):

Table 9 Stages of public participation

Stages		Outline
1	Information dissemination at project site	The project owner and consultant company disseminates information to stakeholders in order to inform them about the project inception, scope, impact exposure as well as preliminary information and people who get impact from the project.
2	Interviewing the authorities, involved departments	The project owner and consultant company interviews with authorities, involved departments and stakeholders, and/or prepares the Focus Group discussion in order to get the opinion and comments on the project.
3	Dissemination Workshop	The project and consultant company prepares the public disseminationworkshop in order to show the result of Environmental Impact Assessment Report and stakeholders interview

Following points are also described.

- Dissemination by the project owner with local authorities and local communities of the development project
- Feedback from relevant provincial departments/ agencies and relevant local authorities
- Comments from relevant non-government organizations (NGOs);
- Consultation with affected local communities
- Conclusions on results of the public consultation

Also, the project owner establishes and informs the grievance redress mechanism which deals with complaints and grievances.

7. Environmental Impacts and Mitigation Measures

This chapter provides information on impacts and mitigation measures by project phase.

7.1 A summary of impacts and mitigation measures

The view on determination of impacts and mitigation measures are described. The project phase is covered from design to closure. The following points are included.

- Matrix to show the relation between the project activities and impact on environmental resources for determining the potential of impact level
- Geographic Information System (GIS) by using Tool Overlay to identify an area where the projects impact on environment
- Check list for identifying the impact level by the summary table below

The summary of 7.2 is shown by such as following table.

Table 10 Summary of impacts and mitigation

Environmental and Socio-Economic Aspects	Negative Impacts	Scope of Impacts			Mitigation Measure	Remark
		Low	Moderate	High		
1. Negative impacts of design and construction phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
2. Negative impacts of operation phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
3. Negative impacts of closure phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						

7.2 Impacts and mitigation measures by project phase

In this section, the contents and degree of impacts is described by project phase. , It includes methodologies for estimating/forecasting impacts and evaluation of estimated/forecasted impacts.

Mitigation measures on the expected impact is described with the description how and what level the expected impacts are mitigated.

Following is the example for listed possible impacts and mitigation measures by impact items. When describing the expected impact, not only describing the expected impact but also how the expected is derived and evaluation of the impact (for example, comparison with the environmental standard) is described. Also, when describing the mitigation measures, not only the measure itself but also how the measure mitigates the impact and how much impact is mitigated is described.

(Reference)

Environmental, Health, and Safety Guidelines for Railways, IFC, 2007

7.2.1 Impacts and mitigation measures during design and construction phase

Physical Resources

1) Soil erosion/quality

(Design and construction phase common)

- Impact due to the removal of top soil.
- Impact due to erosion and consequent modification of natural conditions.
- Impact due to destabilization of slopes.
- Impact due to usage of heavy machinery for material transportation.
- Impact on subsidence by drainage change and additional weight to the soil in subsidence prone area.
- Impact of bridge construction due to crossing a river or stream

【Mitigation measures】

(Design and construction phase)

- Engineering measures for slope protection and erosion prevention.
- Drainage improvements for prevention of soil erosion and siltation of water course. Also, drainage and curtain covering the pathway to prevent erosion in the bridge construction case.
- Slope stabilization techniques and erosion control measures.

(Design phase)

- While selecting railway alignment, avoiding areas prone to landslides, soil erosion, and subsidence.
- The erosion potential of construction alternatives is carefully examined and selecting the one involving least disturbance to the natural ground

(Construction phase)

- Reduction of the need for borrow pits and minimization of excess spoil material generation.
- Restoration, revegetation and rehabilitation measures.
- Construction of drainage ensuring the stability of the slope.

2) Air quality

(Construction phase)

- Impact due to vehicular emissions from vehicles including heavy vehicles used for construction.
- Impact due to dust generation from material handling, storage, operation of crushers and hot mix plants, movement of construction vehicles, construction activities, excavation of soil and cutting of embankment near to habitation, hospitals, schools, sanctuaries etc.

【Mitigation measures】

(Design phase)

- Selecting alignment which avoids passing close to housing, schools, hospitals etc.
- Providing sufficient capacity to avoid traffic congestion, even with projected increase in traffic flow.
- Ensuring buffer area with planting tall leafy vegetation between railways and human settlements.

(Construction phase)

- Periodical watering and transporting construction materials with tarpaulin coverage during the construction phase.
- Provision of air pollution control systems in stone crushers and hot mix units to meet the emission regulation.

3) Noise & vibration

(Design and construction phase)

- Impact of noise on the surrounding community due to vehicle movement.
- Impact of noise on wild life from crossing railway corridors and the project becoming a barrier to regular wild life travel routes.
- Impact of noise and vibration during construction activity including operation of various equipment.
- Impact of vibrations during blasting activity, if any

【Mitigation measures】

(Design phase)

- Avoiding alignment from noise sensitive areas.
- Provision for machines and equipment with acoustic enclosures and silencers.
- Provision of noise barriers.
- Ensuring buffer area with planting tall leafy and dense vegetation between railways and noise sensitive areas.

- Use of log rail and light weight train.
- Use of noise and vibration absorbing material in the base.

(Construction phase)

- Provision of mandatory acoustic enclosure /acoustic treatment of room for stationary generator sets.
- Avoiding or minimizing stone quarrying and blasting activity.

4) Water quality

(Design and construction phase)

- Impact due to drain from construction site.
- Impact due to wastewater generated from the temporary project offices and temporary workers housing area.
- Impacts caused by oil leaks from machinery, changing machinery or pollution caused from unsuitable storage conditions and location.

【Mitigation measures】

(Design and construction phase)

- Measures to minimize sedimentation, erosion and wastewater run-off such as basins, artificial wetlands, grass filter strips and buffer zones.
- Silt screens and sediment traps to be made before out-letting to water bodies to minimize turbidity and silting in local water bodies.
- Wastewater treatment for wastewater from the yard and stations.
- Storing broken machinery and equipment adequately in a warehouse.

5) Hydrology/ groundwater and water use/rights

(Design and construction phase)

- Impact due to surface water flow modifications such as potential flooding and decrease of water supply. Because railway construction that intersect drainage basins, generally modify the natural flow of surface water by concentrating flows at certain points and in many cases, increasing the speed of flow, result in flooding, soil erosion, channel modification and siltation of streams.
- Impact on channel capacities and existing floodways.
- Impact on water facilities such as, wells, hand pumps, tube wells etc. falling along the alignment.
- Coordination with provincial department of water resources and meteorology (DoWRAM) and other agricultural groups to collect information and discuss mitigation measures.
- If the railway has a tunnel section, impact on groundwater.

【Mitigation measures】

(Design phase)

- While selecting railway alignment, avoiding the location of cutting significant water flows.
- In case of flood prone areas and/or areas with very flat slopes, hydrological surveys are conducted before alignment finalization. Inputs derived from these surveys such as the need for provision of culverts/bridges or other cross/railway side drainage structures is considered in the alignment finalization.
- Drainage improvements to avoid water logging and flooding due to disturbance of natural drainage pattern are considered.
- Water flow speed control is exercised to check surface runoff's and silt loads during construction activities.
- Design and construct a detour while constructing a bridge across a canal, stream or on any irrigation project.
- In dry areas, railway drainage can be designed to retain water in small dams or maintain a high water table.
- Rehabilitation of water flows and provision of alternative water supplies.

Biological Resources

6) Protected areas

(Design and construction phase)

- Impact due to the passage of alignment in and next to the protected area.
- Impact due to the disturbance to the access to the protected area.
- Impact due to changes in land profile.

【Mitigation measures】

(Design and construction phase)

- Selecting alignment which avoids passing through or close to the sensitive area.
- Providing new location for rehabilitating/compensating, if potential impacts are unavoidable.

7) Ecosystem including biodiversity such as forest and wildlife

(Design and construction phase)

- Impact due to removal of trees in the alignment.
- Impact on forest resources, economically important plants including medicinal plants and threat to endangered species.
- Impact on wildlife habitat including wildlife corridors and biodiversity due to change in land use.

- Impact due to fragmentation of wildlife habitat and territories.
- Pressure on habitats of wildlife as a result of increased access provided by railways.
- Impact due to changes in water quality, soil profile, noise, light and air pollution, which may affect the nature and character of habitats.
- Impact on food chain, if the project may destruct the food chain of the ecosystem.

【Mitigation measures】

(Design phase)

- Selecting alignment which avoids passing through or close to biodiversity sensitive area.
- Providing new habitats for rehabilitating/compensating.
- Providing railway crossing structures such as underpass for passage of wildlife and non-structural measure such as ultrasound.

(Construction phase)

- Prohibiting workers to set an animal trap, hunt or kill the wildlife.
- Prohibiting logging outside of the railway boundary for the purpose of construction.

<u>Social and Economic Resources</u>

8) Resettlement and decent livelihood

In principle, resettlement including livelihood restoration is managed by resettlement plan/framework prepared by the project owner and approved by Inter-Ministerial Resettlement Committee (IRC). The summary and data from resettlement plan/framework is described. Social and economic survey on potential project affected people provides an important basis to prepare the resettlement plan/framework.

(Design phase)

- Describing land acquisition including ownership of land, land use and population.
- Clarifying the procedure and institutional setting on land acquisition and resettlement, considering vulnerable people and marginal groups.
- Clarifying the policy on compensation and livelihood restoration.
- Impacts due to the land acquisition on residence, land and living measures

【Mitigation measures】

(Design phase)

- Selecting alignment which minimizes the resettlement and impacts by land acquisition and resettlement.
- Careful plan and study on land acquisition and resettlement.

(Construction phase)

- Implementation of land acquisition and resettlement as planned.
- Monitoring the progress of the process and the situation after the resettlement.

(Reference)
- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

9) Land use

Adverse land use impacts may arise from the displacement of existing uses, preventing access across it or new land use. Indirect impacts may arise on the natural resources of the area. Identification and assessment of land use, ownership, property values and economic activities is important.

In urban areas, the principal impacts arise from the dislocation of urban activities.

In rural areas, the principal impacts arise from the acquisition and severance of rural holdings. High quality of agricultural land could be lessened by severance.

Natural systems, visual amenity and historic/cultural resources could be disturbed.

【Mitigation measures】

(Design phase)

- While selecting railway alignment, avoiding areas of productive lands such as fertile agriculture lands.
- Provision of access or alternative routes and alternative land.
- Economic compensation.

(Reference)
- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

10) Heritage/culture

(Design and construction phase)

- Impact on the heritage/cultural site itself and access to the heritage/cultural site through the identification of the heritage/cultural site.
- Coordination with Ministry of Culture and Fine Arts or related institution to collect information and discuss mitigation measures.

【Mitigation measures】

(Design and construction phase)

- Selecting alignment which avoids passing through or close to the heritage/cultural site.
- Providing new location or rehabilitating/compensating heritage/cultural site.

11) Infrastructure

(Design and construction phase)

- Impact on existing infrastructure, such as traffic disturbance on roads.
- Impact on existing infrastructure by change of existing road such as diversion and

closure of lane for the construction work.

- Impact on existing infrastructure by cutting existing infrastructure such as communication, power and water

【Mitigation measures】

(Design and construction phase)

- Provision of local access roads where access to main arteries for promoting traffic efficiency and safety.
- Provision of alternative routes during construction if existing traffic is much disrupted.
- Re-installation of existing infrastructure.

12) Landscape

(Design phase)

- Impact on the significant landscape by the project such as major land clearing and tree cutting.

【Mitigation measures】

(Design and construction phase)

- Landscaping, rehabilitation and compensation.

13) Marginal group

(Design and construction phase)

- Impacts on the poor, ethnic minorities & indigenous people.
- Collecting information from the latest National Census.

【Mitigation measures】

(Design and construction phase)

- Planning and implementing indigenous peoples plan.
- Provision of livelihood program.

14) Working condition

(Construction phase)

- Impacts on working condition, accidents, health and safety of construction workers.
- Coordination with Ministry of Labour and Vocational Training or related institution to collect information and discuss mitigation measures.

【Mitigation measures】

(Construction phase)

- Complying with Labour Law and Law on Social Security Schemes.
- Providing safety measures such as mandatory helmet and health check.

15) Public health

(Construction phase)

- Potential of occurrence of species communicating diseases such as mosquito by pooling of water.
- Potential of occurrence of communicable diseases through workers.
- Impact on pneumonia/respiratory disease is caused by dust

【Mitigation measures】

(Construction phase)

- Provision of drainage at the project site including borrow pits.
- Routine watering and reducing the dust that leads to pneumonia occurrence.
- Appropriate waste management to avoid inappropriate waste disposal at the project site.
- Provision of health education/training program for the construction workers by the contactor.

16) Risks (man-made risks)

(Construction phase)

- Impact due to spillages and accidents of vehicles/storage with chemicals and fuels.
- Potential impact on the increase of traffic accident.

【Mitigation measures】

(Construction phase)

- Appropriate drainage arrangements with catch drains and catch pits is planned to prevent the spillage of chemicals and fuels reaching the water bodies.
- Provision of signs and safe crossings.

(Reference)

National Road Safety Policy, 2014

17) Climate change

(Design phase)

- Impacts and mitigation measures are described in qualitative way when the project increases the emission of climate change gas significantly.

18) Waste management

(Construction phase)

- Impacts by dust and particulate matter from construction waste including its storage.

- Impacts on waste landfill site by accumulating construction waste.

【Mitigation measures】

(Construction phase)

- Minimizing amount of waste
- Control of dust and particulate matter by water spraying.
- Designating appropriate landfill site for disposal of waste.

7.2.2 Impacts and mitigation measures during operation phase

Physical Resources

1) Soil erosion/quality

- Impact due to erosion and consequent modification of natural conditions.
- Impact due to destabilization of slopes.
- Impact due to traffic.
- Impact on subsidence by drainage change and additional weight to the soil in subsidence prone area.

【Mitigation measures】

- Maintenance program for all erosion control works.

2) Air quality and noise & vibration

- Impact due to emissions and dust caused by train engine and generators, if any.
- In the case impact is expected, emission levels are expected to increase with the increase in train numbers. Quantitative analysis is better in future while qualitative analysis is acceptable with well planned mitigation measures.
- Clarifying the methodology to explain the expected impact
- Impact of noise on the surrounding community due to train movement.
- Impact of noise on wild life.
- If the railway has the elevated section, the railway height is considered.

【Mitigation measures】

- Increase of energy efficiency of the railway system to reduce fuel consumption
- Ensuring buffer area with planting tall leafy vegetation between railways and human settlements.
- Preventing encroachment to the buffer area.
- Setting noise barrier.
- Appropriate railway maintenance.
- Keeping smooth traffic by preventing congestion.
- Monitoring on air quality and noise.

3) Water quality

- Impacts by drain with sedimentation and increased turbidity.
- Run-off such as oils, greases and waste water from railway side fuel storage, stations and the yard.

【Mitigation measures】

- Maintenance program for controlling run-off and waste water.
- Setting excreta storing tank at the toilet of the train and treatment of the stored excreta
- Monitoring on water quality.

4) Hydrology/ groundwater and water use/rights

- Impact due to surface water flow modifications such as potential flooding and decrease of water supply.
- Impact on channel capacities and existing floodways.
- Impact on water facilities such as, wells, hand pumps, tube wells etc. falling along the alignment is assessed.
- If the railway has a tunnel section, impact on groundwater.

【Mitigation measures】

- Maintenance program for controlling water flow change and water use.
- Monitoring on hydrology and water use.

<u>Biological Resources</u>

5) Protected areas

- Impact on the protected objects under the protected area.
- Impact due to the disturbance to the access to the protected area.
- Impact due to changes in land profile.

【Mitigation measures】

- Maintenance program for controlling measures.
- Monitoring on the situation of the protected area.

6) Ecosystem including biodiversity

- Impact on forest resources, economically important plants including medicinal plants and threat to endangered species.
- Impact on wildlife habitat and biodiversity due to change in land use.
- Impact due to fragmentation of wildlife habitat and territories.
- Pressure on habitats of wildlife as a result of increased access provided by railways such as collision with train vehicle.

- Impact due to changes in water quality, soil profile, noise, light and air pollution, which may affect the nature and character of habitats.
- Impact on food chain, if the project may destruct the food chain of the ecosystem.

【Mitigation measures】

- Warning and speed control to prevent collision with wildlife.
- Maintenance program for controlling measures.
- Monitoring on the situation of the ecosystem.

<u>Social and Economic Resources</u>

7) Involuntary resettlement and livelihood

【Mitigation measures】

- Maintenance and operating program as planned in the resettlement planning.
- Monitoring on the situation after the land acquisition and resettlement.

8) Land use

【Mitigation measures】

- Maintenance program as planned in the planning.
- Monitoring on the situation after the land use change.

9) Heritage/culture

- Impact on the heritage/cultural site itself and access to the heritage/cultural site by the traffic caused by the project.

【Mitigation measures】

- Maintenance program as planned.
- Monitoring on the situation during the operation.

10) Infrastructure

- Impact on existing infrastructure through the induced traffic by the project.

【Mitigation measures】

- Planning and constructing additional structure, if needed.
- Monitoring on the situation during the operation.

11) Landscape

【Mitigation measures】

- Monitoring on the situation during the operation.

12) Marginal group

【Mitigation measures】

- Implementing indigenous peoples plan, if any.
- Provision of livelihood program.
- Monitoring on the situation during the operation.

13) Working condition

- Impacts on working condition, accidents, health and safety of operation and maintenance workers.

【Mitigation measures】

- Complying with Labor Law and Law on Social Security Schemes.

14) Public health

- Potential of occurrence of species communicating diseases such as mosquito by pooling of water.

【Mitigation measures】

- Appropriate water management generated at the railway establishments.
- Provision of health program for the workers.

15) Risks (man-made risks)

- Impact due to spillages and accidents of train vehicles/storage with chemicals and fuels.
- Potential impact on the increase of traffic accident.

【Mitigation measures】

- Appropriate drainage arrangements with catch drains and catch pits is planned to prevent the spillage of chemicals and fuels reaching the water bodies.
- Provision of safe crossings.
- Safety education/training to the residents.
- Contingency plan to prepare for accidents.

(Reference)

National Road Safety Policy, 2014

(Others)

16) Waste management

- Impact from waste from road sweeping, shops and restaurants and gas stations.

【Mitigation measures】

- Appropriate waste management plan by kind of source of waste.

17) Cumulative impacts

Cumulative impacts are described with focus on combination with other projects, with map of other project site. Cumulative impacts can be the case when other major transportation or major area development project in the same project site. Methods could include following;

- Rough estimation of cumulative pollution loads
- Matrix list for identifying the relation between project activities and impact
- Showing Geographic Information System (GIS) by Tool Overlay to identify an area on the projects impact
- Check list for identifying the impact level

【Mitigation measures】

- Keeping enough distance between infrastructures/buildings

7.2.3 Impacts and mitigation measures during closure phase

How the environmental management plan is continued when change of project owner is described.

Also how the environmental and social condition is transferred/ maintained when part or whole project is closed is described.

7.3 Description of the positive environmental and socio-economic impacts

Positive impacts for both environmental and socio-economic impacts are described.

8. Environmental Management Plan (EMP)

This chapter provides points to clarify the management of the environmental measures planned.

1) Agency

Agency/institution responsible for project implementation and monitoring is described. Also, supervising (control) institution is described.

2) Institutional arrangement

Institutional set-up such as procedures and organization to manage each impacts and mitigation measures is described.

3) Trainings

Training programs for staffs for environmentally and socially sound performance is described.

4) Monitoring plan including methodology

The plan to monitor impact and mitigation measures is shown. Also, following points are described.

- Baseline conditions before construction through the analysis of existing conditions.
- Monitoring plan including parameters, methodology, monitoring points and frequency, by impact.
- Environmental standards or guidelines for monitoring.
- Progress/situation on mitigation measures by impact.
- Quarterly monitoring report to be submitted to the Ministry of Environment and relevant ministries/agencies.
- Emergency response plan for emergency case such as serious accident.

5) Assessment of monitoring results

Criteria to assess monitoring results is described.

6) Budget plan for EMP

The budget plan to implement EMP is described. The contribution to the Social and Environmental Fund is described.

(Reference)

- Sub-decree on the Establishment of Social and Environmental Fund
- Joint Prakas of Ministry of Environment and Ministry of Economy and Finance

7) Monitoring report

The above points are compiled to the monitoring report by the agency/institution responsible for project implementation and monitoring. The monitoring report is submitted to the Ministry of Environment and if necessary, to relevant ministries.

9. Economic Analysis and Environmental Value

This chapter provides the economic analysis.1) Project benefit

Project benefits are described such as improvements in the physical infrastructure and access, improvements in social services by better transport, development of economy including tourism development and improvements in life style.

2) Economic analysis

Cost benefit analysis of the project is described with methodologies and indicators/parameters including valuation methods including adverse environmental and social impact. Following points are shown with sources and references.

- Financial analysis: base on profit and loss of the project

- Economic analysis: economic valuation of cost and benefit
- Environmental damage analysis: direct and indirect cost analysis on individual resources

https://wedocs.unep.org/bitstream/handle/20.500.11822/28857/EIA_Operational_CBA.pdf?sequence=1&isAllowed=y

10. Conclusions and Recommendations

This chapter provides the conclusions and recommendations. The conclusion is described with the justification, mitigation of major impacts and overall benefits of the project including promotion of local livelihood.

Also, the project owner's assurance and responsibility for the environmental impact assessment is clarified.

The recommendation to the project owner and, if any, to the stakeholders shall be described.

11. References

Reference documents quoted are written down with the author/institution, title of the document, name of the journal, if any and year published.

12. Annex

Attached documents such as maps and figures are shown as Annex.

添付資料 7　Guidelines on Environmental Impact Assessment for Railway Sector Projects (IEIA case)

Guideline on Environmental Impact Assessment

for

Railway Sector Projects (IEIA case)

Table of Contents

Abbreviation

CARDI	Cambodian Agricultural Research and Development Institute
CI	Conservation International
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FAO	Food and Agriculture Organization
GIS	Geological Information System
GPS	Global Positioning System
IEIA	Initial Environmental Impact Assessment
JICA	Japan International Cooperation Agency
RoW	Right of Way
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund

I. Preface

This guideline is to provide a guidance on contents of IEIA ((Initial Environmental Impact Assessment) study process and IEIA reports by showing what is to be described in IEIA report in railway sector for the IEIA project. This guideline covers railway projects including bridges.

In the IEIA report, reference data/information source is to be provided.

(IEIA is the preliminary assessment of primarily secondary data of physical, biological and socio-economic environment and resources on the area within or in the surrounding the project site. It forms basis for identification, prediction and analysis of potential adverse environmental and social impacts by project activities, aiming to identify actions to minimize negative impacts and maximize positive impacts.)

(Reference)

Sub-decree on Environmental Impact Assessment Process, 1999

Prakas on General Guidelines for Initial and Full Environmental Impact Assessment Reports, 2009

II. The Guideline

0. Executive Summary

A general summary of the IEIA report is provided (within 5-10 pages recommended). It includes at least the following information from the IEIA report:

- Objectives of the IEIA
- Project Owner/Proponents
- Project description including project site
- Existing Environmental Resources
- Public Participation
- Impacts and Mitigation Measures
- Environmental Management Plan
- Economic analysis and environmental value
- Conclusions and Recommendations

1. Introduction

This chapter provides the introductory part of the IEIA report.

1.1 Project overview

The items to be described include the following.

- Summary of the project background, the rationale for development of the project, and general situation on the project site are described.

- The nature of the project such as new, extension, widening, rehabilitation or combination of these is described.
- The summary of the railway structure such as number of lanes is described.

1.2 Objectives of the IEIA

The reason and timing that the IEIA is prepared and the consultant who prepares the IEIA report are described.

1. 3 Scope and Method

Scope of the study including covered area by the study is described.

Method of the study is described on the following points.

- How the data is collected and analyzed
- Basic and common method for understanding existing environmental resources
- How the impacts are predicted/estimated.

2. Legal Framework

In this chapter, legal setting is described by clarifying related legal and policy document.

Important legal and policy documents related to the project is described. This includes the title, issued year and explanation of laws, sub-decrees and policies which are much related to the project.

3. Project Description

This chapter provides what is the project and related information.

3.1 Background and experiences of the project owner/company

Following items are described.

- The background of the project,
- The project owner/company including registration information and address,
- The construction company (if it is already decided)
- The capital of construction and operation including the financer.
- If there is a background study such as feasibility survey, it is in introduced.

3.2 Project site, project activities and schedule

1) Project site

Following items are described.

- Location of the project on the map (1:10,000) with administrative boundaries and

GPS coordinates

- Description on the alignment by section with pictures and general condition for bridges and tunnels, if any
- Broad geology, and topography
- Environmentally sensitive places such as the protected area and land acquisition

2) Project activities

Following is described.

- The specification of the project: It includes length and width of the alignment, number of bridges to be constructed/implemented etc.
- Structure of railway by section: The structure could be plane, canal, elevated, semi-underground or underground (tunnel) (typical cross section figure is useful).
- Project alternative
- Technologies involved for design and construction
- Views/priorities adopted for selection of the alignment of right of way with the reason of the selection among the alternatives.
- Waste management, what waste is generated and how waste is collected and disposed
- The project implementation schedule is shown by bar chart.

(Reference)

- Width of Right of Way (ROW) is specified by the Sub-decree on Right of Way of National Roads and Railways, 1999.

- Ministry of Public Works and Transport sets several roads and bridges standards/guidelines such as Bridge Design Standard (2003).

4. Description of Existing Environment

This chapter provides the condition of existing environment by type of resources.

4.1 Natural Environment

Natural environment features on project area and surroundings is described by the items in 4.1.1 and 4.1.2.

4.1.1 Physical Resources

1) Soil

Soil profile of the alignment such as geological data is described.

(Reference)

- CARDI (Cambodian Agricultural Research and Development Institute) soil type can be used to describe using ArcGIS software.

- Topographic information can be used from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).

- Global Soil Organic Carbon Map, FAO, 2017

2) Climate

Affecting weather information is described. The information could be temperature, rain fall, wind speed and wind direction, for a few years.

(Reference)

- Information by Department of Meteorology, Ministry of Water Resources and Meteorology
- UNDP Climate Change Country Profiles, UNDP

3) Air quality

Power source of train is clarified. If the power source is oil/coal engine, there is a potential of impact on air quality, while if the power source is electricity, there is no potential impact on air quality from train in operation phase.

Air quality situation is described by selected pollutants with comparison of data observed/referred and standard value.

If data is taken by sampling, describe methodology, period and location.

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Ambient Air Quality Standard.

4) Noise and Vibration

Noise and vibration situation is described.

If data is taken by sampling, describe methodology, period and location.

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Maximum permitted noise level.

5) Water quality

Water quality situation is described by selected pollutants with comparison of data observed/referred and standard value.

If data is taken by sampling, describe period and location.

If the railway has a tunnel section, the groundwater quality is described.

(Reference)

- Sub-decree on Water Pollution Control, 1999 prescribes Water Quality Standard in public water areas.

6) Hydrology

River, lake, reservoir, wetland and drainage system is described with map.
Run-off characteristics of watersheds is described.
(Reference)
- the Study on Hydro-Meteorological Monitoring for Water Quantity Rules in Mekong River Basin (JICA, 2004) (for hydrologic information)
- Department of Hydrology and River Works, Ministry of Water Resources and Meteorology (for hydrologic information)
- Mekong River Commission website

4.1.2 Biological Resources

1) Forest
Situation on forest area such as forest cover with map is described.
The designated protected area (especially Core zone and Conservation zone) on forest is described, if there is in proximity of the project site.
(Reference)
- The Law on Forestry (Royal Kram)
- The Protected Areas Law
- Cambodia Forest Cover, 2014 (Forestry Administration, 2016)

2) Protected area
The designated protected area concerning biological resources is described, especially Core zone and Conservation zone, if there is in proximity of the project site.
(Reference)
- Protected Areas Law
- Sub-decree on individual Protected area, related Ministry

3) Biodiversity and ecological systems
Situation on biodiversity (aquatic resources included) and ecological system (wetland system included) is described, especially endangered species and important ecological system, if there is in proximity of the project site.
The designated protected area and sensitive area is described.
(Reference)
- WWF (World Wide Fund for Nature) (https://www.worldwildlife.org), CI (Conservation International) (https://www.conservation.org) and WCS (Wildlife Conservation Society) (https://www.wcs.org) website on endangered species.

4.2 Social and Economic Resources

1) Demography and economic status

Population, public health and economic situation is described such as economic growth, income level, major industry/product.

(Reference)

- Economic Census of Cambodia by National Institute of Statistics

2) Land use and land registration

Land use is described.

In the case land acquisition is planned, land ownership and occupancy with the relation with the Right-of-way is described.

(Reference)

- Land use information can be used by revised information from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Land law (2001)
- Expropriation Law (2010)
- Sub-Decree No.197 "Right of Way of National Road Channels and Railroads of the Kingdom of Cambodia"
- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

3) Infrastructure

Major public infrastructures in the area such as roads, irrigation, and water supply are described.

4) Heritage/culture

Heritage (cultural heritage, historical monuments, landscape, ancient temples, pagodas and customs/traditions) is described, especially ones designated/listed by the Protected Area Law and UNESCO/Government, if any.

(Reference)

- Law on Protection of Cultural Heritage prescribes protected sites and inventory on cultural property.

5) Marginal group

Situation on the poor, ethnic minority and indigenous people is described such as by the latest National Census Reports.

(Reference)

- Information by local government

6) Others

The important result of the social and economic study such as replacement cost study is described if it is not covered in the above.

The presence of unexploded weapons is described when there is possibility.

5. Public Participation

This chapter provides the public participation process, especially the process to involve project affected people and other stakeholders. Refer to the Guideline on Public Participation in Environmental Impact Process, 2016 for detail.

The plan of public participation has 3 stages following the Term of Reference on Infrastructure and Tourism Development Project (Prakas No.120, 2018):

Table 1 Stages of public participation

Stages		Outline
1	Information dissemination at project site	The project owner and consultant company disseminates information to stakeholders in order to inform them about the project inception, scope, impact exposure as well as preliminary information and people who get impact from the project.
2	Interviewing the authorities, involved departments	The project owner and consultant company interviews with authorities, involved departments and stakeholders, and/or prepares the Focus Group discussion in order to get the opinion and comments on the project.
3	Consultation Workshop	The project and consultant company prepares the public consultation workshop in order to show the result of Environmental Impact Assessment Report and stakeholders interview

Also, the project owner establishes and informs the grievance redress mechanism which deals with complaints and grievances.

6. Environmental Impacts and Mitigation Measures

This chapter provides information on impacts and mitigation measures.

6.1 A summary of impacts and mitigation measures

- The view on determination of impacts and mitigation measures are described. The project phase is covered from design to closure.

The summary of 6.1 is shown by such as following table.

Table 2 Summary of impacts and mitigation

Environmental and Socio-Economic Aspects	Negative Impacts	Scope of Impacts			Mitigation Measure	Remark
		Low	Moderate	High		
1. Negative impacts of design and construction phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
2. Negative impacts of operation phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
3. Negative impacts of closure phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						

6.2 Impacts and mitigation measures

In this section, the contents and degree of impacts is described. It includes methodologies for estimating impacts and evaluation of estimated/forecasted impacts. Also mitigation measures on the expected impact is described with the description how the expected impacts are mitigated. When individual impact and mitigation measure is a phase specific one, the corresponding phase is clarified.

Following is the example for listed possible impacts and mitigation measures by impact items.

<u>Physical Resources</u>

1) Soil erosion/quality

- Impact due to erosion and consequent modification of natural conditions.
- Impact on subsidence by drainage change and additional weight to the soil in subsidence prone area.
- Impact of bridge construction due to crossing a river or stream
- Impact due to traffic (operation phase)

【Mitigation measures】

- Engineering measures for slope protection and erosion prevention/control.
- Drainage improvements for prevention of soil erosion and siltation of water course.
- While selecting railway alignment, avoiding areas prone to landslides, soil erosion,

and subsidence.(design phase)

- Reduction of the need for borrow pits and minimization of excess spoil material generation. (construction phase)
- Restoration, revegetation and rehabilitation measures.
- Construction of drainage ensuring the stability of the slope. (construction phase)
- Maintenance program for erosion control works (operation phase)

2) Air quality and noise

- Impact on air due to vehicular emissions from vehicles including heavy vehicles used for construction.
- Impact on noise on the surrounding community due to train.
- Impact due to dust generation from material handling, storage, equipment and vehicles, construction activities, excavation of soil and cutting of embankment near to habitation, hospitals, schools, sanctuaries etc. (construction phase)

【Mitigation measures】

- Selecting alignment which avoids passing close to housing, schools, hospitals etc. (design phase)
- Providing sufficient capacity to avoid traffic congestion, even with projected increase in traffic flow. (design phase)
- Ensuring buffer area with planting tall leafy vegetation between railways and human settlements.
- Provision of noise barrier, if needed.
- Periodical watering.
- Railway maintenance. (operation phase)

3) Water quality

- Impact due to drain.
- Impact due to oil leaks, greases, waste water generated.

【Mitigation measures】

- Measures to minimize sedimentation, erosion and wastewater run-off such as basins, artificial wetlands, grass filter strips and buffer zones.
- Silt screens and sediment traps.
- Maintenance program for controlling run-off and monitoring. (operation phase)

4) Hydrology

- Impact due to surface water flow modifications such as potential flooding and decrease of water supply. Because railway construction that intersect drainage basins, generally modify the natural flow of surface water by concentrating flows at certain points and in many cases, increasing the speed of flow, result in flooding, soil erosion, channel modification and siltation of streams.

- Impact on channel capacities and existing floodways.
- If the railway has a tunnel section, impact on groundwater.

【Mitigation measures】

- While selecting railway alignment, avoiding the location of cutting significant water flows.(design phase)
- Drainage improvements to avoid water logging and flooding due to disturbance of natural drainage pattern are considered.
- Water flow speed control.

Biological Resources

5) Protected areas

- Impact due to the passage of alignment in and next to the protected area.
- Impact due to the disturbance to the access to the protected area.
- Impact due to changes in land profile.

【Mitigation measures】

- Selecting alignment which avoids passing through or close to the sensitive area.(design phase)
- Maintenance program for controlling and monitoring.(operation phase)
- Providing new location for rehabilitating/compensating, if needed.

6) Ecosystem including biodiversity such as forest and wildlife

- Impact on forest resources and biodiversity, and threat to endangered species including their habitat.
- Pressure on habitats of wildlife as a result of increased access provided by railway.

【Mitigation measures】

- Selecting alignment which avoids passing through or close to biodiversity sensitive area.(design phase)
- Providing new habitats for rehabilitating/compensating.
- Providing railway crossing structures such as underpass for passage of wildlife and non-structural measure such as ultrasound.
- Prohibit workers to set an animal trap, hunt or kill the wildlife.
- Warning and speed control measures to prevent collision with wildlife.(operation phase)
- Maintenance program and monitoring.(operation phase)

Social and Economic Resources

7) Resettlement and decent livelihood

In principle, resettlement including livelihood restoration is managed by resettlement plan/framework prepared by the project owner and approved by Inter-Ministerial Resettlement Committee (IRC). The summary and data from resettlement plan/framework is described. Social and economic survey on potential project affected people provides an important basis to prepare the resettlement plan/framework.

【Mitigation measures】

- Selecting alignment which minimizes the resettlement and impacts by land acquisition and resettlement.(design phase)
- Implement land acquisition and resettlement as resettlement plan.(construction phase)
- Monitor the progress of the process and the situation after the resettlement.

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

8) Land use

Adverse land use impacts may arise from the displacement of existing uses, preventing access across it or new land use. Indirect impacts may arise on the natural resources of the area. Identification and assessment of land use, ownership, property values and economic activities is important.

【Mitigation measures】

- While selecting railway alignment, avoiding areas of productive lands such as fertile agriculture lands.(design phase)
- Economic compensation.

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

9) Heritage/culture

- Impact on the heritage/cultural site itself and access to the heritage/cultural site through the identification of the heritage/cultural site.

【Mitigation measures】

- Selecting alignment which avoids passing through or close to the heritage/cultural site.(design phase)
- In case avoidance is not possible, providing new location or rehabilitating/compensating heritage/cultural site.

10) Infrastructure

- Impact on existing infrastructure, such as traffic disturbance, diversion or closure.
- Impact on existing infrastructure by cutting existing infrastructure such as communication, power and water

【Mitigation measures】

- Provision of alternative routes if existing infrastructure is much disrupted.

11) Marginal group

- Impacts on the poor, ethnic minorities & indigenous people.

【Mitigation measures】

- Planning and implementing indigenous peoples plan.
- Provision of livelihood program when needed.

12) Public health and working condition

- Potential of occurrence of communicable diseases through pooling of water and workers.
- Impacts on working condition, accidents, health and safety of construction workers.(construction phase)

【Mitigation measures】

- Providing education/training program and safety measure.

13) Risks (man-made risks)

- Impact due to spillages and accidents of train/storage with chemicals and fuels.
- Potential impact on the increase of traffic accident.

【Mitigation measures】

- Appropriate drainage arrangements.
- Provision of signs and safe crossings.

7. Environmental Management Plan (EMP)

This chapter provides points to clarify the management of the environmental measures planned.

1) Agency

Agency/institution responsible for project implementation and monitoring is described. Also, supervising (control) institution is described.

2) Trainings

Training programs for staffs for environmentally and socially sound performance is described.

3) Monitoring plan including methodology

The plan to monitor impact and mitigation measures is shown. Also, following points are described.

- Monitoring plan including parameters, methodology, monitoring points and frequency, by impact.
- Semi-annual monitoring report to be submitted to the Ministry of Environment and relevant ministries/agencies.
- Budget plan for EMP

4) Assessment of monitoring results

Criteria to assess monitoring results is described.

8. Economic Analysis and Environmental Value

Project benefits are described such as improvements in the physical infrastructure and access.

9. Conclusions and Recommendations

The conclusion is described with the justification, mitigation of major impacts and overall benefits of the project.

Also, the project owner's assurance and responsibility for the environmental impact assessment is clarified.

10. References

Reference documents quoted are written down with the author/institution, title of the document, name of the journal, if any and year published.

11. Annex

Attached documents such as maps and figures are shown as Annex.

添付資料 8　Guidelines on Environmental Impact Assessment for Metal Industry Sector Projects (Full EIA case)

Guideline on Environmental Impact Assessment

for

Metal Industry Sector (Factory) Project (full EIA case)

Table of Contents

Abbreviation

BOD	Biological Oxygen Demand
CARDI	Cambodian Agricultural Research and Development Institute
CI	Conservation International
CO	Carbon monoxide
COD	Chemical Oxygen Demand
dB	Decibel
DO	Dissolved Oxygen
DoWRAM	Department of Water Resources and Meteorology
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FAO	Food and Agriculture Organization of the United Nations
GIS	Geological Information System
GPS	Global Positioning System
HSs	Hazardous Substances
IEE	Initial Environmental Examination
IFC	International Finance Corporation
JICA	Japan International Cooperation Agency
O_3	Ozone
NO_2	Nitrogen dioxide
NPN	Non-protein Nitrogen
PM	Particulate Matter
RAP	Resettlement Action Plan
RoW	Right-of-Way
SO_2	Sulfur dioxide
SO_4	Sulfate
TDS	Total Dissolved Solid
TN	Total Nitrogen
TOR	Terms of Reference
TP	Total Phosphorous
TSP	Total Suspended Particulate
TSS	Total Suspended Solid
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US-EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
WCS	Wildlife Conservation Society,
WWF	World Wide Fund for Nature

I. Preface

This guideline is to provide guidance on contents of EIA (Environmental Impact Assessment) study process and an EIA report by showing what is to be described in the report in metal industry sector (factory) projects for the full-scaled EIA project. This guideline in particular focuses on factories for processing and refining of metals, which are needed special cares prior and during construction as well as operation phase. In the EIA report, reference data/information source is to be provided.

(Reference)

Sub-decree on Environmental Impact Assessment Process, 1999

Prakas on General Guidelines for Initial and Full Environmental Impact Assessment Reports, 2009

Prakas on Terms of Reference on Infrastructure and Tourism Development Project, 2018

II. The Guideline

0. Executive Summary

A general summary of the EIA report is provided (within 15-20 pages recommended). It includes at least the following information from the EIA report:

- Objectives;
- Project Proponents;
- Project Description including Project Site;
- Other Project Alternatives;
- Existing Environmental Resources;
- Public Participation including Issues raised by Stakeholders and any Outstanding Issues;
- Impacts and Mitigation Measures;
- Environmental Management Plan; and
- Economic Analysis and Environmental Value
- Conclusions and recommendations

1. Introduction

1.1 Project Overview

- Summary of the project background, the rationale for development of the project, and general situation on the project site.
- The nature of the project such as new, extension, widening, rehabilitation or combination
- The summary of the factory structure such as number of buildings, location, related facilities etc.

1.2 Objectives of the EIA

The reason and timing that the EIA is prepared and the consultant who prepares the EIA report are described.

2. Scope and Methodologies and Scope of the Study

This chapter provides points related to the Terms of Reference of the EIA study which are stipulated in the relevant prakas and sub-decree in Cambodia.

2.1 Scope of the Study

Scope of the study including covered area by the study is described.

2.2 Data Source

Appropriate methods of dada collection are included in this section. The items to be described include how the data is collected such as the measurement, updating situation and title of data source document. For example, in the case of air quality measurement by the project owner, the items to be described include how the sampling date and point is selected and measurement method of pollutants. In the case of data from existing document, justification/relevance of the referred document is described.

Also, when data is described, it is clarified whether primary data (data from the field, observation at and around the project site) or secondary data (collected and quoted data from technical document).

2.3 Methodology of the Study

It is clarified how the impacts in each project phase are predicted/ estimated.

Method of the data analysis is described. For example, it is clarified how the expected impact in air quality is compared with the air quality standard in Cambodia, as well as cases in water quality, noise/vibration, soil contamination, wastes (including hazardous materials) etc. When non-Cambodian standards/guidelines are used, justification/relevance of the referred document is described.

Also, the items to be described include basic and common methodologies for understanding physical resources, biological resources and social and economic resources in this section and the detail in individual resource is described in the individual sections.

For example, the methodologies on social and economic study are described including following:

- The area required for the project;
- Selection of targeted villages/communities;
- Sample size compared with the population/number of household;
- All items surveyed (for example, questionnaire, photographs, acquired data etc); and
- (if included) The replacement cost policy and methodologies to identify the ownership of assets.

Further, methodologies for public participation is described (Details are described in 6. Public Participation).

The EIA preparer describes the time table of the EIA survey and team composition including name and work role.

3. Legal Framework

In this section, legal setting is described by clarifying related legal and policy document. Legal and policy documents related to the project are described. This includes the title, issued year and explanation of laws, sub-decrees and policies which are related to the project (refer to Table 1).

The donor policies in donor supported project case are described, if any.

(Reference)

Table 1 Example of related Laws and Sub-decrees

Title	Year	Explanation
Law on Constitution of Kingdom of Cambodia	1993	
Law on Environmental Protection and Natural Resources Management	1996	
Law on Road	2014	
Law on road traffic	2015	
Law on Water Resource Management	2007	
Law on Forestry	2002	
Law on Fishery	2006	
Law on Protected Area	2008	
Law on Cambodia Traffic	2006	
Law on Land	2001	
Law on Labor	1997	
Law on the Protection of Cultural Heritage	1996	
Law on Investment	1994	
Law on Administration of Factory and Handicraft	2006	
Law on Construction	2019	
Law on Land Management, Urban Planning and Constructions	1994	
Law on Management and Exploitation of Mineral Resources	2001	
Royal-Decree on establishment and management of Tonle Sap Biosphere Reserve (In Tonle Sap area case)	2001	
Sub-Decrees on Environmental Impact Assessment Process	1999	
Sub-Decree on the Establishment of Environmental and Social Fund	2016	
Sub-Decrees on the Air Pollution and Noise Disturbance Control,	2000	
Sub-Decrees on Water Pollution Control	1999	
Sub-Decrees on Solid Waste Management	1999	
Sub-decree on Management of Garbage and Solid Waste of Downton	2015	
Sub-Decrees on the Management the Reserved Land along the National Road and Railroad	2009	
Sub-decree on Urbanization of Capital City, Towns and Urban Areas	2015	
Sub-decree on the Management of Drainage and Wastewater Treatment System	2017	
Sub-decree on Land Acquisition and Involuntary Resettlement	2018	

Note 1: The consultant can add or delete laws for suitable tabulation to the concerned project.

Note 2: Input essential but simple descriptions in Explanation columns.

4. Project Description

This chapter provides what is the project and related information.

4.1 Background and Experiences of the Project Owner/ Company

The items to be described include the background of the project, the project owner/company including registration information and address, the construction company (if it is already decided) and the capital of construction and operation including the financer. The experiences of the project owner/company in the industrial sector are described.

4.2 Project Site

Following items are described:

1) Location and boundary of the project on the map with GPS coordinates;
2) Description on the alignment by section with pictures and general condition for bridges and tunnels, if any;
3) Broad geology, topography and connectivity;
4) Villages, settlements and land use including demographic, socio, cultural and economic aspects;
5) Environmentally sensitive places such as the protected area and land acquisition; and
6) Supporting information, if any.

(Examples)

- Existing infrastructure such as power plant, water supply, port and major road.
- In case of the factory is located in a flood-prone area, the details of drainage, flood passages and information on flood periodicity in the area to be provided.
- If there is area susceptible natural hazards such as landslides, erosion, flooding, subsidence, earthquakes, details to be provided.
- If the proposed project involves any land reclamation, details to be provided for the activity for which and the area of land to be reclaimed.
- If the proposed area involves any migratory path of animals, details about fauna, habitat and period of the year in which activity take place, to be provided
- If the construction of factories will cause impact such as destruction of forest, and/or reduction in wetland areas, details to be provided.
- In case the project involves any dredging, details to be given.
- If there is a mineral resource area, details to be provided.
- In case the proposed area was used for a facility or ground using and/or saving hazardous chemical(s), details including type, amount and usage purpose of chemical(s) to be provided.

4.3 Project Type

1) Project Specification

The specification of the project is described such as

Table 2 for example. It may include scale of the proposed area, buildings by purpose etc. The table below is an example of specification.

Table 2 Example of Specification in Metal Industry Sector (Factory) Projects

Description	Quantity (unit)
Scale of the proposed area (length, width and area)	(m, m^2)
Buildings by purpose - Name (e.g. office, painting, manufacturing etc) & area	(m^2)
Yards by purpose - Name (e.g. stock yard, parking etc.) & area	(m^2)
Product name	
Daily capacity of production	(ton/day)
Production lines - Name and number	
Major equipment by purpose - Name and number	
Others to be necessary	

2) Layout of factory and affiliated structures such as power plant, port, major road, water supply (water demand), etc. and yards (perspective illustration and birds-eye view diagram are useful and helpful).
3) Technologies involved for design and construction. They also include activities for site preparation.
4) Description of procedures and criteria adopted for selection of the proposed area and alternatives considered
5) Activities for site preparation

In case the proposed area is required embankment, details of fill materials, its volume and initial and final levels after filling are to be provided. Also, if the proposed area is required soil improvement such as replacement or refinement, the details of the area to be improved is to be provided, including locations, volume and quantity of earth to be treated and type of soil. Description on cleaner production, green spaces, and greenhouse gases reduction shall be explained, if any.

4.4 Alternatives

The project alternatives are described. For example, alternatives can be described in option 1, option 2 and zero-option (the case without project), with the reason on the selection of the project among the alternatives and the selection of alternatives.

The comparison of alternatives is described by a table.

These details are comprised of:

- Description of various alternatives by locations, layouts or technologies studied;
- Description of each alternative;
- Summary of adverse and positive impacts of each alternative in terms of engineering, environmental and socio-economical aspects;
- Procedures and criteria adopted for selection of alternative; and
- Selection of the alternative which is the best with respect to use of resources and adverse environmental impact.

In describing the project and its alternatives, following characteristics can be the key:

- Spatial requirements;
- Natural resources (including productive land) consumption;
- Project benefits and costs (such as resettlement versus better access to market); or
- Waste production during the construction and operation/maintenance periods

4.5 Activities of the Project

Project activities are described. For example:

- Administration (management) of the project;
- Sources and quantity of input to be used including water, energy and machinery requirements;
- Local and foreign workforce requirements including their housing;
- Quantity of final output/products: If it is described in the project overview, refer to it;
- Income and expenditure (Revenue and cost);
- Overall waste management plan: To describe what waste is generated and how waste is collected and disposed by project phase; and
- Risk management policy: To describe policy to respond to natural hazards and to secure safety.

4.6 Work Plan/ Schedule

1) Project Phasing.

The phasing of the project is described, if any.

2) Project Implementation Schedule.

The project implementation schedule is shown by bar chart.

5. Description of Existing Environment

This chapter provides the condition of existing environment by type of resources.

5.1 Natural Environment

Natural environment features on project area and surroundings is described by item 5.1.1 and 5.1.2.

5.1.1 Physical Resources

1) Soil

Soil profile of the project site can include geological data, topology, soil type, slope condition, soil mechanic and watershed. A detailed seismology and geology study is provided, if available.

The history on land slide is provided, if any.

In case the project area is suspicious to have been soil contaminated, the preliminary survey shall be taken to identify the evidence as follow.

1) Conduct a ground history survey, 2) Identify the pollutants, 3) Classify the level of contamination and select plots for soil sampling, 4) Collect and measure samples.

Although substances to be surveyed will be determined in accordance with the process above, the following substances are related to metal processing in general.

Metals and their oxides (Cd, Ti, Al, Fe, Ni, Cr, Cu, Pb, Zn or Sn)

Total Organic Carbon (TOC), Oil, Acid (e.g. hydrochloric, sulfuric, nitric), Alkaline, and solvent wastes

(Reference)

- CARDI (Cambodian Agricultural Research and Development Institute) soil type can be used to describe using ArcGIS software.
- Topographic information can be used from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Soil Screening Guidance User's Guide (US- EPA, 1996)
- Global Soil Organic Carbon Map, FAO, 2017

2) Climate

The items to be described include the following.

・ Affecting weather information is described. The information could be temperature (maximum and minimum), rain fall, wind speed and pattern, wind direction, relative humidity and sea level (in coastal area) for several years (at least last 5 years).

・ The history on storm surge and earthquake, if any.

・ Information on climate change such as adaptation study, if any.

(Reference)

- Information by Department of Meteorology, Ministry of Water Resources and Meteorology
- UNDP Climate Change Country Profiles, UNDP

3) Air quality

Air quality situation is described by pollutants.

The items to be described include air quality situation by pollutants, major pollutants source such as power station and weather condition.

Baseline data is also described. At least 2 samples (one at the project site and another in the community near the project site considering wind direction and geography) are measured, while more samples can be measured when necessary. The description includes methodology, period and location with its characteristics such as distance from the sensitive area (community, hospital, school, temple/pagoda, etc.) and map.

The above information includes sampling locations, number of samples and time period (averaging time).

Since the area under expected impact depends on the natural and social conditions, the scale of direct and indirect impact areas will be determined taking into account of those conditions (e.g. 500m from the edge of the project area). When site sampling is conducted, sampling sites are at least recommended at the project site and at the sensitive receptors site. Table 3 shows an example of data on air quality.

Example of data on air quality situation is shown in the Table 3 and concentration of hazardous substance can be referred to the Annex 2 of Sub-decree on Air Pollution (2000).

Table 3 Example of Data on Air Quality

No	Parameter	Unit	Average time	Observed	Standard	method
1	Carbon monoxide (CO)	mg/m^3	8 hours		20	

No	Parameter	Unit	Average time	Observed	Standard	method
2	Nitrogen dioxide (NO_2)	mg/m^3	24 hours		0.1	
3	Sulfur dioxide (SO_2)	mg/m^3	24 hours		0.3	
4	Ozone (O_3)	mg/m^3	1 hour		0.2	
5	Lead (Pb)	mg/m^3	24 hours		0.005	
6	Total Suspended Particulate (TSP)	mg/m^3	24 hours		0.33	
7	PM10	mg/m^3	24 hours		0.05	
8	PM2.5	mg/m^3	24 hours		0.025	
9	Hazardous Substances (HSs)	mg/m^3	24 hours			

(Source) Sub-decree on Air Pollution and Noise Disturbance and Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Ambient Air Quality Standard.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project
- PM10 and PM 2.5 in Japanese Ambient Air Quality Standards as below:

Item	1 hour	24 hour average	1 year average
PM10	0.20 (mg/m^3)	0.10 (mg/m^3)	-
PM2.5	-	35 (μg/m^3)	15(μg/m^3)

- Lead in USEPA National Ambient Air Quality Standards: 0.15μg/m^3 in terms of a 3-month average concentration
- Environmental Impact Assessment Technique for Road Project, National Institute for Land and Infrastructure Management, Japan, 2013 (on the area under expected impact)
- Types of hazardous substances can be selected considering what substances will give adverse impacts in the ambient air during operation of the projected factory. Refer to Annex 2 of the reference for the maximum allowable concentrations. Note typical HSs in the National Hazardous Ambient Air Pollutant Standards in Japan are referred to the following four substances:

  Benzene: 0.003 mg/m^3 in terms of a one-year average concentration

  Trichloroethylene: 0.2 mg/m^3 in terms of a one-year average concentration

  Tetrachloroethylene: 0.2 mg/m^3 in terms of a one-year average concentration

  Dichloromethane: 0.15 mg/m^3 in terms of a one-year average concentration
- The table below indicates possible substances emitted in the air from metal products manufacturing by process.

Process	Substances Emitted in the Air
Sintering	Fugitive dust, particulates, carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NOx), chloride (Cl) and fluoride (F) compounds, VOCs (e.g. polystyrene vapors, hydrocarbons), metallic fumes (volatilized metal and metal oxides)
Metal Shaping	
Metal cutting, grinding and/ or forming (including forging, wire	Fume and cutting fluid mists [in processes where cutting / lubricating / cooling fluids are heated (e.g. wire drawing)]. In case of hot works or high

Process	Substances Emitted in the Air
drawing, pressing, stamping, among others)	wearing effects, some lubricants may decompose and produce VOCs
Thermal Treatment	
Quenching, annealing and other general treatments	Mist, VOC /solvents, fumes, particulates (e.g. chromium or nickel oxidized vapors)
Surface Preparing	
Abrasive treatments (e.g. shot, sand blasting)	Dust, comprising abrasive particles, metals and metal oxides.
Solvent degreasing and emulsion, alkaline, and acid cleaning	Solvents (associated with solvent degreasing and emulsion cleaning only), VOC, fumes, acid or alkaline vapors containing ammonia, ammonium chloride (NH_4Cl)
Welding	Particulate, chromium [VI] (Cr^{6+}) and nickel oxidized vapors, ozone (O_3), vapors (as metals or as oxides) of lead (Pb), cadmium (Cd), zinc (Zn), tin (Sn), iron (Fe), molybdenum (Mo), manganese (Mn), cobalt (Co), vanadium (V), silica and silicates (SiO_2), fluorides (F), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO_2), phosgene (carbonyl chloride($COCl_2$)), phosphine (PH_3)
Surface Finishing	
Anodizing, chemical conversion coating, electroplating	Metal-ion-bearing mists and acid mists, hydrochloric acid (HCl), sulfuric acid (H_2SO_4), ammonia (NH_3), ammonium chloride (NH_4Cl), zinc oxide (ZnO), particulate matter (PM), lead (Pb), copper (Cu), chlorine (Cl_2)
Painting	Solvents
Other metal finishing techniques (Including polishing, hot dip coating, and etching)	Metal fumes and acid fumes, zinc oxide (ZnO) (from water quench), VOC, nitrogen oxides (NOx), particulate matter (PM), sulfur oxide (SO_2) (from heating the zinc bath)

Source: IFC (2007) Environmental, Health, and Safety Guidelines for Metal, Plastic, and Rubber Products Manufacturing

4) Noise and Vibration

Noise and vibration situation is described.

Baseline data is also described. At least 2 samples (one at the project site and another in the public building/area) are measured, while more samples can be measured when necessary. The description includes methodology, period and location with its characteristics such as distance from the sensitive area (community, hospital, school, temple/pagoda, etc.) and map. While the area under expected noise impact depends on the natural and social conditions, 200m for noise, 100m for vibration from the edge of factory borders can be referred for the area under expected impact. Table 4 and Table 5 show examples of data on noise and vibration, respectively.

Table 4 Example of Data on Noise

No	Characteristics of sampling site*	Period of time					
		From 6h AM to 18h		From 18h to 22h		from 22h to 6hAM	
		Observed (dB(A))	Standard (dB(A))	Observed (dB(A))	Standard (dB(A))	Observed (dB(A))	Standard (dB(A))
1	Quiet areas - Hospitals - Libraries - School - Kindergarten		45		40		35
2	Residential area: - Hotels - Administration offices - House		60		50		45
3	Commercial and service areas and mix		70		65		50
4	Small industrial factories intermingling in residential areas		75		70		50

Source: Sub-decree on Air Pollution and Noise Disturbance

Table 5 Example of Data on Vibration

Daytime (From 06 to 18)		Nighttime (From 18 to 06)	
Observed	Standard	Observed	Standard
	65 dB		60 dB

Source: Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Maximum permitted noise level.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project
- Vibration standard as maximum level to protect living environment from road traffic vibration in Japan as below

Type of area	Daytime 7am – 8pm	Nighttime 8pm – 7am
Residential area*	65 dB	60 dB
Residential, commercial and industrial area**	70 dB	65 dB

* Area where needs quiet

**: Area where needs to control vibration to keep living environment

- Environmental Impact Assessment Technique for Road Project, National Institute for Land and Infrastructure Management, Japan, 2013 (on the area under expected impact)

5) Water Quality

The items to be described include water quality situation by pollutants and water source of premises such as existing local water supply is described.

Baseline data is also described. At least 2 samples (one at the project site (downstream side) and another at the natural water area) are measured, while more samples can be measured when necessary. Determination of the number of sampling points depends on the scale of factory, neighboring circumstances, suggestion by supervising authority etc. Concentrations of target parameters in the drained water (after treatment) into the public water body are comparable with reference standard. It includes methodology, period and location with its characteristics and map. When site sampling is conducted, sampling sites are recommended at the project site and at the important water user site such as water supply source.

Table 6 shows an example of data on water quality.

Table 6 Example of Data on Water Quality

No	Parameters	Unit	Observed	Standards	Method
1	pH	-			
2	Total Dissolved Solid (TDS)	mg/l			
3	Total Suspended Solid (TSS)	mg/l			
4	Dissolved Oxygen (DO)	mg/l			
5	Biological Oxygen Demand (BOD_5)	mg/l			
6	Chemical Oxygen Demand (COD)	mg/l			
57	Oil and Grease Coliform	mg/l			
8	Detergent	mg/l			
9	Sulfate (SO_4)	mg/l			
106	Total Nitrogen (TN)	mg/l			
117	Total Phosphorous (TP)	mg/l			
12	Lead (Pb)	mg/l			
13	Arsenic (As)	mg/l			
14	Cadmium (Cd)	mg/l			
15	Iron (Fe)	mg/l			
16	Mercury (Hg)	mg/l			
17	Total Coliform	MPN/100ml			

Note 1: When consideration for aquatic organism is needed, Linear Alkyl Benzene Sulfonic Acid and its salts (LAS) used in detergent can be set as a parameter.

Note 2: When hazardous substances used for production are anticipated to give adverse impact on the surface and/or ground water in and near the project area, substances listed in Annexes of the Sub-decree below mentioned shall be added.

(Reference)

- Sub-decree on Water Pollution Control, 1999 prescribes Water Quality Standard in public water areas.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project (refer to Table 7 and Table 8 for parameters and standards on surface water and ground water qualities, respectively)

Table 7 Parameters and Standard on Surface Water Quality

No	Parameters	Unit	River water	Lake and reservoir	Marine
1	Acid or Base (pH)	-	6.5 – 8.5	6.5 - 8.5	7.0 – 8.3
2	Total Dissolved Solid (TDS)	mg/l	<1000	<1000	<1000
3	Total Suspended Solid (TSS)	mg/l	25-100	1-15	<60
4	Dissolved Oxygen (DO)	mg/l	7.5-2.0	7.5-2.0	7.5-2.0
5	Biological Oxygen Demand (BOD_5)	mg/l	1-10	<30	<30
6	Chemical Oxygen Demand (COD)	mg/l	<50	1-8	2-8
7	Oil and Grease	mg/l	<5.0	<5.0	0

No	Parameters	Unit	River water	Lake and reservoir	Marine
8	Detergent	mg/l	<5.0	<5.0	0
9	Sulfate (SO_4)	mg/l	<300	<300	<300
10	Total Nitrogen (TN)	mg/l	0.1-0.6	0.1-0.6	0.2-1.0
11	Total Phosphorus (TP)	mg/l	0.005-0.05	0.005-0.05	0.02-0.09
12	Lead (Pb)	mg/l	<0.01	<0.01	<0.01
13	Arsenic (As)	mg/l	<0.01	<0.01	<0.01
14	Cadmium (Cd)	mg/l	<0.001	<0.001	<0.001
15	Iron (Fe)	mg/l	<1	<1	<1
16	Mercury (Hg)	mg/l	<0.0005	<0.0005	<0.0005
17	Total Coliform	NPN/ 100ml	<5000	<5000	<5000

Source: Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

Table 8 Parameters and Standard on Groundwater Quality when Required

No	Parameters	Unit	Standards
1	pH	-	6.5-8.5
2	Turbidity	NTU	5
3	Electrode Conductivity (EC)	NTU	500-1500
4	Total Dissolved Solid (TDS)	mg/l	800
5	Total Hardness (as $CaCO_3$)	mg/l	300
6	Chloride	mg/l	250
7	Fluoride (F)	mg/l	1.5
8	Nitrate (NO_3)	mg/l	50
9	Sulfate (SO_4)	mg/l	250
10	Iron (Fe)	mg/l	0.3
11	Arsenic (As)	mg/l	0.05
12	Mercury (Hg)	mg/l	0.001
13	Chromium (Cr)	mg/l	0.05
14	Manganese (Mn)	mg/l	0.1
15	Aluminum (Al)	mg/l	0.2
16	Benzene (C_6H_6)	mg/l	0.01
17	Dichloromethane (CH_2Cl_2)	mg/l	-
18	Cadmium (Cd)	mg/l	0.003
19	Total coliform	MPN/100ml	0
20	E-coli	MPN/100ml	0

Note: Parameters are selected depending on the geology and the tunnel structure/construction work

(Source) Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

The table below indicates possible substances discharged to the water body from metal products manufacturing by process.

Process	Air Emission
Sintering	Metal oxides, phenols, grease, spilled oils, suspended and dissolved solids and metals (metal-bearing sludge)
Metal Shaping	
Metal cutting, grinding and/ or forming (including forging, wire drawing, pressing, stamping, among others)	Waste machining fluids (e.g. ethylene glycol, oil-based fluids; oil-water-emulsions, synthetic emulsions) and acid (e.g. hydrochloric, sulfuric, nitric), alkaline, and solvent wastes
Surface Preparing	

Process	Air Emission
Solvent degreasing and emulsion, alkaline, and acid cleaning	Surfactants, emulsifiers, detergents, terpenes, alkaline or acid wastes, metal salts, dissolved base materials
Welding	Contaminated cooling bath used to quench after welding
Surface Finishing	
Anodizing, chemical conversion coating, electroplating	Acid / alkaline wastes, metals, metal salts, zinc, chromium (VI), cyanide
Painting	Solvent wastes, spills, and still bottom
Other metal finishing techniques (Including polishing, hot dip coating, and etching)	Metal (e. g. zinc, chromium [VI] (Cr^{6+})) and acid or alkaline wastes

Source: IFC (2007) Environmental, Health, and Safety Guidelines for Metal, Plastic, and Rubber Products Manufacturing

6) Hydrology and Water Resource

The items to be described include river, lake, reservoir, wetland and drainage system with map. Describe the characteristics on water resources for the factory including location and type of water source.

Also, the items to be described include the following.

- Water level (with warning water level, if any) and flow rate of river/lake by table.
- Run-off characteristics of watersheds. Delineation of watersheds and drainage pattern in the area of influence using aerial/ remote sensing images is recommended.
- The history on flood and storm surge, if any.

(Reference)

- The Study on Hydro-Meteorological Monitoring for Water Quantity Rules in Mekong River Basin (JICA, 2004) (for hydrologic information)
- Department of Hydrology and River Works, Ministry of Water Resources and Meteorology (for hydrologic information)
- Mekong River Commission website (http://www.mrcmekong.org)

7) Waste Management

Clarify availability of waste management (collection, treatment/recycle and disposal) service on both hazardous and non-hazardous wastes. It includes covered type of waste and permit information by service provider.

5.1.2 Biological Resources

1) Forest

The items to be described include the following.

- Situation on forest area such as vegetation and forest cover with map
- The designated protected area (especially Core zone and Conservation zone) on forest, if there is in proximity of the project site. Clarification on zoning is important
- The methodologies for the study, such as direct observation (with map on location), local interview, analysis of reference documents.

(Reference)

- The Law on Forestry (Royal Kram) prescribes permanent forest reserve, production forest, protection forest and community forest. Also the Law has provisions on environmental and social impact assessment.
- The Protected Areas Law
- Cambodia Forest Cover, 2014 (Forestry Administration, 2016)

2) Protected Area

The items to be described include the following.

- The designated protected area concerning biological resources, especially Core zone and Conservation zone, if there is in proximity of the project site.
- Clarification on zoning is important and zoning information could be collected from the Sub-decree on individual Protected area or local government.
- The methodologies for the study such as direct observation (with map on location), local interview, analysis of reference documents.

For the location of the target facility, it is better to avoid the area inside or neighboring the Core zone and Conservation zone

(Reference)

- Protected Areas Law prescribes the category of the protected areas and zoning (Core zone, Conservation zone, Sustainable use zone and Community zone) of the protected areas.
- Sub-decree on individual protected area, related Ministry

3) Wildlife Species and Habitats

Wildlife species and their habitats are described, especially endangered species. This includes rare species, endemic species and movement (corridor and migratory pattern).

The methodologies for the study are also described such as direct observation (with map on location), local interview analysis of reference documents etc.

(Reference)

- WWF (World Wide Fund for Nature, https://www.worldwildlife.org), CI (Conservation International, https://www.conservation.org) and WCS (Wildlife Conservation Society, https://www.wcs.org) website on endangered species.

4) Biodiversity and Ecological Systems

The items to be described include the following.

- Situation on biodiversity and ecological system, including endangered species and important biological corridor, if there is in proximity of the project site.
- The designated protected area and sensitive area
- The ecology resources function (forest/ecology system situation and function) with the result of 1), 2) and 3).
- The methodologies for the study such as direct observation, local interview or analysis of reference documents.

5) Aquatic Resources

Situation on aquatic resources is described. It can be inland resources and/or marine resources in the case the project site is in the coastal or sea area. Since fishery is important resource in both food and employment in Cambodia, sampling shall be done with minimum amount of resources and illegal seize be avoided.
The methodologies for the study are described such as direct observation, local interview, analysis of reference documents etc.
(Reference)
Reports of Ministry of Agriculture, Forest and Fishery

6) Wetland Systems (if related)
Situation on wetland is described, if there is crossing in or near designated wetland site such as by the Ramsar Convention (Boeng Chhmar and Associated River System and Flood Plain, Prek Toal Ramsar Site, Koh Kapik and Associated Islets, and Middle Stretches of Mekong River North of Stoeng Treng).

5.2 Social and Economic Resources

1) Social and Economic Study Methodologies
The methodologies of social and economic study are described including following:

- The area covered such as length from the right of way;
- Selection of targeted villages/communities among the total alignment;
- Sampling method and sample size compared with the population/number of household;
- Items surveyed; and
- (If included) the replacement cost policy including eligibility and methodologies to identify the ownership/occupancy of assets.

(Reference)
- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

2) Demography and Settlement
Population, villages and settlements is described.
(Reference)
- General Population Census by National Institute of Statistics

3) Economic Status
Economic situation is described such as economic growth, income (primary and secondary) level, major industry/product and major employment.
(Reference)
- Economic Census of Cambodia by National Institute of Statistics

4) Land Use and Land Registration
Land use is described such as industrial area, forest area, city area and agriculture area. Also the land use master plan is described, if any.
In the case land acquisition is planned, land ownership and occupancy with the relation with the

Right-of-way is described.
(Reference)
- Land use information can be used by revised information from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Land law (2001)
- Expropriation Law (2010), if applicable.
- Sub-Decree on Right of Way of National Road Channels and Railroads of the Kingdom of Cambodia (2009)

5) Water Use
Water resources and water use including water source and purpose is described.

6) Energy Use
Major energy source is described. If the target facility needs power supply outside, available power resource is described.

7) Infrastructure
Major public infrastructures in the area (e.x. roads, irrigation, parks, water supply and sewerage etc.) are described. If the target facility needs water supply outside, available water resource is described. If the target facility connects to the sewage system outside, existing sewerage system is described.

8) Education
Situation on education is described such as literacy rate and school enrollment rate. The crossing of the alignment and school routes is described, if any.

9) Public Health and Well-being
Situation on public health and well-being is described.
(Reference)
- Cambodia Demographic and Health Survey by National Institute of Statistics

10) Heritage/ Culture
Heritage (cultural heritage, historical monuments, landscape, ancient temples, pagodas and customs/traditions) is described, especially ones designated/listed by the Protected Area Law and UNESCO/Government, if any.
Cultural characteristics and important cultural/traditional sites are also described.
(Reference)
- Law on Protection of Cultural Heritage prescribes protected sites and inventory on cultural property.
- Information by Ministry of Culture and Fine Arts

11) Marginal Group
The poor, ethnic minority and indigenous people is identified. Situation on the poor, ethnic minority and

indigenous people is described such as by specific socio-economic survey and the latest National Census Reports.
(Reference)
- Sub-Decree on Procedures of Registration of Land of Indigenous Communities
- Information by local government

12) Tourism Destinations
Situation on tourism resources and their use is described, if any.
(Reference)
- Tourism Development Strategic Plan 2012-2020

13) Others
The result of the social and economic study such as replacement cost study is described if it is not covered in the above. The presence of unexploded weapons is described when there is possibility.

6. Public Participation

The items to be described include the following.

- The public participation process, especially the process to provide project affected people and other stakeholders the opportunities to be informed and consulted, to express an opinion about projects including activities, and to allow effective involvement.
- The methodology and procedure of public participation such as identification of project affected people and other stakeholders, how to inform including access to the information and how to consult including feedback.

The plan of public participation has 3 stages indicated in Table 9 following the Term of Reference on Infrastructure and Tourism Development Project (Prakas No.120, 2018):

Table 9 Stages of Public Participation

Stages		Outline
1	Information dissemination at project site	The project owner and consultant company disseminates information to stakeholders in order to inform them about the project inception, scope, impact exposure as well as preliminary information and people who get impact from the project.
2	Interviewing the authorities, involved departments	The project owner and consultant company interview with authorities, involved departments and stakeholders, and/or prepares the Focus Group discussion in order to get the opinion and comments on the project.
3	Dissemination Workshop	The project and consultant company prepares the public dissemination workshop in order to show the result of Environmental Impact Assessment Report and stakeholders interview

Following points are also described:

- Dissemination by the project owner with local authorities and local communities of the development project;
- Feedback from relevant provincial departments/ agencies and relevant local authorities;

- Comments from relevant non-government organizations (NGOs);
- Consultation with affected local communities; and
- Conclusions on results of the public consultation.

Also, the project owner establishes and informs the grievance redress mechanism which deals with complaints and grievances.

7. Environmental Impacts and Mitigation Measures

This chapter provides information on impacts and mitigation measures by project phase.

7.1 Summary of Impacts and Mitigation Measures

The view on determination of impacts and mitigation measures are described. The project phase is covered from design to closure. The following points are included:

- Matrix to show the relation between the project activities and impact on environmental resources for determining the potential of impact level;
- Geographic Information System (GIS) by using Tool Overlay to identify an area where the projects impact on environment; and
- Check list for identifying the impact level by the summary table below.

The result is summarized by using a table like shown in Table 10..

Table 10 Summary of Impacts and Mitigation Measures

Environmental and Socio-Economic Aspects	Negative Impacts	Scope of Impacts			Mitigation Measure	Remark
		Low	Moderate	High		
1. Negative impacts of design and construction phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
2. Negative impacts of operation phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
3. Negative impacts of closure phase						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						

7.2 Impacts and Mitigation Measures by Project Phase

In this section, the contents and degree of impacts is described by project phase. It includes methodologies for estimating/forecasting impacts and evaluation of estimated/forecasted impacts.

Mitigation measures on the expected impact are described with the description how and what level of the expected impacts are mitigated.

Following is the example for listed possible impacts and mitigation measures by impact items. When describing the expected impact, not only describing the expected impact but also how the expected impact is derived and evaluation of the impact (for example, comparison with the environmental standard) is described. Also, when describing the mitigation measures, not only the measure itself but also how the measure mitigates the impact or how much impact is mitigated is described.

(Reference)

- Environmental, Health, and Safety Guidelines, IFC[1] (there are many guidelines covering sectors such as infrastructure and many type of industries, and general guidelines including health & safety. It is also useful to consider potential impacts from locating/inviting premises.)

7.2.1 Impacts and Mitigation Measures during Design and Construction Phase

Physical Resources

1) Soil Erosion/Quality

[Adverse impacts]

(Design and construction phase)

- Impact due to the removal or excavation of topsoil
- Impact due to erosion and consequent modification of natural conditions
- Impact due to high embankment of the ground
- Contamination due to usage of heavy machinery for material transportation
- Impact on subsidence by drainage change and additional weight to the soil in subsidence-prone area.

[Mitigation measures]

(Design and construction phase)

- Implement engineering measures for soft foundation and erosion prevention are considered
- Improve drainage for prevention of soil erosion and siltation of watercourses is planned.
- Plan slope stabilization techniques and erosion control measures.

(Design phase)

- While selecting the project area, attention is paid to avoid areas prone to landslides, soil erosion, and subsidence.
- The erosion potential of construction alternatives is carefully examined and the one involving least disturbance to the natural ground is preferred.

(Construction phase)

- Reduction of the need for borrow pits and minimization of excess spoil material generation is considered
- Revegetation and rehabilitation measures are considered
- Construction of drainage ensuring the slope for flowing.

2) Air Quality

[Adverse impacts]

(Construction phase)

[1] https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines

- Impact due to emissions from vehicles including heavy vehicles used for construction.
- Impact due to dust generation from material handling, storage, operation of crushers and hot mix plants, movement of construction vehicles, construction activities, excavation of soil and cutting of embankment near to habitation, hospitals, schools, sanctuaries etc. is addressed.

[Mitigation measures]

(Design phase)

- Select the project area which avoids large scale of involuntary resettlement and traversing environmentally/historically-protected areas.
- Provide sufficient capacity to avoid traffic congestion, even with projected increase in traffic flow.
- Locate the facility which will generate hazardous air pollutants during operation far from human settlements and sensitive receptors.

(Construction phase)

- Conduct periodical watering and transporting construction materials with tarpaulin coverage during the construction phase.
- Provide air pollution control systems in stone crushers and hot mix units to meet the emission regulation.
- Maintain good conditions for construction vehicles to avoid excess emissions.

3) Noise & Vibration

[Adverse impacts]

(Design and construction phase)

- Impact of noise during construction activity including equipment operation
- Impact of vibrations during blasting activity, if any.

[Mitigation measures]

(Design phase)

- Avoide the project area near noise sensitive areas.
- Provide machines and equipment with acoustic enclosures and silencers.
- Provide noise barriers surrounding the machinery generating large noise.
- Locate the facility which will generate large noise during operation far from human settlements and sensitive receptors.

(Construction phase)

- Provide mandatory acoustic enclosure /acoustic treatment of room for stationary generator sets.
- Avoide or minimize blasting activity.

4) Water Quality

[Adverse impacts]

(Design and construction phase)

- Impact due to drain from construction site is assessed.
- Impact due to wastewater generated from the temporary project offices and temporary workers housing area is assessed.
- Impacts caused by oil leaks from machinery, changing machinery or pollution caused from unsuitable

storage conditions and location.

[Mitigation measures]

(Design and construction phase)

- Measure to minimize sedimentation, erosion and wastewater run-off such as basins, artificial wetlands, grass filter strips and buffer zones.
- Set silt screens and sediment traps to be made before out-letting to water bodies to minimize turbidity and silting in local water bodies
- Treat wastewater for domestic wastewater.
- Store broken machinery and equipment adequately in a warehouse.

5) Hydrology/ Groundwater and Water Use/ Rights

[Adverse impacts]

(Design and construction phase)

- Impact due to surface water flow modifications such as potential flooding and decrease of water supply. Because road construction that intersect drainage basins, generally modify the natural flow of surface water by concentrating flows at certain points and in many cases, increasing the speed of flow, result in flooding, soil erosion, channel modification and siltation of streams.
- Impact on channel capacities and existing floodways.
- Impact on water facilities such as, wells, hand pumps, tube wells etc. falling along the alignment is assessed.
- Coordinate with provincial Department of Water Resources and Meteorology (DoWRAM) and other agricultural groups to collect information and discuss mitigation measures.
- If the projected factory will use groundwater, impacts on groundwater such as water intake location, amount required and contamination shall be considered.

[Mitigation measures]

(Design phase)

- While selecting the project area, attention is paid to avoid the location of cutting significant water flows.
- In case of flood prone areas and/or areas with very flat slopes, hydrological surveys shall be conducted before location and building layout determination. Inputs derived from these surveys such as the need for provision of drainage structures is considered during the design stage.
- Drainage improvement to avoid water logging and flooding due to disturbance of natural drainage pattern is considered.
- Water flow speed control is exercised to check surface runoff’s and silt loads during construction activities.
- Design and construct a detour while constructing a bridge across a canal, stream or on any irrigation project.
- In dry areas, road drainage can be designed to retain water in small dams or maintain a high water table.
- Rehabilitate water flows and provision of alternative water supplies.

Biological Resources

6) Protected Areas

[Adverse impacts]

(Design and construction phase)

- Impact due to the location of the project area in and next to the protected area.
- Impact due to the disturbance to the access to the protected area.
- Impact due to changes in land profile.

[Mitigation measures]

(Design and construction phase)

- Select the project area avoiding the environmentally/ historically-protected areas.
- Provide new location for rehabilitating/compensating, if potential impacts are unavoidable.

7) Ecosystem including Biodiversity such as Forest and Wildlife

[Adverse impacts]

(Design and construction phase)

- Impact due to removal of trees in the project area.
- Impact on forest resources, economically important plants including medicinal plants and threat to endangered species.
- Impact on wildlife habitat including wildlife corridor and biodiversity due to change in land use.
- Impact due to fragmentation of wildlife habitat and territories.
- Pressure on habitats of wildlife as a result of increased access by the project.
- Impact due to changes in water quality, soil profile, noise, light and air pollution, which may affect the nature and character of habitats.
- Impact on food chain, if the project may destruct the food chain of the ecosystem.

[Mitigation measures]

(Design phase)

- Select the project area avoiding the environmentally/historically-protected areas.
- Provide new habitats for rehabilitating/compensating.
- Provide road crossing structures such as underpass for passage of wildlife and non-structural measure such as ultrasound, if required.

(Construction phase)

- Prohibit workers to hunt or kill the wildlife.
- Prohibit logging outside of the factory boundary for the purpose of construction

Social and Economic Resources

8) Resettlement and Livelihood

In principle, resettlement including livelihood restoration is managed by resettlement plan/framework) prepared by the project owner and approved by Inter-Ministerial Resettlement Committee (IRC)). The summary and data from resettlement plan/ framework is described. Social and economic survey on potential project affected people provides an important basis to prepare there settlement plan/ framework.

[Adverse impacts]

(Design phase)

- Describe land acquisition including ownership of land, land use and population.
- Clarifying the procedure and institutional setting on land acquisition and resettlement, considering vulnerable and marginal groups.
- Clarifying the policy on compensation.
- Impacts due to the land acquisition on residence, loss/change of living measures

[Mitigation measures]

(Common)

- Plan and implement the resettlement plan and compensation plan.

(Design phase)

- Select the project area which minimizes the resettlement and impacts by resettlement.
- Implement careful plan and study on land acquisition and resettlement.

(Construction phase)

- Implement land acquisition and resettlement as planned (Resettlement Action Plan: RAP).
- Manage complaints from project affected persons and stakeholders in line with the grievance redress framework.
- Monitor the progress of the process and the situation after the resettlement.

9) Land Use

[Adverse impacts]

(Design and construction phases)

- Adverse land use impacts may arise from the displacement of existing uses, preventing access across it or new land use. Indirect impacts may arise on the natural resources of the area. Identification and assessment of land use, ownership, property values and economic activities is important.
- In urban areas, the principal impacts arise from the acquisition of residential and business properties and from the dislocation of urban activities.
- In rural areas, the principal impacts arise from the acquisition and severance of rural holdings. High quality of agricultural land may be lessened by severance.
- Natural systems, visual amenity and historic/cultural resources may be disturbed.

[Mitigation measures]

(Design phase)

- While selecting the project area, attention is paid to avoid areas of productive lands such as fertile agriculture lands.
- Restore earning opportunity through livelihood program or provision of land.
- Provide of access or alternative routes if the existing road could be disturbed.
- Establish economic compensation.

10) Heritage/ Culture

[Adverse Impact]

(Design and construction phase)

- Impact on the heritage/cultural site itself and access to the heritage/cultural site through the

identification of the heritage/cultural site.
- Coordinate with Ministry of Culture and Fine Arts to collect information and discuss mitigation measures.

[Mitigation measures]
(Design and construction phase)
- Select alignment which avoids passing through or close to the heritage/cultural site.
- Provide new location or rehabilitating/compensating heritage/cultural site.

11) Infrastructures
[Adverse impacts]
(Design and construction phase)
- Impact on existing infrastructure, such as traffic disturbance on other roads.
- Impact on existing infrastructure by constructing the factory such as diversion and closure of lane for the construction work.
- Impact on existing infrastructure by cutting existing infrastructure such as communication, power and water

[Mitigation measures]
(Design and construction phase)
- Provide local access roads where access to main arteries has been restricted for the purpose of promoting traffic efficiency and safety.
- Provide alternative routes during construction if existing traffic is much disrupted.
- Re-install existing infrastructures.

12) Landscape
[Adverse impacts]
(Design and construction phase)
- Impact on the significant landscape by the project such as building structure and tree cutting.

[Mitigation measures]
(Design and construction phase)
- Consider landscaping, rehabilitation and compensation.

13) Marginal Group
[Adverse impacts]
(Design and construction phase)
- Impacts on the poor, ethnic minorities & indigenous people.
- Collect information from the latest National Census.

[Mitigation measures]
(Design and construction phase)
- Plan and implement indigenous peoples plan.
- Provide livelihood program.

14) Working Condition
[Adverse impacts]
(Construction phase)

- Impacts on working condition, accidents, health and safety of construction workers.
- Coordinate with Ministry of Labor and Vocational Training to collect information and discuss mitigation measures.

[Mitigation measures]
(Construction phase)

- Comply with Labor Law and Law on Social Security Schemes.
- Provide safety measures such as mandatory helmet and health check.

15) Public Health
[Adverse impacts]
(Construction phase)

- Potential of occurrence of species communicating diseases such as mosquito by pooling of water.
- Potential of occurrence of communicable diseases through workers.
- Impact on pneumonia/respiratory disease is caused by dust

[Mitigation measures]
(Construction phase)

- Provide drainage at the project site including borrow pits.
- Conduct routine watering and reducing the dust that leads to pneumonia occurrence.
- Implement appropriate waste management to avoid waste disposal at the project site.
- Provide health education/training program for the construction workers by the contactor.

16) Risks (man-made risks)
[Adverse impacts]
(Construction phase)

- Impact due to spillages and accidents of vehicles/storage with chemicals and fuels.
- Potential impact by accident.
- Accidents caused by construction equipment in operation.

[Mitigation measures]
(Construction phase)

- Appropriate drainage arrangements with catch drains and catch pits is planned to prevent the spillage of chemicals and fuels reaching the water bodies.
- Provide appropriate training and drills to construction works, intensively to the non-skilled.
- Provide traffic safety measures such as signs and/ or safe crossings.

(Reference)
National Road Safety Policy, 2014

17) Climate Change
[Adverse impacts/ Mitigation measures]

(Design phase)

- Impacts and mitigation measures are described in qualitative way when the project increases the emission of climate change gas significantly.
  * For example, estimate the cumulative amount of GHGs during construction and establish mitigation measures such as developing the effective operation plan of equipment, controlling fuel consumption etc.

18) Waste Management

[Adverse impacts]

(Construction phase)

- Impacts by dust and particulate matter from construction waste including its storage.
- Impacts on waste landfill site by accumulating construction waste.
- Impacts on wastes generated by construction, especially on hazardous wastes.
- Insufficient management of solid and liquid wastes from the workers' camp.

[Mitigation measures]

(Construction phase)

- Control of dust and particulate matter by water spraying.
- Design appropriate landfill site.
- Establish and implement the waste management plan in the work place and providing proper training to workers.
- Establish and implement the waste management plan in the workers' camp and providing proper training.

7.2.2 Impacts and Mitigation Measures during Operation Phase

<u>Physical Resources</u>

1) Soil Erosion/Quality

[Adverse impacts]

- Impact due to erosion and consequent modification of natural conditions.
- Impact due to destabilization of embankment.
- Impact on subsidence by drainage change and additional weight to the soil in subsidence prone area.

[Mitigation measures]

- Establish and implement the maintenance program for all erosion control works.
- Prevent soil contamination by prevention of seepage of wastewater or hazardous waste.

2) Air Quality

[Adverse impacts]

- Impact of emission on the ambient air due to directly or through mal-maintained filtration emission of hazardous substances.

[Mitigation measures]

- Ensure premises complying related regulation by installing and operating control equipment. If needed, voluntary control of pollutants by locating premises which are not prescribed in regulation.

- Establish and implement the emission control plan for target substances.
- Maintain the duct and filtration system of the equipment.

(Reference)

- Environmental, Health, and Safety Guidelines, IFC

3) Noise & Vibration

[Adverse impacts]

- Impact of noise and vibration on the surrounding community and the nature due to factory operation.

[Mitigation measures]

- Install devices/equipment with low noise/vibration generation.
- Stop operation of devices/equipment with large noise/vibration generation during night time.
- Install noise barrier around the target equipment.
- Set the devices/equipment in a place as much as far from the community or sensitive receptors.

(Reference)

- Environmental, Health, and Safety Guidelines, IFC

4) Water Quality

[Adverse impacts]

- Impacts by drain with sedimentation and increased turbidity after insufficient treatment outside the factories into the public water system.
- Impact by drain with hazardous substances after insufficient treatment outside the factories into the public water system.
- Run-off such as substances, oils, greases and waste water from factories, storages or establishment in the area.

[Mitigation measures]

- Ensuring premises complying related regulation by installing and operating control equipment. If needed, voluntary control of pollutants by locating premises which are not prescribed in regulation.
- Establish and implement the emission control plan for target substances.
- Maintain the drainage and water treatment system of the factory.
- Maintain facilities in good condition to prevent unexpected spill-out.

(Reference)

- Environmental, Health, and Safety Guidelines, IFC

5) Hydrology/ Groundwater and Water Use/ Rights

[Adverse impacts]

- Impact due to surface water flow modifications such as potential flooding and decrease of water supply.
- Impact on channel capacities and existing floodways.
- Impact on water facilities such as, wells, hand pumps, tube wells etc. falling in the project area is assessed.
- Potential impact on groundwater due to penetrating the hazardous substances into the ground.

[Mitigation measures]

- Establish and implement the maintenance program for controlling water flow change and water use.
- Control water use by the premise to be located.
- Maintain the target substances properly in order to prevent to pouring outside the stock tanks.
- Prevent groundwater contamination by prevention of seepage of wastewater or hazardous waste.

Biological Resources

6) Protected Areas

[Adverse impacts]

- Impact on the protected objects under the neighboring protected area due to unexpected air and water pollutions.
- Impact due to the disturbance to the access to the protected area.
- Impact due to changes in land profile.

[Mitigation measures]

- Establish and implement the environmental management program for controlling pollution.

7) Ecosystem including Biodiversity

[Adverse impacts]

- Impact on forest resources, economically important plants including medicinal plants and threat to endangered species.
- Impact on wildlife habitat and biodiversity due to change in land use.
- Impact due to fragmentation of wildlife habitat and territories.
- Impact due to changes in water quality, soil profile, noise, light and air pollution, which may affect the nature and character of habitats.
- Impact on food chain, if the project may destruct the food chain of the ecosystem.

[Mitigation measures]

- Establish the environmental management program for controlling pollution.

Social and Economic Resources

8) Resettlement and Livelihood

[Adverse impacts]

- Complaints from project affected persons who are not satisfied with the livelihood assistance.

[Mitigation measures]

- Maintain and operate program as planned in the resettlement planning.
- Manage complaints from such persons in line with the grievance redress framework.

9) Land Use

[Adverse impacts]

- Complaints from project affected persons who are not satisfied with the land use by the project owner.

[Mitigation measures]

- Manage complaints from such persons in line with the grievance redress framework.

10) Heritage/ Culture

[Adverse impacts]

- Impact on the heritage/cultural site itself and access to the heritage/cultural site by the project implementation (e.g. increase of traffic or visitors).

[Mitigation measures]

- Implement the maintenance program as planned.

11) Infrastructure

[Adverse Impacts]

- Impact on existing infrastructure through the project implementation (e.g. excess use of existing roads).

【Mitigation measures】

- Plan and construct additional structure, if needed.

12) Landscape

[Adverse impacts]

- Impact by adding new buildings in and around the project area which may disturb the surrounding landscape.

[Mitigation measures]

- Design carefully to the landscape by incorporating opinions from stakeholders and employing manners with a viewpoint of environmental and engineering perspectives.

13) Marginal Group

[Adverse impacts]

- Complaints from project affected marginal groups who are not satisfied with the livelihood assistance.

[Mitigation measures]

- Manage complaints from such groups in line with the grievance redress framework and related programs.

14) Working Condition

[Adverse impacts]

- Impacts on working condition, accidents, health and safety of operation and maintenance workers.

[Mitigation measures]

- Comply with Labor Law and Law on Social Security Schemes.

15) Public Health

[Adverse impacts]

- Potential of occurrence of species communicating diseases such as mosquito by pooling of water.

[Mitigation measures]

- Conduct appropriate water management generated at the road establishments.

- Provide health program for the workers.

16) Risks (man-made risks)

[Adverse impacts]

- Impact due to exposure of hazardous substances outside and fires in the project area toward the surrounding area.

[Mitigation measures]

- Establish and implement the factory operational guideline.
- Hold frequent communications with the surrounding community and related authorities.
- Implement safety education/training to the workers.
- Establish a contingency plan to prepare for accidents.

17) Waste Management

[Adverse impacts]

- Impact on the environment by poor treatment of wastes generated by factory operation, especially those containing hazardous substances.

[Mitigation measures]

- Implement the waste management plan properly.
- Implement education/training of treating and managing wastes to employees.
- Achieve appropriate contract and recording between waste generator and waste management service provider.

18) Cumulative Impacts

Cumulative impacts are described with focus on combination with other projects, with map of other project sites. Cumulative impacts can be the case when a project/ activity that may give severe impacts on the target project is identified. Such projects include major road or major area development project in the same project site and/ or its neighborhood. Methods could include following:

- Matrix list for identifying the relation between project activities and impacts.
- Showing potential Geographic Information System (GIS) by Tool Overlay to identify an area on the projects impact.
- Check list for identifying the impact level.

【Mitigation measures】

- Keeping enough distance between infrastructures/buildings

7.2.3 Impacts and Mitigation Measures during Closure Phase

How the environmental management plan is continued when change of project owner is described. Also how the environmental and social condition is transferred/ maintained when part or whole project is closed is described.

7.3 Description of the Positive Environmental and Socio-economic Impacts

Positive impacts for both environmental and socio-economic impacts are described.

8. Environmental Management Plan (EMP)

The Environmental Management Plan (EMP) is an environmental management tool used to ensure that undue or reasonably avoidable adverse impacts of the construction, operation and decommissioning of a project are prevented, and that the positive benefits of the projects are enhanced. Impacts and corresponding mitigation measures by item are summarized to help an understanding of the content. Following points are described to clarify the management of the environmental measures planned.

1) Agency

Agency/institution responsible for project implementation and monitoring is described. Also, supervising (control) institution is described. Possible responsible institutions include the project entity (owner), related authorities, contractors for construction and management, third party, stakeholders etc.

2) Institutional arrangement

Institutional set-up such as procedures and organization to manage each impacts and mitigation measures is described.

It includes communication network with locating premises.

3) Training

Training programs for staffs for environmentally and socially sound performance is described.

4) Monitoring plan including methodology

The plan to monitor impact and mitigation measures is shown. Also, following points are described.

- Baseline conditions before construction through the analysis of existing conditions.
- Monitoring plan including parameters, methodology, monitoring points and frequency, by impact.
- Methodology of monitoring includes parameters of impact and schedule.
- Environmental standards or guidelines for monitoring.
- Progress/situation on mitigation measures by impact.
- Quarterly monitoring report to be submitted to the Ministry of Environment and relevant ministries/agencies.
- Emergency response plan for emergency case such as serious accident.

5) Assessment of monitoring results

Criteria to assess monitoring results are described.

6) Budget plan for EMP

The budget plan to implement EMP is described. The contribution to the Social and Environmental Fund is described.

(Reference)

- Sub-decree on the Establishment of Social and Environmental Fund
- Joint Prakas of Ministry of Environment and Ministry of Economy and Finance

7) Monitoring report

The above points are compiled to the monitoring report by the agency/institution responsible for project implementation and monitoring. The monitoring report is submitted to the Ministry of Environment and if necessary, to relevant ministries.

9. Economic Analysis and Environmental Value

This chapter provides the economic analysis.

1) Project Benefit

Project benefits are described such as improvements in the physical infrastructure and access, improvements in social services by better transport, development of economy including tourism development and improvements in life style.

2) Economic Analysis

A cost-benefit analysis (CBA) of the project is described with methodologies and indicators/parameters including valuation methods including adverse environmental and social impact. Following points are shown with sources and references.

- Financial analysis: base on profit and loss of the project
- Economic analysis: economic valuation of cost and benefit
- Environmental damage analysis: direct and indirect cost analysis on individual resources

(Reference)

- UNEP (1988) Environmental Impact Assessment: Operational Cost Benefit Analysis - Marc Report No. 42
https://wedocs.unep.org/bitstream/handle/20.500.11822/28857/EIA_Operational_CBA.pdf?sequence=1&isAllowed=y

10. Conclusions and Recommendations

This chapter provides the conclusions and recommendations.

The conclusion is described with the justification, mitigation of major impacts and overall benefits of the project including promotion of local livelihood.

Also, the project owner's assurance and responsibility for the environmental impact assessment is clarified.

Recommendations to the project owner and/ or the stakeholders shall be described.

11. References

Reference documents quoted are written down with the author/institution, title of the document, name of the journal, if any and year published.

12. Annex

Attached documents such as maps and figures are shown as Annex.

Documents quoted for the Guideline

Environmental Impact Assessment for International Cooperation, Japan Ministry of the Environment 2000 (in Japanese)
Technical Guideline for Environmental Assessment: Ambient Air, Water, Soil and Environmental Loads, Japan Ministry of the Environment 2017 (in Japanese)
Technical Guideline for Environmental Assessment: Biodiversity and Communication with Nature, Japan Ministry of the Environment 2017 (in Japanese)
Environmental, Health, and Safety Guidelines for Metal, Plastic, and Rubber Products Manufacturing, International Finance Corporation (IFC), 2007
Environmental, Health, and Safety Guidelines- Base Metal Smelting and Refining, International Finance Corporation (IFC), 2007
Environmental Impact Assessment Guidance Manual for Highways, Ministry of Environment and Forests, India, 2010
Sectoral guidelines for Environmental Reports – Major Roads, Government of Pakistan, 1997

Appendix

Annex of Prakas No.120, April 11, 2018
Term of Reference on Infrastructure and Tourism Development Project (Unofficial translation)

This ToR determines the project activities, scope, methods of study, IEIA and EIA report format for using in the Ministry of Environment and other stakeholders involved with infrastructure and tourism development project.

1. **Introduction**

   The project owner and consultant company have to describe the main points as below:

   - Mission, vision and purpose of investment in participation of national economic development on infrastructure and tourism sector
   - Law that require the investment company to prepare the IEIA/EIA report and ToR for preparing IEIA and EIA report
   - Importance of ToR for preparing the SEIA for infrastructure and tourism development project.

2. **Purpose of Term of Reference (ToR)**

   The main purposes of ToR are:

   - As a guide to prepare the Social and Environmental Impact Assessment (SEIA) report with high quality and accuracy
   - Determining the scope and methods of study on the existing environmental resources (physical, biological and economic-social resources).
   - Determining the stakeholders and public participation for consultation
   - Determining the report format, research team components, and project plan in matrix.

3. **Project Description**

   The consultant company must show as below:

   - Importance of the project
   - Project option analysis
   - History and experiences of company involved with the project implementation
   - Source of capital (public and private sector or development partnership) and type of the project
   - Relevant legal documents
   - Geographic site: geographical location, boundary, surface area and project site compare to key areas attached with map (Datum: UTM_WGS1984_48N) and google map.

   - Summarize the project activities (duration of the project) including:

- Plan of land allocation for the project (attached land allocation layout, every building layout, green area…etc.) land allocation plan for the project (land for construction and infrastructure, green area and land for parking lots follow to master plan…etc.) (attached with land allocation layout, every building layout and architecture layout…etc.).
- Project implementation plan
- Technical construction
- Requirement of machine, instrument, materials and other equipment
- Requirement of raw materials (construction materials and construction components)
- Requirement of human resources, labor force and amount of tourist (amount, position, nationality and salary in construction and implementation stage.
- Requirement of energy usage
  - Public or private electricity (power using)
  - Generator (amount and power)
  - Solar power system
- Requirement of water usage (source and quantity)
- Solid waste and wastewater management plan
  - Solid waste: shall identify the source and types of waste disposal from project activities as well as describe the area, storage and waste management
  - Wastewater: treatment plant construction site, technic and treatment process, size, capacity and final effluent area)
  - Sludge waste: sludge waste management discharged from wastewater treatment plant
  - Gaseous waste: gas management emitted from generator and other machines
  - Hazardous waste: plaster and painting…etc.
- Irrigation preparation for rainwater in the project site
- Health and safety management for staff-workers, tourists and people
- Risk management (natural disaster, fire protection system, safety sign, emergency alert system, exit, training on first aid, fire exit method, physician, nurse and lawyer for solving the risk happened at factory
- Timeline for project activities

4. Scope and Methods of Study

For scope and methods of study on IEIA or EIA report, the project owner and consultant company have to evaluate the existing environmental resources covered on and around the project site such as physical, biological and economic-social resources.

For data collection, the project owner and consultant company have to rely on:

Secondary data: collect and quote data from technical document of the main projects such as technical report of company, master plan and other involved documents.

Primary data: collect data from the field, observation at and around the project site focusing on physical, biological and economic-social resources as well as using scientific detail methods.

4.1 Existing environmental resources

- Physical resources
  - **Soil:**
    - Geology: define the methods, and use the existing data
    - Topology: study about altitude and watershed classification attached with map and source as well define the method, equipment/materials for the study
    - Type of soil and fertile soil classification: study about type of soil and fertile soil (low, medium, high) and soil suitability.
    - Soil quality and soil texture: define the sampling base on type and size of soil in the project site as well as parameter to analyze such as:
      - Chemical soil characteristic: N, P, K, Ca, Mg, Na, Organic Matter, C/N Ratio, Total phosphorus, Dissolved phosphorus, Cation Exchange Capacity (CEC), Acid or Base (pH), Electrode conductivity…etc.
      - Physical soil characteristic: moisture, clay (%), fine silt (%), coarse silt (%), fine sand (%), and coarse sand (%).
    - Mines resource (if have) existing data
    - Soil Mechanic: suitable for high building
  - **Climate:** define the data including temperature, rain fall, wind speed and direction, and humidity (data at least last 5 years of Ministry of Water Resource and Meteorology or Department of Water Resource and Meteorology) related to flood and natural disaster used to happen at and around the project site. <u>Note</u>: *in case climate data does not have at province of the project site, the project owner or consultant company can use the data of the province nearby the project site.*
  - **Air Quality:** analyze air at least 2 samples, one at the project site and another samples in the village near the project site by following the wind direction and geographical site (IEIA Report 1 sample and ESIA at least 2 samples) containing of at least 8 parameters such as CO, NO2, SO2, TSP, O3, Pb, PM10, and PM2.5.

Table 1: Parameters and standard for air quality control

No	Parameters	Unit	MoE standard	Time
1	CO	mg/m^3	20	8 hours
2	NO2	mg/m^3	0.1	24 hours
3	SO2	mg/m^3	0.3	24 hours
4	O3	mg/m^3	0.2	1 hour
5	Pb	mg/m^3	0.005	24 hours
6	TSP	mg/m^3	0.33	24 hours
7	PM10	mg/m^3	0.05	24 hours
8	PM2.5	mg/m^3	0.025	24 hours

- Air quality analysis: project owner and consultant company can suggest to analyze the sample at Ministry of Environment's laboratory. In case project owner and consultant company analyzed by private laboratory or other equipment, it must be officially recognized by the Ministry of Environment.
- Standard Comparison: for the result of analysis, the project owner and consultant company have to compare with air quality standard in table above.

Noise and Vibration

- The project owner and consultant company have to measure the noise and vibration at least 2 samples, one from project site and another one from public area (school, hospital, pagoda and shrine) in order to get the baseline data for verifying in the future.
- Noise and vibration measurement: the project owner and consultation company can suggest to analyze the sample at Ministry of Environment's laboratory. In case the project owner and consultant company analyzed by private laboratory or other equipment, it must be officially recognized by the Ministry of Environment.
- Noise and vibration measurement period: 24hours by setting time spacing 1hours once.
- Standard comparison: for the result of analysis, the project owner and consultant company have to compare with the noise standard in table below:

Table 2: Parameters and standard for noise control

No	Place	Duration		
		From 06:00 AM to 18:00 PM	From 18:00 PM to 22:00 PM	From 22:00 PM to 06:00 AM
1	Quiet Place - Hospital - Library - School - Kindergarten	45 dBA	40 dBA	35 dBA
2	Resident place - Hotel, administration place - Villas, Flats	60 dBA	50 dBA	45 dBA
3	Business, services area	70 dBA	65 dBA	50 dBA
4	Small scale industrial mixed with resident area	75 dBA	70 dBA	50 dBA

Note: method based on real method

- For vibration standard, the project owner and consultant company determine from 06: 00 AM to 18:00 PM and 18:00 PM to 06:00 AM and the result of vibration level measurement have to compare with the vibration standard in table below:

Table 3: Parameters and standard for vibration control

No	Time	Standard level (dBA)
1	From 06:00 AM to 18:00 PM	65
2	From 18:00 PM to 06:00 PM	60

- **Hydrology:** study about the source/final waterway system, flow, torrent, name, size, length of waterway, (public water source) in and near the project site. The project owner and consultation company must determine the waterway circle (upper and lower water table at project site) distance at least 1 km around the project site as well as attached with map of waterway system. Note: *for project is located near the public water source.*

- **Surface water quality:**
  - Determine the amount of sampling and sampling collection site based on the real geography location and natural waterway system which could get negative effect from the project at least 2 samples. One sample collect from natural water source is near the project site and another one at final effluent of the project.
  - Identify the surface water sampling collection method for water quality analysis, parameters and water quality standard.
  - Parameters and standard
    - **Surface water quality control:** the project owner and consultant company can suggest to analyze the sample at Ministry of Environment's laboratory. In case the project owner and consultant company analyzed by private laboratory or other equipment, it must be officially recognized by the Ministry of Environment.
    - **Standard comparison:** for the result of analysis, the project owner and consultant company have to compare with the water quality standard in table 4 below:

Table 4: Parameters and standard for surface water quality

No	Parameters	Unit	River water	Lake and reservoir	Marine
1	Acid or Base (pH)	-	6.5 – 8.5	6.5 - 8.5	7.0 – 8.3
2	Total Dissolved Solid (TDS)	mg/l	<1000	<1000	<1000
3	Total Suspended Solid (TSS)	mg/l	25-100	1-15	<60
4	Dissolved Oxygen (DO)	mg/l	7.5-2.0	7.5-2.0	7.5-2.0
5	Biological Oxygen Demand (BOD5)	mg/l	1-10	<30	<30
6	Chemical Oxygen Demand (COD)	mg/l	<50	1-8	2-8
7	Oil and Grease	mg/l	<5.0	<5.0	0

8	Detergent	mg/l	<5.0	<5.0	0
9	Sulfate (SO4)	mg/l	<300	<300	<300
10	Total Nitrogen (TN)	mg/l	0.1-0.6	0.1-0.6	0.2-1.0
11	Total Phosphorus (TP)	mg/l	0.005-0.05	0.005-0.05	0.02-0.09
12	Lead (Pb)	mg/l	<0.01	<0.01	<0.01
13	Arsenic (As)	mg/l	<0.01	<0.01	<0.01
14	Cadmium (Cd)	mg/l	<0.001	<0.001	<0.001
15	Iron (Fe)	mg/l	<1	<1	<1
16	Mercury (Hg)	mg/l	<0.0005	<0.0005	<0.0005
17	Total Coliform	NPN/100ml	<5000	<5000	<5000

Note: - Amount of parameters require to analyze more (necessary case such as heavy metal…etc.)

- Based on real method

Table 5: Parameters and standard of wastewater discharge from business building, villa, and resort

No	Parameters	Unit	Standard level	
			Toxic substance discharge permit to sewage system	Toxic substances discharge permit to public water sources
1	Acid or Base (pH)	-	5 – 9	6 – 8
2	Total Suspended Solid (TSS)	mg/l	<150	<80
3	Oil and Grease	mg/l	<20	<20
4	Biological Oxygen Demand (BOD5) (5days at 20°C)	mg/l	<80	<30
5	Chemical Oxygen Demand (COD) ($Cr2O_7^{2-}$)	mg/l	<120	<50
6	Detergent-LAS	mg/l	<15	<7
7	Total Nitrogen (T-N)	mg/l	<10	<6
8	Total Phosphorus (T-P)	mg/l	<1	<0.5
9	NH3	mg/l	<8	<5
10	Coliform	NPN/100ml	-	500-2500

Note: - Amount of parameters require to analyze more (necessary case such as heavy metal…etc.)

- Based on real method

❖ **Groundwater Quality**

➢ Brief description about groundwater sources at and near the project site

➢ Determining the amount of sampling, sampling collection site based on real geographical situation and waterway system could get the negative impact from the project.

- Identifying the groundwater sampling collection methods for water quality analysis and parameters that need to analyze including water quality standard.
- Parameters and standard
  - Groundwater quality control: the project owner and consultant company can suggest to analyze at the Ministry of Environment's laboratory. In case the project owner and consultant company analyzed by private laboratory or other equipment, it must be officially recognized by the Ministry of Environment.
  - **Standard comparison:** for the result of analysis, the project owner and consultant company have to compare with the water quality standard in table 6 below:

Table 6: Parameters and standard for groundwater quality

No	Parameters	Unit	Standards
1	pH	-	6.5-8.5
2	Turbidity	NTU	5
3	Electrode Conductivity (EC)	NTU	500-1500
4	Total Dissolved Solid (TDS)	mg/l	800
5	Total Hardness (as $CaCO_3$)	mg/l	300
6	Chloride	mg/l	250
7	Fluoride (F)	mg/l	1.5
8	Nitrate (NO_3)	mg/l	50
9	Sulfate (SO_4)	mg/l	250
10	Iron (Fe)	mg/l	0.3
11	Arsenic (As)	mg/l	0.05
12	Mercury (Hg)	mg/l	0.001
13	Chromium (Cr)	mg/l	0.05
14	Manganese (Mn)	mg/l	0.1
15	Aluminum (Al)	mg/l	0.2
16	Benzene (C_6H_6)	mg/l	0.01
17	Dechloromethane (CH_2Cl_2)	mg/l	-
18	Cadmium (Cd)	mg/l	0.003
19	Total coliform	MPN/100ml	0
20	E-coli	MPN/100ml	0

Note: - *Amount of parameters require to analyze more (for necessary case such as heavy metal…etc.) For Benzene and Dichloromethane are not required to analyze in case the Ministry of Environment's Laboratory cannot analyze.*

- *Based on real method*

- ❖ **Map preparation:** every study on soil, air, noise and vibration, surface water and groundwater sampling collection, the project owner and consultant company have to well-prepare the map of each sampling collection site.

- **Biological resources**
  - ❖ **Forest resources:** brief description about forest situation at the project site attached with forest cover in 2002, 2006, and 2010 or current map of forest cover officially issued by Forest Administration and purpose of the study, scope and methods of forest resources study.

    <u>Note:</u> in case, the forest in project site is already cleared, study on protective forest and forest along natural water environment (circular area 1.0 km) at and near the project site and will be conducted as representative sample.
    - ➢ **Purpose of study:** to know about species, presence/absence of species, forest classification, density, log volume, carbon stock estimation (based on national guideline or legal documents or references that national institution, organization and other development partners have been implemented), vulnerability, describe about forest/ecology resources function (forest system situation and function analysis).
    - ➢ **Methods and study instrument:** forest assessment or forest inventory by computing the model lots followed by national technical inventory and attached map of model lots or scientific methods of study based on the real forest situation and also interview key informant and other stakeholders.
    - ➢ **Methods of data analysis:**

      Identify clearly about the methods of data analysis such as SPSS, Excel or other software.

    <u>Note:</u> for project conduct in the city, no need to study the forest resources.

  - ❖ Wildlife and biodiversity resources: the purpose of study, scope (the study have to conduct at and around the project site in circular area from 01-02 km) and method of wildlife and biodiversity resources study and instrument for assisting the study.
    - ➢ **The purpose of study:** to know about the presence/absence, distribution, corridor, source of food, movement and habitat.
    - ➢ **Methods and study instrument:** 1) observation and 2) key informant interview (identifying the key informants' identity, age, sex…etc.) attached with map of observation area.

      <u>Note:</u> completely separated between the methods of study on mammal, bird, and reptile with clearly description about each species.
    - ➢ **Methods of data analysis:** Identify clearly about the method of data analysis such as SPSS, Excel or other software.

      <u>Note:</u> for the project is located in the city, no need to study on wildlife resources.

- ❖ Aquatic and fishery resources: the purpose is to study at and around the project site in circular area from 01-02 km and methods of aquatic and fishery resources study.
  - ➢ **Purpose of study:** to know about presence, habitat, movement, sources of food and vulnerability…etc.
  - ➢ **Methods:** 1) Observation through using fishing net, fishing trap and fishing line and 2) key informant interview (identifying the key information identity, age, sex…etc.) and attached with map of observation area.
- ❖ **Methods of data analysis:** Identify clearly about method of data analysis such as SPSS, Excel and other software.
- ❖ **Protected area:** in case the project site is near the conservation area or protected area, the project owners and consultant company have to describe that the investment project is near the protected area and attached with Map of those protected area.

  Note: for project is in the city, no need to consider about protected area.

- **Economic and social resources**

  The project owner and consultant company have to limit the scope and methods of study on economic-social resources to be clear by determining the circular distance from project site between 0.5-2 km based on:1) settlement 2) geographical site and 3) wind direction. The project owner and consultation company have to use Random Sampling Interview and Taro Yamane formula or other scientific research formulas that is possible for determining the sample size and attached with questionnaire. Sample size has to determine the acceptable sampling error between 05 -10% based on the real geographical situation. Identify clearly about sampling methods for interview people and cited the sources and references.

- ❖ For the economic and social resources study, the project owner and consultant company have to study about:
  - Demography
  - Settlement
  - Land use and state land registration (attached with relevant documents)
  - Occupation and economic activities (income-expenses and poverty rate)
  - Infrastructure
  - Energy usage (energy sources and stove using…etc.)
  - Water usage
  - Public health (health, hygiene and sanitation...etc.)
  - Education
  - Tourism area
  - Landscape

- Culture (cultural heritage, shrine area, conservation area, cemetery forest, community, forest, community fishery, tradition and indigenous people).
- Environmental pollution management (solid waste, wastewater, hazardous waste, air and noise from people activities at and around the project site).
- Road traffic
- Unexploded weapons
- Land solving and construction mechanism (for infrastructure, electrical transmission line and tourism area project…etc.)

4.2 Public participation

The plan of public participation has 3 stages:

1. **Information dissemination at project site**

   The project owners and consultant company have to disseminate information to stakeholders in or around the project site in order to inform them about the project inception, scope, impact exposure as well as preliminary information from authority, stakeholders and people who get impact from the project.

   Participants component: Department of Environment, Department Agriculture Forestry and Fisheries, Department of Mines and Energy, involved departments. District/Commune authority, village, community, NGO and people who get impact from the project.

   Venue: can conduct at project site or public area (pagoda or school) or conference room.

   Period of information dissemination: at least 1 day.

2. **Interviewing the authorities, involved departments**

   a. **Interview the authority and relevant department**

      The project owners and consultant company have to separate the interview with authorities, involved departments, and stakeholders in order to get the opinion and comments on Infrastructure and Tourism Project.

      Participants component: City/province administration, Department of Environment, Department of Land Management, Urbanization and Construction, Department of Tourism, Department of Agriculture Forestry and Fisheries, Department of Water Resource and Meteorology, Department Public Works and Transport, Department of Labor and Vocational Training, Department of Culture and Fine Arts, Department of Planning and Statistic, Department of Rural Development and Department of Health and Cambodia Mine Action Center (if the project site is in mine and unexploded weapons area).

      Venue: can conduct at project site or public area (pagoda or school) or conference room.

      Period of information dissemination: at least 1 week.

b. Interview the authority, impacted community and stakeholders

The project owners and consultant company have to prepare the Focus Group Discussion or individual interview with stakeholders in order to get the opinion and comments on Infrastructure and Tourism Development Project.

Participants component: local authority (commune, village), community representative, NGO and people who get impact from the project.

Venue: can conduct at project site or public area (pagoda or school) or conference room.

Period of information dissemination: at least 4 weeks.

3. Consultation Workshop

The project owners and consultant company have to prepare the public consultation workshop in order to show the result of Social and Environmental Impact Assessment Report and stakeholders interview above.

Participants component: Ministry of Environment (Department of EIA), city/province authority, Department of Environment, Department of Land Management, Urbanization and Construction, Department of Tourism, Department of Agriculture Forestry and Fisheries, Department of Water Resource and Meteorology, Department Public Works and Transport, Department of Women's Affairs, Department of Tourism, Department of Culture and Fine Arts, Department of Economy and Finance, Department of Labor and Vocational Training, Cambodia Mine Action Center (if the project site is in mine and unexploded weapons area), community and people who get impact from the project.

Venue: can conduct at project site or public area (pagoda or school) or conference room.

Period of information dissemination: at least 1 day.

Conclude the consultation workshop result and show the percentage of people supported and unsupported the project.

Note: *IEIA report preparation is not required to conduct the consultation meeting, except the projects that provide serious impact on society and environment.*

4.3 Determining the potential of environmental impact and mitigation measure

4.3.1 Environmental impact and mitigation measure

The project owners and consultation company have to identify the scope and methods for determining the potential of SEIA before implementation (project design and construction), implementation, and after finishing the project following methods:

- Matrix design to show the relation between the project activities and impact on environmental resources for determining the potential of impact level (have or haven't)
- Geographic Information System (GIS) by using Tool Overlay to identify an area where the projects impact on environment
- Check list for identifying the impact level (less, moderate, and more)

For requested project, the project owner and consultant company evaluate focusing on before implementation, implementation and project closure stage.

For existing project or progressing project, the project owner and consultant company evaluate focusing on construction stage or/and implementation and project closure stage.

- **Before implementation stage:** the project owner and consultant company have to divide into 2 stages are project design and construction design by determining the environmental impact and mitigation measure on physical, biological and economic-social resources. Project design stage refers to plan preparation, land dispute solution, boundary limitation, and construction stage refers to land clearing, and other infrastructure construction at project site…etc.
- **Implementation stage:** the project owner and consultant company have to determine the environmental impact and mitigation measure on physical, biological and economic-social resources. This stage refers to construction activities starting and project progressing.
- **Project closure stage:** after finishing the project activities, the project owner will transfer the development project on infrastructure and tourism sector to government (for project rental land from government) and for the project located on private land, the company owner has to implement the rental land contract from government. Therefore, before land transfer, the project owner and consultant company have to determine the environmental impact, mitigation measure and environmental rehabilitation measure on physical, biological and economic-social resources.

4.3.2 Environmental impact is accumulation for EIA report

The project owner and consultant company have to study the impact assessment as accumulation through joint activities between projects and projects or other activities focus on physical resources, biological resources, and economic-social resources (attached with map of project site or other activities).

The project owner and consultant company have to identify the scope and methods for determining the potential of Social and Environmental Impact as accumulation through using Geographic Information System (GIS) by Tool Overlay to identify an area where the projects impact on environment (attached with map of project site and other activities).

4.4 Environmental Management Plan

The project owner and consultant company have to describe the environmental management plan as the main plan for environmental control and design the checklist for environmental control in the construction, implementation and closure stage. The company has to prepare as following:

1. Introduction
2. Control institution preparation and responsibility

a) National control institution
b) Provincial control institution
c) Responsible institution

3. Summarize the impact and mitigation measure toward of environmental management plan
4. Training program
5. Monitoring program
   a) Determining the environment resources, site, parameters, and materials for control
   b) Institution for control, responsible person and budget for control
   c) Compile the documents, data analysis and compare to the baseline data and follow to the technical standard.
6. Budget plan for monitoring program
7. Monitoring report preparation
8. Social and environmental fund: this fund was followed by Sub-decree No.238 A.N.Kr.B.K Date 21 November 2016 on the Establishment of Social and Environmental Fund and Joint Prakas of Ministry of Environment and Ministry of Economy and Finance

4.5 Economic cost analysis and environmental damage (for EIA report)

The project owner and consultation company have to identify the scope, methods, formula, purpose and indicators of social and economic analysis focusing on financial, economic and environmental damage analysis with clear sources and reference.

1. Financial analysis: base on profit and loss of the project owner
2. Economic analysis: base on company profit and pay for government
3. Environmental damage analysis: direct and indirect cost analysis on
   - Physical resources, territory, air and noise pollution, vibration, surface water/groundwater quality, erosion, and soil quality.
   - Biological resources: Ecology system service, product and non-timber forest product, wildlife resources, fishery resources, eco-tourism value, and environmental value…etc.
   - Economic-social resources: occupation, revenue…etc.

5. Format Identification on IEIA and EIA Report

The project owner and consultant company have to prepare EIA and IEIA report by following to the Prakas on General Guideline for Writing EIA and IEIA Report of Ministry of Environment and brief description about the study in each chapter.

Content of EIA Report	Content of IEIA Report
- List of Tables - List of Picture - List of Graphic - List of Map - List of Abbreviation - Abstract - Chapter 1: Introduction - Chapter 2: Scope and Methods of study - Chapter 3: Legal Framework - Chapter 4: Project Description - Chapter 5: Description about the Existing Environmental Resources - Chapter 6: Public Participation - Chapter 7: Environmental Impact and Mitigation Measure - Chapter 8: Environmental Management Plan - Chapter 9: Economic analysis and environmental value - Chapter 10: Conclusion and Recommendation - References - Annex	- List of Tables - List of Picture - List of Graphic - List of Map - List of Abbreviation - Abstract - Chapter 1: Introduction including scope and Methods of study - Chapter 2: Legal Framework - Chapter 3: Project Description - Chapter 4: Description about the Existing Environmental Resources - Chapter 5: Public Participation - Chapter 6: Environmental Impact and Mitigation Measure - Chapter 7: Environmental Management Plan - Chapter 8: Conclusion and Recommendation - References - Annex

6. Research Team Component

The project owner and consultant company has to show the name of company director, experts and assistants for studying the project and structure of consultant company is registered. In case of consultant company collaborate with other private consultant partners or other experts who do not have the name in the registration, the company has to inform the Ministry of Environment before 1 month.

7. Project Work Plan of Consultation Company

The project owner and consultant company have to determine the timeline of study from starting time until final report submit to Ministry of Environment for review and comments.

8. Annex

The project owner and consultant company have to attach with legal document involved with the project, for example rental land contract, consultant company registration letter at Ministry of Environment, authorization letter to consultant company, and prepare EIA report from project owner company, legal documents from involved ministries, institution and authorities…etc.

Prakas No. 021, 03 February 2020

Classification of Environmental Impact Assessment for Development Project (Unofficial translation)

Article 1:

The purpose of this Prakas is to help and guide the private development project owner and public for implementing the procedure of Environmental Impact Assessment (EIA) for effectiveness of development project in the Kingdom of Cambodia.

Article 2:

The goal of this Prakas is to classify the Environmental Impact Assessment for development projects which require the Environmental Protection Contract (EPC) or Initial Environmental and Social Impact Assessment (IESIA) or Environmental and Social Impact Assessment (ESIA).

Article 3:

The limitation of this Prakas is to implement for types of development projects have been requested as well as existing activities and in progress of private individual, private company, public company, ministry-institution as stated in Annex of Prakas, except special and urgent development projects shall be approved by Royal Government of Cambodia.

Article 4:

Types of development projects require to prepare the Environmental Protection Contract (EPC) refer to projects that provide small impact on environment and society as stated in Annex. In case the projects that provide moderate or severe impact on environment and society, the Ministry of Environment require the project owner to prepare the Initial Environmental and Social Impact Assessment (IESIA) or Environmental and Social Impact Assessment (ESIA). For applying for the Environmental Protection Contract, owners are required to attach an Environmental Management Plan.

Article 5:

Types of development projects require to prepare the Initial Environmental and Social Impact Assessment (IESIA) refer to the projects that provide moderate impact on environment and society as stated in Annex. In case this projects that provide severe impact on environment and society, the Ministry of Environment require the project owner to prepare Environmental and Social Impact Assessment (ESIA).

Article 6:

Types of development projects require to prepare the Environmental and Social Impact Assessment (ESIA) refer to the projects that provide severe impact on environment and society as stated in Annex.

Article 7:

Period of review and official approval on Environmental Protection Contract are 28 days of working day in accordance with Inter-Ministerial Prakas on Provision of Public Service of the

Ministry of Environment between the Ministry of Environment and Ministry of Economy and Finance.

Period of review and consultation on IESIA/ESIA report shall be implement in accordance with Sub-Decree No.72 Dated on 11 August 1999 on Environmental Impact Assessment Process and other legal documents.

Article 8:

Type of development project as attachment in Annex of this Prakas can modify through the Prakas of Minister of Environment.

Article 9:

Any provision contrary to this Prakas shall be abrogated.

Article 10:

Secretary of State, Under Secretary of State, Director of Cabinet, Secretary General of National Council for Sustainable Development, Director General of all units under the Ministry of Environment, General Inspector of General Inspectorate, Director Department of Environmental Impact Assessment and all Directors unit under the Ministry of Environment shall implement this Prakas starting from the date of signature onward.

Copied to:

- Council of Ministers
- All involved Ministries-Institutions
- Cabinet Office of Samdech Akeak Moha Sena Padey Techo Hun Sen, Prime Minister
- Cabinet Office of Samdech, His Excellency, Lok Chum Teav, Deputy Prime Minister
- All Municipal/Provincial Hall
- As Article 10 (to implement)
- Royal Office
- Achieve

Annex of Prakas No. 021 on Classification of EIA for Development Projects

No	Type of Project	Classification of EIA in accordance with size of development projects		
		ESIA	IESIA	EPC
1. Mines, energy and industrial sector				
1	Mining and/or petroleum and/or gas exploration		All size	
2	Mining industry exploitation	All size		
3	Petroleum and/or gas exploitation	All size		
4	All construction mineral exploitation such as limestone, marble, sandstone, cracked rock, gravel, sand, laterite, clay, phosphate, Kaolinite. etc.	> 40 ha	>10 - 40 ha	≤10 ha
5	Mining handicraft exploitation			≤1 ha and depth 5m
6	Valuable Mining Processing Plant	All size		
7	Mining wash facility	All size		
8	Gas production plant	All size		
9	Petroleum Refinery plant	All size		
10	Petrochemical plant	All size		
11	Oil and/or gas drainage construction	Length ≥ 2km		
12	Fuel and/or gas storage facility for supply or fuel and/or gas center	> 1000 000 liters	60 000 - ≤1000 000 liters	
13	Fuel and/or gas station or fuel and/or gas center	> 60 000 liters	>40 000 - 60 000 liters	≥8000 – 40 000 liters
14	Cement factory	All size		
15	Hydropower plant	> 50 MW	≥ 1-50 MW	< 1 MW
16	Electrical plant	> 50 MW	≥ 5-50 MW	< 5 MW
17	Electrical sub-station construction		All size	
18	Chemical fertilizer factory	All size		
19	All painting production factory	All size		
20	Chemical factory	All size		
21	All metal processing, nail, barbed wire, wire mesh	≥ 300 ton /month		
22	All type of metal foundry factory	All size		
23	Steel H and other material factory	All size		
24	Natural Diesel production factory	All size		

No	Type of Project	Classification of EIA in accordance with size of development projects		
		ESIA	IESIA	EPC
25	Ethanol/Methanol factory	All size		
26	Fuel oil refinery from old tire (factory)	All size		
27	Batteries and flashlight batteries factory	All size		
28	Wine, beer and alcohol factory	All size		
29	Cigarette and tobacco factory	All size		
30	Calcium Carbide (CaC_2) factory	All size		
31	Lubricant and machine oil factory	All size		
32	Paper factory	All size		
33	Pulp and paper processing factory	All size		
34	Tannery, leather processing factory	All size		
35	Organic fertilizer factory		All size	
36	All type of electrical and electronic equipment factory		All size	
37	Production and install machinery, industrial equipment and involved appurtenances factory		All size	
38	Machinery factory		All size	
39	Plastic factory		All size	
40	Plastic processing and plastic production factory		All size	
41	Insecticide factory		All size	
42	Detergent, soap and liquid soap factory		All size	
43	Waste recycling, incineration factory		All size	
44	Weaving and dying factory		All size	
45	Garment, laundry, printing, and dying factory		All size	
46	Sponge and round rubber factory		All size	
47	Firework, explosion substance for decorating in festival and other ceremony (factory)		All size	
48	Coconut oil refinery factory		All size	
49	Cassava and other production processing		All size	
50	All type of button and zipper factory		All size	
51	Wool and leather garment factory, and tanning processing		All size	
52	Aluminum can factory		All size	
53	Starch factory		All size	

No	Type of Project	Classification of EIA in accordance with size of development projects		
		ESIA	IESIA	EPC
54	Acacia and Eucalyptus chopping factory		All size	
55	All type of glass and bottle factory		All size	
56	Karola and ceramic tile facility		All size	
57	Charcoal factory (from sugarcane bagasse, coconut shell, and rice husk)		All size	
58	Rubber latex and rubber processing factory		≥1000 ton/year	<1000 ton/year
59	Salt production and processing factory		≥3000 ton/year	<3000 ton/year
60	Concrete Mixing factory		>30 000 m^3/month	≤30 000 m^3/month
61	Sewer and concrete construction material facility		>30 000 m^3/month	≤30 000 m^3/month
62	Sugar factory		≥3 000 ton/year	<3000 ton/year
63	Board factory		≥ 100 000 m^3/year (log)	< 100 000 m^3/year (log)
64	Saw factory		≥ 50 000 m^3/year (log)	< 50 000 m^3/year (log)
65	All type of bike tires and rubber		≥ 500 ton/year	< 500 ton/year
66	Feed mill factory		≥ 10 000 ton/year	< 10 000 ton/year
67	Food and canned accessories factory		≥ 500 ton/year	< 500 ton/year
68	All type of drink and fruit juice factory		All size	
69	Jam (fruit) factory		≥ 500 ton/year	< 500 ton/year
70	Factory or rice and grain mill / rice and grain processing factory			≥ 3000 ton/year
71	Fish sauce, soy sauce, chili sauce and tomato sauce factory			≥ 500 000 liters/year
72	Furniture facility			≥ 1 000 m3/year (log)
73	Pillar concrete and electrical pillar factory			All size
74	Machinery installation factory			All size
75	Cotton factory			All size
76	Machine and ship repairing facility			All size
77	Water treatment plant and water supply			All size

No	Type of Project	Classification of EIA in accordance with size of development projects		
		ESIA	IESIA	EPC
	system			
78	Tile production facility			All size
79	Rice powder factory			All size
80	All type of electrical and electronic equipment installation factory			All size
81	Lifting equipment installation factory			All size
82	Umbrella factory			All size
83	Candy factory			All size
84	Shoe factory			All size
85	All type of wallet factory			All size
86	Sport material factory			All size
87	Mattress factory			All size
88	Wallet, towel, mosquito net, and doll factory			All size
89	Packing production for export (factory)			All size
90	Glove, shock, towel and hat factory			All size
91	Elastic straps (for pants) factory			All size
92	Carton box factory			All size
93	Yarn and scotch tape factory			All size
94	Artificial hair factory			All size
95	Door and mirror factory			All size
96	Wooden floor panel, wall panel, fibro roof and tile			All size
97	All type of office materials factory			All size
98	Zinc, scroll door, and construction steel factory			All size
99	Clothing badge factory			All size
100	Cold tea and Yogurt factory			All size
101	Tissue paper factory			All size
102	All type of fishing equipment factory			All size
103	Shoe sheathing factory			All size
104	All type of raincoat factory			All size
105	Drying grain factory			All size
106	All type of sliding curtain factory			All size
107	Garment factory			All size
108	Car accessories factory			All size
109	Freshwater factory			All size

No	Type of Project	Classification of EIA in accordance with size of development projects		
		ESIA	IESIA	EPC
110	Glass and bottle carrier factory			All size
111	Beauty care material factory			All size
112	Clothes hanger equipment and all type of plastic factory			All size
113	Tube factory			All size
114	Kitchen material and decorating furniture from paper and cloth (factory)			All size
115	Plate, pot, tea pot, cup, and other materials factory			All size
116	Souvenir and packing material factory			All size
117	All type of Cambodia noodle and instant noodle factory			All size
118	All type of belt factory			All size
119	Table cover, mattress cover and pillowcase factory			All size
120	Shoe accessories factory			All size
121	Decorating car material factory			All size
122	Clothes accessories factory			All size
123	Production and installation charger of computer and phone factory			All size
124	Spirit house factory			All size
125	Candle factory			All size
126	Sack factory			All size
127	Ice factory			All size
128	Production and installation of all type of technician equipment factory			All size
129	Equipment for construction sector factory			All size
130	(Exploitation) buy, storage and recycle all type of tires			All size
131	Resin grinding and resin production factory			All size
2. Health sector				
132	Hospital	All size		
133	Referral hospital		All size	
134	Laboratory		All size	
135	Blood cleaning center		All size	

No	Type of Project	Classification of EIA in accordance with size of development projects		
		ESIA	IESIA	EPC
136	Medical equipment factory		All size	
137	Medicine factory		All size	
138	Raw material for producing medicine factory		All size	
139	Polyclinic and clinic			All size
140	Health Center			All size
141	Pharmacy warehouse			All size
3. Water Resource Sector				
142	Irrigation system		≥5000 ha	1000 - <5000ha
143	Waterway system		≥5000 ha	1000- <5000ha
4. Agricultural Sector				
144	Floodplain and coastal land	All size		
145	Jungle exploitation	≥ 500 ha		< 500 ha
146	Land that have forest	≥ 500 ha		< 500 ha
147	Land of agricultural and industrial crop	≥ 500 ha		< 500 ha
148	Forest concession	≥ 500 ha		< 500 ha
149	Fishing port, except fishing port as family		All size	
150	Poultry farm and type of bird feeding for meat and/or egg		≥ 50 000 birds	5000- <50 000 birds
151	Cattle, pig, sheep, goat, horse, monkey farm and animal feeding for meat and/or milk		≥ 500 animals	100- <500 animals
152	Crocodile, Tortoise and Turtle		≥ 500 animals	100- <500 animals
153	Fish, crab, shrimp, lobster aquaculture and others		≥ 10 ha	5 - <10 ha
154	Algae plant aquaculture		≥ 20 ha	5 - <20 ha
155	Restore and develop the agricultural and industrial crop		≥500 ha	<500 ha
156	Slaughter house		≥100animal/ day	10- <100 animal/day
157	Insecticide and agricultural fertilizer warehouse			≥10 000 ton/year
5. Tourism Sector				
158	Tourism area	>50 ha	>10-50 ha	≤10 ha

No	Type of Project	Classification of EIA in accordance with size of development projects		
		ESIA	IESIA	EPC
159	Karaok, Club and Disco	Surface area >45000 m^2	Surface area >15000-45000 m^2	Surface area >3000-15000 m^2
160	Golf field		≥18 holes	<18 holes
161	Zoo		≥10ha	<10ha
162	Restaurant		>500 chairs	>100-500 chairs
163	Tourism port		All size	
164	Floating restaurant			≥300 chairs
165	Beer Garland			All size
166	Tourism cafeteria			≥300 chairs
6. Infrastructural Sector				
167	Airport construction	All size		
168	Urban development	All size		
169	Stadium construction	All size		
170	Industrial waste landfill	All size		
171	Industrial park/ special economic zone	All size		
172	Mechanical treatment system facility and drainage system	All size		
173	Railway construction	All size		
174	Port construction, except port as family	All size		
175	Build and operate cable in the bottom of the sea and infrastructure including the cable connection from the bottom of the sea to mainland	All size		
176	All type of building construction (office, multidisciplinary, business, condo, housing estates, flat and villa, super market and other buildings.	Surface area >45000m^2	Surface area >15000-45000 m^2	Surface area >3000-15000 m^2
177	Hotel construction at coastal area/riverside	>230 rooms	≥60-230 rooms	<60 rooms
178	Hotel construction besides coastal area/riverside	>250 rooms	≥80-250 rooms	<80 rooms
179	Road construction	>100 km	≥30-100 km	10- < 30 km
180	Extension of road and railway construction	>100 km	≥50-100 km	10- < 50 km
181	Road construction in the Protected Area	>30 km	≥10-30 km	< 10 km

No	Type of Project	Classification of EIA in accordance with size of development projects		
		ESIA	**IESIA**	**EPC**
182	Road rehabilitation and extension construction in Protected Area	>50 km	≥10-50 km	< 10 km
183	Power transmission line	>230 Kv	≥115-230 Kv	<115 Kv
184	Sludge and Sediment pumping	≥ 50 000 m^3		<50 000 m^3
185	Guesthouse Construction		≥ 80 rooms	< 80 rooms
186	Navigation		≥ 100 ton	< 100 ton
187	Natural wastewater treatment and drainage system		All size	
188	Landfill		All size	
189	Bridge construction		Can load ≥ 30 ton	
190	Telecommunication and information network		All size	
191	Cable optic on land network		All size	
192	Data center		All size	
193	Experiment center including quality monitoring, technical and certification		All size	
194	Basic telecommunication service (mobile phone, desk phone, internet and other services.			All size
195	Booth, shop and sky market construction			All size
196	Telephone system installation facility			All size
197	Cemetery			≥ 5ha

添付資料 9　Guidelines on Environmental Impact Assessment for SEZ and Industrial Zone Sector Projects (Full EIA case)

Guideline on Environmental Impact Assessment

for

SEZ and Industrial Zone Sector Projects (Full EIA case)

Table of Contents

Abbreviation

BOD	Biological Oxygen Demand
CARDI	Cambodian Agricultural Research and Development Institute
CI	Conservation International
CO	Carbon monoxide
COD	Chemical Oxygen Demand
dB	Decibel
DO	Dissolved Oxygen
DoWRAM	Department of Water Resources and Meteorology
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FAO	Food and Agriculture Organization of the United Nations
GIS	Geological Information System
GPS	Global Positioning System
IFC	International Finance Corporation
JICA	Japan International Cooperation Agency
O_3	Ozone
NO_2	Nitrogen dioxide
PM	Particulate Matter
RoW	Right-of-Way
SO_2	Sulfur dioxide
TDS	Total Dissolved Solid
TN	Total Nitrogen
TOR	Terms of Reference
TP	Total Phosphorous
TSP	Total Suspended Particulate
TSS	Total Suspended Solid
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
VOC	Volatile Organic Compounds
WCS	Wildlife Conservation Society,
WWF	World Wide Fund for Nature

I. Preface

This guideline is to provide a guidance on contents of EIA (Environmental Impact Assessment) study process and EIA reports by showing what is to be described in EIA report in special economic zone (SEZ) and industrial zone sector for the full EIA project. This guideline covers SEZ and industrial zone, entailing infrastructure and expected locating premises development (Premises are subject to EIA Sub-decree).

In the EIA report, reference data/information source is to be provided.

This guideline is not applicable to big SEZ or industrial zone development for heavy pollution potential industries, such as petro-chemical industries. For such projects, comprehensive EIA covering all of zone development, infrastructure development, locating industries and cumulating impacts are supposed to be assessed.

(Reference)

Sub-decree on Environmental Impact Assessment Process, 1999

Prakas on General Guidelines for Initial and Full Environmental Impact Assessment Reports, 2009

II. The Guideline

0. Executive Summary

A general summary of the EIA report is provided (within 15-20 pages recommended). It includes at least the following information from the EIA report:

- Objectives of the EIA
- Project Owner/Proponents
- Project Description including project site
- Other Project Alternatives
- Existing Environmental Resources
- Public Participation including issues raised by stakeholders and any outstanding issues
- Impacts and Mitigation Measures
- Environmental Management Plan
- Economic analysis and environmental value
- Conclusions and recommendations

1. Introduction

1.1 Project overview

The items to be described include the following.

- Summary of the project background, the rationale for development of the project, and general situation on the project site

- The nature of the project such as new, extension, widening, rehabilitation or combination
- The summary of the project such as zoning concept and facilities

1.2 Objectives of the EIA

The reason and timing that the EIA is prepared and the consultant who prepares the EIA report are described.

2. Scope and Methodologies of the Study

This chapter provides points related to the Terms of Reference of the EIA study includingwhich are stipulated in the relevant Prakas and Sub-decree in Cambodia.

2.1 Scope of the Study

Scope of the study including covered area by the study is described.

2.2 Data source

The items to be described include how the data is collected such as the measurement, updating situation and title of data source document. For example, in the case of air quality measurement by the project owner, the items to be described include how the sampling date and point is selected and measurement method of pollutants. In the case of data from existing document, justification/relevance of the referred document is described.

Also, when data is described, it is clarified whether primary data (data from the field, observation at and around the project site) or secondary data (collected and quoted data from technical document).

2.3 Methodologies of the study

It is clarified how the impacts in each project phase is predicted/estimated.

Appropriate methods of dada collection are included in this section. Method of the data analysis is described. For example, it is clarified how the expected impact in air quality is compared with the air quality standard in Cambodia, as well as cases in water quality, noise/vibration and wastes (including hazardous materials) etc. When non-Cambodian standards/guidelines are used, justification/relevance of the referred document is described.

Also, the items to be described include basic and common methodologies for understanding physical resources, biological resources and social and economic resources in this section and the detail in individual resource is described in the individual sections.

For example, the methodologies on social and economic study is described including following.

- The area required for the project
- Selection of targeted villages/communities
- Sample size compared with the population/number of household
- All items surveyed (for example, questionnaire, photographs, acquired data etc); and
- (if included) The replacement cost policy and methodologies to identify the ownership of assets

Further, methodologies for public participation is described (The detail is described in 6. Public Participation).

The EIA preparer describes the time table of the EIA survey and team composition including name and work role.

3. Legal Framework

In this section, legal setting is described by clarifying related legal and policy document. Legal and policy documents related to the project is described. This includes the title, issued year and explanation of laws, sub-decrees and policies which are related to the project.

The donor policies in donor supported project case is described, if any.

(Reference)

Table 1 An example of related Laws and Sub-decrees

Title	Year	Explanation
Law on Constitution of Kingdom of Cambodia	1993	
Law on Environmental Protection and Natural Resources Management	1996	
Law on Road	2014	
Law on Road Traffic	2015	
Law on Water Resource Management	2007	
Law on Forestry	2002	
Law on Fishery	2006	
Law on Protected Area	2008	
Law on Land	2001	
Law on Labor	1997	
Law on the Protection of Cultural Heritage	1996	

Law on Investment	1994	
Law on Administration of Factory and Handicraft	2006	
Law on Construction	2019	
Law on Land Management, Urban Planning and Constructions	1994	
Royal-Decree on establishment and management of Tonle Sap Biosphere Reserve (In Tonle Sap area case)	2001	
Sub-Decrees on Environmental Impact Assessment Process	1999	
Sub-Decree on the Establishment of Environmental and Social Fund	2016	
Sub-Decrees on the Air Pollution and Noise Disturbance Control,	2000	
Sub-Decrees on Water Pollution Control	1999	
Sub-Decrees on Solid Waste Management	1999	
Sub-decree on the Establishment and Management of the Special Economic Zone	2005	
Sub-decree on Urbanization of Capital City, Towns and Urban Areas	2015	
Sub-decree on Management of Garbage and Solid Waste of Downton	2015	
Sub-decree on the Management of Drainage and Wastewater Treatment System	2017	
Sub-decree on Land Acquisition and Involuntary Resettlement	2018	

Note 1: The consultant can add or delete laws for suitable tabulation to the concerned project.

Note 2: Input essential but simple descriptions in Explanation columns.

4. Project Description

This chapter provides what is the project and related information.

4.1 Background and experiences of the project owner/company

Following items are described.

- The background of the project,
- The project owner/company including registration information and address,
- The construction company (if it is already decided)

- The capital of construction and operation including the financer.
- The experiences of the project owners/company in the sector are described. If there is a background study such as feasibility survey, it is in introduced.

4.2 Project site

Following items are described.

1) Location and boundary of the project on the map with GPS coordinates
2) Description on the project site by section/zone with pictures
3) Broad geology, topography and connectivity
4) Villages, settlements and land use including demographic, socio, cultural and economic aspects
5) Environmentally sensitive places such as the protected area and land acquisition
6) Supporting information, if any

(Examples)

- Plan to secure green space/zone
- Existing infrastructure such as power plant, water supply, port and major road.
- In case of the factory is located in a flood-prone area, the details of drainage, flood passages and information on flood periodicity in the area to be provided.
- If there is area susceptible natural hazards such as landslides, erosion, flooding, subsidence, earthquakes, details to be provided.
- If the proposed project involves any land reclamation, details to be provided for the activity for which and the area of land to be reclaimed.
- If the proposed area involves any migratory path of animals, details about fauna, habitat and period of the year in which activity take place, to be provided
- If the construction of factories will cause impact such as destruction of forest, and/or reduction in wetland areas, details to be provided.
- In case the project involves any dredging, details to be given.
- If there is a mineral resource area, details to be provided.
- In case the proposed area was used for a facility or ground using and/or saving hazardous chemical(s), details including type, amount and usage purpose of chemical(s) to be provided.

4.3 Project types

1) Project specification

The specification of the project such as Table 2 is described. It includes area by zoning and length of the road. The table below is an example of specification.

Table 2 Example of project specification in SEZ/Industrial zone projects

no	Description	Quantity(unit)
	Area (total and its breakdown) (area by phase, if any)	(km^2)
	Road length	(m)
	Number of plots	

2) Outline of the SEZ or industrial zone is described. This could be design, zoning, industries to be invited/located, infrastructure and facilities.

- Layout plan including drawings.
- Zoning includes such as industrial zone, office zone and residential zone.
- Locating/inviting industries by industrial sector or type of industries.
- Infrastructure such as power plant, port, major road, water supply (water demand), wastewater treatment, drainage, waste storage and flood protection, for both inside and outside of the SEZ or industrial zone. It includes utility service provider such as zone developer, outside supplier or locating industry.
- Facilities include such as common depot/yard and canteen.

3) Technologies involved for design and construction are described. It includes activities for site preparation.

4) Procedures and criteria adopted for selection of the location is described.

5) Activities for site preparation

In case the proposed area is required embankment, details of fill materials, its volume and initial and final levels after filling are to be provided. Also, if the proposed area is required soil improvement such as replacement or refinement, the details of the area to be improved is to be provided, including locations, volume and quantity of earth to be treated and type of soil. Description on cleaner production, green spaces, and greenhouse gases reduction shall be explained, if any.

4.4 Alternatives

The project alternatives are described. For example, alternatives can be described in option 1, option 2and zero-option (the case without project), with the reason on the selection of the project among the alternatives and the selection of alternatives.,

The comparison of alternatives is described by a table.

These details are comprised of:

- Description of various alternatives by locations, layouts or technologies studied

- Description of each alternative
- Summary of adverse and positive impact of each alternative in terms of engineering, environmental and socio-economical aspects
- Procedures and criteria adopted for selection of alternative
  Selection of the alternative which is the best with respect to use of resources and adverse environmental impact

In describing the project and its alternatives, following characteristics can be the key:

- Spatial requirements
- Natural resources (including productive land) consumption
- Project benefits and costs (such as resettlement versus better access to market) or
- Waste production during the construction and operation/maintenance periods

4.5 Activities of the project

Project activities are described. For example;

- Administration (management) of the project
- Sources and quantity of input to be used including water, energy and machinery requirements
- Local and foreign workforce requirements including their housing
- Quantity of final output/products: If it is described in the project overview, refer to it.
- Income and expenditure (Revenue and cost)
- Overall waste management plan: To describe what waste is generated and how waste is collected and disposed by project phase.
- Risk management policy: To describe policy to respond to natural hazards and to secure safety.

4.6 Work plan/ schedule

1) Project phasing.

The phasing of the project is described, if any.

2) Project implementation schedule.

The project implementation schedule is shown by bar chart.

5. Description of Existing Environment

This chapter provides the condition of existing environment by type of resources.

5.1 Natural Environment

Natural environment features on project area and surroundings is described by the items in 5.1.1 and 5.1.2.

5.1.1 Physical Resources

1) Soil

Soil profile of the project site can include geological data, topology, soil type, slope condition, soil mechanic and watershed. A detailed seismology and geology study is provided, if available.

The history on land slide is provided, if any.

(Reference)

- CARDI (Cambodian Agricultural Research and Development Institute) soil type can be used to describe using ArcGIS software.
- Topographic information can be used from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Global Soil Organic Carbon Map, FAO, 2017

2) Climate

The items to be described include the following.

- Affecting weather information is described. The information could be temperature, rain fall, wind speed and pattern, wind direction, relative humidity and sea level (in coastal area) for several years (average data for at least last 5 years).
- The history on storm surge and earthquake, if any.
- Information on climate change such as adaptation study, if any.

(Reference)

- Information by Department of Meteorology, Ministry of Water Resources and Meteorology
- UNDP Climate Change Country Profiles, UNDP

3) Air quality

The items to be described include air quality situation by pollutants, major pollutants source such as power station and weather condition.

Baseline data is also described. At least 2 samples (one at the project site and another in the community near the project site considering wind direction and geography) are measured, while more samples can be measured when necessary. Determination of the number of sampling points depends on the scale of SEZ/Industrial zone, neighboring circumstances, suggestion by supervising authority etc. Concentrations of target parameters in the emission gas are comparable with reference standard. The description includes methodology, period and location with its characteristics such as distance from the sensitive area (community, hospital, school, temple/pagoda, etc.) and map.

While the area under expected impact depends on the natural and social conditions, 150m from the edge of the zone can be referred for the area under expected impact.

When site sampling is conducted, sampling sites are recommended at least at the project site and at the sensitive receptors site.

Example of data on air quality situation is shown in the Table 3 and concentration of hazardous substance can be referred to the Annex 2 of Sub-decree on Air Pollution (2000).

Table 3 Example of data on air quality situation

No	Parameter	Unit	Average time	Observed	Standards	Method
1	Carbon monoxide (CO)	mg/m^3	8 hours		20	
2	Nitrogen dioxide (NO_2)	mg/m^3	24 hours		0.1	
3	Sulfur dioxide (SO_2)	mg/m^3	24 hours		0.3	
4	Ozone (O_3)	mg/m^3	1 hour		0.2	
5	Lead (Pb)	mg/m^3	24 hours		0.005	
6	Total Suspended Particulate (TSP)	mg/m^3	24 hours		0.33	
7	PM10	mg/m^3	24 hours		0.05	
8	PM2.5	mg/m^3	24 hours		0.025	

(Source) Sub-decree on Air Pollution and Noise Disturbance and Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Ambient Air Quality Standard.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project
- Types of hazardous substances can be selected considering what substances will give adverse impacts in the ambient air during operation of the projected factory. Refer to the Annex 2 of Sub-decree on Air Pollution and Noise Disturbance, 2000
- Environmental Impact Assessment Technique for Road Project, National Institute for Land and Infrastructure Management, Japan, 2013(on the area under expected impact)

4) Noise and Vibration

Noise and vibration situation is described.

Baseline data is also described. At least 2 samples (one at the project site and another in the public building/area) are measured, while more samples can be measured when necessary. The description includes methodology, period and location with its characteristics such as distance from the sensitive area (community, hospital, school, temple/pagoda, etc.) and map. While the area under expected noise impact depends on the natural and social conditions, 200m for noise, 100m for vibration from the edge of project site can be referred for the area under expected impact.

Table 4 Example of data on noise

No	Area	Period of time					
		From 6 to 18		From 18 to 22		from 22 to 6	
		Observed	Standard (dB(A))	Observed	Standard (dB(A))	Observed	Standard (dB(A))
1	Quiet areas - Hospitals - Libraries - School - Kindergarten		45		40		35
2	Residential area: - Hotels - Administration offices - House		60		50		45
3	Commercial and service areas and mix		70		65		50
4	Small industrial factories intermingling in residential areas		75		70		50

(Source) Sub-decree on Air Pollution and Noise Disturbance

Table 5 Example of data on vibration

Daytime (From 06to 18)		Nighttime (From 18 to 06)	
Observed	Standard	Observed	Standard
	65 dB		60 dB

(Source) Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

(Reference)

- Sub-decree on Air Pollution and Noise Disturbance, 2000 prescribes Maximum permitted noise level.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project
- Environmental Impact Assessment Technique for Road Project, National Institute for Land and Infrastructure Management, Japan, 2013 (on the area under expected impact)

5) Water quality

The items to be described include water quality situation by pollutants and water source of premises such as existing local water supply is described.

Baseline data is also described. At least 2 samples (one at the project site (downstream side) and another at the natural water area) are measured, while more samples can be measured when necessary. Determination of the number of sampling points depends on the scale of SEZ/Industrial zone, neighboring circumstances, suggestion by supervising authority etc. Concentrations of target parameters in the effluent water (after treatment) into the public water body are comparable with reference standard. It includes methodology, period and location with its characteristics and map. When site sampling is conducted, sampling sites are recommended at the project site and at the important water user site such as water supply source. Table 6 shows an example of data on water quality.

Table 6 Example of data on water quality

No	Parameters	Unit	Observed	Standards	Method
1	pH	-			
2	Total Dissolved Solid (TDS)	mg/l			
3	Total Suspended Solid (TSS)	mg/l			
4	Dissolved Oxygen (DO)	mg/l			
5	Biological Oxygen Demand (BOD5)	mg/l			
6	Chemical Oxygen Demand (COD)	mg/l			
7	Oil and Grease	mg/l			
8	Detergent	mg/l			
9	Sulfate (SO4)	mg/l			
10	Total Nitrogen (TN)	mg/l			
11	Total Phosphorous (TP)	mg/l			
12	Lead (Pb)	mg/l			
13	Arsenic (As)	mg/l			
14	Cadmium (Cd)	mg/l			
15	Iron (Fe)	mg/l			
16	Mercury (Hg)	mg/l			
17	Total Coliform	NPN/100ml			

Note1: When consideration for aquatic organism is needed, Linear Alkyl Benzene Sulfonic Acid and its salts (LAS) which is used in detergent can be set as a parameter.

Note 2: When hazardous substances used for production are anticipated to give adverse impact on the surface and/or ground water in and near the project area, substances listed in Annexes of the Sub-decree below mentioned shall be added.

(Reference)

- Sub-decree on Water Pollution Control, 1999 prescribes Water Quality Standard in public water areas.
- Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

Table 7 Parameters and standard for surface water quality

No	Parameters	Unit	River water	Lake and reservoir	Marine
1	Acid or Base (pH)	-	6.5 – 8.5	6.5 - 8.5	7.0 – 8.3
2	Total Dissolved Solid (TDS)	mg/l	<1000	<1000	<1000
3	Total Suspended Solid (TSS)	mg/l	25-100	1-15	<60
4	Dissolved Oxygen (DO)	mg/l	7.5-2.0	7.5-2.0	7.5-2.0
5	Biological Oxygen Demand (BOD_5)	mg/l	1-10	<30	<30
6	Chemical Oxygen Demand (COD)	mg/l	<50	1-8	2-8
7	Oil and Grease	mg/l	<5.0	<5.0	0
8	Detergent	mg/l	<5.0	<5.0	0
9	Sulfate (SO_4)	mg/l	<300	<300	<300
10	Total Nitrogen (TN)	mg/l	0.1-0.6	0.1-0.6	0.2-1.0
11	Total Phosphorus (TP)	mg/l	0.005-0.05	0.005-0.05	0.02-0.09
12	Lead (Pb)	mg/l	<0.01	<0.01	<0.01
13	Arsenic (As)	mg/l	<0.01	<0.01	<0.01
14	Cadmium (Cd)	mg/l	<0.001	<0.001	<0.001
15	Iron (Fe)	mg/l	<1	<1	<1
16	Mercury (Hg)	mg/l	<0.0005	<0.0005	<0.0005
17	Total Coliform	NPN/ 100ml	<5000	<5000	<5000

(Source) Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism

Development Project

Table 8 Parameters and standard for groundwater quality when required

No	Parameters	Unit	Standards
1	pH	-	6.5-8.5
2	Turbidity	NTU	5
3	Electrode Conductivity (EC)	NTU	500-1500
4	Total Dissolved Solid (TDS)	mg/l	800
5	Total Hardness (as $CaCO_3$)	mg/l	300
6	Chloride	mg/l	250
7	Fluoride (F)	mg/l	1.5
8	Nitrate (NO_3)	mg/l	50
9	Sulfate (SO_4)	mg/l	250
10	Iron (Fe)	mg/l	0.3
11	Arsenic (As)	mg/l	0.05
12	Mercury (Hg)	mg/l	0.001
13	Chromium (Cr)	mg/l	0.05
14	Manganese (Mn)	mg/l	0.1
15	Aluminum (Al)	mg/l	0.2
16	Benzene (C_6H_6)	mg/l	0.01
17	Dichloromethane (CH_2Cl_2)	mg/l	-
18	Cadmium (Cd)	mg/l	0.003
19	Total coliform	MPN/100ml	0
20	E-coli	MPN/100ml	0

Note: Parameters are selected depending on the geology and the tunnel structure/construction work

(Source) Prakas on the Enforcement of TOR guideline for Infrastructure and Tourism Development Project

6) Hydrology and Water Resource

The items to be described include river, lake, reservoir, wetland and drainage system with map.

Describe the characteristics on water resources for the factory including location and type of water source.

Also, the items to be described include the following.

- If the water supply for the SEZ/Industrial zone is sourced out, available water resource for the planned source

- Water level (with warning water level, if any) and flow rate of river/lake by table.
- Run-off characteristics of watersheds. Delineation of watersheds and drainage pattern in the area of influence using aerial/remote sensing images is recommended.
- The history on flood and storm surge, if any.

(Reference)

- The Study on Hydro-Meteorological Monitoring for Water Quantity Rules in Mekong River Basin (JICA, 2004) (for hydrologic information)
- Department of Hydrology and River Works, Ministry of Water Resources and Meteorology (for hydrologic information)
- Mekong River Commission website

7) Waste management

Clarify availability of waste management (collection, treatment/recycle and disposal) service on both hazardous and non-hazardous waste. It includes covered type of waste and permit information by service provider.

5.1.2 Biological Resources

1) Forest

The items to be described include the following.

- Situation on forest area such as vegetation and forest cover with map
- The designated protected area (especially Core zone and Conservation zone) on forest, if there is in proximity of the project site. Clarification on zoning is important
- The methodologies for the study, such as direct observation (with map on location), local interview, analysis of reference documents.

(Reference)

- The Law on Forestry (Royal Kram) prescribes permanent forest reserve, production forest, protection forest and community forest. Also the Law has provisions on environmental and social impact assessment.
- The Protected Areas Law
- Cambodia Forest Cover, 2014 (Forestry Administration, 2016)

2) Protected area

The items to be described include the following.

- The designated protected area concerning biological resources, especially Core zone and Conservation zone, if there is in proximity of the project site.

- Clarification on zoning is important and zoning information could be collected from the Sub-decree on individual Protected area or local government.
- The methodologies for the study such as direct observation (with map on location), local interview, analysis of reference documents.

For the location of SEZ/Industrial zone, it is better to avoid the area inside or neighboring the Core zone and Conservation zone

(Reference)

- Protected Areas Law prescribes the category of the protected areas and zoning (Core zone, Conservation zone, Sustainable use zone and Community zone) of the protected areas.
- Sub-decree on individual Protected area

3) Wildlife species and habitats

Wildlife species and their habitats are described, especially endangered species. This includes rare species, endemic species and movement (corridor and migratory pattern). The methodologies for the study are also described such as direct observation (with map on location), local interview and analysis of reference documents.

(Reference)

- WWF (World Wide Fund for Nature (https://www.worldwildlife.org), CI (Conservation International (https://www.conservation.org), and WCS (Wildlife Conservation Society (https://www.wcs.org) website on endangered species.

4) Biodiversity and ecological systems

The items to be described include the following.

- Situation on biodiversity and ecological system, including endangered species and important biological corridor, if there is in proximity of the project site
- The designated protected area and sensitive area
- The ecology resources function (forest/ecology system situation and function) with the result of 1), 2) and 3).
- The methodologies for the study such as direct observation, local interview or analysis of reference documents.

5) Aquatic resources

The items to be described include the following.

- Situation on aquatic resources. It can be inland resources and/or marine resources in the case the project site is in coastal or sea area. Fishery is important resource in both food and employment in Cambodia.

- The methodologies for the study, such as direct observation, local interview or analysis of reference documents.

(Reference)

Reports of Ministry of Agriculture, Forest and Fishery

6) Wetland systems, if related

Situation on wetland is described, if there is crossing in or near designated wetland site such as by the Ramsar Convention (Boeng Chhmar and Associated River System and Flood Plain, Prek Toal Ramsar Site, Koh Kapik and Associated Islets, and Middle Stretches of Mekong River North of Stoeng Treng).

5.2 Social and Economic Resources

1) Social and economic study methodologies

Well designed social and economic study is important, as SEZ/Industrial zone requires big area of land. The methodologies of social and economic study is described including following.

- The project area and location
- Selection of targeted villages/communities
- Sampling method and sample size compared with the population/number of household
- Items surveyed.
- (if included) The replacement cost policy including eligibility and methodologies to identify the ownership/occupancy of assets

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

2) Demography and settlement

Population, villages and settlements is described.

(Reference)

- General Population Census by National Institute of Statistics

3) Economic status

Economic situation is described such as economic growth, income (primary and secondary) level, major industry/product and major employment.

(Reference)

- Economic Census of Cambodia by National Institute of Statistics

4) Land use and land registration

Land use is described such as industrial area, forest area, city area and agriculture area. Also the land use master plan is described, if any.

In the case land acquisition is planned, land ownership and occupancy with the relation with the project area is described.

(Reference)

- Land use information can be used by revised information from the Study on the Establishment of GIS Base Data for the Kingdom of Cambodia (JICA, 2002).
- Land law (2001)
- Expropriation Law (2010)
- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

5) Water use

Water resources and water s use including water source and purpose is described.

6) Energy use

Major energy source is described.

If the power supply for the SEZ/Industrial zone is sourced from outside the zone, power delivery from the planned source is described.

7) Infrastructure

Major public infrastructures in the area (ex. roads, irrigation, parks, water supply and sewage etc.) are described.

If the water supply for the SEZ/Industrial zone is sourced from outside the zone, water use from the planned source is described. If the sewage from the SEZ/Industrial zone is connected to the sewage system outside the zone, existing sewerage system is described.

8) Education

Situation on education is described such as literacy rate and school enrollment rate.

The crossing of the project site and school routes is described, if any.

9) Public health and well-being

Situation on public health and well-being is described.

(Reference)

- Cambodia Demographic and Health Survey by National Institute of Statistics

10) Heritage/culture

Heritage (cultural heritage, historical monuments, landscape, ancient temples, pagodas and customs/traditions) is described, especially ones designated/listed by the Protected Area Law and UNESCO/Government, if any.

Cultural characteristics and important cultural/traditional sites are also described.

(Reference)

- Law on Protection of Cultural Heritage prescribes protected sites and inventory on cultural property.
- Information by Ministry of Culture and Fine Arts

11) Marginal group

The poor, ethnic minority and indigenous people is identified.

Situation on the poor, ethnic minority and indigenous people is described such as by specific socio-economic survey and the latest National Census Reports.

(Reference)

- Sub-Decree on Procedures of Registration of Land of Indigenous Communities
- Information by local government

12) Tourism destinations

Situation on tourism resources and their use is described, if any.

(Reference)

- Tourism Development Strategic Plan 2012-2020

13) Others

The result of the social and economic study such as replacement cost study is described if it is not covered in the above.

The presence of unexploded weapons is described when there is possibility.

6. Public Participation

The items to be described include the following.

- The public participation process, especially the process to provide project affected people and other stakeholders the opportunities to be informed and consulted, to express an opinion about projects including activities, and to allow effective involvement.
- The methodology and procedure of public participation such as identification of project affected people and other stakeholders, how to inform including access to

the information and how to consult including feedback.

The plan of public participation has 3 stages following the Term of Reference on Infrastructure and Tourism Development Project (Prakas No.120, 2018):

Table 9 Stages of public participation

Stages		Outline
1	Information dissemination at project site	The project owner and consultant company disseminates information to stakeholders in order to inform them about the project inception, scope, impact exposure as well as preliminary information and people who get impact from the project.
2	Interviewing the authorities, involved departments	The project owner and consultant company interviews with authorities, involved departments and stakeholders, and/or prepares the Focus Group discussion in order to get the opinion and comments on the project.
3	Dissemination Workshop	The project and consultant company prepares the public disseminationworkshop in order to show the result of Environmental Impact Assessment Report and stakeholders interview

Following points are also described.

- Dissemination by the project owner with local authorities and local communities of the development project
- Feedback from relevant provincial departments/ agencies and relevant local authorities
- Comments from relevant non-government organizations (NGOs);
- Consultation with affected local communities
- Conclusions on results of the public consultation

Also, the project owner establishes and informs the grievance redress mechanism which deals with complaints and grievances.

7. Environmental Impacts and Mitigation Measures

This chapter provides information on impacts and mitigation measures by project phase.

7.1 A summary of impacts and mitigation measures

The view on determination of impacts and mitigation measures are described. The project phase is covered from design to closure. The following points are included.

- Matrix to show the relation between the project activities and impact on environmental resources for determining the potential of impact level
- Geographic Information System (GIS) by using Tool Overlay to identify an area where the projects impact on environment
- Check list for identifying the impact level by the summary table below

The summary of 7.2 is shown by such as following table.

Table 10 Summary of impacts and mitigation

Environmental and Socio-Economic Aspects	Negative Impacts	Scope of Impacts			Mitigation Measure	Remark
		Low	Moderate	High		
1. Negative impacts of design and construction **phase**						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
2. Negative impacts of operation **phase**						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						
3. Negative impacts of closure **phase**						
A. Natural environment						
- Physical resources						
- Biological resources						
B. Social & economic resources						

7.2 Impacts and mitigation measures by project phase

In this section, the contents and degree of impacts is described by project phase. , It includes methodologies for estimating/forecasting impacts and evaluation of estimated/forecasted impacts.

If the locating companies/factories are not clear, potential impacts from locating/inviting premises are described in qualitative manner in operation phase.

Mitigation measures on the expected impact is described with the description how and what level the expected impacts are mitigated.

Following is the example for listed possible impacts and mitigation measures by impact items. When describing the expected impact, not only describing the expected impact but also how the expected impact is derived and evaluation of the impact (for example, comparison with the environmental standard) is described. Also, when describing the mitigation measures, not only the measure itself but also how the measure mitigates the impact or how much impact is mitigated is described.

(Reference)

- Environmental, Health, and Safety Guidelines, IFC[1] (there are many guidelines covering sectors such as infrastructure and many type of industries, and general guidelines including health & safety. It is also useful to consider potential impacts from locating/inviting premises.)

7.2.1 Impacts and mitigation measures during design and construction phase

Physical Resources

1) Soil erosion/quality

(Design and construction phase common)

- Impact due to the removal of top soil.
- Impact due to erosion and consequent modification of natural conditions.
- Impact due to destabilization of slopes.
- Impact due to usage of heavy machinery for material transportation.
- Impact on subsidence by drainage change and additional weight to the soil in subsidence prone area.

【Mitigation measures】

(Design and construction phase)

- Engineering measures for slope protection and erosion control.
- Drainage improvements for prevention of soil erosion and siltation of water course. Also, drainage and curtain covering the pathway to prevent erosion in the bridge construction case.
- Slope stabilization techniques and erosion control measures.

(Design phase)

- While selecting project site, avoiding areas prone to landslides, soil erosion, and subsidence.
- The erosion potential of construction alternatives is carefully examined and selecting the one involving least disturbance to the natural ground

(Construction phase)

- Reduction of the need for borrow pits and minimization of excess spoil material generation.
- Restoration, revegetation and rehabilitation measures.
- Construction of drainage ensuring the stability of the slope.

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[1] https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines

2) Air quality

(Construction phase)

- Impact due to vehicular emissions from vehicles including heavy vehicles used for construction.
- Impact due to dust generation from material handling, storage, operation of crushers and hot mix plants, movement of construction vehicles, construction activities, excavation of soil and cutting of embankment near to habitation, hospitals, schools, sanctuaries etc.

【Mitigation measures】

(Design phase)

- Selecting project site which avoids area close to housing, schools, hospitals etc.
- Providing sufficient capacity to avoid traffic congestion, even with projected increase in traffic flow.
- Ensuring buffer area with planting tall leafy vegetation between project site and human settlements.

(Construction phase)

- Periodical watering and transporting construction materials with tarpaulin coverage during the construction phase.
- Provision of air pollution control systems in stone crushers and hot mix units to meet the emission regulation.

3) Noise & vibration

(Design and construction phase)

- Impact of noise on the surrounding community due to vehicle movement.
- Impact of noise on wild life and becoming the project becoming a barrier to regular wild life travel routes.
- Impact of noise and vibration during construction activity including operation of various equipment.
- Impact of vibrations during blasting activity, if any

【Mitigation measures】

(Design phase)

- Avoiding noise sensitive areas.
- Provision for machines and equipment with acoustic enclosures and silencers.
- Provision of noise barriers.
- Ensuring buffer area with planting tall leafy and dense vegetation between project site and noise sensitive areas.

(Construction phase)

- Provision of mandatory acoustic enclosure /acoustic treatment of room for stationary generator sets.
- Avoiding or minimizing stone quarrying and blasting activity.

4) Water quality

(Design and construction phase)

- Impact due to drain from construction site.
- Impact due to wastewater generated from the temporary project offices and temporary workers housing area.
- Impacts caused by oil leaks from machinery, changing machinery or pollution caused from unsuitable storage conditions and location.

【Mitigation measures】

(Design and construction phase)

- Measures to minimize sedimentation, erosion and wastewater run-off such as basins, artificial wetlands, grass filter strips and buffer zones.
- Silt screens and sediment traps to be made before out-letting to water bodies to minimize turbidity and silting in local water bodies.
- Wastewater treatment.
- Storing broken machinery and equipment adequately in a warehouse.

5) Hydrology/ groundwater and water use/rights

(Design and construction phase)

- Impact due to surface water flow modifications. If the project intersects drainage basins, it may modify the natural flow of surface water by concentrating flows at certain points and in many cases, increasing the speed of flow, result in flooding, soil erosion, channel modification and siltation of streams.
- Impact on channel capacities and existing floodways.
- Impact on water facilities such as, wells, hand pumps, tube wells etc. falling around the construction area.
- Coordination with provincial department of water resources and meteorology (DoWRAM) and other agricultural groups to collect information and discuss mitigation measures.

【Mitigation measures】

(Design phase)

- While selecting project site, avoiding the location of cutting significant water flows.
- In case of flood prone areas and/or areas with very flat slopes, hydrological surveys are conducted before project site finalization. Inputs derived from these surveys

such as the need for provision of culverts/bridges or other drainage structures is considered.

- Drainage improvements to avoid water logging and flooding due to disturbance of natural drainage pattern are considered.
- Water flow speed control is exercised to check surface runoff's and silt loads during construction activities.
- Design and construct a detour while constructing a bridge across a canal, stream or on any irrigation project.
- In dry areas, drainage can be designed to retain water in small dams or maintain a high water table.
- Rehabilitation of water flows and provision of alternative water supplies.

<u>Biological Resources</u>

6) Protected areas

(Design and construction phase)

- Impact due to the project in and next to the protected area.
- Impact due to the disturbance to the access to the protected area.
- Impact due to changes in land profile.

【Mitigation measures】

(Design and construction phase)

- Selecting project site which avoids in or close to the sensitive area.
- Providing new location for rehabilitating/compensating, if potential impacts are unavoidable.

7) Ecosystem including biodiversity such as forest and wildlife

(Design and construction phase)

- Impact due to removal of trees in the project site.
- Impact on forest resources, economically important plants including medicinal plants and threat to endangered species.
- Impact on wildlife habitat including wildlife corridors and biodiversity due to change in land use.
- Impact due to fragmentation of wildlife habitat and territories.
- Pressure on habitats of wildlife as a result of increased access.
- Impact due to changes in water quality, soil profile, noise, light and air pollution, which may affect the nature and character of habitats.
- Impact on food chain, if the project may destruct the food chain of the ecosystem.

【Mitigation measures】

(Design phase)

- Selecting project site which avoids in or close to biodiversity sensitive area.
- Providing new habitats for rehabilitating/compensating.
- Providing non-structural measure such as ultrasound.

(Construction phase)

- Prohibiting workers to set an animal trap, hunt or kill the wildlife.
- Prohibiting logging outside of the project boundary for the purpose of construction.

<u>Social and Economic Resources</u>

8) Resettlement and decent livelihood

In principle, resettlement including livelihood restoration is managed by resettlement plan/framework prepared by the project owner and approved by Inter-Ministerial Resettlement Committee (IRC)). The summary and data from resettlement plan/framework is described. Social and economic survey on potential project affected people provides an important basis to prepare the resettlement plan/framework.

(Design phase)

- Describing land acquisition including ownership of land, land use and population.
- Clarifying the procedure and institutional setting on land acquisition and resettlement, considering vulnerable people and marginal groups.
- Clarifying the policy on compensation and livelihood restoration.
- Impacts due to the land acquisition on residence, land and living measures

【Mitigation measures】

(Design phase)

- Selecting project site which minimizes the resettlement and impacts by land acquisition and resettlement.
- Careful plan and study on land acquisition and resettlement.

(Construction phase)

- Implementation of land acquisition and resettlement as planned.
- Monitoring the progress of the process and the situation after the resettlement.

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

9) Land use

Adverse land use impacts may arise from the displacement of existing uses, preventing access across it or new land use. Indirect impacts may arise on the natural resources of the area. Identification and assessment of land use, ownership, property values and economic activities is important.

In urban areas, the principal impacts arise from the dislocation of urban activities.
In rural areas, the principal impacts arise from the acquisition and severance of rural holdings. High quality of agricultural land could be lessened by severance.
Natural systems, visual amenity and historic/cultural resources could be disturbed.

【Mitigation measures】

(Design phase)

- While selecting project site, avoiding areas of productive lands such as fertile agriculture lands.
- Provision of alternative land.
- Economic compensation.

(Reference)

- Sub-decree on Land Acquisition and Involuntary Resettlement (2018)

10) Heritage/culture

(Design and construction phase)

- Impact on the heritage/cultural site itself and access to the heritage/cultural site through the identification of the heritage/cultural site.
- Coordination with Ministry of Culture and Fine Arts or related institution to collect information and discuss mitigation measures.

【Mitigation measures】

(Design and construction phase)

- Selecting project site which avoids passing through or close to the heritage/cultural site.
- Providing new location or rehabilitating/compensating heritage/cultural site.

11) Infrastructure

(Design and construction phase)

- Impact on existing infrastructure, such as traffic disturbance on roads.
- Impact on existing infrastructure by change of existing road such as diversion and closure of lane for the construction work.
- Impact on existing infrastructure by cutting existing infrastructure such as communication, power and water

【Mitigation measures】

(Design and construction phase)

- Provision of local access roads where access to main arteries for promoting traffic efficiency and safety.
- Provision of alternative routes during construction if existing traffic is much

disrupted.

- Re-installation of existing infrastructure.

12) Landscape

(Design phase)

- Impact on the significant landscape by the project such as major land clearing and tree cutting.

【Mitigation measures】

(Design and construction phase)

- Landscaping, rehabilitation and compensation.

13) Marginal group

(Design and construction phase)

- Impacts on the poor, ethnic minorities & indigenous people.
- Collecting information from the latest National Census.

【Mitigation measures】

(Design and construction phase)

- Planning and implementing indigenous peoples plan.
- Provision of livelihood program.

14) Working condition

(Construction phase)

- Impacts on working condition, accidents, health and safety of construction workers.
- Coordination with Ministry of Labor and Vocational Training or related institution to collect information and discuss mitigation measures.

【Mitigation measures】

(Construction phase)

- Complying with Labor Law and Law on Social Security Schemes.
- Providing safety measures such as mandatory helmet and health check.

15) Public health

(Construction phase)

- Potential of occurrence of species communicating diseases such as mosquito by pooling of water.
- Potential of occurrence of communicable diseases through workers.
- Impact on pneumonia/respiratory disease is caused by dust

【Mitigation measures】

(Construction phase)

- Provision of drainage at the project site including borrow pits.
- Routine watering and reducing the dust that leads to pneumonia occurrence.
- Appropriate waste management to avoid inappropriate waste disposal at the project site.
- Provision of health education/training program for the construction workers by the contactor.

16) Risks (man-made risks)

(Construction phase)

- Impact due to spillages and accidents of vehicles/storage with chemicals and fuels.
- Potential impact by accident.

【Mitigation measures】

(Construction phase)

- Appropriate drainage arrangements with catch drains and catch pits is planned to prevent the spillage of chemicals and fuels reaching the water bodies.
- Provision of traffic safety measures such as signs and safe crossings.

(Reference)

National Road Safety Policy, 2014

17) Climate change

(Design phase)

- Impacts and mitigation measures are described in qualitative way when the project increases the emission of climate change gas significantly.

18) Waste management

(Construction phase)

- Impacts by dust and particulate matter from construction waste including its storage.
- Impacts on waste landfill site by accumulating construction waste.

【Mitigation measures】

(Construction phase)

- Minimizing amount of waste
- Control of dust and particulate matter by water spraying.
- Designating appropriate landfill site for disposal of waste.

7.2.2 Impacts and mitigation measures during operation phase

<u>Physical Resources</u>

1) Soil erosion/quality

- Impact due to erosion and consequent modification of natural conditions.
- Impact due to destabilization of slopes.
- Impact on subsidence by drainage change and additional weight to the soil in subsidence prone area.

【Mitigation measures】

- Maintenance program for all erosion control works.
- Prevention of soil contamination by prevention of seepage of wastewater or hazardous waste

2) Air quality and noise & vibration

- Impact of emissions from promises to be located (could be qualitative when premises are not fixed).
- Impact due to vehicular emissions and dust caused by vehicles.
- Clarifying the methodology to explain the expected impact
- Impact of noise on the surrounding community due to vehicle movement.
- Impact of noise on wild life.

【Mitigation measures】

- Ensuring premises complying related regulation by installing and operating control equipment. If needed, voluntary control of pollutants by locating premises which are not prescribed in regulation.
- Ensuring buffer area with planting tall leafy vegetation between project site and human settlements.
- Preventing encroachment to the buffer area.
- Setting noise barrier.
- Monitoring on air quality and noise.

(Reference)

- Environmental, Health, and Safety Guidelines, IFC

3) Water quality

- Impact of wastewater from promises to be located (could be qualitative when premises are not fixed).
- Impacts by drain with sedimentation and increased turbidity.
- Run-off such as oils, greases and waste water.

【Mitigation measures】

- Ensuring premises complying related regulation by installing and operating control equipment. If needed, voluntary control of pollutants by locating premises which are not prescribed in regulation.
- Maintenance program for controlling run-off and waste water.
- Monitoring on water quality.

(Reference)

- Environmental, Health, and Safety Guidelines, IFC

4) Hydrology/ groundwater and water use/rights

- Impact due to surface water flow modifications such as potential flooding and decrease of water supply.
- Impact on channel capacities and existing floodways.
- Impact on water resource if groundwater or neighboring water source is used for water supply to the premise to be located.

【Mitigation measures】

- Maintenance program for controlling water flow change and water use.
- Control of water use by the premise to be located.
- Monitoring on hydrology and water use.
- Prevention of groundwater contamination by prevention of seepage of wastewater or hazardous waste.

<u>Biological Resources</u>

5) Protected areas

- Impact on the protected objects under the protected area.
- Impact due to the disturbance to the access to the protected area.
- Impact due to changes in land profile.

【Mitigation measures】

- Maintenance program for controlling measures.
- Monitoring on the situation of the protected area.

6) Ecosystem including biodiversity

- Impact on forest resources, economically important plants including medicinal plants and threat to endangered species.
- Impact on wildlife habitat and biodiversity due to change in land use.
- Impact due to fragmentation of wildlife habitat and territories.
- Impact due to changes in water quality, soil profile, noise, light and air pollution, which may affect the nature and character of habitats.

- Impact on food chain, if the project may destruct the food chain of the ecosystem.

【Mitigation measures】

- Maintenance program for controlling measures.
- Monitoring on the situation of the ecosystem.

<u>Social and Economic Resources</u>

7) Involuntary resettlement and livelihood

【Mitigation measures】

- Maintenance and operating program as planned in the resettlement planning.
- Monitoring on the situation after the land acquisition and resettlement.
- Employment by locating premises.

8) Land use

【Mitigation measures】

- Maintenance program as planned in the planning.
- Monitoring on the situation after the land use change.

9) Heritage/culture

- Impact on the heritage/cultural site itself and access to the heritage/cultural site by the project.

【Mitigation measures】

- Maintenance program as planned.
- Monitoring on the situation during the operation.

10) Infrastructure

- Impact on existing infrastructure through the induced traffic by the project.

【Mitigation measures】

- Planning and constructing additional structure, if needed.
- Monitoring on the situation during the operation.

11) Landscape

【Mitigation measures】

- Monitoring on the situation during the operation.

12) Marginal group

【Mitigation measures】

- Implementing indigenous peoples plan, if any.

- Provision of livelihood program.
- Monitoring on the situation during the operation.
- Employment by locating premises.

13) Working condition

- Impacts on working condition, accidents, health and safety of operation and maintenance workers.

【Mitigation measures】

- Complying with Labor Law and Law on Social Security Schemes.

14) Public health

- Potential of occurrence of species communicating diseases such as mosquito by pooling of water.

【Mitigation measures】

- Appropriate wastewater management generated at premises.
- Provision of health program for the workers.

15) Risks (man-made risks)

- Impact due to spillages and accidents of vehicles/storage with chemicals and fuels.
- Potential impact on the increase of traffic accident.

【Mitigation measures】

- Appropriate drainage arrangements with catch drains and catch pits is planned to prevent the spillage of chemicals and fuels reaching the water bodies.
- Provision of traffic safety measures such as safe crossings.
- Safety education/training to the residents.
- Contingency plan to prepare for accidents.

(Reference)

National Road Safety Policy, 2014

(Others)

16) Waste management

- Impact from waste generated by premises to be located.

【Mitigation measures】

- Appropriate waste management plan by kind of source of waste.
- Appropriate contract and recording between waste generator and waste management service provider.

17) Cumulative impacts

Cumulative impacts are described with focus on combination with other projects, with map of other project sites. Cumulative impacts can be the case when a project/ activity that may give severe impacts on the target project is identified. Such projects include major road or major area development project in the same project site and/ or its neighborhood.. Methods could include the following;

- Rough estimation of cumulative pollution loads
- Matrix list for identifying the relation between project activities and impact
- Showing Geographic Information System (GIS) by Tool Overlay to identify an area on the projects impact
- Check list for identifying the impact level

【Mitigation measures】

- Keeping enough distance between infrastructures/buildings

7.2.3 Impacts and mitigation measures during closure phase

How the environmental management plan is continued when change of project owner is described.

Also how the environmental and social condition is transferred/ maintained when part or whole project is closed is described.

7.3 Description of the positive environmental and socio-economic impacts

Positive impacts for both environmental and socio-economic impacts are described.

8. Environmental Management Plan (EMP)

Following points are described to clarify the management of the environmental measures planned.

1) Agency

Agency/institution responsible for project implementation and monitoring is described. Also, supervising (control) institution is described. Possible responsible institutions include the project entity (owner), related authorities, contractors for construction and management, third party, stakeholders etc.

2) Institutional arrangement

Institutional set-up such as procedures and organization to manage each impacts and mitigation measures is described.

It includes communication network with locating premises.

3) Trainings

Training programs for staffs for environmentally and socially sound performance is described.

4) Monitoring plan including methodology

The plan to monitor impact and mitigation measures is shown. Also, following points are described.

- Baseline conditions before construction through the analysis of existing conditions.
- Monitoring plan including parameters, methodology, monitoring points and frequency, by impact.
- Methodology of monitoring includes parameters of impact and schedule.
- Environmental standards or guidelines for monitoring.
- Progress/situation on mitigation measures by impact.
- Quarterly monitoring report to be submitted to the Ministry of Environment and relevant ministries/agencies.
- Emergency response plan for emergency case such as serious accident.
- Monitoring on performance of locating premises, if planned.

5) Assessment of monitoring results

Criteria to assess monitoring results is described.

6) Budget plan for EMP

The budget plan to implement EMP is described. The contribution to the Social and Environmental Fund is described.

(Reference)

- Sub-decree on the Establishment of Social and Environmental Fund
- Joint Prakas of Ministry of Environment and Ministry of Economy and Finance

7) Monitoring report

The above points are compiled to the monitoring report by the agency/institution responsible for project implementation and monitoring. The monitoring report is submitted to the Ministry of Environment and if necessary, to relevant ministries.

9. Economic Analysis and Environmental Value

This chapter provides the economic analysis.

1) Project benefit

Project benefits are described such as improvements in the physical infrastructure and access, improvements in social services by development of economy including improvements in life style.

2) Economic analysis

Cost benefit analysis of the project is described with methodologies and indicators/parameters including valuation methods including adverse environmental and social impact. Following points are shown with sources and references.

- Financial analysis: base on profit and loss of the project
- Economic analysis: economic valuation of cost and benefit
- Environmental damage analysis: direct and indirect cost analysis on individual resources

(Reference)

- UNEP (1988) Environmental Impact Assessment: Operational Cost Benefit Analysis - Marc Report No. 42
https://wedocs.unep.org/bitstream/handle/20.500.11822/28857/EIA_Operational_CBA.pdf?sequence=1&isAllowed=y

10. Conclusions and Recommendations

This chapter provides the conclusions and recommendations.

The conclusion is described with the justification, mitigation of major impacts and overall benefits of the project including promotion of local livelihood.

Also, the project owner's assurance and responsibility for the environmental impact assessment is clarified.

The recommendation to the project owner and, if any, to the stakeholders shall be described.

11. References

Reference documents quoted are written down with the author/institution, title of the document, name of the journal, if any and year published.

12. Annex

Attached documents such as maps and figures are shown as Annex.

Appendix

Characteristics of SEZ and Industrial Zone (Reference)

1. Sub-Decree on the Establishment and Management of the Special Economic Zone
1) Following is the definition from the Sub-Decree on the Establishment and Management of the Special Economic Zone.

- **Export Processing Zone** refers to the zone of industrial activities and other activities related to the production and transformation of goods only for export.
- **Free Trade Area** refers to the area for service provision, storage, demonstration, packaging, cleaning, and finishing of production outputs, products, materials, or other equipments, whose import-export in /out of the zone are provided with duty exemption, except for export to other places in the Kingdom of Cambodia whereby such import-export is subject to the duty and excise in accordance to the applicable law.
- **General Industrial Zone (GIZ)** refers to a zone established for industrial activities and other activities related to the production and transformation of goods for domestic use as well as for export.
- **Special Economic Zone (SEZ)** refers to the special area for the development of the economic sectors which brings together all industrial and other related activities and may include General Industrial Zones and/or Export Processing Zones. Each Special Economic Zone shall have a Production Area which may have a Free Trade Area, Service Area, Residential Area and Tourist Area.
- **Zone Developer** refers to a Cambodian or/and foreign natural or legal person, who implements the Qualified Investment Project, and permitted to invest in the development of physical infrastructures in the zone, and organization of business, services and ensuring the safety and security of the Zone Investors.

2) Articles prescribe the following on environment:
Article 3.1
3. The Establishment of the Special Economic Zone shall be pursuant to the following conditions:

(d) It must have water sewage network, waste water treatment network, location for storage and management of solid wastes, environment protection measures and other related infrastructures as deemed necessary.

(e) It must comply with technical requirements, regulations and basic rules on construction, environment and other obligations in the development of Special

Economic Zone as defined in the instructions issued by relevant ministries or institutions taking into account the geography and specific size of each zone and pursuant to the existing laws, national and international standards.

Article 3.2

3. The Zone Developer who receives an approval for the establishment of a Special Economic Zone from the Cambodian Special Economic Zones Board has 180 (one hundred eighty) working days, which may be extended based on serious reasons, to do the following:

a) Conduct detailed economic feasibility study of the project including the preparation of the master plan of all infrastructures in the zone such as connecting roads from the zone to outside area, water-electricity network, environmental measures, and information concerning local services costs, land rental, factory rental, water, electricity, phone services and security costs, cost of using public space in the area for the Zone Investors, cost for workers, employees and employers to reside, and vocational training center, among others; and

Article 4.2

4. to prepare guidelines on management and workers training, environment, construction, import/export, entitlement to investment incentives and other technical affairs, including facilitation of relations with the ministries or institutions of the Royal Government of Cambodia in order to ensure smooth and effective conduct of the affairs of the Special Economic Zones;

Article 4.4

The Zone Developer has the following duties:

(c) to construct infrastructures in the zone, including electricity, water, road, and telecommunication networks, environment protection and management network, build warehouses, fire-fighting station and other necessary facilities;

Article 10.7

Any violation, by the Zone Investor in any area of the Export Processing Zone, of the principles of movement of goods, not related to the intended purpose, not compliant to the environment management regulations, production regulations, production of non authorized goods, non-conformity with production standards, the production or use of benefits provided by the State which were used for other purposes than the authorized ones, are subject to fine and punishment in accordance with the applicable laws and regulations.

2. Characteristics on impacts

1) Impacts include two aspects;

- Impacts by zone and infrastructure development
- Impacts by locating premises

This resulted in to consider cumulative impacts.

2) Often big area is developed, and size of the developed area becomes tens or hundreds hectares. That resulted in bigger impact can be expected in general.

3) It will bring increased traffic and employment opportunities including immigration which resulted in induced development.

Other reference documents

Environmental Impact Assessment for International Cooperation, Japan Ministry of the Environment 2000 (in Japanese)

Technical Guideline for Environmental Assessment: Ambient Air, Water, Soil and Environmental Loads, Japan Ministry of the Environment 2017 (in Japanese)

Technical Guideline for Environmental Assessment: Biodiversity and Communication with Nature, Japan Ministry of the Environment 2017 (in Japanese)

Environmental, Health, and Safety Guidelines－General EHS Guidelines, International Finance Corporation (IFC), 2007

Environmental, Health, and Safety Guidelines－Industry Sector Guidelines, International Finance Corporation (IFC), 2016

添付資料 10　Revision of Sub-Decree No.27 on Water Pollution Control

Kingdom of Cambodia
Nation Religion King

Royal Government of Cambodia
No. 103 ANKR.BK

Sub-Decree
On
Revision Article 4, Article 9, Article 11, Article 12, Article 17 and Annex 2, Annex 3, Annex 4, and Annex 5 of Sub-Decree No. 27 issued on 06 April 1999 on Water Pollution Control

Hereby Decided

Article 1

Article 4, Article 9, Article 11, Article 12, Article 17 and Annex 2, Annex 3, Annex 4 and Annex 5 of Sub-Decree No. 27 issued on 06 April 1999 on Water Pollution Control has revised as below:

Article 4: New

Standards for effluent discharge from any sources of pollution shall follow the effluent standard specified in Annex 2 of this sub-decree.

Article9: New

Strictly prohibited:

a. Discharge of sewage from pollution source into public drainage system or public water area without treatment or not follow to the effluent standard specified in the annex of official legal document
b. Wastewater discharge without passing through the wastewater treatment plant
c. Sewage embedding or wastewater effluent pumping without passing through wastewater treatment plant
d. Failure to operate the wastewater treatment plant or improper operation of wastewater treatment plant accordance with technical specification specified in the permit of the institution/ministry.

Article 11: New

The types of any sources of pollution that shall be required to have a permit from the Ministry of Environment before discharging or transporting their effluent to other places as mentioned in the Annex 3 of this sub-decree are classified into three following categories:

a. The sources of pollution of category I that are subject to the prior permit from the Ministry of Environment when the amount of their effluent exceed 40 m^3 /day but not including the amount of water volume used for cooling the engine.

b. The sources of pollution of category II that are subject to the prior permit from the Ministry of Environment when the amount of their effluent exceed 20 m^3 /day but not including the amount of water volume used for cooling the engine.

c. The sources of pollution of category III that shall be necessarily required to apply for the permission from the Ministry of Environment.
The procedure of permit requirement for discharge and transportation of effluent shall be specified by the Prakas of the Ministry of Environment on Procedure for Requesting Wastewater Discharge or transportation Permit.

Article 12: **New**

Permit requirement for effluent discharge from pollution sources is approved only if:

a. Equipped with wastewater treatment and waste disposal equipment in accordance with technical specification and in normal condition of operation

b. Wastewater discharge is responding to the effluent standard

Permit requirement for transportation of effluent from pollution sources is approved only if:

a. The purpose of request wastewater transport to other places and the way management of wastewater receiving facility are clearly stated

b. Meet the requirements specified by the Prakas on Procedure for Requesting Wastewater Discharge and Transportation Permit

Article 17: New

The permit of the discharge could be revoked temporarily or definitively if:

a. Failure to comply with effluent standard

b. Failure to comply with requirement stated by discharge permit

c. There are cases of environmental pollution or health hazards caused by deficient or negligible wastewater management activities

Article 2

Any provision which is contradicted to this sub-decree shall be nullified.

Article 3

The Minister in charge of the Council of Minister, the Minister of Economy and Finance, The Minister of Environment, the Ministers of all ministries and Directors of relevant institution shall be in charge of implementing this sub-decree according to their own obligation from the date when this sub-decree is signed on.

Phnom Penh, June 29, 2021

Prime Minister
Samdach Akka Moha Sena Padei Techo Hun Sen

Respectfully Yours,
Minister of Environment
Say Sam Al

Annex 2:
Effluent Standard for Pollution Sources Discharge Wastewater

No	Parameters	Unit	Effluent standard		
			Public water area Category I	Public water area Category II	Sewage connect to central wastewater treatment plant
1	Temperature[1] (T)	°C	<40	<40	<45
2	Color	mg/Pt/l	<50	<150	<300
3	TSS	mg/l	<50	<100	<200
4	pH		6-9	5.5-9	5-9
5	BOD_5	mg/l	<30	<60	<200
6	COD ($Cr_2O_7^{2-}$)	mg/l	<60	<120	<300
7	Oil and Grease	mg/l	<5	<10	<30
8	Detergent	mg/l	<5	<10	<30
9	Ammonia (NH_3 as N)	mg/l	<7	<10	<30
10	Nitrate (NO_3^{-1} as N)	mg/l	<10	<20	-
11	Cl_2	mg/l	<1	<2	-
12	Cl^-	mg/l	<500	<1000	-
13	Phosphate (PO_4^{3-})	mg/l	<2	<5	-
14	Total Nitrogen (T-N)	mg/l	<20	<40	-
15	Total Phosphorus (T-P)	mg/l	<4	<6	-
16	Hydrogen Sulfide (H_2S)	mg/l	<0.2	<0.5	<1
17	Manganese (Mn)	mg/l	<1	<3	<5
18	Boron (B)	mg/l	<1	<2.5	<5
19	Barium (Ba)	mg/l	<2	<5	<7
20	Cyanide Free (CN^{-1})	mg/l	<0.1	<0.2	<1
21	Cyanide total (CN)	mg/l	<1	<1.5	<2
22	Arsenic (As)	mg/l	<0.05	<0.1	<0.5
23	Iron (Fe)	mg/l	<1	<5	<20
24	Lead (Pb)	mg/l	<0.1	<0.3	<0.5
25	Zinc (Zn)	mg/l	<2	<5	<10
26	Copper (Cu)	mg/l	<1	<2	<5

27	Chromium valent 6 (Cr+6)	mg/l	<0.05	<0.1	<0.5
28	Cadmium (Cd)	mg/l	<0.05	<0.1	<0.5
29	Nickel (Ni)	mg/l	<0.2	<0.5	<2
30	Selenium (Se)	mg/l	<0.02	<0.5	<2
31	Mercury (Hg)	mg/l	<0.005	<0.01	<0.05
32	Phenol (C_6H_6O)	mg/l	<0.5	<1	<5

Note:

Public Water Area Category I: refers to closed water source such as pond, well, lake, plain including canal, stream, creek, stung (river) that do not have any flow during the dry season.

Public Water Area Category II: refers to water source such as sea, river, estuary including canal, creek that have flow during the dry season.

(-): have no value

(1): In case effluent discharge or water used for cooling the engine is more than 5000 cubic meter per day, temperature of discharge water can be allowed at 5 °C above the receiving water temperature at a distance of 500 meters from the shore or discharge point.

Annex 3
Type of pollution sources required having a permission from Ministry of Environment before discharging or transporting their wastewater

No	Factory Categories	Category	ISIC
1	Manufacture of wearing apparel	I	1410
2	Manufacture of articles of fur		1420
3	Manufacture of knitted and crocheted apparel		1430
4	Manufacture of other rubber products	I	2219

5 6 7 8	Manufacture of other porcelain and ceramic products Manufacture of cement, lime and plaster Manufacture of articles of concrete, cement and plaster Cutting, shaping and finishing of stone	I	2393 2394 2395 2396
9	Manufacture of furniture	I	3100
10 11 12	Repair of electronic and optical equipment Repair of transport equipment, except motor vehicles Installation of industrial machinery and equipment	I	3313 3315 3320
13	Manufacture of cordage, rope, twine and netting	I	1394
14	Mining of natural and mineral such as phosphate, potassium and magnesium	II	0891
15	Hospital activities	II	8610
16 17 18 19 20	Raising of cattle and buffaloes Raising of horses and other equines Raising of sheep and goats Raising of swine/pigs Raising of poultry	II	0141 0142 0144 0145 0146
21 22	Slaughter house Freezing and processing of crumb rubber	II	- -
23 24	Marin fishing Freshwater aquaculture	II	0321 0322
25 26 27 28 29 30 31 32 33 34 35 36	Processing and preserving of meat Processing and preserving of fish, crustaceans and molluscs Processing and preserving of fruit and vegetables Manufacture of vegetable and animal oils and fats Manufacture of dairy products Manufacture of grain mill products Manufacture of starch & starch products Manufacture of sugar Manufacture of cocoa, chocolate and sugar confectionery Manufacture of macaroni, noodles, couscous and similar farinaceous products Manufacture of other food products n.e.c Manufacture of prepared animal feeds	II	1010 1020 1030 1040 1050 1061 1062 1072 1073 1074 1079 1080
37 38 39 40	Distilling, rectifying and blending of spirits Manufacture of wines Manufacture of malt liquors and malt Manufacture of soft drinks; production of mineral waters and other bottled water	II	1101 1102 1103 1104
41 42 43 44 45	Preparation and spinning of textile fibers Weaving of textiles Manufacture of knitted and crocheted fabric Manufacture of made-up textile articles Manufacture of carpets and rugs	II	1311 1312 1391 1392 1393
46 47	Manufacture of veneer sheets and wood-based panels Manufacture of builders' carpentry and joinery	II	1621 1622
48	Manufacture of pulp, paper, and paperboard	II	1701
49 50	Manufacture of imitation jewellery and related articles Manufacture of musical instruments	II	3212 3220

51	Manufacture of sports goods		3230
52	Manufacture of games and toys		3240
53	Manufacture of medical and dental instruments and supplies		3250
54	Other mining and quarrying n.e.c	III	0899
55	Extraction of crude petroleum	III	0610
56	Extraction of natural gas		0620
57	Finishing of textiles	III	1313
58	Manufacture of refined petroleum products	III	1920
59	Manufacture of basic chemicals	III	2011
60	Manufacture of fertilizers and nitrogen compounds		2012
61	Manufacture of plastics and synthetic rubber in primary forms		2013
62	Manufacture of pesticides and other agrochemical products		2021
63	Manufacture of paints, varnishes and similar coatings, printing ink and mastics		2022
64	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations		2023
65	Manufacture of pharmaceuticals, medicinal, chemical and botanical product	III	2100
66	Manufacture of rubber products	III	2211
67	Manufacture of plastic products		2220
68	Manufacture of basic iron and steel	III	2410
69	Manufacture of basic precious and other non-ferrous metals		2420
70	Casting of iron and steel		2431
71	Casting of non-ferrous metals		2432
72	Manufacture of structural metal products	III	2511
73	Manufacture of tanks, reservoirs and containers of metal		2512
74	Manufacture of steam generators		2513
75	Forging, pressing, stamping and roll-forming of metal; power metallurgy		2591
76	Treatment and coating of metal		2592
77	Manufacture of electronic components and boards	III	2610
78	Manufacture of computers and peripheral equipment		2620
79	Manufacture of communication equipment		2630
80	Manufacture of consumer electronics		2640
81	Manufacture of measuring, testing, navigating and control equipment		2651
82	Manufacture of watches and clocks		2652
83	Manufacture of optical instruments and photographic equipment		2670
84	Manufacture of magnetic and optical media		2680
85	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	III	2710
86	Manufacture of batteries and accumulators		2720
87	Manufacture of fiber optic cables		2731
88	Manufacture of other electronic and electric wires and cables		2732
89	Manufacture of wiring devices		2733
90	Manufacture of electric lighting equipment		2740
91	Manufacture of engines and turbines	III	2811
92	Manufacture of other pumps, compressors, taps and valves		2813
93	Manufacture of bearings, gears, gearing and driving elements		2814
94	Manufacture of lifting and handling equipment		2816
95	Manufacture of office machinery and equipment (except computers and peripheral equipment)		2817

96	Manufacture of agriculture and forestry machinery		2821
97	Manufacture of machinery for mining, quarrying and construction		2824
98	Manufacture of machinery for food, beverage and tobacco processing		2825
99	Manufacture of machinery for textile, apparel and leather production		2826
100	Manufacture of motor vehicles	III	2910
101	Manufacture of bodies (coachwork) for motor vehicles; Manufacture of trailers and semi-trailers		2920
102	Manufacture of parts and accessories for motor vehicles		2930
103	Building of ships and floating structures	III	3011
104	Building of pleasure and sporting boats		3012
105	Manufacture of motorcycles		3091
106	Manufacture of bicycles and invalid carriages		3092
107	Wastewater Treatment plant at SEZ, Industrial Park and Central Wastewater Treatment Plant	III	3700
108	Treatment and disposal of non-hazardous waste	III	3821
109	Treatment and disposal of hazardous waste		3822
110	Manufacture of leather and fur processing	II	-
111	Manufacture of gold mining		-
112	Power plant		-
113	Research and experimental development on natural sciences and engineering	III	7210

Note: ISIC : International Standard Industry Classification

(-) : Have no code

Annex 4
Water Quality Standard in Public Water Areas for Bio-diversity conservation

No	Parameters	Unit	Parameter standard		
			Public water area Category I	Public water area Category II	Marine
1	pH		6.5-8.5	6.5-8.5	7-8.3
2	DO	mg/l	>3	>4	>4
3	BOD5	mg/l	<8	<6	-
4	COD (Mn)	mg/l	<10	<8	8[(1)]
5	TSS	mg/l	<100	<100	<80
6	Salinity	mg/l	<1000	<1000	-
7	NO_3^{-1} as N	mg/l	<2.4	<1.2	<0.06
8	Total Nitrogen (T-N)	mg/l	<3	<2	<2
9	Total Phosphorus (T-P)	mg/l	<0.25	<0.15	<0.09
10	Oil & grease	mg/l	-	-	<0.14

Note:

Public water area category I: refer to closed water source such as lake, pond, well, lowland including stream, creek and canal that do not have any flow in the dry season.
Public water area category II: refer to open water source such as river, estuary including stream, creek, and canal that have flow in the dry season.
(-) Have no value
(1) refer to oxygen demand as $COD_{(OH)}$

Annex 5
Water quality standard in public water areas for public health protection

No.	Parameters	Unit	Standard	CAS No.

1	Carbon tetrachloride	ug/l	<4	56-23-5
2	Hexachloro benzene	ug/l	<0.03	118-74-1
3	DDT	ug/l	<1	50-29-3
4	Endrin	ug/l	<0.01	72-20-8
5	Dieldrin	ug/l	<0.01	60-57-1
6	Aldrin	ug/l	<0.005	309-00-2
7	Isodrin	ug/l	<0.005	465-73-6
8	Perchloroethylene	ug/l	<10	127-18-4
9	Hexachloro butadiene	ug/l	<0.01	87-68-3
10	Chloroform	ug/l	<300	67-66-3
11	cis 1,2 dichloroethylene	ug/l	<40	156-59-2
12	Trichlororethylnen	ug/l	<10	79-01-6
13	1,2,4 Trichlorobenzene	ug/l	<0.4	120-82-1
14	Hexachlorocyclohexane	ug/l	<0.05	58-89-9
15	Benzene	ug/l	<10	71-43-2
16	Cadmium	ug/l	<3	7440-43-9
17	Total mercury (Hg)	ug/l	<0.5	7439-97-6
18	Organic mercury (CH_3Hg^+ and C_6H_5Hg)	ug/l	Not Detectable	-
19	Lead (Pb)	ug/l	<10	7439-92-1
20	Chromium valent 6 (Cr+6)	ug/l	<50	18540-29-9
21	Arsenic (As)	ug/l	<10	7440-38-2
22	Selenium (Se)	ug/l	<10	7782-49-2
23	PCB	ug/l	Not Detectable	1336-36-3
24	Cyanide (CN)	ug/l	<5	57-12-5
25	Dichloromethane	ug/l	<20	75-09-2
26	Total Coliform	MPN/ 100mL	<1000	-

ព្រះរាជាណាចក្រកម្ពុជា

ជាតិ សាសនា ព្រះមហាក្សត្រ

រាជរដ្ឋាភិបាលកម្ពុជា

លេខ: ១០៣ អនក្រ.បក

អនុក្រឹត្យ
ស្តីពី
ការកែសម្រួលមាត្រា៤ មាត្រា៩ មាត្រា១១ មាត្រា១២ មាត្រា១៧ និងតារាងឧបសម្ព័ន្ធ២ ឧបសម្ព័ន្ធ៣ ឧបសម្ព័ន្ធ៤ និងឧបសម្ព័ន្ធ៥ នៃអនុក្រឹត្យលេខ២៧ អនក្រ.បក ចុះថ្ងៃទី៦ ខែមេសា ឆ្នាំ១៩៩៩ ស្តីពីការត្រួតពិនិត្យការបំពុលទឹក

រាជរដ្ឋាភិបាល

- បានឃើញរដ្ឋធម្មនុញ្ញនៃព្រះរាជាណាចក្រកម្ពុជា
- បានឃើញព្រះរាជក្រឹត្យលេខ នស/រកត/០៩១៨/៩២៥ ចុះថ្ងៃទី៦ ខែកញ្ញា ឆ្នាំ២០១៨ ស្តីពីការតែងតាំងរាជរដ្ឋាភិបាលនៃព្រះរាជាណាចក្រកម្ពុជា
- បានឃើញព្រះរាជក្រឹត្យលេខ នស/រកត/០៣២០/៤២១ ចុះថ្ងៃទី៣០ ខែមីនា ឆ្នាំ២០២០ ស្តីពីការតែងតាំង និងកែសម្រួលសមាសភាពរាជរដ្ឋាភិបាលនៃព្រះរាជាណាចក្រកម្ពុជា
- បានឃើញព្រះរាជក្រមលេខ នស/រកម/០៦១៨/០១២ ចុះថ្ងៃទី២៨ ខែមិថុនា ឆ្នាំ២០១៨ ដែលប្រកាសឱ្យប្រើច្បាប់ស្តីពីការរៀបចំនិងការប្រព្រឹត្តទៅនៃគណៈរដ្ឋមន្ត្រី
- បានឃើញព្រះរាជក្រមលេខ នស/រកម/០១៩៦/២១ ចុះថ្ងៃទី២៤ ខែមករា ឆ្នាំ១៩៩៦ ដែលប្រកាសឱ្យប្រើច្បាប់ស្តីពីការបង្កើតក្រសួងបរិស្ថាន
- បានឃើញព្រះរាជក្រមលេខ នស/រកម/១២៩៦/៣៦ ចុះថ្ងៃទី២៤ ខែធ្នូ ឆ្នាំ១៩៩៦ ដែលប្រកាសឱ្យប្រើច្បាប់ស្តីពីកិច្ចការពារបរិស្ថាននិងការគ្រប់គ្រងធនធានធម្មជាតិ
- បានឃើញអនុក្រឹត្យលេខ១៣៥ អនក្រ.បក ចុះថ្ងៃទី៥ ខែកក្កដា ឆ្នាំ២០១៦ ស្តីពីការរៀបចំនិងការប្រព្រឹត្តទៅរបស់ក្រសួងបរិស្ថាន
- បានឃើញអនុក្រឹត្យលេខ២៧ អនក្រ.បក ចុះថ្ងៃទី៦ ខែមេសា ឆ្នាំ១៩៩៩ ស្តីពីការត្រួតពិនិត្យការបំពុលទឹក
- យោងតាមសំណើរបស់រដ្ឋមន្ត្រីក្រសួងបរិស្ថាន

សម្រេច

មាត្រាមួយ .-

មាត្រា៤ មាត្រា៩ មាត្រា១១ មាត្រា១២ មាត្រា១៧ និងតារាងឧបសម្ព័ន្ធ២ ឧបសម្ព័ន្ធ៣ ឧបសម្ព័ន្ធ៤ និងឧបសម្ព័ន្ធ៥ នៃអនុក្រឹត្យលេខ២៧ អនក្រ.បក ចុះថ្ងៃទី៦ ខែមេសា ឆ្នាំ១៩៩៩ ស្តីពីការត្រួតពិនិត្យការបំពុលទឹក ត្រូវបានធ្វើការកែសម្រួល ដូចតទៅ៖

មាត្រា៨ ._ ថ្មី

ការបញ្ចេញសំណល់រាវពីប្រភពបំពុលនានា ត្រូវអនុលោមតាមកម្រិតកំណត់ស្តង់ដានៃការបញ្ចេញសំណល់រាវដែលមានចែងក្នុងតារាងឧបសម្ព័ន្ធ២ នៃអនុក្រឹត្យនេះ។

មាត្រា៩ ._ ថ្មី

ហាមឃាត់ជាដាច់ខាត៖

ក-ការបញ្ចេញទឹកកខ្វក់ពីប្រភពបំពុលចូលទៅក្នុងបណ្តាញលូសាធារណៈឬតំបន់ទឹកសាធារណៈ ដោយមិនបានធ្វើប្រព្រឹត្តកម្មសម្អាតឬមិនឆ្លើយតបស្តង់ដាបញ្ចេញដែលមានចែងក្នុងលិខិតបទដ្ឋានគតិយុត្តជាធរមាន។

ខ-ការបញ្ចេញសំណល់រាវមិនឆ្លងកាត់អាងប្រព្រឹត្តកម្មសម្អាតសំណល់រាវ។

គ-ការបង្កប់លូឬការបូមបញ្ចេញសំណល់រាវវាងមិនឆ្លងកាត់អាងប្រព្រឹត្តកម្មសម្អាតសំណល់រាវ។

ឃ-ការមិនដាក់ឱ្យដំណើរការអាងប្រព្រឹត្តកម្មសម្អាតសំណល់រាវឬដំណើរការអាងប្រព្រឹត្តកម្មសម្អាតសំណល់រាវមិនត្រឹមត្រូវតាមលក្ខណៈបច្ចេកទេស ដែលបានកំណត់នៅក្នុងលិខិតអនុញ្ញាតរបស់ក្រសួង ស្ថាប័នមានសមត្ថកិច្ច។

មាត្រា១១ ._ ថ្មី

ប្រភពបំពុលដែលតម្រូវឱ្យសុំការអនុញ្ញាតពីក្រសួងបរិស្ថាន មុននឹងធ្វើការបញ្ចេញចោលឬដឹកជញ្ជូនចេញនូវសំណល់រាវរបស់ម្ចាស់សំណើទៅកន្លែងដទៃទៀត ដូចមានចែងនៅក្នុងតារាងឧបសម្ព័ន្ធ៣ នៃអនុក្រឹត្យនេះ មានបីកម្រិតដូចខាងក្រោម៖

ក-ប្រភពបំពុលកម្រិតទី១ តម្រូវឱ្យមានការសុំអនុញ្ញាតពីក្រសួងបរិស្ថាន ក្នុងករណីដែលបរិមាណសំណល់រាវរបស់ប្រភពបំពុលនោះមានចំនួនច្រើនជាង៤០ម៉ែត្រគូបក្នុងមួយថ្ងៃ ដោយពុំគិតបញ្ចូលនូវបរិមាណទឹកដែលប្រើប្រាស់សម្រាប់ប្រព័ន្ធត្រជាក់គ្រឿងចក្រ។

ខ-ប្រភពបំពុលកម្រិតទី២ តម្រូវឱ្យមានការសុំអនុញ្ញាតពីក្រសួងបរិស្ថាន ក្នុងករណីដែលបរិមាណសំណល់រាវរបស់ប្រភពបំពុលនោះមានចំនួនច្រើនជាង២០ម៉ែត្រគូបក្នុងមួយថ្ងៃ ដោយពុំគិតបញ្ចូលនូវបរិមាណទឹកដែលប្រើប្រាស់សម្រាប់ប្រព័ន្ធត្រជាក់គ្រឿងចក្រ។

គ-ប្រភពបំពុលកម្រិតទី៣ តម្រូវឱ្យមានការសុំការអនុញ្ញាតពីក្រសួងបរិស្ថាន ទោះបីក្នុងបរិមាណណាក៏ដោយ។

នីតិវិធីនៃការស្នើសុំការអនុញ្ញាតធ្វើការបញ្ចេញចោលឬដឹកជញ្ជូនចេញនូវសំណល់រាវរបស់ម្ចាស់សំណើទៅកន្លែងដទៃទៀត ត្រូវកំណត់ដោយប្រកាសរបស់រដ្ឋមន្ត្រីក្រសួងបរិស្ថានស្តីពីនីតិវិធីនៃការស្នើសុំការអនុញ្ញាតធ្វើការបញ្ចេញចោលឬដឹកជញ្ជូនចេញនូវសំណល់រាវ។

មាត្រា១២ ._ ថ្មី

ការស្នើសុំបញ្ចេញចោលនូវសំណល់រាវពីប្រភពបំពុលអាចទទួលបានការអនុញ្ញាត លុះត្រាតែ៖

ក-មានការបំពាក់បរិក្ខារប្រព្រឹត្តកម្មសម្អាតសំណល់រាវ និងបញ្ចេញសំណល់រាវបានត្រឹមត្រូវតាមលក្ខណៈបច្ចេកទេស និងស្ថិតក្នុងស្ថានភាពដំណើរការជាប្រក្រតី។

ខ- ការបញ្ចេញសំណល់រាវ គឺបានឆ្លើយតបនឹងស្តង់ដានៃការបញ្ចេញសំណល់រាវ។

ការស្នើសុំដឹកជញ្ជូនចេញនូវសំណល់រាវពីប្រភពបំពុលអាចទទួលបានការអនុញ្ញាត លុះត្រាតែ៖

ក-មានការបញ្ជាក់ច្បាស់ពីគោលបំណងនៃការស្នើសុំដឹកជញ្ជូនចេញនូវសំណល់រាវ និងមធ្យោបាយគ្រប់គ្រងសំណល់របស់ទីតាំងដែលទទួលសំណល់រាវ។

ខ-បានបំពេញលក្ខខណ្ឌតម្រូវដូចមានកំណត់នៅក្នុងប្រកាសរបស់រដ្ឋមន្ត្រីក្រសួងបរិស្ថានស្តីពីនីតិវិធីនៃការស្នើសុំការអនុញ្ញាតធ្វើការបញ្ចេញចោលឬដឹកជញ្ជូនចេញនូវសំណល់រាវ។

មាត្រា១៧.-ថ្មី

លិខិតអនុញ្ញាតបញ្ចេញចោលឬដឹកជញ្ជូនចេញនូវសំណល់រាវ ត្រូវព្យួរជាបណ្ដោះអាសន្នឬដកហូតជាស្ថាពរ ក្នុងករណីណាមួយដូចខាងក្រោម៖

ក-មិនបានអនុវត្តត្រឹមត្រូវតាមស្តង់ដានៃការបញ្ចេញសំណល់រាវ។

ខ-ខកខានមិនបានអនុវត្តលក្ខខណ្ឌតម្រូវ ដែលមានកំណត់ក្នុងលិខិតអនុញ្ញាត។

គ-កើតមានករណីការបំពុលបរិស្ថានឬការបង្កគ្រោះថ្នាក់ដល់សុខភាពបណ្ដាលមកពីសកម្មភាពគ្រប់គ្រងសំណល់រាវមានការខ្វះចន្លោះឬការធ្វេសប្រហែស។

មាត្រាពីរ .-

បទប្បញ្ញត្តិទាំងឡាយណាដែលផ្ទុយនឹងអនុក្រឹត្យនេះ ត្រូវទុកជានិរាករណ៍។

មាត្រាបី .-

រដ្ឋមន្ត្រីទទួលបន្ទុកទីស្តីការគណៈរដ្ឋមន្ត្រី រដ្ឋមន្ត្រីក្រសួងសេដ្ឋកិច្ចនិងហិរញ្ញវត្ថុ រដ្ឋមន្ត្រីក្រសួងបរិស្ថាន រដ្ឋមន្ត្រីគ្រប់ក្រសួងនិងប្រធានគ្រប់ស្ថាប័នដែលពាក់ព័ន្ធ ត្រូវទទួលបន្ទុកអនុវត្តអនុក្រឹត្យនេះតាមភារកិច្ចរៀងៗខ្លួនចាប់ពីថ្ងៃចុះហត្ថលេខាតទៅ។

ថ្ងៃ អង្គារ ៥ រោច ខែបឋមាសាឍ ឆ្នាំឆ្លូវ ត្រីស័ក ព.ស.២៥៦៥

ធ្វើនៅរាជធានីភ្នំពេញ ថ្ងៃទី ២៩ ខែ មិថុនា ឆ្នាំ២០២១

នាយករដ្ឋមន្ត្រី

សម្តេចអគ្គមហាសេនាបតីតេជោ ហ៊ុន សែន

បានយកសេចក្តីគោរពជម្រាបជូន

សម្តេចអគ្គមហាសេនាបតីតេជោនាយករដ្ឋមន្ត្រីសូមហត្ថលេខា

រដ្ឋមន្ត្រីក្រសួងបរិស្ថាន

សាយ សំអាល់

កន្លែងទទួល :

-ក្រសួងព្រះបរមរាជវាំង
-អគ្គលេខាធិការដ្ឋានក្រុមប្រឹក្សាធម្មនុញ្ញ
-អគ្គលេខាធិការដ្ឋានព្រឹទ្ធសភា
-អគ្គលេខាធិការដ្ឋានរដ្ឋសភា
-ខុទ្ទកាល័យសម្តេចអគ្គមហាសេនាបតីតេជោនាយករដ្ឋមន្ត្រី
-ខុទ្ទកាល័យសម្តេច ឯកឧត្តម លោកជំទាវឧបនាយករដ្ឋមន្ត្រី
-ដូចមាត្រាបី
-រាជកិច្ច
-ឯកសារ កាលប្បវត្តិ

តារាងឧបសម្ព័ន្ធ២

កម្រិតកំណត់ស្តង់ដានៃការបញ្ចេញសំណល់រាវ

ល.រ	ប៉ារ៉ាម៉ែត្រ	ខ្នាត	បរិមាណសារធាតុបំពុលដែលអនុញ្ញាតឱ្យបញ្ចេញចូល		
			តំបន់ទឹកសាធារណៈប្រភេទទី១	តំបន់ទឹកសាធារណៈប្រភេទទី២	បណ្ដាញលូភ្ជាប់ទៅស្ថានីយប្រព្រឹត្តកម្មទឹកកខ្វក់រួម
១	សីតុណ្ហភាព[១] (T)	$^{\circ}C$	<៤០	<៤០	<៤៥
២	ពណ៌ (Color)	mg Pt/l	<៥០	<១៥០	<៣០០
៣	សារធាតុរឹងអណ្តែតក្នុងទឹក (TSS)	mg/l	<៥០	<១០០	<២០០
៤	pH		៦-៩	៥,៥-៩	៥-៩
៥	BOD_5	mg/l	<៣០	<៦០	<២០០
៦	COD ($Cr_2O_7^{-2}$)	mg/l	<៦០	<១២០	<៣០០
៧	ប្រេងឬខ្លាញ់ (Oil & grease)	mg/l	<៥	<១០	<៣០
៨	សាប៊ូ (Detergent)	mg/l	<៥	<១០	<៣០
៩	អាម៉ូញាក់ (NH_3- as N)	mg/l	<៧	<១០	<៣០
១០	នីត្រាត (NO_3^{-1} as N)	mg/l	<១០	<២០	-
១១	ក្លរក្នុងទំរង់សេរី (Cl_2)	mg/l	<១	<២	-
១២	ក្លរជាអ៊ីយ៉ុង (Cl^-)	mg/l	<៥០០	<១០០០	-
១៣	ផូស្វាត (PO_4^{-3})	mg/l	<២	<៥	-
១៤	អាសូតសរុប (T-N)	mg/l	<២០	<៤០	-
១៥	ផូស្វ័រ (T-P)	mg/l	<៤	<៦	-
១៦	អ៊ីដ្រូសែនស៊ុលហ្វីត (H_2S)	mg/l	<០,២	<០,៥	<១
១៧	ម៉ង់កាណែស (Mn)	mg/l	<១	<៣	<៥
១៨	បរ (B)	mg/l	<១	<២,៥	<៥
១៩	បារ្យ៉ូម (Ba)	mg/l	<២	<៥	<៧
២០	ស្យានីតក្នុងទំរង់សេរី (CN^{-1})	mg/l	<០,១	<០,២	<១
២១	ស្យានីតសរុប (CN)	mg/l	<១	<១,៥	<២
២២	អាសេនិច (As)	mg/l	<០,០៥	<០,១	<០,៥
២៣	ដែក (Fe)	mg/l	<១	<៥	<២០
២៤	សំណ (Pb)	mg/l	<០,១	<០,៣	<០,៥
២៥	ស័ង្កសី (Zn)	mg/l	<២	<៥	<១០
២៦	ទង់ដែង (Cu)	mg/l	<១	<២	<៥
២៧	ក្រូម (Cr^{+6})	mg/l	<០,០៥	<០,១	<០,៥
២៨	កាត់ម្មូម (Cd)	mg/l	<០,០៥	<០,១	<០,៥
២៩	នីកែល (Ni)	mg/l	<០,២	<០,៥	<២
៣០	សេលេញ៉ូម (Se)	mg/l	<០,០២	<០,៥	<២

៣១	បារ៉ត (Hg)	mg/l	<0,00៥	<0,0១	<0,0៥
៣២	ផេណុល (C_6H_6O)	mg/l	<0,៥	<១	<៥

កំណត់សម្គាល់៖

តំបន់ទឹកសាធារណៈប្រភេទទី១៖ សំដៅដល់ប្រភពទឹកបិទមានជាអាទិ៍ ស្រះ ត្រពាំង បឹង ទីទំនាប រួមបញ្ចូលទាំង ប្រឡាយទឹក អូរ ព្រែក ស្ទឹង ដែលមិនមានចរន្តទឹកហូរនៅរដូវប្រាំង។

តំបន់ទឹកសាធារណៈប្រភេទទី២៖ សំដៅដល់ប្រភពទឹកចំហមានជាអាទិ៍ សមុទ្រ ទន្លេ ពាម រួមបញ្ចូលទាំង ប្រឡាយទឹក ព្រែក ស្ទឹង ដែលមានចរន្តទឹកហូរនៅរដូវប្រាំង។

(-) ៖ ពុំមានកំណត់តម្លៃ

(១)៖ ករណីការបញ្ចេញសំណល់រាវឬទឹកដែលប្រើប្រាស់សម្រាប់ការបញ្ចុះកម្តៅម៉ាស៊ីនគ្រឿងចក្រដែលមានបរិមាណលើសពី៥០០០ម៉ែត្រគូបក្នុងមួយថ្ងៃ សីតុណ្ហភាពទឹកបញ្ចេញអាចអនុញ្ញាតក្នុងកម្រិត៥℃ (អង្សាសេ)លើសសីតុណ្ហភាពប្រភពទឹកទទួលនៅចំណុចចម្ងាយ៥០០ម៉ែត្រពីច្រាំងឬចំណុចបញ្ចេញ។

តារាងឧបសម្ព័ន្ធ៣
ប្រភពបំពុលដែលតម្រូវឱ្យមានការសុំអនុញ្ញាតពីក្រសួងបរិស្ថាន មុននឹងធ្វើការបញ្ចេញចោលឬដឹកសំណល់រាវទៅកាន់កន្លែងដទៃ

ល.រ	ប្រភពបំពុល	កម្រិតទី	កូដ(ISIC)
១	ទីតាំងផលិតសម្លៀកបំពាក់	១	1410
២	ទីតាំងផលិតផលិតផលនិងសម្ភារៈពីរោមសត្វ		1420
៣	ទីតាំងផលិតសម្លៀកបំពាក់ដោយចាក់និងត្បាញ		1430
៤	ទីតាំងផលិតផលិតផលនិងសម្ភារៈប្រើប្រាស់ផ្សេងៗចេញពីកៅស៊ូធម្មជាតិ ឬកៅស៊ូសំយោគ(ក្រៅពីកង់រថយន្ត)	១	2219
៥	ទីតាំងផលិតផលិតផលនិងសម្ភារៈពីសេរាមិចនិងព័រស៊ីឡែន	១	2393
៦	ទីតាំងផលិតស៊ីម៉ងត៍ កំបោរ និងម្នាងសិលា		2394
៧	ទីតាំងផលិតលផិតផលសម្រាប់សំណង់ពីបេតុង		2395
៨	ទីតាំងកាត់ថ្ម សំលៀង និងផលិតផលិតផល និងសម្ភារៈពីថ្ម		2396
៩	ទីតាំងផលិតគ្រឿងសង្ហារឹម	១	3100
១០	ទីតាំងជួសជុលឧបករណ៍អុបទិកនិងឧបករណ៍អេឡិចត្រូនិក	១	3313
១១	ទីតាំងជួសជុលយានយន្តដឹកជញ្ជូន លើកលែងម៉ូតូ		3315
១២	ទីតាំងដំឡើងម៉ាស៊ីននិងឧបករណ៍ឧស្សាហកម្ម		3320
១៣	ទីតាំងផលិតខ្សែ ខ្សែពួរ និងសំណាញ់	១	1394
១៤	ទីតាំងជីករ៉ែធម្មជាតិនិងឧនិជ មានជាអាទិ៍រ៉ែផូស្វាត រ៉ែប៉ូតាស្យូម រ៉ែម៉ាញ៉េស្យូម	២	0891
១៥	ទីតាំងមន្ទីរពេទ្យនិងសម្ភព	២	8610
១៦	ទីតាំងចិញ្ចឹមគោនិងក្របី	២	0141
១៧	ទីតាំងចិញ្ចឹមសេះ		0142
១៨	ទីតាំងចិញ្ចឹមចៀមនិងពពែ		0144
១៩	ទីតាំងចិញ្ចឹមជ្រូក		0145
២០	ទីតាំងចិញ្ចឹមមាន់និងទា		0146
២១	ទីតាំងសត្តឃាត	២	-
២២	ទីតាំងបង្កកនិងកែច្នៃកៅស៊ូក្រែប		-
២៣	ទីតាំងវារីវប្បកម្មទឹកប្រៃ	២	0321
២៤	ទីតាំងវារីវប្បកម្មទឹកសាប		0322
២៥	ទីតាំងកែច្នៃនិងថែរក្សាសាច់	២	1010
២៦	ទីតាំងកែច្នៃនិងថែរក្សាផលិតផលជលផល		1020
២៧	ទីតាំងកែច្នៃនិងថែរក្សាបន្លែនិងផ្លែឈើគ្រប់ប្រភេទ		1030
២៨	ទីតាំងផលិតប្រេងពីរុក្ខជាតិនិងខ្លាញ់សត្វ		1040

២៩	ទីតាំងផលិតទឹកដោះនិងផលិតផលពីទឹកដោះ		1050
៣០	ទីតាំងផលិតផលិតផលពីធញ្ញជាតិ		1061
៣១	ទីតាំងផលិតម្សៅមីនិងផលិតផលពីម្សៅមី		1062
៣២	ទីតាំងផលិតស្ករ		1072
៣៣	ទីតាំងផលិតកាកាវនិងសូកូឡា		1073
៣៤	ទីតាំងផលិតមីនិងគុយទាវ		1074
៣៥	ទីតាំងផលិតផលិតផលអាហារ		1079
៣៦	ទីតាំងផលិតចំណីសត្វ		1080
៣៧	ទីតាំងផលិតស្រាឬអាល់កុល (កម្រិតអាល់កុលខ្ពស់)	២	1101
៣៨	ទីតាំងផលិតស្រាឬភេសជ្ជៈ (កម្រិតអាល់កុលទាប)		1102
៣៩	ទីតាំងផលិតស្រាបៀរ		1103
៤០	ទីតាំងផលិតភេសជ្ជៈនិងទឹកបរិសុទ្ធ		1104
៤១	ទីតាំងផលិតសរសៃអំបោះ អំបោះហុង អំបោះខ្សែន	២	1311
៤២	ទីតាំងតម្បាញក្រណាត់ ក្រណាត់សូត្រ ស្បៃ		1312
៤៣	ទីតាំងផលិតក្រណាត់ដោយចាក់និងប៉ាក់		1391
៤៤	ទីតាំងផលិតភួយ ក្រណាត់តង់ ក្រណាត់កម្រាល វាំងនន		1392
៤៥	ទីតាំងផលិតកម្រាលព្រំ		1393
៤៦	ទីតាំងផលិតក្តារបន្ទះ ឈើសន្លឹក ឈើកំណាល់រថភ្លើង	២	1621
៤៧	ទីតាំងផលិតគ្រឿងបង្គុំសំណង់ពីឈើ		1622
៤៨	ទីតាំងផលិតម្សៅក្រដាស ក្រដាស និងផលិតផលពីក្រដាស	២	1701
៤៩	ទីតាំងផលិតគ្រឿងអលង្ការកាខ្សែនិងខ្សែនាឡិកាពីលោហៈ	២	3212
៥០	ទីតាំងផលិតឧបករណ៍ភ្លេង		3220
៥១	ទីតាំងផលិតសម្ភារៈកីឡា		3230
៥២	ទីតាំងផលិតសម្ភារៈល្បែងនិងតុក្កតា		3240
៥៣	ទីតាំងផលិតឧបករណ៍វេជ្ជសាស្ត្រ		3250
៥៤	ទីតាំងជីករ៉ែ (បាសាល់ ក្រាហ្វីត ត្បូង ក្វាត និងរ៉ែស៊ីលីកាត)	៣	0899
៥៥	ទីតាំងបូមយកប្រេងឆៅ	៣	0610
៥៦	ទីតាំងដកយកឧស្ម័នធម្មជាតិ		0620
៥៧	ទីតាំងវាយនភ័ណ្ឌសម្រេច មានដកពណ៌ឬជ្រលក់ពណ៌	៣	1313
៥៨	ទីតាំងផលិត ចម្រាញ់ប្រេងកាត	៣	1920
៥៩	ទីតាំងផលិតសារធាតុគីមី	៣	2011
៦០	ទីតាំងផលិតជីនិងសមាសធាតុអាស៊ូត		2012
៦១	ទីតាំងផលិតប្លាស្ទិកនិងកៅស៊ូសំយោគ(ទំរង់បឋម)		2013
៦២	ទីតាំងផលិតថ្នាំសម្លាប់សត្វល្អិតនិងផលិតផលគីមីកសិកម្ម		2021
៦៣	ទីតាំងផលិតថ្នាំពណ៌ ថ្នាំលាប ថ្នាំប៉ូលា ថ្នាំបោះពុម្ព និងជីលែង		2022

៦៤	ទីតាំងផលិតសាប៊ូដុំ សាប៊ូម្សៅ និងសាប៊ូទឹក		2023
៦៥	ទីតាំងផលិតឱសថពីគីមីនិងពីរុក្ខជាតិ	៣	2100
៦៦	ទីតាំងផលិតសំបកកង់ បំពង់ជ័រពីកៅស៊ូ និងកែច្នៃឡើងវិញ	៣	2211
៦៧	ទីតាំងផលិតផលិតផលនិងសម្ភារៈពីប្លាស្ទិក		2220
៦៨	ទីតាំងផលិតដែកនិងដែកថែប	៣	2410
៦៩	ទីតាំងផលិតលោហធាតុមានតម្លៃនិងលោហធាតុមិនមែនដែក		2420
៧០	ទីតាំងផលិតផលិតផលពីលោហៈ		2431
៧១	ទីតាំងស្លរំលាយលោហៈមិនមែនដែក		2432
៧២	ទីតាំងផលិតផលិតផលសំណង់ពីលោហធាតុ	៣	2511
៧៣	ទីតាំងផលិតធុង អាង និងប្រអប់ដែលធ្វើពីលោហធាតុ		2512
៧៤	ទីតាំងផលិតម៉ាស៊ីនចំហាយឬគ្រឿងបង្គុំ		2513
៧៥	ទីតាំងដំ សង្កត់ និងរមូរដែកឬលោហធាតុ		2591
៧៦	ទីតាំងស្លរំលាយ ចាក់ពុម្ព និងស្រោបលោហធាតុ		2592
៧៧	ទីតាំងផលិតគ្រឿងបន្លាស់អេឡិចត្រូនិក	៣	2610
៧៨	ទីតាំងផលិតកុំព្យូទ័រនិងគ្រឿងបង្គុំ		2620
៧៩	ទីតាំងផលិតឧបករណ៍ទំនាក់ទំនង		2630
៨០	ទីតាំងផលិតគ្រឿងអេឡិចត្រូនិក		2640
៨១	ទីតាំងផលិតឧបករណ៍វាស់ តេស្ត រុករក និងត្រួតពិនិត្យ		2651
៨២	ទីតាំងផលិតនាឡិកាដៃនិងនាឡិកាប៉ោល		2652
៨៣	ទីតាំងផលិតឧបករណ៍អុបទិក		2670
៨៤	ទីតាំងផលិតឧបករណ៍ប្រព័ន្ធផ្សព្វផ្សាយអុបទិកនិងម៉ាញ៉េទិក		2680
៨៥	ទីតាំងផលិតម៉ាស៊ីនភ្លើង ម៉ូទ័រ ឧបករណ៍បញ្ជានិងចែកចាយចរន្តអគ្គិសនី	៣	2710
៨៦	ទីតាំងផលិតថ្មពិល អាគុយ		2720
៨៧	ទីតាំងផលិតខ្សែកាបអុបទិក		2731
៨៨	ទីតាំងផលិតខ្សែភ្លើងនិងខ្សែកាបអគ្គិសនី		2732
៨៩	ទីតាំងផលិតឧបករណ៍ខ្សែភ្លើង		2733
៩០	ទីតាំងផលិតអំពូលភ្លើងគ្រប់ប្រភេទ		2740
៩១	ទីតាំងផលិតប្រេងម៉ាស៊ីន	៣	2811
៩២	ទីតាំងផលិតម៉ាស៊ីនបូម ម៉ាស៊ីនបង្កើនសម្ពាធខ្យល់ ស្នប់		2813
៩៣	ទីតាំងផលិតចង្កូត ស្ពី ប្រអប់លេខ និងគ្រឿងបង្គុំ		2814
៩៤	ទីតាំងផលិតឧបករណ៍សម្រាប់លើកដាក់		2816
៩៥	ទីតាំងផលិតគ្រឿងបរិក្ខារនិងសម្ភារៈការិយាល័យ		2817
៩៦	ទីតាំងផលិតគ្រឿងយន្តកសិកម្ម		2821
៩៧	ទីតាំងផលិតគ្រឿងយន្តសម្រាប់ការរុករករ៉ែនិងសំណង់		2824
៩៨	ទីតាំងផលិតគ្រឿងយន្តសម្រាប់កែច្នៃម្ហូបអាហារ ភេសជ្ជៈនិងថ្នាំជក់		2825

៩៩	ទីតាំងផលិតគ្រឿងយន្តសម្រាប់វាយនភ័ណ្ឌ		2826
១០០	ទីតាំងផលិតយានយន្ត	៣	2910
១០១	ទីតាំងផលិតតួទោចក្រយានយន្ត យានយន្ត និងកន្ទុយសណ្តោង		2920
១០២	ទីតាំងផលិតគ្រឿងបន្លាស់និងគ្រឿងបង្គុំយានយន្ត		2930
១០៣	ទីតាំងសាងសង់នាវានិងសំណង់បណ្តែតទឹក	៣	3011
១០៤	ទីតាំងសាងសង់ទូកកម្សាន្តនិងកីឡា		3012
១០៥	ទីតាំងផលិតទោចក្រយានយន្ត		3091
១០៦	ទីតាំងផលិតកង់		3092
១០៧	ទីតាំងប្រព្រឹត្តកម្មសំណល់រាវ (តំបន់សេដ្ឋកិច្ចពិសេស សួនឧស្សាហកម្ម និងស្ថានីយប្រព្រឹត្តកម្មទឹកកខ្វក់រួម)	៣	3700
១០៨	ទីតាំងប្រព្រឹត្តកម្មនិងបោះចោលសំណល់មិនមែនគ្រោះថ្នាក់	៣	3821
១០៩	ទីតាំងប្រព្រឹត្តកម្មនិងបោះចោលសំណល់គ្រោះថ្នាក់		3822
១១០	ទីតាំងសម្លាប់ស្បែកឬកែច្នៃរោមសត្វ	៣	-
១១១	ទីតាំងអាជីវកម្មរ៉ែមាស		-
១១២	ទីតាំងផលិតអគ្គិសនី		-
១១៣	ទីតាំងស្រាវជ្រាវ និងអភិវឌ្ឍការពិសោធន៍លើវិទ្យាសាស្ត្រធម្មជាតិ និងវិស្វកម្ម	៣	7210

កំណត់សម្គាល់៖

(ISIC) ៖ ចំណាត់ថ្នាក់ឧស្សាហកម្មស្តង់ដាអន្តរជាតិ (International Standard Industry Classification)

(-) ៖ ពុំមានលេខកូដ

តារាងឧបសម្ព័ន្ធ៤

កម្រិតកំណត់ស្តង់ដាគុណភាពទឹកតំបន់ទឹកសាធារណៈ សម្រាប់អភិរក្សជីវៈចម្រុះនៅក្នុងទឹក

ល.រ	ប៉ារ៉ាម៉ែត្រ	ខ្នាត	កម្រិតកំណត់ស្តង់ដា		
			តំបន់ទឹកសាធារណៈប្រភេទទី១	តំបន់ទឹកសាធារណៈប្រភេទទី២	ទឹកសមុទ្រ
១	pH		៦,៥-៨,៥	៦,៥-៨,៥	៧,០-៨,៣
២	កម្រិតរលាយអុកស៊ីសែន(DO)	mg/l	>៣	>៤	>៤
៣	BOD_5	mg/l	<៨	<៦	-
៤	COD_{Mn}	mg/l	<១០	<៨	<៨⁽¹⁾
៥	សារធាតុរឹងអណ្តែតក្នុងទឹក(TSS)	mg/l	<១០០	<១០០	<៨០
៦	ជាតិអំបិល (Salinity)	mg/l	<១០០០	<១០០០	-
៧	នីត្រាត (NO_3^{-1} as N)	mg/l	<២,៤	<១,២	<០,០៦
៨	អាសូតសរុប (T-N)	mg/l	<៣	<២	<២
៩	ផូស្វ័រសរុប (T-P)	mg/l	<០,២៥	<០,១៥	<០,០៩
១០	ប្រេង ឬខ្លាញ់(Oil & grease)	mg/l	-	-	<០,១៤

កំណត់សម្គាល់៖

តំបន់ទឹកសាធារណៈប្រភេទទី១៖ សំដៅដល់ប្រភពទឹកបិទមានជាអាទិ៍ បឹង ត្រពាំង ស្រះ ទីទំនាប រួមបញ្ចូលទាំងស្ទឹង ព្រែក អូរ និងប្រឡាយទឹកដែលមិនមានចរន្តទឹកហូរនៅរដូវប្រាំង។

តំបន់ទឹកសាធារណៈប្រភេទទី២៖ សំដៅដល់ប្រភពទឹកចំហមានជាអាទិ៍ ទន្លេ ពាម រួមបញ្ចូលទាំងស្ទឹង ព្រែក អូរ និងប្រឡាយទឹកដែលមានចរន្តទឹកហូរនៅរដូវប្រាំង។

(-) ៖ ពុំមានកំណត់តម្លៃ

[១]៖ សំដៅដល់តម្រូវការអុកស៊ីសែនតាមបែបប៉ូតាស្យូមពែម៉ង់កាណាតអាល់កាឡាំង $COD_{(OH)}$

តារាងឧបសម្ព័ន្ធ៥

កម្រិតកំណត់ស្តង់ដាគុណភាពទឹកតំបន់ទឹកសាធារណៈ សម្រាប់ការការពារសុខភាពសាធារណៈ

លរ	ប៉ារ៉ាម៉ែត្រ	ខ្នាត	កម្រិតស្តង់ដា	កូដ (CAS No.)
១	កាបូនតេត្រាក្លរ (CCl_4)	µg/l	<៤	(56-23-5)
២	អ៊ិចសាក្លរ៉ូបង់សែន (C_6Cl_6)	µg/l	<០,០៣	(118-74-1)
៣	ដេដេតេ (DDT)	µg/l	<១	(50-29-3)
៤	អង់ឌ្រីន ($C_{12}H_8Cl_6O$)	µg/l	<០,០១	(72-20-8)
៥	ឌីអលឌ្រីន ($C_{12}H_8Cl_6O$)	µg/l	<០,០១	(60-57-1)
៦	អេនឌ្រីន ($C_{10}H_{13}NO_3$)	µg/l	<០,០០៥	(309-00-2)
៧	អ៊ីសូឌ្រីន ($C_{12}H_8Cl_6$)	µg/l	<០,០០៥	(465-73-6)
៨	ពែក្លរ៉ូអេទីឡែន (C_2Cl_4)	µg/l	<១០	(127-18-4)
៩	អ៊ិចសាក្លរ៉ូប៊ុយតាឌីអែន (C_4Cl_6)	µg/l	<០,០១	(87-68-3)
១០	ក្លរ៉ូហ្វម ($CHCl_3$)	µg/l	<៣០០	(67-66-3)
១១	១,២ ឌីក្លរ៉ូអេទីឡែន ($C_2H_2Cl_2$)	µg/l	<៤០	(156-59-2)
១២	ទ្រីក្លរ៉ូអេទីឡែន (C_2HCl_3)	µg/l	<១០	(79-01-6)
១៣	១,២,៤ ទ្រីក្លរូបង់សែន ($C_6H_3Cl_3$)	µg/l	<០,៤	(120-82-1)
១៤	អ៊ិចសាក្លរ៉ូស៊ីក្លូអ៊ិចសែន ($C_6H_6Cl_6$)	µg/l	<០,០៥	(58-89-9)
១៥	បង់សែន (C_6H_6)	µg/l	<១០	(71-43-2)
១៦	កាត់ម្យូម (Cd)	µg/l	<៣	(7440-43-9)
១៧	បារ៉ែតសរុប (Hg)	µg/l	<០,៥	(7439-97-6)
១៨	បារ៉ែតសរីរាង្គ (CH_3Hg^+ និង C_6H_5Hg)	µg/l	មិនអាចរកឃើញ	-
១៩	សំណ (Pb)	µg/l	<១០	(7439-92-1)
២០	ក្រូមវ៉ាឡង់៦ (Cr^{+6})	µg/l	<៥០	(18540-29-9)
២១	អាសេនិច (As)	µg/l	<១០	(7440-38-2)
២២	សេលេញ៉ូម (Se)	µg/l	<១០	(7782-49-2)
២៣	ប៉ូលីក្លរ៉ូ ប៊ីផេនីល (PCB)	µg/l	មិនអាចរកឃើញ	(1336-36-3)
២៤	ស្យានីតសរុប (CN)	µg/l	<៥	(57-12-5)
២៥	ឌីក្លរ៉ូមេតាន (CH_2Cl_2)	µg/l	<២០	(75-09-2)
២៦	កូលីហ្វមសរុប (Total coliform)	MPN /100mL	<១០០០	-

កំណត់សម្គាល់៖

កូដ CAS No. ៖ សំដៅដល់លេខកូដសារធាតុគីមី (Chemical Abstract Service Number)

(-) ៖ ពុំមានកំណត់លេខកូដ

添付資料 11　Guideline on Wastewater Treatment Process and Facilities

Guidelines
on
Wastewater Treatment Processes and Facilities

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1.0 WATER POLLUTION

1.1. Introduction – What is Pollution

Pollution is defined as *any alteration of the physical, chemical, and/or biological properties of any water, air, and/or land resources or any discharge* thereto of any liquid, gaseous, or solid waste, or any production of unnecessary noise, or any emission of objectionable odor, as will or is likely to *create* or to *render* such water, air, and/or land resources *harmful, detrimental, or injurious to public health, safety, or welfare* or which will adversely *affect their utilization* for domestic, industrial, commercial, agricultural, recreational, or other legitimate purposes.

A shorter definition of water pollution is any change in the water that makes it unsuitable for its intended use. A *pollutant* is therefore any agent that causes undesirable change. *Wastewater* is any water that is contaminated or polluted so that it is no longer suitable for its intended purpose, be it for drinking, swimming, washing, raising of fishes, or any other legitimate purpose.

Control of water pollution or the discharge of untreated wastewater is important because water is necessary in maintaining not only our quality of life but also life itself. Our bodies are made up of about 75% water. We can survive without food for several days but not without water. We use water to wash and clean ourselves, grow, provide, and prepare our food, produce goods in our factories, convey goods and people, and provide a venue for recreation.

1.2. Types and Sources of Water Pollution

Water pollution can be classified in the following manner: as to its *physical source*, its *persistence*, and its *cause* of occurrence.

Water pollution classified as to its physical source are as follows: ***Water Pollution from Point Sources*** and ***Water Pollution from Non-Point Sources.*** Water pollution from **point sources** is pollution caused by substances or energy that come from easily identifiable sources. Examples of point sources of water pollution are readily identifiable wastewater-generating industries or factories and sewage systems from which pollutant-bearing water is discharged into the environment through pipes, sewers, canals, or ditches.

Water pollution from **non-point sources** is pollution caused by substances or energy that come from dispersed, and often hard-to-identify (or pinpoint) sources or areas. Examples of non-point sources of water pollution include agricultural lands and wastes from urban areas - large area sources of pollutant-bearing wastewater (*i.e.*, urban wastes, agricultural runoff that is contaminated with pesticides, etc.)

Water pollution as to its persistence is classified as follows: ***Non-persistent*** (or degradable) and ***persistent*** (or non-degradable). ***Non-persistent*** water pollution is caused by substances, whether in gas, solid, liquid or energy forms, that can be broken down completely, or reduced to tolerable or acceptable levels, by natural physical, chemical, and/or biological processes. Some substances (***biodegradable substances)*** that cause non-persistent pollution such as waste food, are broken down or degraded by living organisms (usually specialized bacteria forms).

Persistent water pollution is caused by substances, whether in gas, solid, liquid or energy forms, that either cannot be broken down by natural processes, or, take a very long time (beyond the normal life span of man) before they can be broken down completely, or reduced to tolerable or acceptable levels. Plastics which take a very long time to degrade or be broken down are examples of persistent pollution.

Water pollution can also be classified as to its cause of occurrence: ***Natural Water Pollution*** and ***Man-Made Water Pollution***. ***Natural water pollution*** occurs naturally as in the case of ash and dust from volcanic eruptions that would contaminate water bodies.

Man-made water pollution occurs due to the activities of man. Considering that adverse natural occurrences generally are not that frequent, pollution has generally been conceived as something "man-made." From the observation that pollution is generally man-made and considering that man is engaged in many forms of pursuits - domestic, commercial, and industrial activities, water pollution can also be classified in terms of the type of human activity that may cause water pollution due to the wastewater generated by their activity,: ***domestic, commercial, industrial, agricultural***, etc.

1.3. Water Pollutants and Their Effects

Water pollution is caused by substances called ***pollutants***. Polluted water generated from human activities is generally called ***wastewater***. Water pollutants can be identified according to their specific wastewater sources: ***industrial wastewater*** (which includes commercial), ***domestic wastewater*** (also called sewage), ***agricultural wastewater***, etc. Industrial wastewater is further classified as to the type of industry generating it. The wastewater of each type of industry has typical characteristics owing from the specific chemical substances used and production processes involved.

Water pollutants are generally classified into four categories: ***biological agents, dissolved chemicals or substances, non-dissolved chemicals, sediments***, and ***heat***. However, for purposes of removing or abating the pollutants, most environmental science authors classify water pollutants into eight types: ***disease-causing agents, oxygen-demanding wastes, water-soluble inorganic chemicals, inorganic plant nutrients (such as nitrogen and phosphorous), organic chemicals, sediment pollution, thermal pollution,*** and ***radioactive substances***. Due to the increasing industrialization of most countries in the world, and therefore the increasing use of and dependence on metals and related metals industries, a ninth distinctive category has emerged, toxic ***heavy metals***.

Disease-Causing Agents. Disease-causing agents (pathogens) can come from both human and animal wastes borne by wastewaters from domestic (usually called sewage), commercial, and organic matter-based industrial wastewaters, and hospital wastes. These types of pollutants may be in the form of bacteria, viruses, protozoa, and parasitic worms that cause diseases, sickness, and death in man. Sometimes, man inadvertently gets exposed to these disease-causing agents (also called pathogenic organisms) when they get in contact with wastewater or drink contaminated water.

Organisms like bacteria, viruses, and protozoa can cause gastrointestinal infections (like diarrhea, dysentery, cholera), deadly sicknesses (like malaria, typhoid fever, and other forms of fevers that cause death), and respiratory diseases (like tuberculosis, influenza, and pneumonia). Parasitic worms can cause diseases like schistosomiasis and can cause men to harbor parasitic nematodes like roundworms and flatworms that can debilitate the host human. One can also add toxic organisms like those dinoflagellates which when ingested (indirectly through eating mussels and other shellfishes) by man can even cause death.

Below are examples of specific pathogens typically found in domestic sewage:

Infectious Agent	Disease
Salmonella typhi (bacterium)	Typhoid fever
Vibrio cholera (bacterium)	Cholera
Salmonella species (bacteria)	Salmonellosis
Escherichia Coli (E. Coli), Campylobacter species (bacteria)	Diarrhea
Hepatitis A virus	Infectious Hepatitis
Poliovirus	Poliomyelitis
Shigella species (bacteria), Entamoeba bistolytica (protozoan)	Dysentery
Giardia intestinalis (protozoan)	Giardiasis
Roundworms, Flatworms	Numerous parasitic diseases
Leptospira spp. (bacteria)	Leptospirosis
Adenovirus (47 types)	Respiratory disease, Eye infections

Oxygen-Demanding Wastes. Organic chemicals or substances in the right concentrations can over-feed specific organisms in aquatic ecosystems. This overfeeding can be caused by the addition of inorganic nutrients that are normally limiting for plants, or, by the addition of organic substances that serve as food for biological decomposers. Decomposition occur under two conditions: aerobic where oxygen is present and anaerobic where oxygen is absent. There are also organic wastes which can cause the depletion of the amount of dissolved oxygen in the water when degraded by oxygen-consuming bacteria.

Since the amount of oxygen dissolved in water is a good indicator its capacity to support various forms of water (aquatic) life and therefore, the water quality, oxygen depletion can induce "catastrophic" results because of the resulting inability of the body of water to support aquatic life, resulting in death of fishes and other forms of oxygen-using aquatic life.

Severe depletion of dissolved oxygen from water bodies can accelerate eutrophication (sometimes described as "artificial eutrophication" since the acceleration is usually caused by human activities). Eutrophication is a normal process in bodies of waters, where the water is enriched by nutrients and becomes turbid because of the vast numbers of algae and cyanobacteria supported by the nutrients.

Near-absolute depletion of oxygen in an aquatic body can result in the death of species that need oxygen (such as fish), and a rise in the growth of anaerobic species. Anaerobic species can live in the absence of oxygen and can cause the production of foul-smelling and potentially toxic end products of anaerobic respiration such as those listed below:

	Compounds in Which Each Element Ends Up	
Chemical Element in the Organic Compound	***In Aerobic Decomposition (where oxygen is present)***	***In Anaerobic Decomposition (where oxygen is absent)***
Carbon	Carbon Dioxide	Methane
Sulfur	Sulfate Salts	Hydrogen Sulfide (stinks, is poisonous)
Nitrogen	Nitrate Salts	Ammonia (stinks, is poisonous)

Chemistry of Aerobic and Anaerobic Decomposition (Kupchella 1993)

Biochemical Oxygen Demand *(BOD)* – Biochemical Oxygen Demand is a measure of the amount of oxygen required by aerobic microorganisms to decompose and stabilize the organic (and biodegradable) matter or substances in the water sample, through biochemical reactions. The concentration of organic substances in (waste)water that require oxygen for their decomposition is measured as BOD. These oxygen-demanding organic substances are usually **not toxic** or harmful in themselves. In fact, they usually serve directly as food for some higher life forms and other types of organisms, and certainly for a wide variety of microorganisms. BOD is used as a surrogate or proxy measurement of the organic substances present in the (waste)water.

Microorganisms naturally present in water consume (*eat*) or decompose such organic substances. In the course of decomposing the organic matter or substances, the aerobic bacteria (those requiring the presence of oxygen to survive) need oxygen to "*burn*" (oxidize) the food. They obtain this oxygen from the oxygen dissolved in the water. As the microorganisms consume oxygen to decompose the organic substances, the amount of oxygen dissolved in the water is reduced or depleted. The dissolved oxygen concentration in the water can then decrease below a level required by fishes to survive, and, the fishes are killed by asphyxiation ("*suffocation*").

High Biochemical *Oxygen Demand* can cause a rapid decrease in the dissolved oxygen (D.O.) levels. The amount of BOD that a specific receiving water can accommodate is a function of several factors including the re-oxygenation rate of the water, rate of activity of microorganisms, and tolerance of fishes to low D.O. levels. A five-day BOD (oxygen demand for five days) of 50 mg/l of oxygen is often deemed low enough to be accommodated by the self-oxygenation capacity of the water with enough dilution.

Chemical Oxygen Demand *(BOD)* – Chemical Oxygen Demand is another measure of the amount of oxygen needed to oxidize (or decompose or stabilize) organic compounds or substances present in (waste)water. Since the procedure for COD determination uses a strong oxidizing chemical (potassium dichromate) and a strong acid (sulfuric acid) and digestion at 150°C, practically 100% of the "oxygen demand" of the organic compounds (and even of inorganic compounds that are not normally biodegradable) is measured.

In contrast, the “oxygen demand” measured or determined using the BOD analytical procedure is limited to the amount of oxygen consumed by microorganisms during the incubation period (typically, 5 days). Many organic substances, especially complex compounds take a long time to biodegrade and their corresponding “oxygen demand” is not measured as BOD. This is why COD is always greater than BOD.

Water-Soluble Inorganic Chemicals. Water soluble inorganic chemicals include salts, acids, alkalis, as well as toxic chemicals and heavy metals such as lead and mercury. Due to their emergence as one of the major pollutants facing the world today, heavy metals are discussed separately. Dissolved salts, sometimes called agents of hardness, are naturally present in water supplies and are also present in high concentrations in certain types of wastes. Dissolved salts interfere with specific industrial processes such as textile dyeing and beer-brewing, and they can become deposited in pipes and other water-handling equipment. Other inorganic salts, such as magnesium sulfate causes a chronic chemical type of diarrhea because it has a cathartic effect on the digestive tract when present in large amounts.

Nonmetallic salts such as arsenic are known to be extremely poisonous. Selenium is poisonous and have killed thousands of migratory birds in the 1980’s, as it causes developmental malformations in such birds.

Acids and alkalis can interfere with the normal environmental conditions of living organisms in aquatic ecosystems. Only a few organisms can survive conditions of very high alkalinity or acidity. Very high alkalinity or acidity can make water unfit for drinking. Aquatic life such as game fish and amphibians are generally the first to be killed due to increased acidity levels in water. Increased acidity would limit aquatic life only to a few resistant species of mosses and fungi. Acids such as sulfuric and nitric acid and alkalis such as sodium hydroxide can damage biological tissues on contact. High alkalinity, which can come from alkaline industrial wastewater or by-products of high photosynthetic rates in eutrophic waters can be lethal to fish life.

Other inorganic chemicals such as salts that are normally not toxic in low concentrations – may become concentrated enough to worsen water quality or adversely affect aquatic biological communities.

Inorganic Plant Nutrients. Water soluble nitrates and phosphates are some examples of inorganic plant nutrients which can lead to the fast growth of undesirable aquatic life when discharged to the aquatic environment. These same nutrients can also lead to pollution of ground water when discharged in excessive amounts in the soil. The presence of excessive amount of nutrients in water bodies can encourage high biological productivity in aquatic ecosystems, such as algal blooms, thick growths of aquatic plants, and resulting high levels of sediment accumulation. These conditions combine to accelerate eutrophication and thus cause a water body to grow old at unnaturally fast rates. The presence of nutrients can also encourage the accelerated multiplication of minute organisms called dinoflagellates that produce toxic “*red tides*” which kill fish and even humans, when contaminated fish or other aquatic or marine produce is ingested by man.

Organic Chemicals. Certain organic chemicals can be very toxic and cause cancer, birth defects, and/or even genetic disorders. Studies in laboratory animals have shown that exposure to DDT (Di-chloro Di-phenyl Tri-chloroethane, a pesticide) was associated with an increased frequency of cancer. Subsequent studies indicated the bioaccumulation of DDT in aquatic ecosystems and could become hazardous to humans. Formaldehyde, a widely used synthetic organic chemical is both a direct and indirect allergenic, and a powerful sensitizer as well. People expose to it become hypersensitive to many other materials in their environment as they suffer from what is called "sick-house" syndrome.

Other toxic organic chemicals like phenols, surfactants, and agricultural pesticides tend to resist conventional methods of wastewater treatment and thus, pose a special problem to man. For this reason, scientists have special interests in developing non-conventional methods for the treatment, abatement, or removal of these toxic organic chemicals. Toxic organic chemicals are poisonous as they react with specific cellular components to kill cells of living organisms.

Sediments. *Sediments* and suspended solids can lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharged into the aquatic environment. Sediment build-up is actually normal in water bodies, but an accelerated rate of sediment build-up can prove detrimental to aquatic life, since it can fill lakes and reservoirs, obstruct shipping channels, and also make water purification (for drinking purposes) more expensive. Excessive sediment deposits (sch as run-off from open pit mines) can also smother aquatic life on coral reefs and shoals near the shores. Excessive amounts of sediments in a body of water can impede the transmission of sunlight through the water resulting in the reduced survival of aquatic life such as aquatic plants which require sunlight for photosynthesis.

Turbidity is a measure of the interference to the transmission of light through water. It is caused by the presence of fine solids that remain suspended in the water. The effect of turbidity is similar to that of color in inhibiting photosynthesis. This parameter has been replaced by the suspended solids concentration as a controlled or regulated parameter. Turbidity is actually a better measure of the direct effect of the suspended insoluble particles (determined as suspended solids) on the transmission of light.

However, *suspended solids* have another effect distinct from turbidity. The insoluble solids may settle to the bottom of the receiving water body. The settled solids may decompose, and change the ecological balance at the bottom, or they may cover the bottom to the extent of preventing photosynthetic activity by plants at the bottom or prevent access to the bottom biota by the bottom grazing fishes.

Thermal Pollution. Thermal pollution is generally caused by man, through the discharge of heated water (used as cooling agent for industrial equipment) directly into water bodies. Changes in water temperature can adversely affect water quality and aquatic life because it lowers the dissolved oxygen content and make aquatic organisms more susceptible to disease and parasites. The dissolved oxygen in water is affected because oxygen solubility in water decreases as temperatures increase.

In addition, since water temperatures are usually much more stable than air temperatures, aquatic organisms are poorly adapted to rapid temperature changes. Thus, changes in water temperature can be lethal to these organisms. Most biota are acclimated to the specific temperature ranges in their immediate environment. While fishes and aquatic plants can thrive within a naturally occurring variation of temperatures, artificially induced temperature changes affect their metabolism. Growth and propagation are impaired when a change in temperature of about 3 C^o is artificially induced by the discharge of water with an elevated temperature. Less complex organisms are more sensitive to temperature changes; different species predominate in different temperature ranges. An upper temperature limit of $40^{\circ}C$ effectively controls the induced temperature rise to within tolerable levels as long as there is sufficient dilution in the receiving water body.

Radioactive Substances. There are radioisotopes that are water soluble or capable of being biologically amplified in food chains and food webs. These types of radioisotopes can cause genetic damage, cancer, and DNA mutations that lead to birth defects.

Heavy Metals. Heavy metal is a generic term for metals that have a high atomic weight. The more common heavy metal pollutants are aluminum, cadmium, chromium, copper, lead, mercury, and zinc. Heavy metals adversely affect human health. The heavy metals in the wastewater when discharged into the environment can intrude into water bodies and eventually be drunk by man, and later adversely affect man's health. The heavy metals in the water bodies eventually get into fish and shellfish, which are part of man's staple food. Metals like zinc, manganese, copper, nickel, and lead were found to be bioaccumulated in the tissues of fish. Oysters in the estuarine reaches of rivers may exhibit heavy metal contamination. These heavy metals in fish and shellfish eventually get into man, because these organisms are part of man's diet.

The relation between *aluminum*, calcium, and pH in drinking water and the risk for cognitive impairment (such as Alzheimer's) was identified in a study of data collected in 1988 - 89 in a population-based survey of 3,777 French men and women aged 65 and older (Jacqmin et al: 1994).

Cadmium concentrations in whole blood were detected in 128 male and 150 female adult subjects in Singapore with no occupational exposure to cadmium, thus it could be inferred that cadmium entered their bodies through other means, such as cadmium intrusion into their environment (Chia et al: 1994). A condition known as *Itai-Itai* (Japanese word that literally translates to *Ouch-Ouch*) disease that developed in Japanese people living near the Jintsu River was traced to cadmium poisoning.

The hexavalent state of *chromium*, commonly used for chrome plating, is highly toxic to all life forms and cannot be directly removed by chemical precipitation. The less toxic trivalent state, common in certain dye stuff used in the textile industry, can be removed by precipitation.

Copper is toxic to algae, marine plants, invertebrates, and fishes. This is the reason why copper compounds are often used to control algal growth in cooling towers. Copper has a lesser effect on mammals. Aside from toxicity, copper imparts an undesirable taste to the water. While a concentration of 0.2 mg/l can already be toxic to some fishes, copper concentrations in wastewater discharges as high as 1.0 mg/l is often acceptable because of expected dilution effects in the receiving water body.

Lead is deemed a most harmful because it is a cumulative poison, that is, it builds up in the organism, whether simple or complex. Lead is neurotoxic (causes nerve damage) at any level of exposure. Non-fatal concentrations may eventually reach fatal concentrations with continued ingestion or exposure. Even non-fatal doses of lead can cause *plumbism*, a lead-caused disease characterized by several severe physical disabilities. Actual toxic concentrations are variable according to specific conditions. A limit of 0.05 mg/l of lead may be acceptable for drinking water purposes. For fish and aquatic life propagation, 0.5 mg/l may avoid toxic effects and limit accumulation of lead in the fish bodies (which makes the fish unsuitable for consumption.).

Mercury, when converted by bacteria into methyl mercury, is soluble in water and is likewise bio-accumulated in aquatic organisms. It can cause neurological damage in man due to methyl mercury poisoning. The disease is more commonly known as Minamata disease, named after the village in Japan where the first human case, and subsequently thousands of human cases, occurred. The neurological damage manifested in nervous problems include numbness, tingling sensations, headaches, blurred vision, slurred speech, loss of muscle control, violent trembling, paralysis, and even death. In areas were mercury poisoning has been observed, there were also occurrences of children born with deformities, paralysis, and permanent mental retardation.

Zinc is toxic to certain marine plants at 10 mg/l. At this concentration, it has also been found to inhibit photosynthesis. Toxic levels for fishes are less easily identified. However, a concentration of 5.0 mg/l has been considered as sufficiently safe for most aquatic life.

Other pollutants. Other water pollutants of special interest are pH, color, odor, and oil and grease.

pH value is a measure of the acidity or alkalinity of a water solution or sample. Mathematically, the pH is the negative logarithm of the molar hydrogen ion concentration. The pH of pure, neutral water is 7.0. When a water solution is acidic, there are more hydrogen ions and the pH value falls below 7. When the water solution is alkaline, there is an excess of hydroxyl ions. These react with the hydrogen ions present to form water (H-OH). As a result, the hydrogen ion concentration decreases. Consequently, the pH value increases above 7.

Most biochemical reactions that maintain life or promote growth whether in unicellular organisms or more complex life forms are pH dependent. For unicellular organisms, the pH of the surrounding environment has an immediate and direct effect on the intracellular reactions.

Most microorganisms can survive only within a narrow pH range. Other microorganisms that can survive under certain non-neutral pH conditions try to control the pH in their immediate surroundings to prevent the growth of other microorganisms with which they are competing.

For higher life forms such as fishes and aquatic plants, a wider pH range is acceptable, but pH condition below 6.8 or above 8.4 can be lethal. Fishes and other motile life forms may have sufficient mobility to avoid such non-neutral water conditions, but for aquatic plants the non-neutral pH conditions are fatal. In any case, non-neutral waters are not suitable for the propagation of fishes and other aquatic resources. For primary contact recreation waters (such as swimming), the allowable range is limited to 6.5 to 8.3. The limits are mainly based on the buffering capacity (ability to maintain a given pH condition) of the tears. Non-neutral pH conditions irritate the eyes.

Color does not only "offend" the aesthetic sensibilities of man. Since color is produced by the use of combinations of organic and inorganic chemicals as well as some heavy metals such as chromium, the presence of color should trigger suspicion of the presence of other water pollutants. The effect of color on the suitability of use of water is direct for aquatic plants but indirect for fishes. The presence of color in the water affects the transmission of sunlight necessary for the photosynthetic activity in plants. At least 10% of the incident sunlight should reach the bottom of the photosynthetic zone of the body of water. If the amount of incident sunlight is insufficient, photosynthetic activity is inhibited or stopped. The plants would then die.

The photosynthetic process releases oxygen that dissolves in the water. Fishes need this dissolved oxygen for "breathing". With the inhibition of photosynthesis by interference with light transmission by the color in the water, the available oxygen supply to fishes is reduced to the point where propagation and/or growth is inhibited. Color in excess of 150 PCU (Platinum-Cobalt Units) in the receiving water may inhibit photosynthesis and reduce dissolved oxygen supply to the extent that propagation and growth of fishes and aquatic plants are affected.

Odor is another pollutant that offends the aesthetic sensibilities of man. Odors are usually caused by gases produced by the decomposition of organic matter or by substances added to the wastewater. Some odors are caused by gases that are toxic (such as hydrogen sulfide). Other odors are simply offensive. Offensive odors can cause poor appetite for food, lowered water consumption that can cause disastrous results in humans, impaired respiration, nausea and vomiting, and mental perturbation. Among humans, offensive odors can lead to the deterioration of personal and community pride and interfere with human relations. The effect of odors is related primarily to the psychological stress they produce, rather than to the harm done to the human body.

1.4. Need for Water Pollution Control

Bodies of water, such as lakes and rivers, have a natural ability to clean itself. This capacity to clean itself is called its *assimilative* capacity. In the past, the amount of pollutants discharged to our lakes and rivers were within their assimilative capacity; hence, the quality of the water in the lakes and rivers did not become worse. With continuing industrialization, development, and population growth, indiscriminate discharge of untreated wastewater increased well beyond the assimilative capacity of the receiving bodies of water. As a result, their water quality deteriorated, posing great threats and risks to public health and causing significant welfare losses. The threats to public health arise from toxic or hazardous contaminants and from pathogens and other disease vectors. Welfare losses include loss or reduction in subsistence (food supply), recreation, economic, and tourism opportunities, aesthetic values, cost of clean-up, not only of routine pollution but also of catastrophic environmental accidents such as oil spills and fish kills.

Water pollution control is, therefore, necessary to **protect public health and welfare**, and to **prevent or reduce damage to public and private property**. Water quality standards define the minimum conditions necessary to assure the suitability of water for its designated purpose, use or classification, and, the protection of public health and welfare.

2.0 WATER POLLUTION MANAGEMENT AND CONTROL

2.1. Management of Pollution

Protection of the environment is not an easy task. There are laws and regulations promulgated to better define the actions and activities that protect, preserve, and/or enhance our environment. Companies desiring to do business need to be attuned to and to support national aspirations, *e.g.*, conservation, environmental protection. Yet, businesses and industries also need to meet its financial objectives to remain viable. Often, environmental protection requires substantial financial resources. The strategy successfully adopted by individual companies in resolving the seeming conflict between economic growth and environmental protection can serve as an effective model for other industry sectors, in particular, small and medium enterprises.

Industries have generally recognized the need for treating their wastes before discharge, if only to comply with the regulations. As industries relied on end-of-pipe treatment technologies to control water pollution, it became obvious that wastewater treatment was both complicated and costly. Clearly, a better approach was required.

2.2. Pollution Prevention - The Essential Strategy

The strategy of the more progressive industries consists of two interrelated phases – *pollution prevention or waste minimization* and *residual waste treatment*. Numerous industry experiences show that prevention of pollution at the source is cost effective and often income generating. Yet, while total elimination of waste is the ultimate and ideal goal of pollution prevention; in practice, some waste streams (*residual waste*) are unavoidable and need to be properly treated for safe disposal to the environment. Thus, industry and other sources of water pollutants will not only need to consider water pollutant source reduction techniques such as waste minimization, pollution prevention, cleaner production, recycling and re-use, etc. They also must be aware that any remaining wastewater needs to be treated appropriately.

In one case for a desiccated coconut (DCN) factory, the waste minimization study identified coconut water and lost coconut meat as the major sources of organic pollutants. Water use and wastewater generation were reduced by training workers on better cleaning procedures, by improving the efficiency of the coconut meat washing equipment, and by detecting and correcting leaks from pipes, hoses, and valves. These activities resulted in over 60% reduction in wastewater generation.

The amount of coconut meat in the wastewater was reduced by improving cleaning procedures (sweeping up and collecting the spilled meat) and by equipping drains with strainers. The collected meat was sold as raw material for the production of coconut oil. These resulted in the reduction of the raw BOD load by 50%.

Coconut water is recovered and sterilized and sold as is or in concentrated form. Coconut water is a highly effective energy and sport drink that has become very popular in the past few years. Recovery of coconut water not only reduced the organic pollution load but contributed to the company's revenues. In a way, waste minimization resulted in income generation.

It is significant to note that these waste minimization initiatives did not adversely affect product quality or yield but resulted in significant savings (almost 40% of capital costs and more than 50% of operating costs) in wastewater treatment costs. These savings were in addition to the savings from reduced water consumption (such as savings in pumping and chlorination costs). Waste minimization clearly is a cost-effective approach to pollution control.

2.3. Need for Wastewater Treatment

Despite the success of waste minimization programs implemented by industries, many still fail to comply with the effluent standards. Even highly successful waste minimization programs may still leave some unavoidable waste streams that need to be treated to comply with the applicable effluent standards.

While waste minimization is a very important first phase of a comprehensive pollution management program, this guideline focuses more on the wastewater treatment schemes that may be applied on the residual wastewater streams. At the same time, data will be provided on typical liquid discharges of selected industry sectors, where available, to serve as guide in the assessment of their environmental performance.

2.4. Objectives of Wastewater Treatment

The best wastewater treatment process is none at all. This means that a company's waste minimization program has totally eliminated all wastes and nothing needs to be treated. In actual practice, most companies generate unavoidable wastewater needing treatment.

In selecting the best treatment system, it is important not to lose sight of the objective of wastewater treatment. The primary objective of wastewater treatment is:

Compliance with Effluent Standards

In addition to this, the wastewater treatment plant itself should be *cost effective*. There are two (2) aspects of cost-effectiveness. The first refers to *effectiveness* and applies to meeting the primary objective of compliance with the effluent standards. The second refers to *economy* or minimum costs. Costs include capital outlay (depreciation of value of the equipment) and operating costs in terms of labor and supervision, consumable chemicals, electrical power, utilities, and the like.

Ultimately, all these are geared towards the attainment of the primary objective of waste management, which is:

Protection of the Environment

Thus, companies need to look beyond compliance with the effluent standards to the final or **ultimate disposal** of wastes as harmless end products that, in the very least, do not adversely affect the environment and that may, at best, enhance the quality of the environment and ultimately, our quality of life.

3.0 WASTEWATER TREATMENT

3.1. Introduction

Specific industries generate specific pollutants, owing from their distinct manufacturing operations and the raw materials used. For example, pollutants like chromium, phenols, suspended solids and oil and grease, as well as pollutant indicators such as BOD, COD, pH, and color are expected to be generated by a textile mill industry. A food manufacturing factory may have only BOD, COD, pH, and fats, oil, & grease (FOG) as pollutants in their wastewater. Aside from manufacturing processes and raw materials, the environmental regulations, particularly, the effluent standards, can be used as the basis for defining which pollutants must specifically be addressed when considering wastewater treatment options.

The sources, types, and concentrations of pollutants define the wastewater treatment methods, processes, and technologies suitable to a specific industry or wastewater stream. This is typically the guiding principle followed by designers of wastewater treatment facility (WTF) systems when selecting wastewater treatment methods, processes, and technologies required so that the treated wastewater consistently complies with (government-defined) regulatory standards. On the other hand, the quantity (especially the volume of wastewater) defines the size or scale of the WTF.

Upon procurement of the WTF system, the WTF owner must operate the system such that the treated effluent is consistently in compliance with standards defined by the regulations. It thus becomes necessary for the WTF owner to ensure that the personnel assigned to operate and maintain the WTF system possesses sufficient skills and knowledge to effectively and efficiently operate the treatment plant.

3.2. Wastewater Treatment Processes

The main objective of wastewater treatment is to remove, reduce, or modify (to harmless state) the pollutants harmful to human health and detrimental to the water, land and air environments. The (organic and inorganic) pollutants, which could be suspended, colloidal or dissolved, may be removed or modified physically, changed chemically, or treated biologically. Thus, wastewater treatment processes may be classified into three (3) types:

- Physical treatment processes or operations
- Chemical treatment processes
- Biological treatment processes

In actual application, wastewater treatment plants or facilities rarely use only one type of treatment process and often rely on two or all three types. Many chemical and biological treatment processes rely on such physical processes or operations as solid-liquid separation by sedimentation (gravity settling) or flotation to effect treatment.

One should keep in mind also that most treatment processes convert pollutants from one form (or physical state) to another. For example, treatment of slaughterhouse wastewater containing soluble organic matter (measured as BOD) by the activated sludge process results in the production of waste activated sludge, a solid form of organic matter. Likewise, precipitation of dissolved heavy metals from electroplating wastewater generates sludge containing the now insoluble (precipitated) heavy metals.

3.2.1. **Physical Treatment Processes**

Physical treatment processes (sometimes called *unit operations*) depend on physical properties of pollutants to effect treatment. The different physical state of solid pollutants from the liquid physical state of wastewater allows the removal of the solid pollutants from wastewater, through a solid-liquid separation which is a physical process. Physical treatment processes are also used to remove or separate immiscible liquid (like oil) from the wastewater (liquid-liquid separation). Solids or immiscible substances that are heavier (have higher density, a physical property) than water may be removed by gravity induced settling (sedimentation) while solids or immiscible substances that are lighter (have lower density) than water may be removed by flotation. Solids may also be removed by screening or filtration which provides a physical barrier to solids larger than the openings of the screen or pores of the filter.

Physical treatment processes are best suited for the removal of solids from water because they are effective and very economical, especially in terms of cost per unit quantity of pollutant removed. They are often applied in the initial stages of treatment in a wastewater treatment facility. That is why physical treatment is often referred to as *primary treatment*. The most common physical treatment processes are screening, sedimentation, flotation, and filtration.

3.2.2. **Chemical Treatment Processes**

Chemical treatment processes make use of chemical reactions to remove pollutants or reduce their concentration in the wastewater being treated. Chemical treatment processes include neutralization (acid-base reactions) or pH adjustment, precipitation and coagulation of toxic heavy metals and other pollutants, oxidation of toxic cyanide, and reduction of hexavalent chromium to trivalent state. Activated carbon filtration and ion exchange are also considered chemical treatment processes.

Chemical treatment processes are most often applied on inorganic pollutants. Chemical treatment is also used as an aid in physical treatment processes such as the addition of chemicals to enhance sedimentation.

3.2.3. **Biological Treatment Processes**

Biological treatment processes rely on living organisms to treat wastewater. While plants and trees may also be used to treat wastewater such as in constructed wetlands and in *silviculture* (establishing and/or developing forests), the following discussions on biological treatment processes are limited to those involving microorganisms.

Biological treatment processes are well suited for the treatment of organic pollutants, often measured as biochemical oxygen demand (BOD).

3.3. Physical Treatment Processes

3.3.1. Screening and Comminution

Gross or large solids in the wastewater stream are best removed by physical means such as screening. Screening out of gross solids reduces the solids and pollutant load while protecting downstream treatment units such as pumps, mixers, and aerators from damage.

The most common screening device is the inclined bar rack which consist of appropriately spaced parallel bars. The size of the solids to be removed defines the bar spacing. The width of the channel in which it is to be installed usually defines the width of the bar rack. The bar rack may be manually or mechanically cleaned.

Figure 1 Examples of Static Screen, Vibratory Screen, Rotary Drum Screen, and Comminutor *(clockwise from top left)*

In addition to bar racks, fine screens of various mesh sizes are also used for screening out solids. Typical examples are static hyperbolic screens which are generally self-cleaning and rotating drum screens which are equipped with doctor blades to remove screened materials and sprays to prevent plugging of the screen openings.

It is important to consider how screening equipment is operated, in particular, the removal of screened materials from the screen (manual or mechanical) and method of disposal. Provision of scrapers, whether manual or mechanical, bins or containers for screenings, and a trolley or cart will ensure that the screens are properly operated, kept clean, and will remain useful and effective.

The effectiveness of bar screens is dependent on the bar spacing. Due to its usual application in wastewater channels, some large but thin solids (such as plastic bags) may pass through between the bars. Hence, the effectiveness of bar screens (bar racks) ranges from less than 50% to more than 80% solids capture or removal. On the other hand, screens using perforated plates or wire mesh may capture more than 95% of solids larger than its perforations or openings.

In some cases, regular (manual) cleaning of screens and disposal of screenings may be deemed to tedious and impractical, especially for small wastewater treatment plants with limited personnel. In such cases, the WTF may include a device to cut up the large solids into smaller sizes (*"comminute"*) to render them more amenable to treatment and to reduce their adverse effect on downstream treatment units. The use of a comminutor is common is sewage treatment plants.

<u>Quick Check of Screening Performance</u>: The effectiveness of screens in removing solids from a wastewater can be verified by visually comparing the influent and effluent streams. The effluent (screened) wastewater stream should have noticeably less solids and be essentially free of solids larger than the openings of the screen.

3.3.2. <u>Clarifiers (Sedimentation Systems)</u>

Sedimentation is the separation of solids from liquid (water) by gravitational forces where the solids have a higher density than the liquid (water). It is the unit operation used in removing the flocculated precipitates and suspended particles from the wastewater. Sedimentation is one of the most common treatment processes applied in wastewater treatment.

There are four types of settling mechanisms: *discrete particle, flocculant, hindered (or zone),* and *compression*. One or more or all types may occur for a given settling situation.

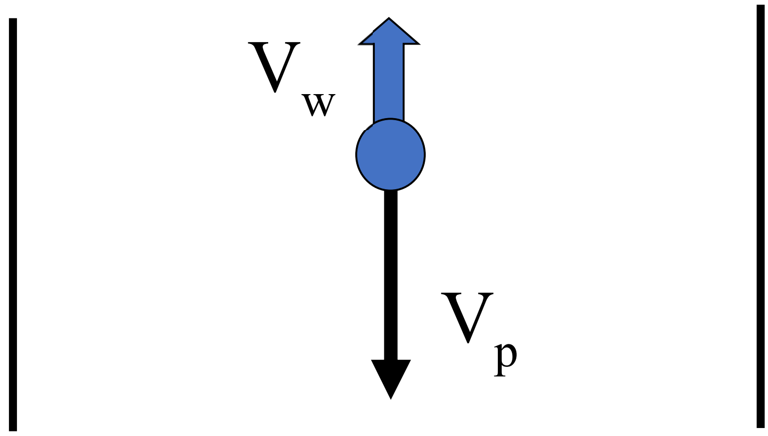
In ***discrete settling***, the concentration of solids is so low that each particle settles independently or with minimal interference by or interaction with its neighboring particles. The settling velocity can be determined using Newton's and Stokes' laws. However, in wastewater treatment applications, there is usually insufficient information on the particles to allow reliable use of Newton's and Stoke's laws/equations. Settling velocity of particles is still determined by **actual tests and measurements.**

In ***flocculant settling***, the particles may also be at a low solids concentration. But the particles tend to coalesce or agglomerate into larger masses that settle at a faster rate. Because of the tendency of the particles to flocculate into lager units, the term flocculant settling is used. This situation is typical in primary settling tanks for domestic sewage, and in integrated clarifier/flocculator units.

In ***hindered settling***, the concentration of solids is so high that the particles interfere with the settling rate of each other. Since they hinder each other, the term hindered settling is used. In hindered settling, the particles settle as a mass, maintaining their relative position with each other. This leaves a clarified layer of water at the top and often there is a distinct solid-liquid interface observable at the top of the settling mass. This type of settling is common for activated sludge settling tanks and thickeners.

Compression settling refers to the type of settling wherein a structure is set up because of the high solids concentration. As solids pile on top, the structure is pushed down or compressed so that the structure earlier formed is compressed. The compression is often accompanied by the release of water entrapped within the structure or settled solids. Compression settling occurs in the lower portions of most settling tanks. This type of settling is most often applied in sludge thickeners.

Figure 2. Forces Acting on a Particle in Sedimentation



Primary clarifiers (*i.e.*, for physical removal of solids), where discrete and flocculant settling occur, are often designed based on *surface loading*. Surface loading is defined as the flow rate divided by the area of the settling surface. Surface loading is actually the average upward velocity of the water mass (V_W). The upward water velocity should be less than the particle settling velocity (V_P) to ensure that the solid particles are removed by sedimentation. Thus, in operating a sedimentation tank or settling tank or clarifier, it is very important that the hydraulic flow rate or resulting upward water velocity or surface loading is not exceeded.

Secondary clarifiers (*i.e.*, for biological treatment stages) where hindered or compression settling occurs, are often designed on the basis of solids flux or solids loading. In any case, the selection of clarifiers requires the correct effective settling area as the most important specification parameter.

The shape of the clarifier also influences its effectiveness and the selection of clarifier. The most common clarifier shape is circular which avoids dead zones and short-circuiting and makes the sludge collection easier. However, rectangular clarifiers are more efficient at using space.

Settling efficiency is theoretically independent of depth but in actual practice, minimum depths are required to prevent scouring and to provide sludge holding capacity.

In addition, the following equipment are needed for a clarifier to function properly:

a. *Influent diffusion drum* or *baffle* to reduce influent water velocities and eddy currents and to distribute the influent flow across the whole settling area.
b. *Overflow weirs and troughs* to collect the clarified supernatant while reducing high velocity currents that may cause entrainment of settled solids.
c. *Effluent* baffles to prevent floating scum from flowing out with the clear supernatant. Baffles for density currents are also very effective.
d. *Collection system* for the settled solids or sludge that may consist of hopper bottoms with steep (60°) slopes or a sludge scraper mechanism (typically on 1:12 sloping floors). It is advisable to select sludge collectors with moving parts or parts requiring regular maintenance or replacement that are easily accessible above water level or without needing to empty the clarifier for servicing.
e. *Scum removal mechanism* that may be a slotted pipe or a mechanical skimmer.
f. *Sludge (and scum) pumping* system that may consist of telescopic valves, sludge (and scum) boxes or holding tanks, and solids handling pumps.

<u>Quick Check of Settling Tank Performance</u>: Since settling or sedimentation is theoretically independent of depth, the adequacy of a settling tank for a given wastewater flow rate may be assessed by determining the surface loading, SL, using the following formula:

$$\boldsymbol{SL} = \frac{\boldsymbol{Q}\ (flow\ rate\ in\ {m^3}/_{hr})}{\boldsymbol{A}\ (surface\ area\ in\ m^2)}$$

An effective settling tank usually has a surface loading (SL) ranging from **0.75 to 1.5** $m^3/hr/m^2$ (or m/h).

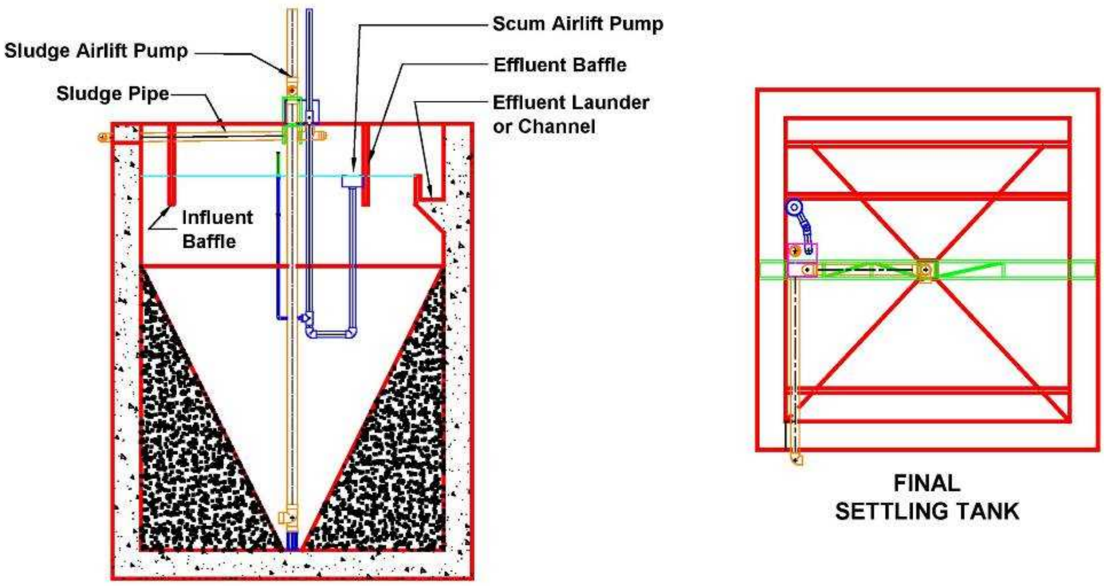


Figure 3 Parts of a Final Settling Tank or Clarifier

The effectiveness of sedimentation depends on the surface loading (flow rate / surface area) and settling characteristics of the solids to be removed. Typically, sedimentation or settling tanks remove less than 70% to more than 95% of suspended solids.

Figure 4 Examples of Sedimentation or Settling Tanks or Clarifier

3.3.3. **Flotation Systems**

Flotation systems may be divided into *plain flotation* as in a grease trap and *air assisted flotation* as in dissolved air flotation. Flotation devices are analogous to sedimentation systems in that they are used for solids-liquid (sometimes liquid-liquid) separation by virtue of the differences in densities, except that in wastewater treatment by flotation, the contaminants are removed from the surface (often easier) and not from the bottom. Another advantage of flotation over sedimentation is that the rise rate is often faster than the settling rate or velocity, especially in air-assisted flotation where larger differences in density can be induced.

Plain flotation is often used for oil and grease removal. The scum or *float* is often removed manually; although, mechanical oil skimmers are available. These oil skimmers often use disc or floating tubes to which the oil cling and from which the oil is scraped off and conveyed into a container. Mechanical scum scrapers are also used and their design is often proprietary but similar to sludge scrapers. Whether the scum or float is manually or mechanically removed, a container (often a drum) is needed for the collected scum or floats.

There are several types of air-assisted flotation devices. They differ only in the manner or creating fine air bubbles that attach to the particles to be floated out. The more common air assisted flotation devices are:

a. *Induced Air Flotation* In induced air flotation (IAF), air is drawn in by means of suction at a pump or negative pressure in an *eductor* or ejector device and mixed with the water flow and broken into fine bubbles.

b. *Dissolved Air Flotation* In dissolved air flotation (DAF), compressed air is mixed with water in a vessel under pressure. The high pressure causes the air to dissolve in the water. When the pressure of the water-air mixture is released through a pressure-reducing valve, the dissolved air goes out of solution to form very fine bubbles.

c. *Cavitation Air Flotation* In cavitation air flotation (CAF), air bubbles are formed by drawing in air to a very high-speed impeller. Cavitation and mechanical shearing occur at the impeller due to its high speed, forming fine air bubbles.

In air-assisted flotation, the important parameter that affects effectiveness and efficiency is the *air-solids ratio*. Other factors that affect the process are effectiveness of mixing of and contact between air bubbles and solids, underflow (clarified water) withdrawal, scum or floats removal, removal of settled solids (if any), and control of air-solids ratio.

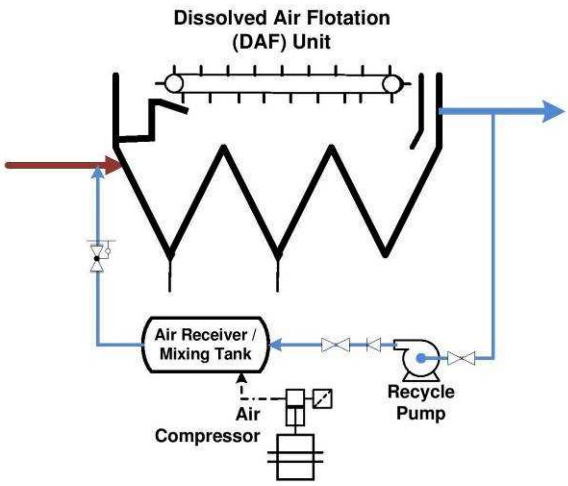


Figure 5 Examples of Dissolved Air Flotation (DAF) Systems

Quick Check of Flotation Device Performance: Since flotation is similar to sedimentation, the adequacy of a flotation device for a given wastewater flow rate may be assessed by likewise determining the surface loading, SL, using the same formula:

$$\boldsymbol{SL} = \frac{\boldsymbol{Q}\ (flow\ rate\ in\ {}^{m^3}/_{hr})}{\boldsymbol{A}\ (surface\ area\ in\ m^2)}$$

An effective induced air flotation device usually has a surface loading (SL) ranging from **1.0 to 2.0** $m^3/hr/m^2$ (or m/h) while a dissolved air flotation device usually has a surface loading (SL) ranging from **3.0 to 6.0** $m^3/hr/m^2$ (or m/h). Air assisted flotation can attain removal efficiencies in excess of 95% with proper conditioning such as addition of the appropriate types and dosages of polyelectrolytes (flocculant aids).

Plain flotation devices such as grease traps are sized based on hydraulic retention times. For small grease traps used under sinks in kitchens of canteens, restaurants, commissaries, or similar food preparation and cooking facilities, a hydraulic retention time of 1.0-2.0 minutes may suffice. For larger plain flotation devices such as those used in service stations where engine oil is changed or vehicles are washed, the hydraulic retention time should be at least 1-2 hours. Solids and/or oil removal efficiencies of plain flotation devices range from as low as 30% to s high as 90%.

3.3.4. **Filtration**

To meet effluent standards and/or to further reduce residual solid pollutant concentrations, the (treated) wastewater may be filtered. Several applications use gravity filtration but pressure filtration is often equally cost effective. Various media are used but silica sand is the most common with anthracite and even activated carbon being also used for specific applications.

Water filters are sized according to filtration rate or surface loading. Most applications use 10-12 $m^3/h/m^2$ but filtration rates as high as 20 to 30 $m^3/h/m^2$ (often used for swimming pool water filtration applications) have been effective. Backwash facilities are needed to generate a backwash rate of at least 30-40 $m^3/h/m^2$ to ensure proper cleaning of the filter media. A break tank is needed to contain the wastewater during filter cleaning and to provide water for backwashing. Where the wastewater being filtered contains organic matter or comes from biological treatment, the provision of air scouring facilities is advisable. Service and backwashing operations of the filter may be manual or automated. Initiation is often by differential pressure across the filter bed or by timers.

The effectiveness of activated carbon filters is dependent on the type of activated carbon (*i.e.*, raw material used to produce the activated carbon). Activated carbon from various raw materials such as coconut shell, peat, or coal have different adsorption (*removal*) effectiveness for different color dye stuff or organic compounds. The most effective type of activated carbon to remove specific dyes or organic compounds are best determined by actual adsorption tests.

Quick Check of Filter Performance: Although the principle of operation of filters is not similar to that of sedimentation or flotation, the adequacy of a filter for a given wastewater flow rate may be assessed by likewise determining the surface loading, SL, using the same formula:

$$\boldsymbol{SL} = \frac{\boldsymbol{Q}\ (flow\ rate\ in\ {m^3}/_{hr})}{\boldsymbol{A}\ (surface\ area\ in\ m^2)}$$

For sediment or suspended solids filtration, a surface loading or filtration rate of 10-12 $m^3/h/m^2$ will produce filtered effluent with 10-20 mg/l total suspended solids (TSS) while surface loading or filtration rate of 20-30 $m^3/h/m^2$ will produce filtered effluent with 30-60 mg/l TSS.

Figure 6 Valveless Sand and Activated Carbon Filters and Effuent of Activated Carbon Filter

3.4. Chemical Treatment Systems

3.4.1. Physical-Chemical Treatment

Chemical treatment often involves physical processes such as addition and mixing of chemicals to react and effect the desired treatment. Chemical treatment equipment consists mostly of mixing devices and chemical dosing or metering devices. They also include control instrumentation, especially for chemical addition. Chemical treatment systems are not exclusively chemical process systems in nature since the pollutants that have been changed or reacted chemically will still have to be separated from the wastewater being treated, for the treatment system to generate treated effluents that comply with Effluent Standards. Thus, chemical treatment systems are more usually referred to as *physical-chemical treatment* systems.

Physical-chemical treatment includes the use of chemical reactions in combination with some other physical means or processes to treat wastewater. *Chemical processes* used as an aid to sedimentation include chemical coagulation, precipitation, and agglomeration. Other examples of *physical chemical processes* include activated carbon absorption to remove soluble organics, breakpoint chlorination for nitrogen reduction, and lime addition for phosphorous reduction.

Disinfection systems involve processes intended to selectively destroy or inactivate pathogenic bacteria, viruses, and amoebic cysts usually found in wastewater. The reuse of wastewater for irrigation and recreation purposes, as well as requirements to control the spread of pathogens dictates the need for disinfection. Disinfection processes include natural (predation, die-off), chemical (chlorination or ozonation), mechanical (ultrasonics) or radiation (ultraviolet). Historically the usual disinfection process involved chemical disinfection using chlorine; however, because of the impacts of chemical disinfection by-products (such as chlorinated hydrocarbons) on water supplies and the need to protect aquatic life, other means of wastewater disinfection, such as ozonation and ultraviolet radiation are fast gaining acceptance.

To better understand chemical treatment, it is necessary to have a working knowledge of water chemistry.

3.4.2. pH and Ionization

Water is a chemical combination of hydrogen (H^+) and hydroxyl (OH^-) ions, or simply HOH. In pure water, only a very small fraction of the water ionizes. Ionization is the separation or dissociation of a molecule into charged atoms or charged groups of atoms of opposite electrical charges. The total positive charge remains equal to the total negative charge so that the entire solution remains electrically neutral.

The charged bodies are called *ions*. Positively charged ions are called *cations* because they are attracted to the cathode terminal of a battery. Conversely. negatively charged ions are called *anions*. In wastewater applications, the total ion concentration is generally low, much less than 0.1% by weight yet the effect of these ions on the properties of the wastewater solution can be profound.

In pure water, the HOH (water) molecule ionizes to produce both acids (H^+) and bases (OH^-). Since there will always be equal numbers of acids and bases ($HOH \Leftrightarrow H^+ + OH^-$), pure water is neutral. Water is only weakly ionized and the concentration of ions is very low. Pure water has about 1.0 x 10^{-7} gm-moles of H^+ ions per liter (and an equal number of OH^- ions). Since this concentration is inconvenient for everyday use, a different expression, **pH**, is used. pH is the negative logarithm of the H^+ ion concentration.

Neutralization simply involves the addition of appropriate amounts of acids (hydrogen ion source) or bases (hydroxyl ion source) such that at equilibrium, the hydroxyl and hydrogen ion concentrations are equal, or pH is equal to 7.0. In wastewater treatment, the exact composition of the wastewater is often difficult to determine. The amount of acid or base needed to neutralize the wastewater should never be based only on the pH measured because of buffering. The total buffering capacity of the wastewater may not always be known. Chemical requirements for neutralization should always be determined by **actual jar tests** on the wastewater being treated.

3.4.3. Solubility and Precipitation

In a manner similar to weakly ionized acids, certain salts or compounds normally considered insoluble, are in fact, very slightly ionized in water. To the extent that these salts are ionized, so also are they considered dissolved. Thus, they are more correctly called **slightly soluble salts**. While the resulting ionic concentrations are low, these levels are sufficient to dramatically alter the quality of the water solution and the potential uses to which they can be applied. The solubility relationships are also governed by chemical equilibrium, and each slightly soluble salt has an ion product or solubility constant.

Most salts have solubilities that vary with temperature or are temperature dependent. In most cases, solubility increases with temperature although a common exception of this are the calcium compounds. This temperature dependence is significant because the wastewater steam to be treated for removal of heavy metals by precipitation may have an elevated temperature. Residual ion concentrations may, therefore, be quite higher than expected in precipitation reactions at lower ambient temperatures.

As stated earlier, the ions normally act independently of each other unless a chemical reaction takes place that will remove the ions from the solution. The heavy metal pollutants that are to be removed from the wastewater remain in solution because the conditions in the wastewater are such that they remain in the ionized and soluble state. When a precipitating agent is added, the heavy metals react with the precipitating agents to form slightly soluble salts or precipitates. As much of the salt remain in the insoluble state as is required to maintain a certain solubility product of the remaining ions of the heavy metal and the precipitating agent.

While reactions between ions are fairly rapid, a finite amount of time is still required for the reaction (such as precipitation) to reach essential completion. Since the rate decreases as the equilibrium level is approached, it is often best to add an excess of reactants (such as precipitating agents) to ensure that the residual concentrations are low enough even though equilibrium may not yet be completely reached due to inadequate or limited reaction time.

In addition, the presence of certain chemicals that act as complexing or chelating agents may prevent the precipitation of heavy metals ions. Complexing agents combine with metal ions to form an essentially different (in terms of how it reacts) chemical species from the simple metal ion. The solubility product of the metal hydroxide may still be maintained but these complexes do not react as simple metal ions and therefore, remain in solution to make the (total) metal ion concentration in the wastewater high. It is necessary to break up the complexes before the metal ions can be free to react in accordance with the solubility product.

While the solubility product or equilibrium relations indicate that each increase in the hydroxyl ion concentration would result in a further decrease in the residual metal concentration, studies have shown that hydroxyl ions also act as complexing agents, especially with iron (Fe), aluminum (Al), calcium (Ca), and zinc (Zn). This explains why, in the attached Fig. 2 below, the residual zinc concentration increases after a minimum point is reached with the increase in pH (corresponding to an increase in hydroxyl ion concentration). This is one reason why the pH of the precipitation system should be maintained **within the designated limits**. Another reason is economy, using more chemicals means spending more for chemicals.

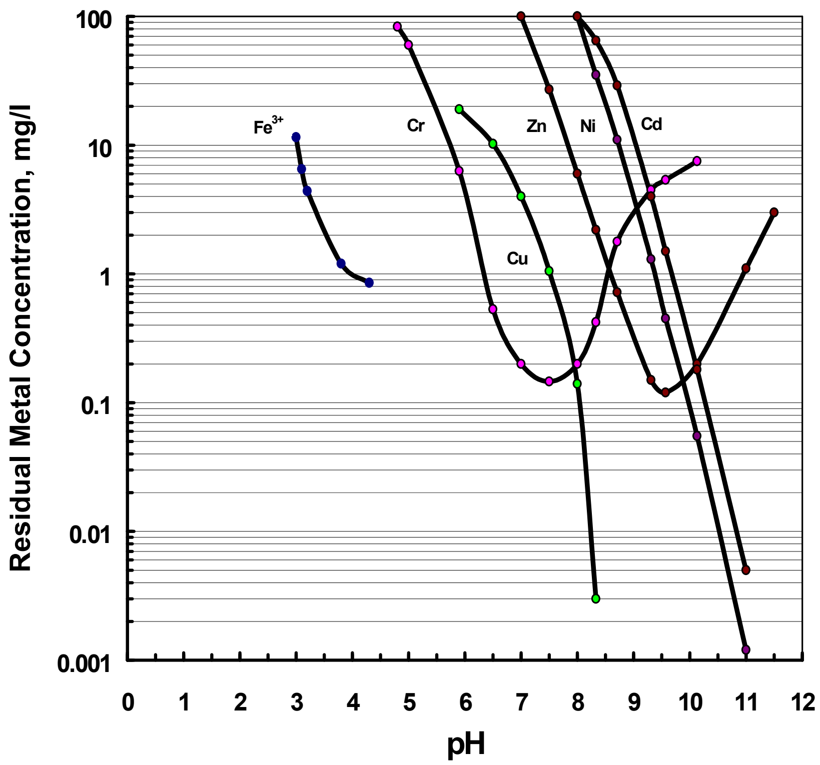


Figure 7 *Residual Concentrations of Various Heavy Metals*

3.4.4. <u>Coagulation and Flocculation</u>

Coagulation and flocculation are both concerned with the agglomeration of finely divided solids into larger particles called *flocs* that settle faster than the fine particles. Coagulation usually applies to the chemical, electrostatic, and absorption mechanisms. Flocculation is generally applied to the operation of stirring the water mass to promote the probability of particle collision that can result in agglomeration and to impart sufficient kinetic energy to the particles so that it can go through the layer of ions that surround the particles and make contact.

The precipitates formed by the addition of hydroxide and suspended solids originally present in the wastewater are often too fine to settle rapidly and completely. To increase their settling rates and thereby reduce the amount of time necessary to hold the wastewater to allow the precipitates and suspended solids to separate from the water mass, it is necessary to agglomerate the fine particles into larger ones that settle faster. This is done by chemical coagulation and flocculation.

Coagulating agents and/or flocculant aids are added to the wastewater to promote the agglomeration of the fine particles into larger, faster settling *flocs*. Mixing must be intense enough to immediately disperse the chemicals added and promote particle collision while gentle enough not to break up the flocs that have already formed.

The best way to determine the optimum combination of flocculation and coagulant dosage is by **actual jar testing** of the wastewater. In practice, it has been found that with a properly designed flocculation unit, the improvement in effluent quality and the reduction in chemical usage do not often justify upgrading of the flocculation system. Moreover, in actual field conditions, the characteristics of the raw wastewater vary widely enough to make the optimum dosage vary continuously.

3.4.5. <u>Agitation and Mixing</u>

Agitation refers to the induced motion of a material in a specified way, usually in a circulatory motion. ***Mixing*** is the random (and uniform) distribution, into and through one another of two or more initially separate phases. In wastewater treatment, wastewater is agitated to keep the properties of the mass uniform and to keep solid particles in suspension. It is ***mixed*** to disperse chemicals added for treatment. Although both terms are used interchangeably, the term "mixing" is more common in wastewater treatment practice. In wastewater practice, the intensity of agitation determines the term used. Mixing is used for vigorous agitation; while, flocculation is applied to gentle stirring.

The intensity of the agitation or mixing action is usually expressed in terms of the velocity gradient, G, in meters per second per meter. The velocity gradient is a function of the power induced by the agitator into the water mass, the volume of the water, and its viscosity. The power imparted by the agitator unit is a function of the design of the impeller, the density of the fluid mixed, the speed of rotation of the impeller (almost all agitators rotate), and the size (diameter) of the impeller.

A good indicator of good mixing (assuming adequate computed velocity gradients and circulation rates) is the absence of vortexes in the water mass. When vortexing occurs, the energy is wasted in rotating the water mass (as a whole) and adding to the potential energy of the water mass by raising its height. The geometry of the mixing tank as well as the placement of the impeller determines the possibility of vortex formation. The tank dimensions, the impeller geometry and dimensions, and impeller speed should be properly selected in the first place. In general, vortex formation can be controlled or minimized by adding baffles to the tank or re-arranging the placement of the impeller.

For wastewater treatment applications, mixing is used in keeping the properties of the water mass uniform (as in the pH adjustment tank and equalization tank), dispersing chemicals added (as in the flash mixing tank and pH adjustment tank), suspending solid particles (as in the flash mixing tank). Mixers are also used in preparing the stock chemical dosing solutions by dissolving and dispersing the solid reagents in water. For continuous flow operations, the hydraulic detention time should range from 15 to 30 minutes. However, most jar tests show that with sufficient mixing (high enough velocity gradients) detention times of less than 5 minutes are feasible for flash mixing and pH adjustment applications where the chemical reactions are fairly fast and complete.

For flocculation, the impellers used are usually of the paddle type. This tends to generate radial flow patterns. The recommended velocity gradient ranges from 20 to 75 fps/ft. There have been instances where higher velocity gradients were used (as high as 150) without breaking up the flocs formed; however, no real advantages were seen in such a high velocity gradient. In fact, power requirements are simply increased.

Figure 8 Examples of Flash Mixing and Flocculation Units

3.4.6. **Sedimentation**

Sedimentation as applied in chemical treatment is the same process described under physical treatment. Generally, discrete particle settling takes place in chemical treatment processes.

It bears repeating that, especially in discrete settling conditions, settling is essentially independent of depth and is determined by the particle settling velocity, which can be translated into a surface loading. This principle is applied in inclined plate clarifiers, which provides a large effective settling area while occupying a small floor space. This makes for an economical settling tank design. The low cost per unit capacity is an important reason why inclined plate clarifiers are popular in chemical treatment systems.

3.4.7. **Oxidation - Reduction Processes**

Chemical reactions involve the loss of gain of electrons forming ions. Chemical substances that lose electrons to other chemical substances are said to be *oxidized* while the chemical substance that receives the electrons are said to be *reduced*. The oxidized material is also called the *reducing agent* while the material that is reduced is called the *oxidizing agent*. In every chemical reaction, each electron loss (oxidation) is accompanied by an equivalent electron gain (reduction). Thus, each chemical reaction may be considered an oxidation-reduction (or *redox*) reaction.

A very common example of an oxidation-reduction reaction is rusting or corrosion of iron. Elemental iron (Fe^0) is oxidized to rust (Fe_2O_3) when it loses electrons (to become Fe^{3+}) to oxygen (elemental O_2 has no electrical charge), which is reduced by gaining the electrons (to become O^{2-}). Oxidized iron combines with reduced oxygen to form rust.

Redox chemical reactions are important in the chemical treatment of wastewater include:

a) Oxidation of toxic cyanide to harmless carbon dioxide and nitrogen gas
b) Reduction of toxic hexavalent (6 positive charge units) chromium to the less toxic trivalent state which can be removed by precipitation as hydroxide salt.

These important oxidation-reduction reactions are presented below:

Cyanide Oxidation

First Oxidation : $2\ CN^- + O_2 \Rightarrow 2\ CNO^-$

Second Oxidation : $2\ CNO^- + O_2 \Rightarrow 2\ CO_2\uparrow + N_2\uparrow + 2\ \textit{electrons}$

A common oxidizing agent is chlorine (either gas or hypochlorite) that accepts the electrons lost in the process.

Chromium Reduction : $Cr^{6+} + 3\ \textit{electrons}^- \Rightarrow Cr^{3+}$

Sodium metabisulfite is a common reducing agent that provides the electrons needed to reduce chromium.

Quick Check of Physical-Chemical Treatment Process Performance: The simplest way to visually examine the treated effluent. It should be clear (minimal or no suspended solids) and colorless. Other than color, the effectiveness of reduction of dissolved pollutants cannot be determined visually. Laboratory analysis is required to determine residual concentrations. The adequacy of the physical treatment equipment may be determined as discussed earlier for the specific treatment process.

3.4.8. **Performance of Chemical Treatment Systems**

3.4.8.1. Neutralization and pH Adjustment

Neutralization and/or pH adjustment treatment systems will always attain the pH set points provided that the instrumentation (pH meter / controller) is properly calibrated and equipment is operating properly. The degree of deviation from the set point can be controlled by the operator. For very precise control (very small deviation from the set point), 2-stage pH control may be required.

3.4.8.2. Precipitation, Coagulation, and Flocculation

In general, the effectiveness of chemical treatment systems using precipitation to remove dissolved pollutants such as heavy metals or color dyestuff is dependent on equilibrium conditions at the end of the treatment (*i.e.*, addition and mixing of treatment chemicals). For example, if the residual copper concentration at pH 8.0 is 0.05 mg/l, it does not change whether the initial concentration of copper in the raw wastewater is 100 mg/l (or 99.95% reduction efficiency) or 10 mg/l (or 99.5% reduction efficiency) or 1 mg/l (or 95% reduction efficiency).

For chemically assisted coagulation and flocculation of fine suspended solids, the reduction efficiency of suspended solids is typically more than 95% with effective sedimentation. Residual suspended solids concentration is usually less than 30 mg/l.

3.4.8.3. Oxidation - Reduction Processes

Oxidation – reduction treatment processes have specific applications. Cyanide is destroyed by oxidation. With the effective and correct control of pH and ORP (oxidation-reduction potential), practically 100% cyanide destruction can be attained.

Hexavalent chromium cannot be removed by hydroxide precipitation. The reduction treatment process is used to convert highly toxic hexavalent chromium to trivalent state. Trivalent chromium is amenable to removal by hydroxide precipitation. Chemical treatment of hexavalent chromium by reduction and precipitation can attain residual chromium concentrations of less than 0.20 mg/l.

3.5. Biological Treatment Systems

3.5.1. Types of Biological Treatment Systems

Most of the organic constituents in wastewater can be utilized as food (substrate) to provide energy for microbial growth. This is the principle in biological treatment processes whereby organic substrate is converted by microorganisms – mostly bacteria with the help of protozoa – to carbon dioxide, water, and more new microorganism cells to effect wastewater treatment.

There are two (2) typical ways of classifying biological treatment processes: in terms of the presence of oxygen (***aerobic*** or with oxygen and ***anaerobic*** or without oxygen) and in terms of the physical state of the microorganisms or *biomass* (***suspended*** in the water or ***attached*** to some fixed, usually inert, material).

In *aerobic* biological treatment systems, heterotrophic bacteria (those that obtain carbon from organic compounds) oxidize about one-third of the colloidal and dissolved organic matter to stable end products such as carbon dioxide and water, and convert the remaining two-thirds into new microbial cells that can either be removed from the wastewater by settling, or, returned into the biological reactor system (typically aeration tanks or vessels) to continue or sustain the biological treatment process. The best-known biological treatment system is the activated sludge process that is an aerobic, suspended-growth system. The trickling filter is an example of an aerobic, attached-growth (or fixed film) biological treatment system.

In *anaerobic* biological treatment processes, two groups of heterotrophic bacteria convert over 90% of the organic matter in the wastewater initially to intermediates (partially stabilized end products, including organic acids and alcohols) and then to methane and carbon dioxide gas through gasification of the simple organic acids. Anaerobic (in the absence of oxygen) treatment systems may also be suspended-growth as in conventional anaerobic or *biogas* digesters and upflow anaerobic sludge blanket (UASB) reactors or attached-growth, which is less common.

Some advantages of anaerobic biological treatment systems over aerobic biological treatment systems are the following:

a. anaerobic systems produce useful energy in the form of methane
b. anaerobic systems typically require less power compared to aerobic systems as the aeration required in aerobic systems are usually generated with equipment that require (mostly electrical) power
c. anaerobic systems produce sludge that is only about 10%-20% of that from aerobic processes for converting the same amount of organic matter., thus reducing the cost of sludge management.
d. anaerobic treatment systems can breakdown or biodegrade several types of toxic or hazardous organic substances such as chloroform and trichloroethylene.

Anaerobic biological treatment systems are clearly advantageous in the treatment of high-strength wastewaters, where handling of large volumes of sludge and otherwise high-power consumption could be problematic.

3.5.2. **Aerobic Biological Treatment Systems**

3.5.2.1. Activated Sludge Systems

The *activated sludge* treatment process is, by far, the most common biological treatment process. Hence, it is considered in more detail than the other treatment processes. Nevertheless, much of the basic principles of the activated sludge process are also applicable to all other biological treatment processes.

The *activated sludge* treatment process involves the following:

a. mixing of wastewater to be treated with a culture of *"active"* microorganisms which assimilates, decomposes, and/or degrades the wastewater pollutants (which serve as the *food* of the microorganisms), in a reactor (aeration tank),
b. agitation or mixing of the mixture of wastewater and activated sludge (called *mixed liquor*) in the reaction vessel to keep the microorganisms in suspension and in contact with food material,
c. aeration to provide the microorganisms with the oxygen needed to sustain life and activity, and
d. separation of the microorganisms from the treated wastewater (treated effluent), usually by sedimentation or gravity settling, and the subsequent recycling of the separated microorganisms (*activated sludge*) to the reactor (aeration tank).

Reaction Unit or Aeration Tank. The presence of microorganisms that can assimilate the pollutants (as food) determines whether the activated sludge treatment process is effective or not. The aeration tank is the place where the biological reaction for the assimilation, degradation, and reduction of the organic pollutants take place. The *activated sludge* (microorganisms) must be mixed intimately with the waste matter, sufficient oxygen must be provided to enable the microorganisms to flourish, and the conditions must be controlled to obtain the maximum biological activity. The following conditions are, therefore, necessary in the reaction unit:

a. Presence of microorganisms that can assimilate the specific waste to be treated.
b. Intimate mixing to maximize access of the microorganisms to their food (pollutants or organic wastes to be treated)
c. Adequate aeration to provide the oxygen required by the microorganisms to survive, grow, and multiply.

Solids Separation Unit or Settling Tank. An essential component of the activated sludge process is the unit where separation of the microorganism from the treated wastewater (after pollutants are removed or reduced) and its return to the reaction tank (aeration tank) to treat more wastes occurs. Separation usually takes place by gravity settling.

Activated Sludge Collection and Recycling Unit. In order to recycle the microorganisms in the activated sludge to the aeration tank to treat more wastes, a collection and pumping mechanism is needed. The sludge recycling system is what defines the *activated sludge process*. Controlling the recycling of the return activated sludge (*RAS*) maintains the correct balance between the waste to be consumed and the microorganisms degrading the waste.

Excess Activated Sludge Wasting Unit. As the microorganisms consume the pollutants (as food), they grow and multiply. To operate effectively, an activated sludge treatment plant requires a proper balance between the available food and the microorganisms. Unless the excess microorganisms are removed (wasted from the system), the microorganism will eventually exceed the food supply. They will not get enough food and will die, adding to the organic pollutant concentration because the cellular mass is itself organic matter and a potential pollutant.

A schematic diagram of the *activated sludge process* is shown on the figure below.

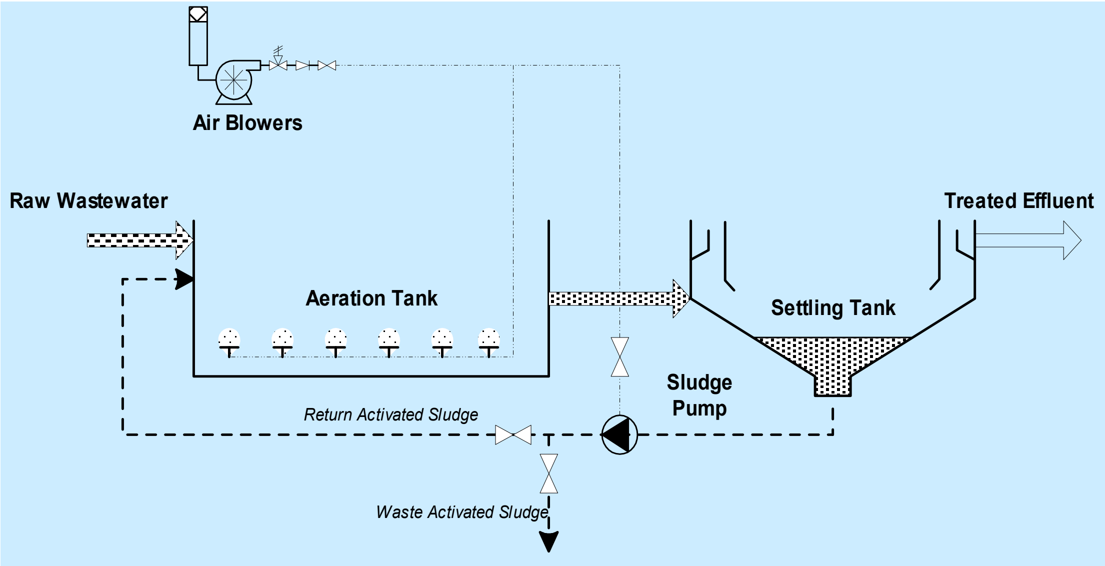


Figure 9 Schematic Process Flow Diagram of the Activated Sludge Process

The activated sludge treatment process is actually an accelerated version of the natural degradation of organic pollutants that takes place in rivers, lakes, or other water bodies. The difference is that we control the conditions in an activated sludge treatment process to promote rapid decomposition of pollutants.

Figure 10 Activated Sludge Treatment Plant: Influent, Aeration Tank, Effluent Launder (Channel), and Flow Metering Effluent Weir Box

Figure 11 Aeration Systems: Diffused Aeration with Blowers, Aspirating Mechanical Aerator, and **Conventional Mechanical Surface Aerator** *(clockwise from top left)*

3.5.2.2. Sequencing Batch Reactors (SBR)

Sequencing batch reactors are a variation of the conventional activated sludge system. Treatment takes place in a single tank, unlike the two-tank arrangement of the conventional activated sludge system. However, treatment is undertaken in batches going through the different stages of filling, aeration / reaction, settling or solids separation, and discharge or decanting of the treated effluent. Provisions have to be made to accommodate the influent wastewater during the different stages (except filling). In most cases, a holding or equalization tank is used or a twin tank arrangement is provided where one tank cycles through the treatment while the other tank accumulates the influent raw wastewater.

The advantage of SBR is that a batch reaction is generally faster and theoretically, an SBR requires a smaller reaction tank than the aeration tank of the conventional activated sludge process. On the other hand, the most significant disadvantage of the SBR is that it is not inherently a continuous flow process; hence, special provisions have to be made for collecting and accumulating the incoming wastewater during the treatment stages.

While sequencing batch reactors (SBR) represent old technology, they have gained more prominence in recent times because of the availability of cheap but powerful controllers (programmable logic controllers or PLC) which can take over the tedious and boring task of cycling the system through the different treatment stages.

Most SBRs are of proprietary design but the basic equipment is similar. As with other activated sludge treatment plants, they require aeration equipment. Diffused and mechanical aeration systems are equally applicable; although, diffused aeration systems may provide slightly better control of oxygenation and mixing rates.

The most distinguishing features of SBRs are:

a. *Decanting Mechanism* that is often proprietary. An important characteristic is its ability to avoid accidental loss of biomass while ensuring effective and rapid discharge of treated effluent.
b. *Controller System* that is often microprocessor (PLC) based. While ease and simplicity of adjustment is essential to enable the operator to respond to changing influent wastewater conditions, the control system should also prevent erroneous settings. At the same time, the option for manual control is important because loss of programming or failure of a complex control system can lead to process failure.

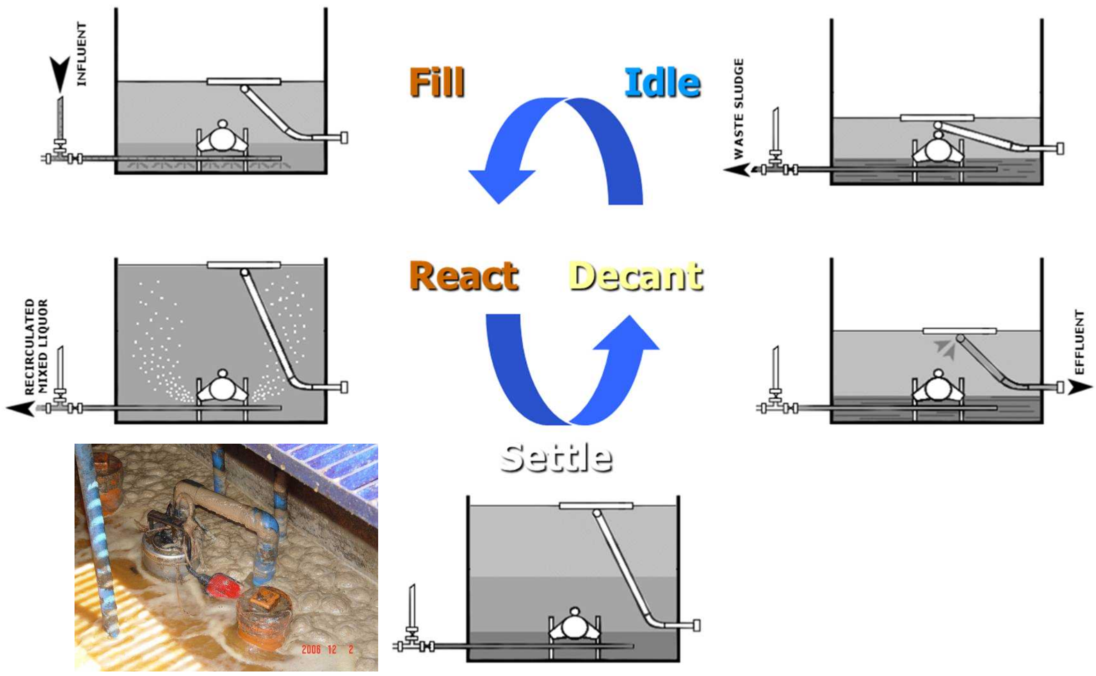


Figure 12 Sequencing Batch Reactor (SBR) Cycle of Operation

<u>Quick Check of Aerobic, Suspended Growth Biological Treatment Process Performance</u>: While many factors affect the performance of activated sludge and SBR treatment systems, the hydraulic retention time (reaction time) in the aeration tank may be used to quickly assess the adequacy of the treatment facility. For 500 mg/l or less raw influent BOD_5, 8-16 hours may be adequate, for >500-1,500 mg/l 20-40 hours may suffice, for >1,500-3,000 mg/l, up to 60 hours.

Although aerobic biological treatment systems can attain BOD_5 reduction efficiencies of 85% to more than 95%, similar to treatment systems based on chemical reactions, the residual BOD_5 concentration in the treated effluent is more dependent on the loading (specifically, F:M or food to mass ratio which is kg BOD/day per kg of activated sludge microorganisms in the aeration tank in the case of activated sludge treatment) than on percentage reduction.

For F:M values of 0.30-0.60 kg BOD/day/kg activated sludge, residual BOD_5 typically ranges from below 30 mg/l to less than 50 mg/l. For F:M values of 0.05-0.15 kg BOD/day/kg activated sludge, residual BOD_5 typically ranges from below 10 mg/l to less than 25 mg/l.

3.5.2.3. Trickling Filters

Trickling filters are a form of *attached growth* or *fixed film*, *aerobic* biological treatment systems. In fixed film processes, microorganisms that consume the organic material (food or BOD) grow as *slime* on fixed media. As the wastewater flows over the slime or biomass, (soluble) organic wastes are adsorbed and consumed by the microorganisms. Oxygen from air diffuses through the thin layer of wastewater to the microorganisms. As the slime layer builds up, the microorganisms on the outermost layer prevents those in the inner layer from getting sufficient food and oxygen. As a result, they begin to die off and lose their ability to cling to the media. Combined with the shear effect of the flowing water, this results in clumps of slime being sloughed off or falling off the media. The material that sloughs off, called *humus*, flows with the wastewater and is separated from the treated wastewater in the secondary clarifier. The newly exposed media surface provides an excellent surface for new microorganisms to grow on, continuing the growth and treatment cycle.

The growth cycle described above points out certain characteristics of attached growth treatment systems. They are best suited for the treatment of soluble BOD and the thickness of the slime (and consequently the equivalent food-to-microorganism ratio) may be controlled using the shearing action of flowing water (hydraulic loading). It is unfortunate that trickling filters are not so popular since their low power requirements translate to low operating cost. This may be due to a lack of understanding of the fundamental principles of trickling filter design.

It is important to note that attached growth treatment processes, such as trickling filters, are more effective on soluble organic pollutants and less so on particulate or suspended solid pollutants. For this reason, trickling filters need primary clarifiers or similar pre-treatment units to be effective.

Trickling filters consist of the following components:

a. *Filter Media* on which the microorganisms can grow.
b. *Distributor System to spread the influent wastewater evenly over the media and flush out excess biomass.*
c. *Underdrain and Ventilation Systems to collect the treated wastewater and humus and allow passage of air for* oxygen supply.

A secondary clarifier is required to separate the *humus* or biomass from the treated wastewater. The settled sludge is not usually recycled but may be recycled under certain conditions. For high BOD applications, the treated wastewater may be recycled to dilute the influent BOD concentration and/or increase hydraulic loading. Alternatively, multiple stages of treatment may be used.

Quick Check of Trickling Filter Performance: Keeping in mind that trickling filters are effective on ***soluble*** BOD, to attain 90% (soluble) overall BOD reduction, the organic loading is limited to 0.5-1.0 kg BOD/day/m^3 (trickling filter total volume) organic loading for a single stage trickling filter; 1.5-2.5 for a 2-stage system, 3.5-4.5 for 3-stage system, assuming each stage has the same volume.

3.5.2.4. Rotating Biological Contactors (RBC)

Rotating biological contactors (RBC) are another type of attached growth biological treatment with a low operating power requirement. In contrast to trickling filters where the media do not move, the media in RBCs are commonly disc-like and rotate around a shaft. The rotation alternately exposes the slime layer to the food (organic wastes) when submerged in the wastewater and oxygen when exposed to the air.

As with trickling filters, RBCs are normally sized or designed on the basis of organic loading (gm BOD per day per m^2 media surface area) to obtain the desired reduction in soluble BOD. Design parameters are specific to a manufacturer's RBC media design due to the difference in surface area per unit volume of RBC media. Nevertheless, allowable loadings are typically a function of (desired) effluent soluble BOD.

While maximizing surface area for a given volume results in compact treatment units, high packing density often result in plugging of the inner portions from excess biomass. This causes an imbalance in the media that in turn causes irregular rotation and overloading of the support bearings, drive train, or shaft. One reason for the decline in popularity of RBCs is the frequent reports of shaft failures.

In terms of media configuration, a plain disk design appears to be the most durable and least prone to uneven loading and shaft failure. The drive mechanism may be mechanical or air powered (buoyancy effect). Mechanical drives are more durable and less prone to stoppage or failure.

An interesting variation of RBCs is the use of fine mesh rotating drum screens in lieu of secondary clarifiers. The rotating drum screen is normally connected to the RBC shaft, eliminating the need for a separate drive mechanism.

Figure 13 Rotating Biological Contactors (RBC) with Mechanical Drive

Quick Check of RBC Performance: Like trickling filters, RBCs are effective on ***soluble*** BOD. To attain 90% (soluble) overall BOD reduction, the organic loading is limited to 1.0-2.0 kg BOD/day/m^3 (RBC media gross volume) and multiple stages are required for influent BOD_5 exceeding 250 mg/l. Hydraulic retention time in the basin or tank typically ranges from 8-12 hours for single stage systems (< 250 mg/l influent BOD_5)

3.5.3. **Anaerobic Treatment Systems**

3.5.3.1. Anaerobic Treatment Processes

Anaerobic treatment is generally applied on high BOD strength (typically > 2,000 mg/l BOD_5 or > 4,000 mg/l COD) wastewater and organic sludges. Anaerobic processes take place in the absence of oxygen. In biochemical reactions, oxygen generally acts as electron receptor in the process of extracting energy from the organic material. In the absence of free oxygen, other chemical species such as nitrates and sulfates can serve as oxygen donors in *anoxic* reactions. In the absence of even such oxygen donors, other compounds, generally complex organic compounds, serve as electron receptors.

Anaerobic treatment processes take place in three (3) stages. In the first stage, called *hydrolysis*, complex or high molecular mass organic compounds are transformed into compounds of lower molecular mass that are suitable as sources for energy and cell carbon with the help of enzymes. In the second stage, called *acidogenesis*, these compounds of lower molecular mass are converted to even simpler forms which are mostly organic acids. Finally, in the final stage, called *methanogenesis*, these organic acids are converted to energy, cellular mass, and by products – mostly methane and carbon dioxide. The gaseous end-product of anaerobic treatment is called *biogas* and typically consists of 50%-75% methane (CH_4), 25%-50% carbon dioxide (CO_2), 0%-10% nitrogen (N_2), 0%-1% hydrogen (H_2), 0.1%-0.5% hydrogen sulfide (H_2S), and 0%-0.1% oxygen (O_2).

One great advantage of anaerobic treatment systems is the low energy consumption, or in many cases, net energy yield (from the methane gas generated). One disadvantage is the much slower reaction rates which generally translates to longer reaction (holding) times and larger tanks. The more complex, three-step nature of the anaerobic process also makes it more difficult to control and balance. The methanogenic microorganisms are particularly slow such that they can be overwhelmed by the acidic conditions created by the acid-forming microorganisms. The result of such imbalance is an inadequately treated and acidic wastewater.

3.5.3.2. Anaerobic Digester (Biogas Tanks)

Anaerobic digesters are often used for biological sludge treatment or as the first treatment stage for high BOD strength wastewater. Most involve the following processes:

a. *Mixing*, to keep the biomass in suspension
b. *Clarification*, to separate the treated wastewater (effluent) from the biomass and to retain the biomass that will process (digest) more wastes
c. *Heating*, to accelerate the processing (digesting) function of the biomass
d. *Gas Collection*, to safely collect the gas produced by the biomass as it digests wastes

Mixing. Anaerobic digesters are actually suspended growth systems like activated sludge systems except that there is no oxygen supply. Suspended growth systems need to be mixed to keep the biomass in suspension. In the simplest designs, the gas bubbles formed during anaerobic decomposition creates enough mixing. Proprietary designs using mechanical mixers or (recycled) gas diffusion systems are generally more effective but more costly.

Clarification. The biomass needs to be separated from the treated water so that the biomass can be retained in the digester to treat more wastes. Simple digester designs achieve clarification or solid liquid separation in the same tank while some designs provide for two vessels, the first serving as digester and the second as clarifier.

Heating. Anaerobic digestion is much slower than aerobic treatment. Hence, anaerobic treatment plants are very much larger than aerobic treatment plants of equivalent capacity. Since the rate of biochemical reactions approximately doubles for every 10°C rise in temperature, anaerobic digesters are sometimes heated to accelerate the treatment process.

Gas Collection System. The combustible (methane) gas and other gases produced during anaerobic digestion needs to be safely collected for use or disposal (burning). Floating covers and similar arrangements provide and maintain positive pressure on the combustible gas side to prevent ingress of air which contains oxygen. A mixture of the methane gas and oxygen from air can be combustible, posing a great risk of fire and/or explosions. For this reason, the gas collection and piping system is equipped with flame arresters. It may also be advisable to provide the WTF area with lightning rods to minimize the risk of lightning hitting a digester with explosive results.

3.5.3.3. Upflow Anaerobic Sludge Blanket (UASB) Reactor

The Upflow Anaerobic Sludge Blanket (**UASB**) digester is a modification of the conventional anaerobic digester. It features a bottom feed (upward flow) and biologically formed *granules* which contain the various types of microorganisms responsible for treatment (digestion). UASBs are generally of proprietary design, in particular, the feed distribution system and the solids-liquid-gas separation system. However, they have become quite popular in recent years, mainly due to the low operating costs and high treatment efficiency.

Typical loadings range from 4-10 kg COD/day/m^3 reactor volume. But proper design and sizing should be based on treatability tests. It takes a long time to develop the granular sludge required for the process but this can be reduced by seeding. On the other hand, the sludge is fairly stable and can remain active even after long periods of low or no flow or feed conditions.

3.5.3.4. Attached Growth Anaerobic Systems

The anaerobic filter is like a trickling filter fed from the bottom. As with trickling filters, the design is often proprietary and specific to the filter media and equipment manufacturer.

The *(Anaerobic) Expanded Bed Process* is similar to a fluidized bed and UASB, except that the biomass is attached to the sand, coal, or other media. The media promotes the formation of dense granules which separates more readily from the wastewater or liquid mass. The design is often proprietary and involves the complete treatment unit or system.

Figure 14 Upflow Anaerobic Sludge Blanket (UASB) Reactor, Overflow / Effluent Collection Channels, Bottom Feed Flow Control System, and UASB Granules *(clockwise from top left)*

<u>Quick Check of the Performance of Anaerobic Treatment Systems</u>: Low rate anaerobic treatment systems such as biogas tanks and anaerobic ponds have hydraulic retention times typically ranging from 30 to 60 days. High rate anaerobic treatment systems such as UASB reactors and anaerobic filters have hydraulic retention times typically ranging from less than 1 to more than 4 days, depending on the influent COD concentration.

Another quick check of the performance of anaerobic treatment systems is biogas production. Gas production in well-operating anaerobic treatment systems is often moderately to highly vigorous and essentially continuous even if the gas flow rate may vary to some degree, subject to influent COD load.

While anaerobic treatment systems can attain BOD reduction efficiencies ranging from less 80% to more than 95%, they are often used to treat wastewater with high BOD_5 concentrations, typically exceeding 1,000-2,000 mg/l. The high BOD_5 concentrations of the influent raw wastewater often means that anaerobic treatment alone is unlikely to produce effluents capable of complying with the effluent standards. Thus, anaerobic treatment systems are almost always followed by a polishing treatment stage using an aerobic treatment process.

3.6. Nutrient Removal Processes

3.6.1. Need for Nutrient Removal

The nutrients, nitrogen and phosphorus, are present in high concentrations in wastewater containing organic substances such as wastewater from food processing factories, slaughterhouses, and piggeries. As mentioned earlier, the discharge of wastewater containing nutrients can cause eutrophication or enhance it by promoting and speeding up the growth of algae and other aquatic plants.

Aside from increasing turbidity and causing aesthetic (visual and odor) problems, some nitrogen compounds may directly or indirectly (due to decomposition of algae and other aquatic plants) exert an oxygen demand which can deplete the dissolved oxygen in the water which fishes and other aquatic animals need to survive. Nutrients in discharged wastewater or effluents are also implicated in the proliferation of dinoflagellates which cause toxic red tides.

In view of the many adverse effects of nutrients in discharged wastewater or effluents, the nutrients, nitrogen and phosphorus, need to be removed from wastewater before its discharge.

Since nutrients mostly come from organic wastes, nutrient removal or reduction is often undertaken only after other (biological) treatment processes which aim to remove other significant pollutants such as organic substances which are measured as BOD and/or COD. Biological treatment processes for controlling BOD and/or COD also coincidentally reduce the concentrations of nitrogen and phosphorus. This reduction facilitates subsequent treatment to remove the residual nutrients because biological treatment for BOD and/or COD control may not reduce nutrient concentrations to a level capable of complying with effluent standards for protecting the environment.

3.6.2. Physical and Chemical Nutrient Removal Processes

Nitrogen compounds can be removed by physical or chemical processes.

Ammonia may be removed by *air stripping*, a physical treatment process. Dissolved ammonia is converted to gaseous state by raising the pH to pH 10-5-11.5. The wastewater is then aerated to remove or strip off the gaseous ammonia; thereby, reducing the influent ammonia concentration by up to 95%.

Other physical treatment processes to remove nutrients include filtration (effective on nutrients in colloidal and suspended solids only), electrodialysis, and reverse osmosis. These physical nutrient removal processes are rarely used.

Ammonia may also be removed by *breakpoint chlorination*, a chemical treatment process. Ammonia reacts with chlorine (or hypochlorite) added in sufficient amounts to form nitrogen gas which escapes harmlessly into the atmosphere while producing hydrochloric acid as by-product. Breakpoint chlorination to remove ammonia is often used after (aerobic) biological treatment which removes most of the ammonia present in the raw wastewater.

Phosphorus is present in wastewater mostly in the form of *phosphates*. Phosphates may be removed by chemical precipitation with lime at pH 9.5-10.5 with or without ferric or aluminum salts as co-precipitation agents. As with other chemical treatment processes involving precipitation, polymer or polyelectrolyte is added to promote and enhance coagulation and solids capture.

Chemical nutrient removal systems typically attain almost 100% removal efficiency when correctly designed and properly operated.

3.6.3. **Biological Nutrient Removal Processes**

Ammoniacal (or organic) forms of nitrogen compounds may be converted to nitrate form (nitrification) by suspended and attached growth aerobic biological treatment systems such as activated sludge, SBR, trickling filter, or RBC. It is important that sufficient oxygen is supplied to convert ammoniacal forms to nitrate in addition to meeting the (carbonaceous) biochemical oxygen demand. Nitrification lowers the pH (more acidic) and addition of lime or caustic soda may be necessary if the wastewater does not have enough alkalinity to maintain the pH in the neutral range.

While nitrification is highly effective, the residual ammonia concentration may still exceed effluent standards. In such cases further treatment by other means, such as air stripping or breakpoint chlorination may be required.

If nitrates are regulated, they may be removed by *denitrification*. Biological denitrification is the process by which nitrates are converted to nitrogen gas under *anoxic* (no dissolved oxygen) conditions, often with the addition of a carbon source such as methanol. Denitrification can remove more than 95% of the nitrates when properly designed and operated.

Bardenpho is a proprietary process which achieves nitrification and denitrification in a reaction tank divided into 4 zones as shown in Figure 15 below.

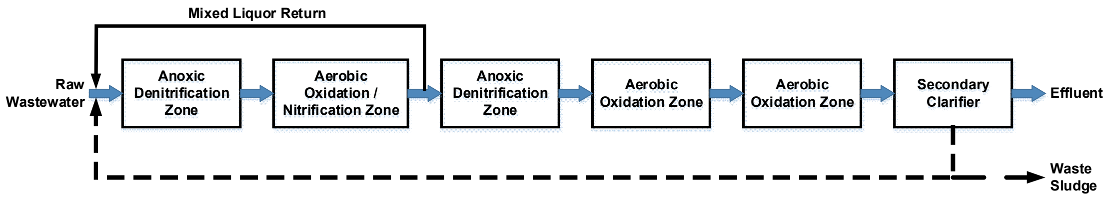


Figure 15 Bardenpho Process (Four Stage)

Other specially developed and typically **proprietary** *biological nutrient removal* systems and processes are used to individually or simultaneously remove or reduce nitrogen and phosphorus compounds from wastewater. While highly effective, biological nutrient removal (BNR) systems are often specifically designed for a given (industrial) wastewater stream based on actual treatability studies. Thus, the desired nutrient reduction efficiency to attain compliance with effluent standards is almost always attained. However, operation of such proprietary BNR systems can be complicated and may be prone to error or process upsets. BNR systems require extensively trained and highly skilled operators.

4.0 SOLIDS AND SLUDGE PROCESSING AND DISPOSAL

4.1. Management of Residuals of Wastewater Treatment

It is important to note that the treatment plant effluent (treated wastewater discharged from the wastewater treatment plant or facility) is the product discharged subject to Effluent Standards. Most treatment systems generate a ***residual waste product*** as the treated effluent is separated from the solids into which the pollutants are transformed. The residual produced by the wastewater treatment system is considered a waste product because the primary object of wastewater treatment is to produce treated wastewater. The waste products can be either of the following: scum, screenings, grit, and sludge.

Scum consists of floatable materials such as oil, grease, fats and waxes usually skimmed off the surface of the wastewater. Typical methods of treatment of scum is on-site burial, landfilling, or processing in sludge digesters.

Screenings can either come from coarse screens or fine screens. Coarse screenings consist of large objects such as rocks and stones, rags and other similar materials screened off with the use of metal bar screens so that these materials do not get into – and damage – mechanical equipment in the wastewater treatment plant. Fine screenings are smaller-sized debris (<4 in. diameter) present in the raw wastewater that are screened off with the use of mesh screens or perforated metal plates. Fine screenings of an organic and biodegradable in nature are usually ground (comminuted) into finer sizes and returned to the treatment plant flow stream, as done in the treatment of domestic sewage. It is sometimes more cost effective to landfill other fine screenings - that are neither organic nor biodegradable - instead of subjecting these to grinding and returning to the treatment plant flow stream.

Grit consists of sand, cinders, bone chips, coffee grounds, seeds and other usually non-putrescible materials that have higher density than water. Removal of grit is done using grit chambers that are either aerated tanks or flow-through sedimentation tanks whereby the accumulated grit is removed either by manual or mechanical means. Disposal of grit is usually by landfilling or by land spreading.

4.2. Sludge Characteristics

Sludge is the settled solids accumulated and separated from the liquid (wastewater) phase during various stages of wastewater treatment. There are many types of ***sludges*** as characterized by the source or the state of the sludge: ***primary sludge, secondary sludge, waste biological sludge, chemical sludges, trickling filter sludge***, ***septage***, ***aerobically digested sludge*** and ***anaerobically digested sludge***.

Based on their common characteristics, sludge may more simply be classified into three (3) types: ***organic or biological sludge***, ***inorganic or chemical sludge***, and ***septage***.

4.2.1. Organic or Biological Sludge

Organic or biological sludge is produced in biological treatment processes such as activated sludge, trickling filters, rotating biological contactors, sequencing batch reactors, etc. Biological sludge containing debris such as grit, paper, and fibers would be produced at plants lacking primary treatment. Plants with primary sedimentation normally produce a fairly pure biological sludge. Thus, the concentrations and the volumes of waste biological sludge are greatly affected by the method of operation of the clarifiers. Biological sludges are generally more difficult to thicken and dewater than primary sludge and most chemical sludge.

Biological treatment destroys some but not all of the organic matter or pollutants by conversion to harmless end products such as carbon dioxide, water, and nitrogen gases. However, most of the organic matter is converted to new cellular mass that is also organic and can still impose an oxygen demand (BOD) on the receiving bodies of water. Excess cellular mass-produced during wastewater treatment is discharged as *organic* or *biological sludge* (often called *waste activated sludge* or *WAS*).

Suspended growth treatment processes are the most common biological treatment processes. The most common example is the activated sludge process or a variation thereof. Sequencing batch reactors (SBR) are also growing in popularity. Suspended growth processes generate about **0.3** to **0.65 kg** (typically **0.6**) of ***waste activated sludge*** *per* ***kg BOD removed***. If the WAS is drawn from the underflow of a (secondary) clarifier or after settling, it often contains only **0.5** to **1.0% solids**. The waste activated sludge has about 60-85% (typically 75-80%) volatile fraction, typically consider the organic fraction, which makes it putrescible and likely to create problems with odors and vermin.

Attached growth treatment processes, such as trickling filters and rotating biological contactors (RBC) also produce excess cellular material; although, the waste sludge generated is sometimes called *humus*. Attached growth processes often generate less sludge per kg of BOD removed (typically 0.4 to 0.5 kg sludge/kg BOD) at a higher concentration (typically 1.0-2.0% solids).

Primary clarification may also generate organic sludge that has lower volatile fraction than sludge from biological treatment processes. Most small wastewater treatment plants or facilities are not equipped with primary clarification facilities and do not generate any primary sludge.

In general, sludge from biological wastewater treatment does not contain toxic or hazardous components in any significant quantity unless the wastewater is contaminated by toxic or hazardous constituents in the first place such as industrial wastewater from the production of pesticides or similar organic chemicals or petroleum products. Wastewater from human or animal sources may contain pathogens that may end up in the sludge produced by wastewater treatment. Such sludges require disinfection prior to disposal.

4.2.2. Inorganic or Chemical Sludge

Inorganic or chemical sludge is produced in physical and chemical treatment processes. The most common type comes from the chemically assisted precipitation and sedimentation of soluble and insoluble (but suspended, colloidal) contaminants. Examples of this type of sludge are heavy metal hydroxides from the treatment of plating wastes (both from traditional electroplaters and semiconductor companies) and sludge from the removal of color and dyestuff from textile mill wastes.

Inorganic sludges typically have low volatile fractions and therefore, have less tendency to putrefy and cause obnoxious odors. On the other hand, inorganic chemical sludges more often contain toxic components, such as heavy metals, which render the sludge toxic or hazardous. Inorganic sludges often have a higher solids concentration than organic or biological sludges; hence, there is often no need to thicken inorganic sludge.

The quantity of inorganic sludge produced is difficult to correlate to a single parameter in the wastewater being treated; hence, the quantity is often estimated based on the volume of wastewater, not on a specific wastewater quality parameter.

4.2.3. Septage

Septage is a partially (anaerobically) digested mixture of liquid and solid material that originates as waterborne domestic wastes. Septage accumulates in a septic tank over a period of several months or even years. It may foam and generally has an offensive because of the hydrogen sulfide and other gases it gives off, unless the sludge is well digested by very long storage.

Septage may be treated at wastewater treatment plants mixed with the influent wastewater – or added directly to the wastewater sludge. If septage is mixed with the influent wastewater, the quantities of solids in the treatment plant would increase, because of the following reasons:

- Septage contributes to grit, scum and screenings.
- Suspended solids in the septage may be largely removed in primary sedimentation, increasing the amount of primary sludge.

In biological treatment processes, septage increases the BOD load to as much as twice the amount of sludge (per unit BOD removed) as ordinary wastewater, and consequently, the sludge production. In some treatment plants, sludge thickening and dewatering properties have been degraded by the addition to septage to the wastewater sludge. Likewise, problems associated with bulking activated sludge may be related to septage. Bulking sludge has very poor thickening and dewatering properties. The metals content of septage may also be high.

4.2.4. **Sludge Quantities and Solids Content**

Type of Sludge	Mass	Volume	% Solids
Biological or Organic			
Waste Activated Sludge	0.3 to 0.65 kg/kg BOD	20 to 80 liters/kg BOD	0.5-2.0%
Primary Sludge	0.10 to 0.20 kg/m^3	5 to 20 liters/m^3	1.5-4.0%
Trickling Filter Sludge	0.3 to 0.6 kg/kg BOD	15 to 60 liters/kg BOD	1.0-3.0%
RBC Sludge	0.3 to 0.6 kg/kg BOD	20 to 70 liters/kg BOD	1.0-2.5%
Chemical or Inorganic			
Heavy Metal Hydroxide	0.10 to 0.30 kg/m^3	2 to 10 liters/m^3	2.0-5.0%
Alum Sludge (*i.e.*, textile)	0.15 to 0.50 kg/m^3	5 to 150 liters/m^3	0.5-2.0%
Lime Sludge	0.15 to 0.50 kg/m^3	5 to 100 liters/m^3	1.0-3.0%

4.3. Sludge Processing

The primary objective of sludge management is to handle wastewater solids from the point of removal to the point of disposal. Processes applicable to sludge management include thickening, stabilization, conditioning, dewatering, composting or thermal reduction and disposal. Sludge are put through these processes to optimize the removal of water from the sludge thereby producing dewatered sludge that is more feasible to economic handling and disposal.

4.3.1. Sludge Handling and Storage

The movement of sludge from one unit of operation to another can be very difficult because of the innate viscosity of sludge. Thus, it is necessary to understand the effect of sludge characteristics on pumping operations and the limitations or advantages of various types of pumps. In addition, decisions on sludge pumping must include considerations of good housekeeping, efficiency, and economy. The sludge pump must be tight to prevent loss of material and minimize the prospect of methane gas explosion.

Positive displacement pumps are commonly used for pumping sludge is essentially “liquid” state, especially when risks of odors or contact with toxic or harmful constituents need to be avoided. “Dewatered” sludge in solid form is more economically transported using conveyors, whether covered or not.

The storage of sludge may need to be an integral part of the wastewater treatment process especially in cases where sludge processing for ultimate disposal is not a continuous activity. Hence, the sludge may need to be temporarily stored (or held) while awaiting processing. Sludge storage also allows the control of the feed rate of the sludge into further processes such as stabilization, conditioning, dewatering, etc. The sludge storage (or holding) system should be leak-free so that the material is not lost by leaching, by air movement, or by dilution from water runoff from surrounding areas.

4.3.2. Sludge Thickening

Sludge thickening increases the solids content of sludge by the partial removal of water, thereby reducing the sludge volume to be handled by subsequent processes or operations. Solids concentrations from thickening are typically two to five times greater than the solids concentration prior to thickening.

The objective of sludge thickening is to reduce water content and increase solids content of the sludge to around 2.5 - 5% solids, and, this is done through gravity thickening or flotation or centrifuging. The common types of thickening devices are the following: *Gravity Thickening*, *Dissolved Air Flotation*, and *Centrifuging*. Sludge thickening is commonly used to treat primary and secondary biological sludges and chemical sludges.

Gravity Thickening. Sludge from wastewater treatment actually contains very little solids (from 1% for most types of organic or biological sludge to 3% for most types of inorganic or chemical sludge). Thickening removes excess water to increase the solids content to as much as 5%. The excess water is returned to the head works of the wastewater treatment plant or facility for further treatment. Thickening reduces the volume of sludge by 50% to over 75%. This volume reduction facilitates further processing and reduces processing costs.

Gravity thickeners are well suited for treating heavy or dense sludge such as primary sludge. Gravity thickeners are essentially clarifiers designed for compression settling (very slow settling rates), typically at a solid loading of 25 to 100 kg solids/d/m^2. They have the same facilities or equipment as clarifiers (sludge scraper, scum skimmer, level detector); although, they are often circular in form. Moreover, sludge collectors in gravity thickeners often have pickets that gently agitate the solid mass to promote the release of bound water from the sludge.

Type of Sludge	Surface Loading	Solids Loading	% Solids
BIOLOGICAL SLUDGE			
Waste Activated Sludge	0.1 to 0.3 m^3/h/m^2	0.5 to 1.5 kg/h/m^2	2.0-3.0%
Aerobically Digested Sludge	0.05 to 0.25 m^3/h/m^2	0.3 to 1.2 kg/h/m^2	2.0-3.0%
Primary Sludge	0.2 to 0.5 m^3/h/m^2	3.5 to 5.5 kg/h/m^2	5.0-10.0%
Trickling Filter Sludge	0.15 to 0.5 m^3/h/m^2	1.5 to 2.0 kg/h/m^2	3.0-6.0%
RBC Sludge	0.15 to 0.5 m^3/h/m^2	1.5 to 2.0 kg/h/m^2	2.0-5.0%
Chemical Sludge	**Not Usually Thickened**		
Heavy Metal Hydroxide	0.3 to 1.0 m^3/h/m^2	5 to 10 kg/h/m^2	4.0-8.0%
Alum Sludge (*i.e.*, textile)	0.4 to 0.8 m^3/h/m^2	5 to 10 kg/h/m^2	3.0-8.0%
Lime Sludge	0.4 to 0.8 m^3/h/m^2	5 to 10 kg/h/m^2	3.0-8.0%

In operating gravity thickeners, it is important to avoid anaerobic conditions at the bottom of tank which leads to anaerobic digestion of the sludge and ultimately, to odor problems. The use of chemical conditioners can often improve performance.

Flotation. Flotation devices are often used to effect concentration of the solids. In some cases, solid (contaminant) liquid separation is effected by flotation instead of the more traditional sedimentation process. Use of flotation reduces the size of the treatment tank and increases the solids concentration in the thickened sludge.

Dissolved air flotation (DAF) is the most common form of flotation used in sludge thickening. In dissolved air flotation (DAF), compressed air is mixed with water (usually recycled clarified water) in a vessel under pressure. The high pressure causes the air to dissolve in the water. When the pressure of the water-air mixture is released through a pressure-reducing valve, the dissolved air goes out of solution to form very fine bubbles. The fine bubbles attach to the solids, increasing the buoyancy and bringing the solids to the surface.

Thickening by air flotation is most appropriate for light sludges, *e.g.*, activated sludge and humus. DAF is also used to remove grease, other solids, and grit. The short detention time (due to the fast rise rate) prevents putrefaction and generation of foul odors. DAF thickeners usually consist of a chemical mixing (and/or flocculation) chamber, flotation tank, surface skimmer (sometimes, also sludge scraper or collector), recycling pump, re-aeration tank, and pressure-reducing valve.

The most important control parameter is the *air-solids ratio*. Other factors that affect the effectiveness of DAF thickeners are the type and dosage of flocculant aids, effectiveness of mixing of and contact between air bubbles and solids, underflow (clarified water) withdrawal, scum or floats removal, and removal of settled solids (if any). Polymers or chemical conditioners are often used to enhance the flotation process.

Centrifuging. Centrifuges are sometimes used for thickening; although, they are now more commonly used for sludge dewatering. By rotating at a high speed, the centrifuge creates a centrifugal force which increases the effect of the difference in density between water and solids. This causes the solids to separate more rapidly from the water mass. The degree of thickening (or dewatering) action is controlled by adjusting the speed of rotation.

Centrifuge thickening systems usually require the use of chemical conditioners and are often characterized by high capital and operating costs.

Chemical Conditioning. Most sludge thickening systems rely on the addition of chemicals to enhance or hasten the thickening process. The sludge particles normally have an electrical charge that interferes with thickening and settling process. The objective of chemical conditioning is to reduce the charge to allow coagulation and flocculation of solids to occur.

Ferrous chloride, typically used for odor control (to inhibit the production of hydrogen sulfide), is also used to improve the dewatering potential of sludge. The divalent metal ions in ferrous chloride, when used with a cationic polymer, can enhance the effectiveness of the polymer and broaden the range of effective dosages. The operator can run the centrifuge at a high capture efficiency and produce higher wet cake solids concentrations.

4.3.3. **Sludge Stabilization**

Organic or biological sludges have a significant fraction of volatile or decomposable matter. This decomposable fraction needs to be stabilized in order to prevent putrefaction and subsequent odor problems. Another purpose of sludge stabilization is to disinfect the sludge and destroy pathogens.

Stabilization processes reduce odors and pathogenic organisms in wastewater sludge. The potential for odors is reduced by retarding the decomposition rate or by decreasing the volatile content of the sludge. Stabilization can be accomplished though biological digestion (oxidation) or chemical oxidation, and the addition of chemicals, heat, or radiation for disinfection purposes.

Chemical stabilization processes include lime treatment, chemical fixation, and chlorine stabilization. Chemical stabilization methods provide odor control and pathogen destruction but do not reduce solids content.

Sludge stabilization is done either before dewatering and subsequent disposal, or after dewatering and before subsequent disposal. Sludge stabilization prior to final disposal is a requirement because the sludge is typically used in land application and treatment (as fertilizer in agricultural activities). Historically, volatile solids reduction was used as a criterion for the degree of sludge stabilization. An alternative criterion, volatile solids concentration as a percentage of total solids, is used to determine the degree of sludge stabilization. Other criteria that can and should be used are control of odor, reduction of vector attraction, reduction in pathogen content.

Bottom line, the objective of sludge stabilization prior to final disposal is reduction of pathogens, not only due to handling considerations (when the sludge is transported and applied to the land) but also for safety considerations subsequent to land application. This is because if active pathogens are still present in the sludge for disposal, all workers that will handle the sludge until the time it is land-applied could be exposed through direct contact with the sludge while it is handled, as well as though indirect contact with the sludge when pathogen-containing sludge particles that have already been land-applied are carried up by the wind, and are inhaled or ingested.

Biological Digestion. Biological digestion is simply an extension of the biological treatment process, in this case, applied to the sludge as the organic contaminant. Biological digestion also destroys some pathogens and reduces their concentration, thereby effecting some degree of disinfection. Biological digestion can be either aerobic or anaerobic.

Aerobic digestion is a biochemical stabilization process based on the principle that with inadequate external food sources, biological cells will consume their own cellular material. In *aerobic digestion*, the sludge is aerated in a tank to supply the required oxygen and mixed to promote intimate contact and prevent settlement of solids. Since no food source (organic matter) is added, the microorganisms comprising the waste sludge start to consume their food reserves (process of *endogenous respiration*) and each other to maintain life functions.

In ***anaerobic digestion***, no oxygen is supplied, forcing microorganisms to use other oxygen sources (such as nitrates) to produce energy. While anaerobic digestion is slower than aerobic digestion, it produces methane that may be used as fuel in the treatment plant to displace some of the energy requirements for treatment. Due to the relative difficulty in operating anaerobic digesters, it is often used only in large facilities. Anaerobically digested sludge has a similarly low volatile fraction as aerobically digested sludge and does not produce any obnoxious odors. As in anaerobic treatment, anaerobic digestion consists of hydrolysis, acid forming stage, and methane forming stage. Anaerobic digestion of primary and secondary biological sludge reduces the quantity of solids for disposal. Digestion time typically lasts for 20-30 days and produces a relatively smelly effluent.

Heavy metals such as copper, chromium, nickel, mercury, zinc, lead, and cadmium have been shown to be toxic to the anaerobic digestion process when small concentrations are in solution. Copper, nickel, and zinc are the most toxic and, at concentration of 1.0 mg/ l or less, can inhibit anaerobic digestion. However, heavy metals get tied up as precipitates when sulfides are present, and as such they settle in the sludges at the bottom of the tank and won't affect the active digestion zone. However, in cases where the enough metal wastes are discharged to use up the sulfides in the precipitation process, concentrations of metals remain in solution. The sulfides can then be added in the form of compounds such as sodium sulfide and sodium sulfate, which in high concentrations are also toxic to sludge digesters.

Anaerobic digesters need to be closed to atmosphere since aerobic conditions retard growth of anaerobic microorganisms and the digestion process. Moreover, the gas (methane)-air (oxygen) mixture is combustible and explosive. Anaerobic digestion reduces volatile solids by 40-60%. The sludge product is usually suitable for use as fertilizer if left for 6-12 months to destroy pathogens. The sludge is, thus, useful for agricultural use. Anaerobic digester equipment includes mixer, recirculation pump and heat exchanger, gas flow meter, sludge flow meter, and gas collection system. Mixing promotes intimate contact of the microorganisms and feed sludge. It also maintains uniform temperature

Lime Stabilization. Instead of digestion, organic sludge may be treated with lime to a pH of 12 or higher, held for at least 2 hours to destroy pathogens (disinfection) and retard putrefaction. This makes the organic sludge suitable for land application. Sometimes, lime is applied on the dewatered sludge to reduce the lime required to maintain a sufficiently high pH for effective disinfection. Since lime treatment does not destroy organic matter but simply inhibits decomposition (putrefaction), the lime stabilized liquid sludge should be disposed of (*e.g.*, by land application) as soon as possible after treatment. The much lower water content of lime stabilized dewatered sludge makes it less prone to putrefaction and allows a longer storage period before disposal is necessary.

Composting. Sludge composting is a form of aerobic digestion that can be used with untreated or digested solids. It is the process of aerobic thermophilic decomposition of organic constituents to a relatively stable, humus-like material. Key factors in the composting process include volatility and type of material, moisture content, oxygen concentration, carbon to nitrogen ratio, temperature and pH.

Waste biological sludge may also be composted to improve its fertilizer value by enhancing nutrient content or availability, prior to land application. The usual composting facilities may be used. While sludge does not provide more nutrients than commercial fertilizers or even conventional compost material, land application sludge is an environment friendly and economical method of sludge disposal. Care should be taken to ensure that concentrations of trace elements, in particular, heavy metals, are not high enough to inhibit plant growth or be toxic.

Composted solids can be applied as a soil amendment and conditioner to improve the physical characteristics of soils with high clay or sand content. Composting is classified into two types of systems: confined (or reactor) composting and unconfined (row) composting. Confined composting includes a container in which the sludge and bulking agent are mixed and composted. Composting in an unconfined system involves the use of open piles or long rows of organic materials. There are two common types of unconfined composting systems: windrows and aerated static piles. In windrow composting, aeration is accomplished through natural convection and mechanical turning. In the static pile process, aeration is provided by forced air ventilation, and the mixed compost is piled on perforated pipe to which a blower is connected. Air is drawn through the top of the pile, out from the bottom of the pile, and through a pile of screened compost that serves as a filter for odorous gases.

Composting requires a large site, and the hours of labor associated with hauling sludge, mixing with bulk media, and dealing with odor control and runoff water are much greater than the other alternatives.

Sludge Fixation. Chemical sludge containing heavy metals is considered toxic or hazardous material and its disposal is regulated. The main danger is leaching of the heavy metals and consequent contamination of ground or surface water. To prevent leaching of the heavy metal content, the heavy metal is *fixed* by mixing and reaction of the heavy metal sludge with cement or encapsulating material.

Portland or to a lesser degree, pozzolan cement is often used as binding and encapsulating material. For strong concrete blocks, sand is also added to the sludge-cement mixture. Concrete mixing equipment may be used but a grinder or macerator is often necessary to break up the sludge cake and allow good mixing with the cement, sand, and water. The resulting blocks may be used as flagstones for walkways or non-loading bearing walls such as fences (in the form of hollow blocks). Cement plaster and paints help ensure that no heavy metal is leached out.

An alternative to cement as binding material is clay to form bricks with heavy metal sludge. Due to similarities in the characteristics of clay and heavy metal sludge, mixing is often easier and a higher sludge to fixation material (clay) ratio than cement or concrete fixation is possible. Brick manufacturing equipment, including the firing oven, is used. Firing ensures that the heavy metals are fully immobilized.

4.3.4. <u>Sludge Conditioning</u>

Sludge conditioning is often performed before dewatering. It refers to chemical and physical methods for altering the hydrophilic ("*water-loving*") properties of sludge in order to improve its dewatering characteristics. Chemical conditioning results in the coagulation of the solids and release of the absorbed water. Chemical conditioning can reduce the initial 90-99% moisture content of incoming sludge to 65-85%, depending on the nature of the solids to be treated.

Proper conditioning improves the efficiency of dewater processes by maximizing cake solids, yield rates, and solids capture. Chemical conditioning typically involves coagulation-flocculation of sludge solids with the hydrolysis products of multivalent ions or organic polymers to form an agglomerated product that releases bound water more readily.

Chemical Conditioning with Polymers. Polymer addition is used to improve the process of sludge dewatering by increasing the cake dryness or sludge throughput. Actual polymer dosages may vary several percentage points because of differing advice from polymer suppliers and different types of polymers available in the market. Nevertheless, optimum dosage is generally defined as that which gives the highest cake solids, maximum throughput rate, cleanest filtrate, and minimum maintenance at the lowest dosage. Most sludges that have undergone anaerobic or aerobic digestion possess a high negative charge, and therefore, a positively charged chemical is often required to coagulate the particles together and improve dewatering efficiency.

Elutriation, usually used in anaerobically digested sludge, has been used a pre-conditioning process to reduce chemical conditioning requirements. It involves washing the sludge with freshwater or plant effluent followed by sedimentation.

Ash has been used as an alternative, or in conjunction with, other chemical conditioning formulations to reduce chemical requirements and improve dewatering efficiency. The ash is blended with the sludge prior to dewatering, or, it is used as a pre-coat on the cloth of the dewatering device.

Physical conditioning methods include heat treatment (to 150°C or 200°C under a pressure of 16-20 barG, with or without air addition) and freezing. Heat conditioned sludge is effectively sterilized and lends itself to easy dewatering.

4.4. <u>Sludge Dewatering</u>

4.4.1. <u>Function of Sludge Dewatering</u>

Dewatering converts sludge from liquid-solids slurry to a state in which it is amenable to manual handling. Dewatering also reduces the overall volume and mass (weight) of sludge, increases its fuel value, and makes the dewatered sludge amenable to disposal techniques such as combustion, land filling, and land application. The objective of sludge dewatering is to reduce water content and increase solids content in the sludge to around.10-40% solids, thereby, reducing transport and disposal costs.

Sludge dewatering can be accomplished through mechanical techniques or thermal or natural evaporation techniques. Mechanical techniques can produce sludge cake at 16% to 45% solid depending on the sludge and the method of conditioning used prior to dewatering. Natural evaporation techniques include sand drying beds and lagoons that are limited to suitable climates and areas with available land. Sludge dewatering techniques are suitable for the processing of digested sludge, chemical sludges, or secondary (biological) sludges. The most common types of sludge dewatering devices are drying beds, plate and frame filter presses, belt presses, and centrifuges.

4.4.2. **Sludge Drying Beds.**

Additional mass and volume reduction can be attained through sludge dewatering. Sludge drying beds are the most common sludge dewatering systems as they are deemed to cost least. However, properly sized drying beds require a large area and if the cost of land is included, they may actually be much more expensive. Nevertheless, they are popular among small treatment plants and often have relatively low cost of operation. Drying beds are, however, very dependent on the weather and may not be practical for areas such as those with rainfall for half the days of the year.

Sludge drying beds are constructed similarly to gravity filters; although, the filter media (often sand) depth is very shallow (200 to 300 mm). Drying beds also require underdrain systems and filtrate is returned to the wastewater treatment plant or facility head works for further treatment. Sludge drying beds are loaded at about 100 to 150 kg (dry solids)/m^2/year. Drying to about 40% solids takes 4 to 7 days and 70% solids content is attainable with longer drying periods. The main problems are that rainfall makes the sludge wet again and overcast skies reduce the dewatering rate.

The dewatered sludge is usually removed manually when it appears dry but large installations may use mechanical sludge cake removal systems. Manual removal is very labor intensive.

Figure 16 Filling Sludge Drying Bed and **Dewatered / Dried (Waste Activated) Sludge**

4.4.3. **(Plate and Frame) Filter Press.**

Filter presses dewater sludge by squeezing it between porous fabric to extract the excess water. The squeezing pressure normally defines the degree of dewatering. Plate and frame filter presses can produce dewatered sludge cake with about 20-40% solids. The important characteristics of plate and frame type filter presses are:

a) *Sludge cake holding capacity* (the more the better)
b) *Sludge feed pump operating pressure* (typically up to 12 bars G for very dry cake)
c) *Closure, loading, and discharging facilities* (the better and more expensive units have mechanized closure and discharge facilities).

While well dewatered sludge cake is relatively easy to discharge, plate and frame filter presses are labor intensive to operate and maintain. But they do produce dry sludge and are relatively cheap. Addition of lime or polymer to the sludge prior to dewatering facilitates water removal and improves the handling characteristics of the dewatered cake.


Figure 17 Plate and Frame Pressure Filter and **Dewatered Sludge Cake**

4.4.4. **Belt Filter Press.**

Belt filter presses are continuous feed dewatering units which operate by pressing the feed sludge between two belts which are squeezed together by two sets of rollers which successively increase the pressure. Water is extracted from the cake in three separate phases; initially by gravity drainage, then by low pressure compression which removes the remaining free water and finally by high compression which forces the interstitial water out from between the sludge particles. The initial gravity drainage section may also be utilized as a thickening device without the compression section of the press.

Belt filter presses automate the process of discharging the sludge cake, thereby reducing labor requirements. They are more expensive than plate and frame filter presses but can be cost effective at higher sludge volumes.

The resulting filtrate should be returned back to the treatment process and the cake transported for disposal. The advantage of the belt filter presses is that they are compact; however, they require high operations and maintenance skills.

The belt filter press system usually includes: (a) sludge feed pumps, (b) polymer preparation and feed system, (c) sludge conditioning chamber, (d) belt drive and pressure units, (e) belt alignment system, (f) sludge cake conveyor, and (g) belt washing system.

Variables that affect operation include: (a) sludge type and characteristics, (b) polymer type and mixing, (c) belt pressure, (d) belt type and configuration, and (e) belt width and speed.

Typical performance parameters belt presses are shown below:

Sludge Type	Feed Solids	Cake Solids
Primary Sludge	3-7%	28-44%
Waste Activated Sludge	1-4%	12-20%
Anaerobic Digested	3-7%	20-35%
Aerobic Digested	1-3%	12-20%

Sludge loading rates vary from 100-600 kg/hr/m (belt width), and hydraulic loading rates range from 5 to 20 m^3/h/m (belt width).

Figure 18 Belt Filter Press

4.4.5. **<u>Centrifuges.</u>**

Centrifuges spin at high speeds to create centrifugal forces which cause the separation of the denser solids from the water mass. In general, higher speeds produce drier cake. The most common type of centrifuge (solid bowl) used in wastewater treatment has a screw to convey the sludge cake to one end for continuous discharge. Centrifuges produce cake with approximately 15 to 30% solids.

Centrifuges are well suited to certain types of sludges such as those with high fats, oils, or greased (FOG) content, which tend to plug or blind the filter cloth of plate and frame or belt filter presses.

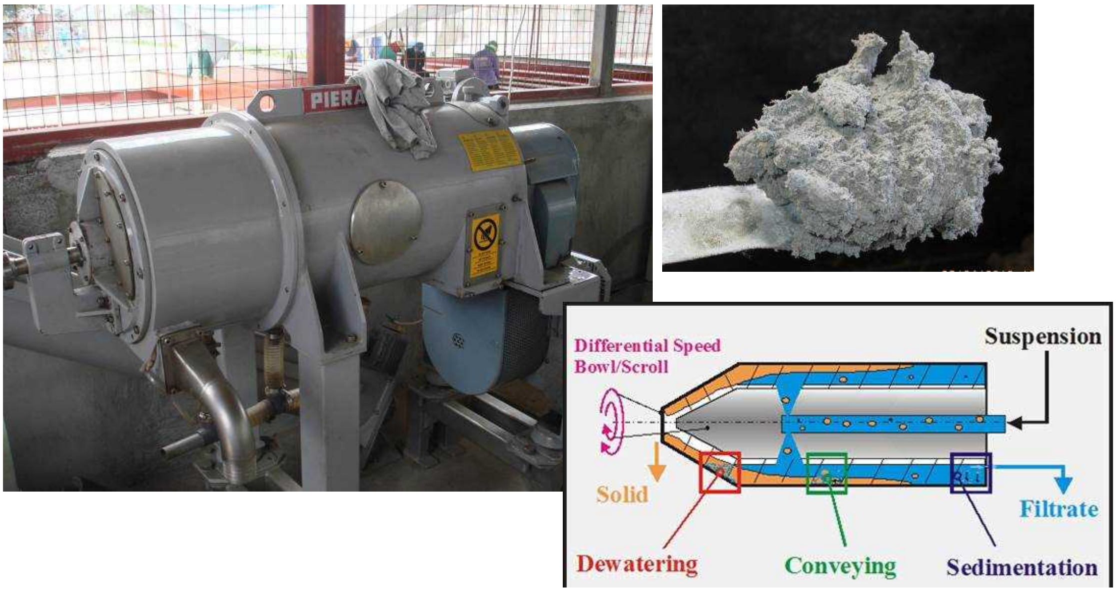


Figure 19 Centrifuge (Decanter), Dewatered Greasy Scum, and **Schematic of Centrifuge** *(clockwise from top left)*

4.4.6. **<u>Low-cost Dewatering System.</u>**

Small companies without sufficient budget for dewatering equipment can opt for a low-cost dewatering system readily adaptable to a developing country in the tropical zone where the wet and dry seasons are well defined. Sludge is put into suspended woven nylon or polyethylene bags through which the water (filtrate) drains (gravity draining) and the solids portion is left inside the bag. The filtrate that drains is returned to the wastewater treatment system through a canal system. These woven nylon or polyethylene bags may be used bags that is re-used. The bag system is very cost-effective for treatment plants up to around 50 m^3/day capacity. It takes a maximum 15 minutes to fill one bag, then around two to four hours gravity drainage when the sludge is dewatered up to about 10% to 12% dry solids. The bag can be unhooked from the suspension system and piled in another elevated area for further gravity draining over one to two weeks after which the solids content can reach up to 60% solids content during the dry season.

4.5. Sludge Disposal

4.5.1. Incineration

Incineration maximizes sludge volume reduction and destroys pathogens and many organic toxic substances. ***Incineration processes*** involves burning at temperatures that will achieve the highest possible levels of combustion to achieve reduction of the sludge into carbon dioxide and other gases and residual ash.

4.5.2. Land Filling

After dewatering, a relatively solid cake still needs to be disposed of. Organic or biodegradable sludge and inorganic or chemical sludge which do **not contain toxic or hazardous components** may be disposed of in a sanitary land fill like ordinary garbage or municipal solid wastes. Care should be taken to minimize leaching. This is particularly important with organic sludge which can become acidic as it putrefies. Most chemical sludges are alkaline and the acidic leachate from ordinary garbage in landfills can dissolve the contaminants (especially toxic heavy metals) in the sludge.

4.5.3. Land Application

Wet or dry (dewatered) sludge with nutrient value (typically waste biological sludge) may be applied directly on land as fertilizer or soil conditioner. The applied sludge is normally immediately plowed in. The usual farm equipment for application of fertilizers is often used for land application of sludge.

4.5.4. Sludge Disinfection

Sludge cakes which may contain pathogens if they come from human or animal sources may need disinfection by treatment with lime or other disinfectant. Sludge disinfection is intended to destroy pathogenic organisms in the sludge, especially sludge from domestic wastewater treatment plants. Sludge disinfection may be required if sludge is intended for land application, for the protection of public health.

4.5.5. Alternative Sludge Disposal Methods

Alternative sludge disposal methods include use as animal feed and as fuel. Dewatered waste activated sludge has been successfully used as ***hog feed supplement***, converted into ***charcoal briquettes***, and used as ***feed for earthworms*** (***vermiculture***).

5.0 GLOSSARY

Acid - a chemical species (substance) donates protons or releases hydrogen (H^+) ions in water solution.

Activated Sludge Treatment Process – an aerobic biological wastewater treatment process wherein a mass of *"active"* (concentrated mass of) microorganisms consisting mostly of bacteria (also called *activated sludge*) is combined with wastewater in a basin (also called *aeration tank*) and mixed to keep the microorganisms in suspension so that the microorganisms can consume the biodegradable organic matter (pollutants) present in the wastewater. The mixture of *activated sludge* and wastewater is provided with oxygen to maintain aerobic conditions. The mass of *activated sludge* solids is then separated from the treated wastewater in a secondary basin and collected to be returned to the first basin to treat more wastewater.

Aerobic –presence of or requiring free (dissolved) oxygen

Air stripping – the process of removing or transferring volatile components (such as volatile organic compounds or VOC) from a liquid (such as wastewater) by passing or bubbling air through the liquid

Alkalinity - chemical measure of ability to neutralize acids or, more broadly, to resist changes in pH upon the addition of acids or bases

Anaerobic - absence of or not requiring free (dissolved) oxygen or oxygen-rich substances (such as nitrates, sulfates, or phosphates)

Anion – negatively charged ion

Anoxic – without (free or dissolved) oxygen but may contain oxygen-rich substances (such as nitrates, sulfates, or phosphates)

Bardenpho - from "**BAR**nard **DEN**itrification and **PHO**sphorus removal," treatment process developed by James L. Barnard to remove the nutrients nitrogen and phosphorus from wastewater and consisting of four (later five) stages: anaerobic or (pre-)anoxic + aerobic + (post-)anoxic + post-aerobic

Base – a chemical species (substance) donates electrons or releases hydroxide (OH^-) ions in water solution.

Biodegradation - the process by which organic substances are decomposed by micro-organisms (mainly aerobic bacteria) into simpler substances such as carbon dioxide, water, and nitrogen and other compounds

Biogas – combustible gas consisting mostly of methane that produced by the decomposition of organic matter in the absence of oxygen

BOD or **Biochemical Oxygen Demand** - amount of dissolved oxygen needed (or "*demanded*") by aerobic microorganisms to break down organic matter present in water at certain temperature (usually 20°C) over a specific time period (usually, 5 days)

Breakpoint chlorination – is the addition of chlorine (compounds) to completely satisfy the chlorine required (or "*demanded*") to fully oxidize reduced forms of (organic) compounds (such as amines or ammonia forms of nitrogen)

Buffer – a water solution consisting of weak acid (or base) that serves to limit or minimize changes in pH during addition of strong acids or bases.

Cation - positively charged ion

COD or **Chemical Oxygen Demand** - amount of oxygen consumed in the decomposition of organic matter and oxidation of inorganic substances present in water using strong oxidizing agents and acids at elevated temperatures

Coagulation – process by which colloidal particles combine or stick together, often in the presence of or by the addition of treatment chemicals

Colloid – substance consisting of microscopically small (5-200 nanometer diameter) particles evenly dispersed throughout another substance (such as a liquid)

Denitrification – reduction of nitrates and nitrites into elemental nitrogen (gas), usually by bacteria

Dinoflagellates - single-celled aquatic organisms with two dissimilar *flagella* (hair-like structure primarily use by cells for locomotion) and having characteristics of both plants and animals which can cause *eutrophication* or *red tides*

Eutrophication - process wherein a body of water becomes enriched in dissolved nutrients (such as phosphates and nitrogen compounds) which stimulate the growth of aquatic plant life (such as *dinoflagellates*) often causing the depletion of dissolved oxygen in the water

Flocculation – mechanical mixing to promote motion of particles in water resulting in collision and adhesion to forms larger particles called *flocs*

Flocs - soft or fluffy particle suspended in a liquid or the fluffy mass of suspended particles formed by these particles

Food to Mass (or Microorganism) Ratio (**F:M**) – ratio of the amount of food (organic matter measured as BOD) introduced or fed into the reaction (aeration) basin to the amount of microorganisms present in the reaction basin.

Humus – organic component of soil formed by the decomposition of organic matter (such as biological sludge) by microorganisms

Hydraulic Detention Time or **Hydraulic Retention Time** (**HRT** or Θ_H) – average amount of time (soluble) substance in water stays in a basin or tank or reactor; equal to the volume of the basin divided by the flow rate of the water flowing in

Ion – atom or molecule with an electrical charge, resulting from the dissociation of substances

Ion product – the product of the concentrations of the ions in (water) solution raised to the power of their coefficients in a balanced chemical equation

Ionization – process by which an atom or molecule gains an electrical charge by gaining or losing electrons when substances are dissolved (in water)

Mixed Liquor – mixture of wastewater and *activated sludge* (microorganisms) in the reaction basin (aeration tank)

Nitrification – biological oxidation of ammonia (or ammoniacal forms of nitrogen compounds) into nitrite and ultimately to nitrate

pH – negative logarithm of the hydrogen ion concentration used to denote how acidic or basic a solution is

(Water) Pollution - any change in the water that makes it unsuitable for its intended use

Point Sources of Pollution - pollution caused by substances that come from easily identifiable sources such as factories or condominiums

Non-Point Sources of Pollution - pollution caused by substances that come from dispersed, and often hard-to-identify (or pinpoint) sources or areas such as farm or agricultural lands

Polyelectrolyte - polymers whose repeating units bear an electrolyte or electrically charged group which dissociate in water solutions

Polymer – large molecule built-up of similar repeating sub-units which bond together

Precipitation – conversion of substances from dissolved to insoluble forms (solids), usually by the addition of other substances

Red Tide – red discoloration of seawater by excessive growth of toxic (red) dinoflagellates

SBR or **Sequencing Batch Reactor** – fill-and-draw type of activated sludge process using a single reactor (tank) which treats wastewater in batches by cycling through fill - react – settle – decant phases (with optional idle phase).

Sedimentation – gravity induced settling or separation of solids from a liquid mass due to a difference in densities

Sludge – wet mixture of settled solid products or residuals (such as precipitates) from wastewater treatment

Solubility – ability of a substance (*solute*) to dissolved in a *solvent*

Solubility Product Constant – ion product of a substance in a saturated solution

Volatile – easily evaporates

Volatile Organic Compounds or **VOC** – organic chemicals with high vapor pressure (evaporates easily) at normal temperatures, examples includes alcohols and perfumes.

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添付資料 12　Guideline on Factory Inspection

Guidelines
on
Factory Inspection

Table of Contents

1. INTRODUCTION

1.1. Purpose of the Guideline

The purpose of this guideline is to assist the General Directorate of Environmental Protection (GDEP), in general, and inspectors, in particular, to conduct industry or factory inspection in order to check for compliance with the **Law on Environmental Protection and Natural Resource Management** (*Preah Reach Kram / NS-RKM-1296/36 / 24 December 1996; Enacted on 18 November 1996*), in the most consistent, comprehensive, competent, and professional manner.

The guideline focuses on providing standardized inspection procedures to the inspectors so that the GDEP can ensure that all inspection activities are treated with due importance and that all appropriate information for inspecting factory performance are collected by the inspectors. It is aimed to assess and to establish the veracity and accuracy of any information on (water) pollution sources, discharges, or transport of wastewater, or any suspected violation of the law.

While an industry or factory inspection includes not only wastewater pollution but also other types and sources of pollution (such as air pollution, solid wastes, and hazardous substances), this guideline concentrates on wastewater pollution only.

1.2. Law on Environmental Protection and Natural Resource Management

The main purpose of the **Law on Environmental Protection and Natural Resource Management** *(Preah Reach Kram / NS-RKM-1296136 / 24 December 1996; Enacted on 18 November 1996)* is *to protect [and] promote environmental quality and public health through the prevention, reduction, and control of pollution*. This law grants the Ministry of 'Environment the authority to conduct inspections to achieve its purpose of protecting and promoting environmental quality and public health.

1.2.1. Mandate of Ministry of Environment (MoE)

The **Law on Environmental Protection and Natural Resource Management** decrees and mandates the Ministry of Environment (MoE) to protect and promote environmental quality and public health. Article 15 grants the MoE the authority to inspect sources that can cause harm to the quality of the environment.

1.2.2. Chapter VI: Monitoring, Record-Keeping, and Inspection

Article 14 of the **Law on Environmental Protection and Natural Resource Management** requires the owners or responsible persons of pollution sources to:

- Install or use (pollution) monitoring equipment
- Provide samples
- Prepare or keep and submit review records and reports for examination

In order to ensure that the owners or responsible persons of pollution sources fulfil these requirements, the Ministry of Environment is authorized to inspect such sources that can cause harm to the quality of the environment. The result of such inspection enables the MoE to identify and address violations of the water (and other) pollution control laws and regulations in order to prevent, reduce, and/or control pollution from these sources.

1.3. Sub-Decree on Water Pollution Control

The purpose of **Sub-Decree on Water Pollution Control** *(No : 27 ANRK.BK Phnom Penh, April 06, 1999)* is *to regulate the water pollution control in order to prevent and reduce the water pollution of the public water areas so that the protection of human health and the conservation of bio-diversity should be ensured*. To achieve its purpose, the sub-decree establishes an **Effluent Discharge Permit** System that regulates the discharge or transport of wastewater from any source of pollution. The Ministry of Environment has the responsibility of monitoring of the discharge or transport of wastewater. Monitoring requires, among others, the inspection of pollution sources and the pollution management and control initiatives of the owners or responsible persons in order to verify compliance or identify violations for corrective action.

1.3.1. Regulation of Water Pollution (Control)

The regulation of water pollution specified in the **Sub-Decree on Water Pollution Control** applies to **all sources** of **pollution** and **activities** causing **pollution**. It defines permissible and prohibited activities which may cause water pollution. It requires compliance with a specified set of standards of effluent discharge or transport and establishes limits of pollution load.

1.3.2. Effluent Discharge Permit

The owner or responsible person of the source of wastewater intending to discharge or transport wastewater is required beforehand to apply for and secure a permit, namely, the Effluent Discharge Permit, from the Ministry of Environment. The Application Form for Effluent Discharge Permit is issued by the MoE.

The MoE reviews the application and issues the permit upon ascertaining and verifying compliance with applicable laws, regulations, standards, and other pertinent technical guidelines for the prevention and/or control of (water) pollution and the protection of the environment and public health. Verification pf compliance may involve inspection of wastewater (pollution) sources.

1.3.3. Monitoring of the Pollution Sources

In addition to the review of the application for the Effluent Discharge Permit and its issuance, the Ministry of Environment has the responsibility to monitor the discharge or transport of effluent (wastewater). During inspection to monitor the discharge or transport, it may be necessary to collect samples for analysis in order to verify compliance with applicable effluent standards and pollution loads. Collection of samples and identification of significant pollution parameters for laboratory analysis is the responsibility of the inspector.

While the treatment of the wastewater, measurement of its flow rate and the concentration of pollutants is the responsibility of the owner and/or operator of the wastewater source and/or treatment facility, verification of compliance with relevant (effluent) standards is the responsibility of the inspector. Analysis of samples of wastewater and/or treated effluent shall be done by the Laboratory of the Ministry of Environment. However, the owner or responsible person of the pollution sources shall bear the cost of the analysis of his/her wastewater samples.

1.3.4. Water Pollution Monitoring in Public Water Areas

The control and monitoring of water pollution in public water areas is also a responsibility of the Ministry of Environment. Inspectors may also be assigned to inspect public water areas and collect samples as part of the monitoring activity of the Ministry of Environment.

1.3.5. Factory Inspection Procedure

The actual factory inspection involves the following steps:

a. Entry to gain access to the factory and its facilities
b. Briefing to advise the factory representative of the purpose of the inspection, to interview the factory representative, and to request for and to review documents, records, permits, and (prior) instructions and orders of the Ministry of Environment.
c. Actual factory and facilities inspection to include all production and/or manufacturing and ancillary or support facilities and pollution control or treatment facilities.
d. Debriefing to inform the factory representative of initial observations and findings and request clarification or additional information as appropriate and to draft the Initial Report, a copy of which is provided to the factory representative.
e. Drafting of Inspection Report including recommendations

Proper planning and preparation will help ensure that the resulting inspection is conducted in the most consistent, comprehensive, competent, and professional manner.

1.4. Objectives of the Factory Inspection Guideline

The objectives of this Factory Inspection Guidelines are as follows:

a. Standardization of the procedures for inspection
   i. *Entry*
   ii. *Briefing and Document Review*
   iii. *Facilities Inspection and Walkthrough*
   iv. *Debriefing and Initial Findings*
   v. *Drafting of Inspection Report and Recommendations*
b. Specification of the criteria for sampling:
   i. *Determination of the need for sampling*
   ii. *Selection of sampling stations, and*
   iii. *Identification of the required and/or priority parameters for laboratory determination or analysis*
c. Standardization and updating of forms for inspection and report writing

1.5. Functions and Responsibilities of Inspectors

1.5.1. Scope of Inspection Function (Activity) of Inspectors

The scope of the Inspection function includes all sources, forms, media, or types of wastes or pollution. However, this guideline is focused on and limited to the inspection and monitoring of liquid or water wastes.

The inspection function does include the following:

a. Review of documents, both at the MoE office and onsite at the factory
b. Ocular inspection and observation during the walk-through of the production and/or manufacturing and support facilities, and waste management facilities
c. Collection of samples and identification of pollution parameters for laboratory analysis
d. Report writing, both onsite at the factory and at the MoE office, including not only the observations and data collected but also recommendations related to compliance or violation and issuance of Effluent Discharge Permit.

The Inspection function is limited to the drafting of recommendations and excludes the actual issuance of the Effluent Discharge. Likewise, the inspection function does not include enforcement of orders of the Ministry of Environment or imposition or collection of penalties. However, orders of the Ministry of Environment may be served during an inspection visit.

1.5.2. Responsibilities of Inspectors

The responsibilities of an inspector may be classified into five (5) categories:

a. Legal Responsibility: The inspector must conduct all inspection activities within the legal framework established by the activities including presenting proper credentials and mission orders, and properly handling confidential business information. To do this, the inspectors must be knowledgeable about environmental and pollution control laws and regulations and effluent standards.
b. Procedural Responsibility: Inspectors must be thoroughly familiar with the inspection procedures and evidence collection techniques to ensure a comprehensive and reliable inspection and to avoid endangering potential legal proceedings resulting from violations observed or uncovered during inspection. To do this, inspectors must possess practical knowledge of regulatory requirements, inspection methodology / technique, and health / safety measures.
c. Safety Responsibility: Aside from the manufacturing or production and related facilities themselves, wastewater treatment plants as well as other pollution control or management facilities may pose some degree of health and safety risks to the inspectors. The inspector, therefore, must be familiar with all the safety risks and prevention practices.
d. Professional Responsibility: Inspectors represent the Ministry of Environment and the Government of the Kingdom of Cambodia. Sometimes, the inspectors may be the initial or sole representative of the Ministry or Government to the factory. Inspectors must, therefore, be professional in their conduct, that is, well-prepared, honest, tactful, courteous, respectful, diplomatic, and properly attired.

e. Quality Assurance Responsibility: The results of an inspection, particularly, the findings and recommendations embodied in the report are the bases on which the MoE decides to issue an Effluent Discharge Permit or imposes penalties and fines for willful violation of laws and regulations on pollution control and environmental protection. Because of this, the inspector must ensure the quality and accuracy of the inspection findings and results of analysis of wastewater or effluent samples, if collected. All data included in the inspection report must be fully accurate and representative of the actual, existing conditions.

1.6. Qualification of Inspectors

Academic Qualifications (minimum criteria for each level)
Skills and Competencies (Knowledge base)
Work Experience
Assessment and Testing

1.6.1. Qualifications of Inspectors

Table 1 (Proposed) Qualifications of Inspectors

Category	Entry Level or Junior Inspector	Inspector	Senior Inspector
Academic Qualifications (minimum criteria for each level)	Graduate of any Engineering or Science Course	Graduate of any Engineering or Science Course; preferably Professional Engineer	Graduate of any Engineering or Science Course; preferably Professional Engineer
Skills and Competencies (Knowledge Base)	Chemistry, Biology, Mathematics	Additional to Junior Inspector: Environmental Laws and Regulations, Manufacturing / Production Processes, Pollution Control, Health and Safety	Additional to Inspector: Environmental Management
Work Experience	None	At least one (1) year as Junior Inspector	At least two (2) years as Inspector
Assessment and Testing	Regular Civil Service Competency	Environmental Laws and Regulations, (Water) Pollution Control	Environmental Management, Waste Management (All Media)

1.6.2. Training

Initial upon Entry / Recruitment: Upon entry or recruitment, the Entry Level or Junior inspector must undergo training on *Water Treatment Processes and Facilities* and *Factory Inspection* in addition to standard procedures of his/her office.

Regular / Refresher Training: At least once a year, each inspector must undergo regular or refresher training (depending on available training courses, either inhouse or external) on his/her required competencies. Regular or refresher training may include on-site or on-the-job training with a more senior inspector.

Specialization Training: For promotion to a higher rank or level, an inspector may undergo specialization training on the additional competencies required for the next rank or level or to expand their knowledge and skills. Specialization training may include courses on (verbal and written) communications and management.

Assessment and Testing: Aside from the regular assessment of job performance according to the standard procedures of his/her office, each inspector shall be tested for degree of acquisition of knowledge and/or skills after each training attended or participated in.

Performance evaluation shall be undertaken in order to assess and validate the inspector's knowledge and skills. The performance evaluation may be done through tests, examinations, and/or interviews after regular / external training or on-site training. It also serves as a basis for promotion. Performance evaluation may be undertaken every year.

2. INSPECTION

2.1. Inspection Procedure

2.1.1. Flow Chart of Inspection Procedure

The following flow chart illustrates the major activities of inspection procedure:

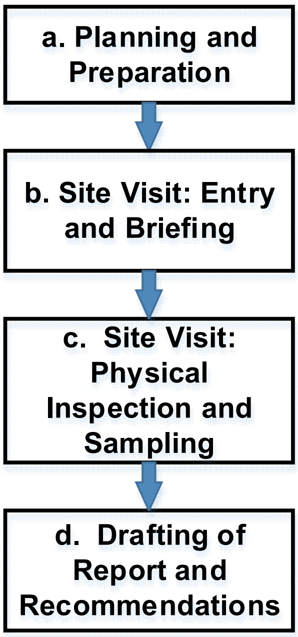

Figure 1 Flow Chart of Inspection Procedure

2.1.2. Annual Inspection Plan

An Annual Inspection Plan is prepared to:

a. Identify factories and/or pollution sources to be inspected,
b. Schedule the dates or periods for the conduct of the inspections,
c. Define the scope of the inspections,
d. Define the composition of the inspection teams

The order of priority of the factories and/or pollution sources to be inspected may be determined according to the following criteria:

1. First priority should be assigned to factories or pollution sources without valid Effluent Discharge Permits but have not applied for a permit.
2. Second priority is assigned to those which have filed applications for (New) Effluent Discharge Permits or which have pending issues for compliance.
3. Third priority is assigned to those whose Effluent Discharge Permits will expire within the next three (3) months.
4. Fourth priority is assigned to those located in areas experiencing water pollution and/or environmental damage based on the information from Ambient Water Quality Monitoring.

Although it is difficult to plan for, court orders (such as to inspect and/or investigate a factory) and valid complaints on environmental damage and/or water pollution should be accorded the highest priority.

The purpose of the inspection, its schedule, and the staff assignments shall define the team composition. The Annual Inspection Plan shall allow enough flexibility to conduct unplanned or unscheduled inspections in order to address emergency or urgent situations such as accidental or intentional discharges of untreated or inadequately treated wastewater or effluent that is likely to cause or has caused serious environmental damage and/or water pollution and/or adverse effects on public health and safety.

The following criteria may be used to determine serious environmental damage and/or water pollution and/or adverse effects on public health and safety:

a. Release of toxic or hazardous substances of any amount
b. Release of mineral oils such as petroleum products) or lipids (such as vegetable or animal oils) exceeding 1,000 liters.
c. Discharge to any public waters or public sewerage system within a period of one (1) hour of 10 m^3 or more of wastewater or effluent that does not comply with the effluent standards.
d. Discharge of any amount of untreated or inadequately treated wastewater or effluents on public lands or waters.

2.2. <u>Planning and Preparation</u>

2.2.1. <u>Flow Chart of Planning and Preparation</u>

The flow chart for *Planning and Preparation* is shown on Figure 2 below.

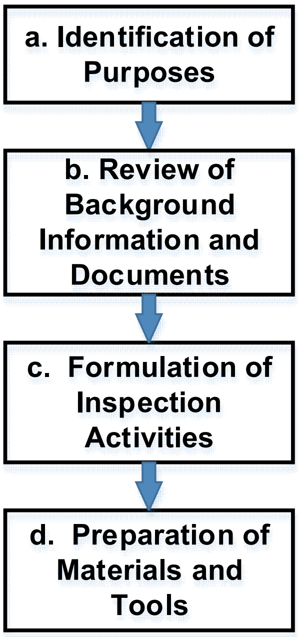

Figure 2 <u>Flow Chart of Planning and Preparation</u>

2.2.2. Identification of Purposes

The purposes of the inspection define the members of the inspection team, the documentation to be reviewed, the scope of the inspection, and the documents, forms, materials, and tools to be prepared for the inspection. While all inspections are intended to investigate and/or monitor sources of (water) pollution, its purpose is related to the Effluent Discharge Permit.

Thus, the purposes of an inspection may be:

a. To investigate factories or pollution sources without valid Effluent Discharge Permits or application for the same (Type: No Effluent Discharge Permit)
b. To investigate factories or pollution sources which have filed applications for (New) Effluent Discharge Permits (per Environmental Management Plan) or which have pending issues for compliance (Type: Effluent Discharge Permit Application).
c. To monitor factories or pollution sources which have filed for renewal of their Effluent Discharge Permit which is about to expire and to assess their performance and compliance (Type: Effluent Discharge Permit Renewal).
d. To investigate factories or pollution sources located in areas where public lands or public waters are experiencing water pollution and/or environmental damage (Type: Compliance Monitoring).
e. To investigate accidental or intentional illegal discharges with potential to cause serious environmental damage or water pollution (Type: Illegal Discharge Investigation).
f. To investigate factories or pollution sources in compliance with court orders to monitor such factories or pollution sources (Type: Compliance Investigation).

Team Formation: It is recommended that, as much as possible, an inspection be conducted by a team rather than a single inspector. The composition of the inspection team is dependent on the purposes of the inspection. At the minimum, the inspection team should consist of a senior inspector as team leader and an officer from the Department of Environmental Quality Research and Laboratory (DEQRL) or other person qualified to collect wastewater or effluent samples when it is anticipated that samples will be collected (which is likely in most cases). In case the inspection is related to the Environmental Impact Assessment system, an officer from the Department of Environmental Impact Assessment (DEIA) should be included in the inspection team.

2.2.3. Review of Background Information and Documents

Collection, study, and analysis of available background information is essential to the effective planning and overall success of an inspection. Relevant materials such as documents supplied by the factory or pollution source and those obtained from GDEP, DILE, DEIA, other inspector's inspection reports and personal experiences, experience from similar types of factories, etc. are useful to the inspector to familiarize himself with the operation and history of the factory or pollution source to be inspected. The information and documents required to be reviewed are listed on Table 2 below.

Table 2 Background Information and Documents

Information and Documents	A	B	C	D	E	F	G
Location and Vicinity Maps	✓ ?	✓	✓	✓	✓ ?	✓	✓
Plant or Factory Layout	✓ ?	✓ ?	✓	✓ ?	✓ ?	✓	✓
Wastewater and Storm/Rain Water Sewer Plan, showing • Discharge points • Sampling points	✓ ?	✓ ?	✓	✓ ?	✓ ?	✓ ?	✓ ?
Rated/Approved and Actual/Current Production Capacity • Product Name and Quantity	✓ ?	✓ ?	✓	✓ ?	✓ ?	✓ ?	✓ ?
Raw Materials • Raw Material Name and Quantity	✓ ?	✓ ?	✓	✓ ?	✓ ?	?	?
Sources of Water Supply	✓ ?	✓ ?	✓	✓ ?	✓ ?	?	?
Water Balance (Incoming Supplies and Outgoing Discharges)	✓ ?	✓ ?	✓	✓ ?	✓ ?	?	?
Wastewater from Each Different Manufacturing or Production Process • Quantity • Quality	✓ ?	✓ ?	✓	✓ ?	✓ ?	?	?
Wastewater Management: • Wastewater Treatment Processes • Schematic Process Flow Diagram and Description	✓ ?	✓	✓	✓ ?	✓ ?	?	?

Where:

A. No Effluent Discharge Permit
B. Effluent Discharge Permit Application
C. Effluent Discharge Permit Renewal
D. Compliance Monitoring
E. Illegal Discharge Investigation
F. Compliance Investigation
G. Others
✓ Information or Document is Required
? Information or Document may be Unavailable, Obtain from Factory

2.2.4. Formulation of Inspection Activities

The activities to be undertaken during inspection should be written down in the *Inspection Plan*. The *Inspection Plan* addresses the following issues in defining the inspection activities:

a. Purposes and/or Objectives: The statement of purposes and/or objectives should specify the type of inspection to be conducted and define the results to be accomplished.
b. Activities: What activities are necessary to accomplish the purposes or objectives of the inspection? For example, if the purpose of an inspection is to determine compliance, collection (and analysis) of representative samples of the discharged effluents is necessary. If the purpose of an inspection is to investigate factories or pollution sources located in areas where public lands or public waters are experiencing water pollution and/or environmental damage, a vicinity map with the locations of factories and other pollution sources is necessary.
c. Procedures: The standard inspection procedures as described in this Factory Inspection Manual are normally followed. However, it is important to indicate specific procedures based on the purposes and/or objectives of the inspection. If there are special procedures to be followed, such as orders from a court of law, these have to noted down and complied with.
d. Resources: What human or personnel and material resources are required for the inspection? Who will be the team members? What forms, instruments, tools, equipment, and vehicles will be needed?
e. Schedule: When will the inspection be conducted? When and where will the inspection team members meet to coordinate and to embark to the factory or pollution sources? Should the owner or responsible persons of the factory or pollution sources be informed of the inspection beforehand?
f. Administrative Issues: What official documents such as mission letter / order, travel order, IDs, certificates, standard forms, and the like will be required and who will obtain or prepare these?

2.2.5. Preparation of Materials and Tools

The materials, instruments, tools, and equipment needed for an inspection are:

a. Official Inspection Documents and Forms
   i. Official Identification Cards
   ii. Mission Letter/Order, Travel Order
   iii. (Onsite) Inspection Minutes Form
   iv. Attendance List Form
   v. Standard Form for Permission to Take Pictures (with Statement of Confidentiality)
   vi. (Walkthrough) Survey Checklist
   vii. Copies of Environmental Protection and Pollution Control Laws
b. Writing and Recording Materials and Instruments
   i. Ball Pens, Marking Pens, Notebooks, Stationery, Clipboard
   ii. Digital Camera (Note: It is not advisable to use the camera of a smartphone because the pictures may be inadvertently uploaded to a non-secure location.)
   iii. Flashlight, Compass, GPS Monitor (Apps in Smartphone will suffice)

c. Sampling and Flow Metering Instruments, Tools, and Equipment
   i. (Steel) Tape Measure, Ruler, Stopwatch
   ii. Bucket or Pail, Graduated Cylinders, Sample Bottles (and Labels)
   iii. Ice Chest, Ice (for sample preservation)
   iv. (Multi-parameter) Field Test Instrument
d. Safety Devices and Equipment
   i. Official Uniforms and/or Work Clothes
   ii. Personal Protective Equipment (PPE) such as Safety Shoes, Safety Helmet, Goggles or Face Shields, Gloves, (Plastic) Aprons, etc.
e. Logistics and Transportation
   i. Vehicles and Travel Funds

2.3. Site Visit

2.3.1. Entry and Briefing

2.3.1.1. Entry to the Factory or Facility (Pollution Source)

Upon arrival at the factory or inspection site, the inspection team leader shall ask for the owner or responsible person or his/her authorized representative to explain the purpose and legal basis of the inspection visit and present their credentials and mission order and seek permission to enter. The inspection team should allow the owner or responsible person or his/her authorized representative enough time to verify the mission order and their credentials.

In case the inspection team is not allowed to enter the factory or facility (pollution source) to conduct the inspection, the inspection team leader shall inquire about the reason for denial of entry. If there is any obstacle or misunderstanding, he shall try to clear it. If entry is still denied despite the explanation; the inspection team leader shall calmly inform and warn the owner or responsible person or authorized representative that denial is a violation of the **Law on Environmental Protection and Natural Resource Management** *(Preah Reach Kram / NS-RKM-1296136 / 24 December 1996; Enacted on 18 November 1996)* and that legal action may follow. The denial of entry shall be immediately reported in writing to the MoE authorities for proper and immediate action.

When inspection team enters the factory or facility after permission is granted, the inspectors shall follow correct administrative procedures and requirements. They should abide by the protocols of the factory or facility, especially those related to safety and confidentiality, and conduct themselves in a professional manner.

2.3.1.2. Briefing and Document Review

After entry to the facility, the inspection team will hold a short meeting with the owner, responsible person, and/or authorized representative of the factory or facility to provide information on the purpose and scope of the inspection and the planned activities in that factory or facility. The inspection team (leader) shall request all participants of the initial meeting to register in the *Attendance List* and request written permission (on the standard form) to take pictures for record keeping purposes and collect samples for analysis, as may be needed to confirm compliance with effluent standards.

The inspection team (leader) should also ask the authorized representative of the factory or facility if there are any areas in the factory or facility which are off-limits or may not be inspected and the reasons for such prohibition. The inspection team (leader) should emphasize that refusal to allow access to or inspection of these areas without valid reason is a violation of the **Law on Environmental Protection and Natural Resource Management** *(Preah Reach Kram / NS-RKM-1296136 / 24 December 1996; Enacted on 18 November 1996)* and that legal action may follow. Any refusal to allow access or inspection of certain areas or to take pictures or collect samples shall be immediately written down in the *Inspection Minutes* form including the reasons for the refusal

The initial meeting and briefing is an opportunity for the inspection team to gain better understanding on the factory or facility operations and to seek assistance and cooperation from the factory or facility staff in gathering the necessary data and more detailed information on factory or facility operations, physical layout, management structure, plant safety requirements, and other information relevant to the inspection.

The initial meeting and briefing should include the following:

a. Explain the purpose of the inspection and the scope of activities during the inspection.
b. Identify or look for the responsible persons at the site and request technical personnel to accompany the team during the site inspection. This will facilitate access to areas that are normally off limits.
c. Clarify safety issues or concerns in the site. Request appropriate personal protective equipment (PPE).
d. Verify the site activities and their environmental implications.
e. Verify applicability of the EDP and/or other environmental permits.
f. Request written permission to take photographs and collect effluent and/or wastewater samples, as necessary.

The following information should be obtained from the factory or facility:

a. History of reports and correspondence on previous inspections,
b. Notices sent to the factory or facility, especially on previous infringements or violations or deficiencies and approvals;
c. Reports on the industry from other relevant authorities;
d. EDP applications, previous environmental recommendations and complaints; Environmental Management Plan, any other relevant documents and/or reports;
e. Company environmental reports, ISO 14001 certification, or others such environmental certificates;
f. Company's business partners;
g. Production and/or manufacturing processes, products, and raw materials, rated or approved and actual production capacities;
h. Waste(water) management plan or program
i. Factory or facility layout plan (especially showing the storm/rain water and wastewater or effluent sewer and drainage pipe lines and/or channels);
j. Test results (such as results of analysis of samples)

2.3.2. Facilities Inspection (Walkthrough Survey)

2.3.2.1. Overall Observation of Facility Condition

Before conducting the factory or facility inspection, the inspection team should make an overall observation of the periphery of the facility to grasp general facility condition. Any signs of apparent spills around the facility, conditions of surrounding vegetation, odour problems and possibility of direct discharge of wastewater to receiving public waters must be identified and recorded, preferably including photographs if permitted. In addition, all other observations pertaining to waste storage areas for chemical or toxic or hazardous materials and wastes, fuel oil / waste oil, and secondary containment for such tanks or storage facilities should be noted.

The other conditions to be observed are:

a. Dead or unhealthy vegetation;
b. Ponds or lagoons that appear to contain oily or discoloured water or sludge;
c. Leaking containers
d. Uncovered piles of waste
e. Oil or discoloration of water in streams or rivers surrounding the property
f. Strong or noxious odours

The inspection team should be adaptable enough to amend the inspection plan and consider pursuing the other observations and/or activities depending on the actual situation. If inspection is for complaint investigation; or if inspection team suspects a potential violation of regulations; the inspection team should conduct interviews and general observation at the immediate vicinity, especially with the residential community, before proceeding with the factory or facility inspection. Taking pictures of the surroundings and gathering additional evidences should be also conducted at this stage.

2.3.2.2. Manufacturing / Production Facilities

The factory or facility inspection shall focus on examining the production and/or manufacturing processes, wastewater management and treatment processes, and any other aspects relevant to wastewater discharge. The points to be inspected and observed are dependent on the types of factories or industries. It is very important to obtain a full description and understanding of the actual production and/or manufacturing processes and to verify information provided by the authorized factory or facility representative. The inspection may provide opportunities to identify problem areas that can be improved through pollution reduction techniques.

The factory or facility inspection should cover all the areas or process equipment where wastewater and/or pollutants are generated, processed, pumped, conveyed, treated, or stored. The manufacturing and/or production processes, storage areas, and treatment equipment of the factory or facility shall be surveyed.

The inspection team should gain a full understanding of the industry’s wastewater generation and treatment. For better understanding of the entire process, it is necessary to start the survey from raw materials receiving or processing to the finished products packing and storage prior to shipment to customers or end-users.

Throughout the inspection, the inspector needs to observe all sources or potential sources of wastewater discharge. The information collected shall include discharge conditions such as:

a. Discharged water is temporarily stored or continually discharged (batch or continuous discharge);
b. Volume of wastewater discharged at each discharge point;
c. Frequency of each discharge;

For certain factories or facilities, wastewater discharge during production may be low or minimal but will greatly increase during cleaning at the beginning and/or end of work shift or production run. The inspection team should be aware of this and make suitable inquiries because these activities are usually undertaken outside the normal times when inspections are conducted such as at night or very early in the morning or late in the afternoon or evening or after regular office or work hours.

Wastewater flow rate or volume is needed to estimate or compute the total pollution load. If available, wastewater flow rate or volume from each process shall be obtained from the authorized representative. The flow rates are best measured during the inspection. The information on water supply to the factory or facility should be obtained from or be provided by the authorized representative. The inspector may be able to roughly estimate the water balance. If the water balance shows large discrepancies between incoming flow (water supply) and outgoing water discharge; the inspection team should inquire into possible reasons or explanation from the authorized representative.

2.3.2.3. Waste(water) Management / Regulated Facilities

In most cases, the wastewater generated by manufacturing or production factories or facilities may require treatment in order to comply with effluent standards. Proper waste management including cleaner production and waste minimization or reduction can help reduce the quantity of wastewater and pollutants but more often than not, the quality of residual wastewater fails to comply with the effluent standards. The wastewater treatment facilities of a factory are a very indispensable component of the waste management program of the factory and are essential to the ability of the factory to comply with the effluent standards.

It is, therefore, imperative to verify the function, operation, and performance of the factory's waste management facilities, particularly, the wastewater treatment facility.

The aspects of the wastewater treatment facility which need to be meticulously inspected include:

a. Abnormal conditions during treatment
    - Excessive vegetation or plant growth in the stabilization ponds;
    - Excessive scum, foam, or floating material accumulated in treatment and settling tanks;
    - Fouling of fabric or other solids in micro-screens with grease or solids;
    - Sludge accumulation in clarifiers indicated by floating sludge and gas bubbles, etc.
b. Unusual discharges

- Surcharging (overflow) of influent lines and overflow weirs

c. Alternative Discharge Points (By-Pass)
   - Old valves or channels from previously upgraded system;
   - Pipes or channels showing occasional use;
   - Erosion or run-off from land discharge sites;
   - Color or settled solids in storm or rain water pipes and/or channels.
d. Abnormal/Obnoxious Odor from:
   - Wet wells, grit chamber,
   - Aerobic and/or anaerobic biological treatment units,
   - Scum removal devices and sludge handling facilities.
e. Broken or Unusual Equipment
   - Presence of special pump, especially not fixed in a location
   - Presence of floating aerators in diffused aeration systems
   - Any structure or equipment that appears to be temporary
   - Clogged sprinklers, dripping nozzles, broken pipes (land discharge)
f. Other Items to Observe:
   - Are the by-products or residuals of treatment or production being properly managed and disposed of?
   - Are safeguards adequate to prevent the discharge of untreated or partially- treated wastes?
   - Is there evidence of past spills?
   - Is there ponding of wastewater in the irrigation field (land discharge)?

Gross Violations or Serious Illegal Discharges: Should the inspection team observe or notice any gross violation of environmental protection or pollution control laws or serious illegal wastewater discharges in the course of the inspection, the inspection team shall immediately collect evidences such as wastewater samples and take pictures even without the express permission of the owner or responsible person of the factory or pollution source.

2.3.2.4. Wastewater or Effluent Sampling and Flow Measurement

Sampling and Flow Measurement: Collection of wastewater and/or effluent samples, and ideally, flow measurement, during an inspection shall be conducted under the following circumstances:

a. When the purpose of the inspection is related to the Effluent Discharge Permit (new or renewal application for EDP),
b. When the purpose of the inspection is to investigate illegal wastewater discharges,
c. When the wastewater being discharged appears to be untreated or inadequately treated (as indicated by the presence of color, suspended solids, and/or obnoxious odors)
d. When the wastewater treatment facility appears to be not functioning effectively (as indicated by broken down or non-functioning equipment or components or presence of obnoxious odors or appearance of the effluent).
e. When the purpose of the inspection is to investigate accidental or intentional wastewater discharges
f. When the purpose of the inspection is to verify compliance with effluent standards,
g. When ordered to do so by a competent court of law.

Sampling Station: For purposes of compliance monitoring, only the wastewater or effluent discharged is sampled. The sampling station shall be the outlet or discharge pipe or channel just before or just after the wastewater or effluent exits the premises or compound of the factory or facility and where it is convenient and safe to collect the wastewater or effluent sample (and measure the flow rate).

Type of Sample: A flow-proportional composite sample is the most representative of the quality or characteristics of the wastewater or effluent. However, practical considerations, such as time constraints, dictate that grab samples are collected. Since the characteristics or quality of treated effluent of a wastewater treatment facility that is operating normally under stable, relatively constant conditions is relatively constant, a grab sample will suffice.

Parameters or Analytes for Determination: While all wastewater samples should be analyzed for the determination of pH, COD, BOD_5, and Total Suspended Solids, additional parameters may be indicated for specific factories or industry sectors. Thus, samples from most food manufacturing facilities may need to be analyzed for oil and grease, surfactants, phosphates, nitrates, ammonia, and coliforms while samples from textile dyeing mills may need to be analyzed for color and heavy metals such as chromium and copper. A reference table of priority pollution parameters of various industry sectors is included in the Annexes.

Sample Collection: The collection of samples (and flow measurement) shall be witnessed and confirmed by the authorized representative of the factory or facility. After collection of the samples, each sample bottle shall be properly labeled to indicate the factory or facility, sampling station, sample collector, time and date of sample collection, name of authorized representative. A suitable seal shall then be fixed on the cap of the sample bottle to ensure its integrity.

2.3.3. Debriefing and Exit

After the (walkthrough) inspection is completed and before the inspection team exits the factory or facility premises, the inspection team shall conduct a closing and debriefing meeting or conference with the authorized representatives (and other technical staff, as appropriate) of the factory or facility to present their preliminary observations and findings. The authorized representative and other competent technical staff should be given the opportunity to confirm the findings and provide explanations or clarifications as appropriate and to review the pictures taken to request deletion of those containing confidential business information. The resulting discussions shall be duly recorded in the *Inspection Minutes*.

The closing and debriefing meeting or conference is an opportunity for the inspection team to request additional information and/or documents which were not earlier available or were found to be necessary as a result of observations during the course of the physical inspection.

After the *Inspection Minutes* and *Attendance Sheet* are duly accomplished and signed by all concerned, the *Inspection Minutes* shall be reproduced, and a copy provided to the authorized representative of the factory or facility.

2.4. Report Writing

2.4.1. Inspection Minutes (Onsite Report)

The *Inspection Minutes* is written and completed during the closing and debriefing meeting or conference before the inspection team leaves the factory or facility. The *Inspection Minutes* contains information on the purpose of the inspection, date and time of the inspection, Mission Order or Letter No., inspection team members, details of the factory or facility and the owners or responsible persons and authorized representatives, and preliminary findings or observations. The preliminary findings or observations should be clearly explained to the owners or responsible persons and authorized representatives and their responses, clarifications, and explanations should be heard and recorded.

It is important to include the following data in the *Inspection Minutes*:

a. Type of factory or facility and manufacturing or production capacity
b. List of waste streams and waste management facilities
c. List of samples collected
d. Findings and observation, especially potential violations
e. Instructions to the factory or facility owners or responsible persons

2.4.2. Inspection Report

2.4.2.1. Evaluation and Interpretation of Findings and Observations

In addition to the *Inspection Minutes* which is written and completed onsite, a more detailed, formal *Inspection Report* is drafted to serve as official basis for any action, direction, order, and penalty as may be appropriate.

The formal *Inspection Report* includes a more detailed description of the findings and observations during the inspection and the evaluation and interpretation of these findings and observations. The focus of the evaluation and interpretation of the findings and observations should be the actual or potential negative, harmful, or damaging impacts (of the wastewater discharges or other violations) on the environment and public waters and on public health and safety.

Any violation noted should be referenced to the pertinent article of the applicable law or regulation. Mitigating circumstances, positive responses, and corrective actions of the owner or responsible person of the factory should likewise be included in discussion of the findings of violations or potential violations. These will have a bearing on the legal and/or enforcement action to be taken by the MoE.

When samples are collected, the results of analysis should be compared with the pertinent effluent standard of the type of industry or factory. It is important to refer to the printout or computer file of the effluent standards even if the inspector knows these by heart to ensure accuracy.

The purpose or purposes of an inspection influence the assessment and evaluation of the results of an inspection.

a. If the purpose of the inspection is to determine the status of compliance with the EDP conditions, effluent standards, and environmental regulations, the results of the inspection, in particular, the results of analysis of effluent samples collected are compared with the relevant parameters in the applicable effluent standards. The type of industry defines the priority or significant pollution parameters.

   Aside from the effluent standards, compliance with gaseous emissions standards, solid waste disposal regulations, and toxic and hazardous materials and waste management should also be evaluated.

   For inspection for renewal or regular inspection for monitoring, compliance with specific and additional conditions in the EDP needs to be assessed and verified. This requires prior review of the EDP conditions and other instructions and/or orders of the MoE.
b. If the purpose of the inspection is to collect information and data which could be used as evidence in the environmental litigation process, it is imperative that the procedure for identifying and collecting information and data be strictly followed to ensure that any evidence collected is admissible in a court of law.
c. If the purpose of the inspection is to verify accuracy of information submitted by factories or facilities with pollution sources pertaining to new EDP applications, renewals, or modifications, the observations and other results of the inspection are compared with the information officially submitted by the owners or responsible persons. The results of analysis of samples collected and analyzed in the MoE laboratory takes precedence over any other result. However, due allowance should be made for normal variations in the results of analysis of samples taken at different occasions even from the same sampling stations.
d. If the purpose of the inspection is to investigate complaints by private or public entities, the results of the inspection should be compared with the specific basis of the complaints. The effluent standards and environmental laws and regulations are the main basis for determining the validity and legality of a complaint.
e. If the purpose of the inspection is to guide the companies in the improvement of their performance in wastewater management and treatment, the results of the inspections should be compared with the data on industry performance in the pertinent industry sector guidelines. Methods for improving environmental performance presented in the industry sector guidelines may be offered to the industry or establishment.
f. The inspection team should take the time to quantify the total effluent pollution load and specific raw wastewater pollution generation rate (such as, m^3 wastewater or kg BOD_5, COD, TSS or other relevant pollutant generated per unit quantity of product produced) by the factory or facility and its industry sector or type. Specific pollution generation rates are helpful in determining the environmental performance of factories and industries and may guide them towards improving their environmental performance.

2.4.2.2. Conclusions and Recommendations

The results of the inspection must provide the evidence on compliance with the environmental protection and water pollution control laws and regulations, effluent standards, and/or EDP conditions. However, the inspection report should not conclude or make a judgement on compliance. It should just indicate recommendations in terms of the compliance. The report should contain only the facts on the inspection. It, however, is realized that the inspector's judgement on the status of compliance of the factory or facility is the critical factor in the MoE official decision as to whether there is compliance or whether a violation occurred or not. It is essential that the inspection report includes the inspector's recommendations regarding compliance and further action.

Although the inspector may communicate with the owner or responsible person or authorized representative his/her view on certain matters; facts and/or figures should not be mixed with his/her personal opinions. If the inspector has concluded non-compliance by the company inspected and provided recommendations for further actions; due date or deadline of the action to be taken by the company shall be set and agreed with the owner or responsible person or authorized representative. In addition, these orders and/or instructions and their respective deadlines or due dates should be mentioned in the enforcement letter sent to the factory or facility with pollution sources.

2.4.2.3. Inspection Report Attributes

The inspector has the basic responsibility of providing documented evidences on discrepancies discovered during the facility inspection. One of the main objectives of the inspection is to organize and coordinate all inspection information and findings into a comprehensive and usable document in accordance with the standard form. In order to meet this objective, information in an inspection report must be presented in a clear and well-organized manner. And then the results of all inspection work are properly described in the form of a written report.

In order to satisfy the requirements in the reporting to organize and coordinate all findings and evidences collected in the inspection in a comprehensive and usable manner; the inspection report shall have the following attributes:

a. Accurate: All information must be factual and based on sound inspection practices. Enforcement personnel must be able to depend on the accuracy of all information.
b. Relevant: Information in the inspection report should be pertinent to the subject of the report.
c. Comprehensive: The subject of the report should be substantiated by as much factual, relevant information as is feasible.
d. Co-ordinated and Consistent: All information pertinent to the subject should be organized into a complete package. Documentary support (photographs, statements, results of analysis of samples, etc.) accompanying the report should be clearly referred so that anyone reading the report will get a clear picture of the subjects.

2.4.2.4. Sample Inspection Report Format

A. Introduction

1. General Information
    - File No. / Factory ID, Name of the Factory, company, enterprise or facility inspected, address, and other contact information
    - Purposes of the inspection;
    - Facts of the inspection (date/time, location, inspection team members)
    - Participants involved in the inspection
2. Summary of Findings
    - Name and position of the factory or company personnel interviewed;
    - Summary of the inspection findings.
3. Historical Background of the Company
    - Status of the company;
    - Size of organization;
    - Type of operations performed at the company under the inspection

B. Inspection Activities

1. Opening conference or entrance briefing
    - Procedures used at arrival, including presentation of credentials, Mission Letter/Order, and other documents;
    - Special problems or observations such as reluctance on the part to give consent/permission, or if consent/permission was withdrawn or denied;
    - Any topics discussed in the opening conference
2. Records
    - Types of records reviewed;
    - Any inadequacies in record-keeping procedures, or if any required information was unavailable or incomplete;
    - Note if record-keeping requirements were being met.
3. Evidence collection
    - Photographs taken during the inspection;
    - Drawings, sketches, maps, charts, or other documents made or taken during the inspection.
4. Physical samples
    - Purpose for which samples were obtained;
    - Sampling station location and time and date of sampling;
    - Sampling methods used to collect sample;
    - Results of laboratory analysis, if any.
5. Recommendations
    - Recommendations based on the observations and analytical data
    - Recommendations after discussion with factory representative.

C. Attachments

1. List of attachments
    - List of all documents, analytical results, photographs, and other supporting information attached to the inspection report.
2. Documents
    - Copies of all documents and other evidences collected during the inspection. All documents should be clearly identified and labelled.
3. Results of Analysis
    - Sample data and results of analysis, if any.

3. ANNEXES

3.1. Environmental Laws and Regulations

3.1.1. Law on Environmental Protection and Natural Resource Management

Preah Reach Kram / NS-RKM-1296136 / 24 December 1996; Enacted on 18 November 1996

3.1.2. Sub-Decree on Water Pollution Control

No : 27 ANRK.BK Phnom Penh, April 06, 1999

3.2. **Standard Forms**

3.2.1. Inspection Checklists

Inspection Plan Checklist

Date: ______ / ______ / ______

Inspectors team member	Name and position / organization	
Date of inspection	______ / ______ / ______	
Facility information	Name & Location:	
	Type of industry (sector):	
	Date of last inspection:	
Type of inspection	A) No Effluent Discharge Permit	B) Effluent Discharge Permit Application
	C) Effluent Discharge Permit Renewal	D) Compliance Monitoring
	E) Illegal Discharge Investigation	F) Compliance Investigation
	G) Others (________________________)	
Purpose of inspection	a) Investigate No Valid Effluent Discharge Permit or EDP Application	b) Investigate Application for New EPL or Renewal of EPL:
	c) Compliance Monitoring of Expiring EDP	d) Investigate (Water) Pollution of Public Waters or Public Lands
	e) Investigate Accidental or Intentional Illegal Discharges Causing Serious Environmental Damage	
	f) Court Order (________________________)	
Information reviewed	1) Vicinity map; 2) Plant / Factory layout; 3) Manufacturing / production process flow diagram	
	4) Sources of water supply; 5) Water Balance; 6) Wastewater quality / quantity	
	7) Wastewater treatment methods; 8) Discharge points; 9) Sampling points	
	10) Production levels; 11) Previous inspection reports; 12) Previous water quality report	
	13) Others (________________________)	
Sampling water	Yes Number of samples: __________ pH; W. Temp.; EC; TSS / (Turbidity) COD; BOD_5; Oil & Grease; Lead Cr^{6+}; Coliforms Others (________________________)	
	No	
Remarks		

Prepared by: ______________________ Approved by: ______________________

Preparation for Inspection Checklist

Date: / /

<table>
<tr><td rowspan="3">Inspectors team member</td><td colspan="3">Name and position / organization</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td>Date of inspection</td><td colspan="3">/ /</td></tr>
<tr><td rowspan="3">Facility information</td><td colspan="3">Location:</td></tr>
<tr><td colspan="3">Type of industry (sector):</td></tr>
<tr><td colspan="3">Date of last inspection / /</td></tr>
<tr><td rowspan="17">Documents / Materials / Tools</td><td>Items</td><td></td><td>Remark (number, e.g.)</td></tr>
<tr><td>Identification Card</td><td>Y or N</td><td></td></tr>
<tr><td>Mission Letter</td><td>Y or N</td><td>Mission Letter.docx</td></tr>
<tr><td>Attendance List</td><td>Y or N</td><td>Attendance List.docx</td></tr>
<tr><td>Inspection Minutes Form</td><td>Y or N</td><td>Inspection Minutes Form.docx</td></tr>
<tr><td>Sample Collection Form</td><td>Y or N</td><td>Sample Collection Form.docx</td></tr>
<tr><td>Inspection Report Form</td><td>Y or N</td><td></td></tr>
<tr><td>Notebooks, pens</td><td>Y or N</td><td></td></tr>
<tr><td>Calculators</td><td>Y or N</td><td></td></tr>
<tr><td>Compass / GPS (smartphone?)</td><td>Y or N</td><td></td></tr>
<tr><td>Camera</td><td>Y or N</td><td></td></tr>
<tr><td>Flashlight</td><td>Y or N</td><td></td></tr>
<tr><td>Stopwatch</td><td>Y or N</td><td></td></tr>
<tr><td>Tape measure, ruler</td><td>Y or N</td><td></td></tr>
<tr><td>Sampling kit and field meter (pH, Temperature, DO, and others)</td><td>Y or N</td><td></td></tr>
<tr><td>Tools for flow measurement (bucket, cylinder, etc.)</td><td>Y or N</td><td></td></tr>
<tr><td>Others (specify)</td><td></td><td></td></tr>
</table>

Prepared by: ______________________________

3.2.2. Environmental Pollution Inspection Report

3.2.2.1. Forms / Documents to be Brought and/or Completed Onsite

a. *Mission Letter.docx* (original)
b. *Attendance List.docx*
c. *Inspection Minutes Form.docx*

3.2.2.2. Sampling (and Analysis)

Sample Collection Checklist

This check list specifies the information to be collected and recorded during sampling, sealing, labelling and transporting of the samples to the MoE Laboratory:

i. Purpose of sampling,
ii. Location of sampling points,
iii. Name and address of the contact person at the field or sampling site or station,
iv. Type of sample,
v. Method of sampling,
vi. Method of preservation, if the sample is wastewater,
vii. Processes generating the waste stream,
viii. Observed sample conditions,
ix. Number and volume of samples taken,
x. Date and time of sample collection,
xi. Sample identification numbers,
xii. Sample distribution,
xiii. Method of transport,
xiv. References such as maps, distances and photographs of sampling site, and
xv. Field observation and measurements.

The above information shall be recorded in the Sample Collection Form and signed by the sampling officer.

Refer to: *Sample Collection Form (provisional).docx*

3.2.2.3. Proposed (Slightly) Revised Version

Refer to: *Environmental Pollution Inspection Report Form v1.docx*

3.2.3. Effluent Discharge Permit

Standard MoE / GDEP Form

3.3. Additional References

3.3.1. Priority Pollution Parameters of Selected Industry Sectors

Industry Sector	pH	BOD_5	COD	TSS	Oil & Grease	Ammonia	Nitrate	Phosphate	Chromium	Copper	Lead
1. Textile	ü	ü	ü	ü	ü			ü	ü	ü	
- Dyeing and Bleaching	ü	ü	ü	ü	ü	ü		ü	ü	ü	
- Industrial Washing	ü	ü	ü	ü	ü	ü		ü			
- Textile Printing	ü	ü	ü	ü	ü	ü		ü	ü	ü	
2. Beverages	ü	ü	ü	ü		ü	ü	ü			
- Alcohol Distillery	ü	ü	ü	ü		ü	ü	ü			
- Fruit Juices	ü	ü	ü	ü	ü	ü	ü	ü			
- Milk Products	ü	ü	ü	ü	ü	ü	ü	ü			
- Carbonated Beverages	ü	ü	ü	ü		ü	ü	ü			
3. Leather Tanning	ü	ü	ü	ü	ü	ü	ü	ü	ü		
4. Vehicle Service Stations	ü	ü	ü	ü	ü			ü			ü
5. Animal husbandry	ü	ü	ü	ü	ü	ü	ü	ü			
- Piggery / Hog Raising	ü	ü	ü	ü	ü	ü	ü	ü			
- Slaughterhouse	ü	ü	ü	ü	ü	ü	ü	ü			
- Poultry Dressing	ü	ü	ü	ü	ü	ü	ü	ü			
- Meat Packing & Processing	ü	ü	ü	ü	ü	ü	ü	ü			
6. Sugar Mill	ü	ü	ü	ü	ü		ü	ü			
7. Paper Mill	ü	ü	ü	ü	ü						

3.3.2. General and Industry Sector Specific Viewpoints on Facility Condition

Refer to document: *Factory Inspection Viewpoints.docx*

3.3.3. Verification of Continuous Operation of Wastewater Treatment Plants (WWTP) or Facilities (WTF)

3.3.3.1. Documentary and Procedural Requirements to Verify Continuous WTF Operation

To ensure continuous operation of its wastewater treatment plants (WWTP) or facilities (WTF), the industry, factory, or facility shall be required to maintain the following documents and records:

a. Daily Logbook of the Operations of the Wastewater Treatment Plant (WWTP) or Facility (WTF), recording at least the following:
   i. Appearance of the final treated effluent: clarity (turbid or not), color, odor, presence of floating matter (scum, foam or froth)
   ii. Volume of wastewater discharged
   iii. Electrical power consumption (kW-hr) of the WTF
   iv. Chemicals consumption or usage; including the quantity (volume) of each chemical solution in each chemical solution tank.
   v. Results of routine tests (pH, dissolved oxygen, turbidity or Secchi disk depth, COD)
   vi. Quantity of sludge disposed of
b. Maintenance Record of WTF Equipment (change of lubrication, v-belts, air and oil filters, other parts subject to wear and tear such as seals and bearings)
c. Results of Analysis of treated effluent discharged (at least once a month)

3.3.3.2. Physical Facilities to Verify Continuous WTF Operation

The installation of the following physical facilities allows verification of the continuous operation of the Wastewater Treatment Plant (WWTP) or Facility (WTF)

a. Non-Resettable Water Meter for the Effluent discharged
b. Electric kW-hr Meter exclusively for the Wastewater Treatment Plant (WWTP) or Facility (WTF) only. The local electric power utility may provide this at no extra charge to the factory or facility.
c. Non-Resettable Run-Time meter for each major piece of equipment
d. IP camera covering the whole WWTP / WTF connected to the Internet

3.3.3.3. Onsite Observations to Verify Continuous WTF Operation

During the physical inspection (walkthrough), the following items should be checked:

a. If motors are warm or hot. Cold (ambient temperature) motors indicate non-use while barely warm motors indicate it has been switched on only recently such as upon arrival of the inspectors.
b. Dust or other debris on equipment, especially, moving equipment. There should a small amount of dust, oil or grease leak. Very clean (not used at all) or very dirty (not used for a long time) motors and moving equipment should be viewed with some suspicion.
c. Presence of stock of chemicals supplies at the WWTP / WTF area or plant room, typically in amounts of consumed in 1-4 days indicate continuous chemical consumption or use.
d. Very dry sludge or no sludge in the sludge drying beds of (dewatered) sludge cake storage indicates no sludge generation which usually means no operation of the WWTP / WTF.
e. Floating scum, especially, dry, caked solids at the walls of treatment tanks may indicate non-operation or at least, poor maintenance of the WWTP / WTF.

4. BIBLIOGRAPHY

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添付資料 13　Guideline on Beverage Factory Inspection

Industrial Inspection and Water Pollution Control Guidelines
BEVERAGE INDUSTRY

Industrial Inspection and Water Pollution Control Guidelines
BEVERAGE INDUSTRY

Table of Contents

1. INTRODUCTION

1.1 Rationale

This industrial (water) pollution control guideline for the beverage industry was prepared under the ***Project for Effective Implementation of EIA and Pollution Control through Capacity Development of Ministry of Environment in the Kingdom of Cambodia*** to enhance the enforcement capacity of environmental inspectors and officers by providing industry specific technical information on (water) pollution sources, characteristics, and treatment methods in the (non-alcoholic) beverage industry.

1.2 Beverage Industry in Cambodia

Aside from the booming economy with a high GDP growth rate exceeding 7% p.a., the large percentage of population below 30 years of age, increasing household income and corresponding household expenditures, and tourism contribute to the high growth rate of the beverage industry.

2. BEVERAGE PRODUCTION

2.1 Introduction

This guideline on the beverage industry sector is limited to carbonated or non-carbonated beverages and fruit juices. It excludes dairy products and alcoholic beverages due to their markedly different production processes.

The (non-alcoholic) beverage industry sector may be divided into two (2) sub-sectors which are often, but not always, separate factories or facilities with different owners. These two (2) sub-sectors are:

1. Syrup / Concentrate Production
2. Bottling or Canning Operations

The Bottling or Canning Operations sub-sector may also be further sub-divided according to the type of packaging into:

1. Can or Bottle Packaging Containers
2. Refillable or Disposable Containers

2.2 Syrup / Concentrate Production / Manufacturing Operations

2.2.1 Syrup / Concentrate Production / Manufacturing Process Flow Diagrams

The production of syrups or concentrates for the beverage industries consists of two (2) major operations:

a. Purified, Sterilized Water Production
b. Syrup or Concentrate Formulation

The production of syrup or concentrate requires high purity water to avoid off-tastes and undesirable side reactions due to contaminants or substances in the water used to prepare the syrup or concentrate.

Purified, Sterilized Water Production: Depending on the quality of the source raw water and desired product water quality, production of purified, sterilized water may involve chemical treatment such as by soda lime process, single or multi media sediment filtration, membrane filtration such as ultrafiltration or reverse osmosis, sterilization by chlorination or ultraviolet (UV) radiation, and dechlorination if sterilized by chlorination. Less commonly, ion exchange softeners or demineralizers may be used. A block diagram showing the typical components of the production process for purified and sterilized water is shown in ***Figure 1*** below.

Purified, Sterilized Water Production

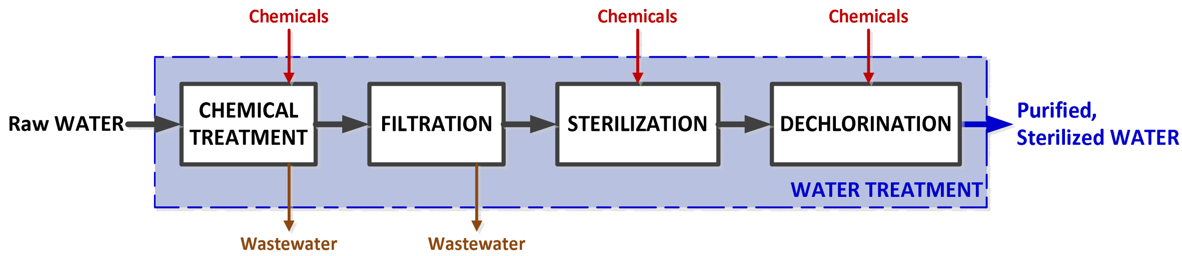

Figure 1 Purified, Sterilized Water Production Process

Syrup or Concentrate Formulation: Formulation of the syrup or concentrate involves the metered or measured addition into and subsequent blending or mixing of the (food grade) flavors, additives, sugars, coloring agents, preservatives, and other ingredients with the purified and sterilized process water. This is often done batch wise with quality monitoring; although, the syrup or concentrate may be formulated in a continuous manner. The formulated syrup or concentrate is then filled into suitable containers and packaged for delivery to customers. The filling machines are mostly automated except in small factories. A block diagram showing the typical steps in the formulation process for syrup or concentrate are shown in ***Figure 2*** below

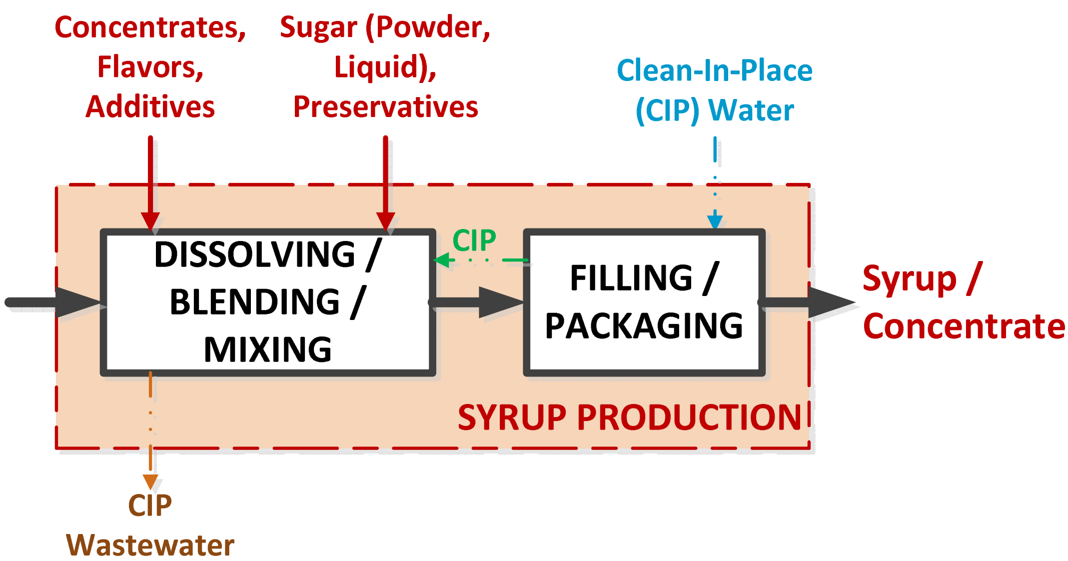

Figure 2 Syrup or Concentrate Formulation Process

2.3 Bottling or Canning Operations

2.3.1 Bottling or Canning Operations Process Flow Diagrams

In addition to the production of purified, sterilized water (similar to that of syrup or concentrate production; although, in much larger volumes with less stringent quality requirements), bottling or canning operations involve the following operations:

a. Bottling or Canning Operations
b. Refillable Bottle Washing Operations

Bottling or Canning Operations: Bottling or canning operations start with the mixing or blending of the syrup or concentrates and other ingredients such as water, sugar, flavors, food coloring, and preservatives to make the beverage. If the beverage is carbonated, the initial mix may still be in slightly concentrated form. The beverage is then injected into its container (bottles or cans, as appropriate) and the container is capped or closed. If the beverage is carbonated, carbonated water is also injected into the container. Carbonated water is produced by mixing purified, sterilized water with carbon dioxide under pressure to dissolve the carbon dioxide in the water to be added to the (slightly concentrated) beverage during can or bottle filling. The cans or bottles may be rinsed to remove spilled beverage and warmed to dry off before labelling. After labelling, the cans or bottles are then packaged for distribution and sale. A block diagram showing the typical components of the canning or bottling operations for carbonated or non-carbonated beverages is shown in ***Figure 3*** below.

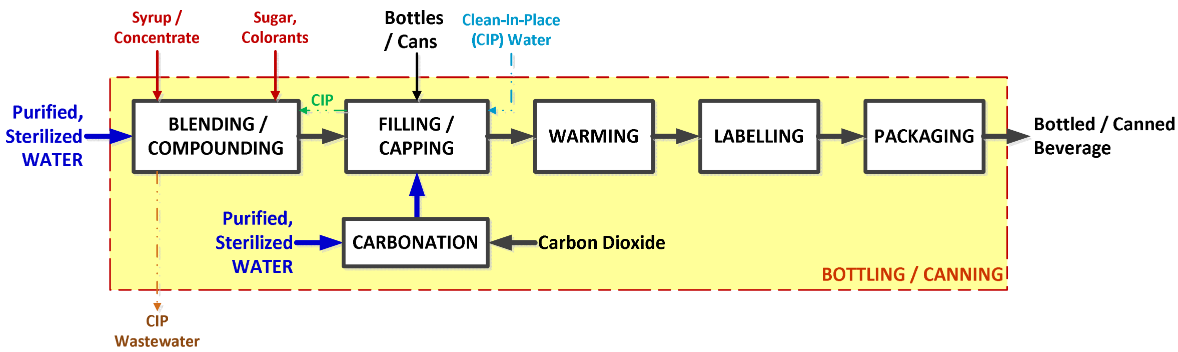

Figure 3 Bottling or Canning Operations

Refillable Bottle Washing Operations: If refillable bottles are used, the dirty bottles first have to be cleaned thoroughly before refilling with the beverage. The dirty bottles are first rinsed to remove product residue, surface dirt, and miscellaneous foreign items such as straw, cigarette butts, etc. The bottles are then pre-washed with water and detergents and other chemical formulations such as citric acid. The pre-wash is done in stages with gradually increasing water temperature. The pre-washed bottles are then washed with caustic solution to remove residues that were not removed in the pre-washing stage. The caustic solution is usually recycled or re-used after screening and/or filtration and is discarded when the caustic soda is exhausted or at the end of a production run. After caustic washing, the bottles are rinsed with clean fresh water, initially heated, then at ambient temperature. A block diagram showing the typical components of the bottle washing operations is shown in **Figure *4*** below.

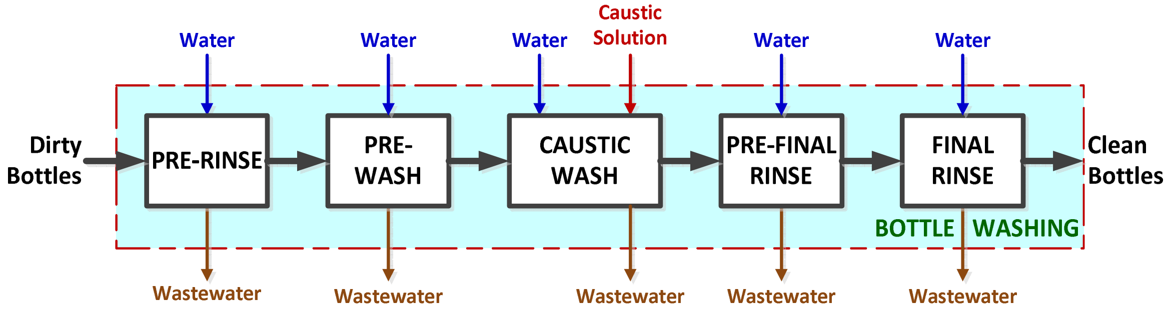

Figure 4 Bottle Washing

3. WASTEWATER GENERATION

3.1 Syrup / Concentrate Production

3.1.1 Sources of Wastewater in Syrup / Concentrate Production

Referring to ***Figure 1*** and ***Figure 2*** above, the specific sources of wastewater from syrup or concentrate production on which inspectors should focus are:

- Filtrate from chemical sludge dewatering at the (chemical) water (supply) treatment plant
- Backwash and rinse water from the sediment filters
- Reject and rinse water from ultrafiltration or reverse osmosis units
- Spent regenerants and rinse water of ion exchangers
- Rinse and used cleaning solutions from the clean-in-place (CIP) system
- Improperly disposed of rejects, off-spec, or expired products or in-process materials *(Note carefully: This is not readily predictable but imposes a very high, sudden load of pollution which can overload the treatment plant.)*
- Wastewater from washing of equipment, utensils, floors, and walls at the start and end of a work shift or production run

3.1.2 Characteristics of Wastewater from Syrup / Concentrate Production

- **SYRUP or CONCENTRATE PRODUCTION**
  - **CIP Wastewater: 15 ~ 50 m³ per Cleaning**
  - **BOD_5 500 ~ 1,800 mg/l**
    (Note: This does not include the effects of improperly disposed of rejects, off-spec, or expired products or in-process materials.)
  - **COD 1,500 ~ 5,000 mg/l**
  - **pH <pH 6.0** *(Note: CIP wastewater may have a pH as high as pH 12.)*
  - **TSS 200 ~ 500 mg/l**
  - **Color 100 ~ 1,000 PCU**
- **WATER TREATMENT**
  - **Wastewater Volume: 5 ~ 10% of Product Water**
  - **BOD5 <100 ~ 300 mg/l**
  - **COD <200 ~ 600 mg/l**
  - **pH pH 4.0 ~ pH 12**
  - **TSS 500 ~ 1,000 mg/l**

3.2 Bottling or Canning Operations

3.2.1 Sources of Wastewater in Bottling or Canning Operations

Aside from the water treatment operations, the inspectors should focus on the following specific sources of wastewater from bottling or canning operations:

- Spills often due to very fast filling and capping speed and leaks often from broken or overfilled bottles, usually flowing to floor drains and/or canals. It is necessary to check if the bunds of the bottling area are high enough to prevent contaminated water from spilling out.
- (Spray) Water for conveyor lubrication and bottle cooling / washing water, usually flowing to floor drains and/or canals
- Rejects, off-spec, returned products which are often dumped as is (highly concentrated wastewater) to wastewater treatment plant
- Clean-In-Place (CIP) wastewater. Since this is usually done at the end of a production run, it may take place outside regular office hours (8:00 AM to 5:00 PM)
- Wastewater from floor and facilities washing usually done at the start and end of the work shift or production run
- Wastewater is mostly coming from CIP at 15-50 m^3 per cleaning cycle

Bottle washing operations also generate their own wastewater streams such as:

- Although the main caustic bottle washing solution is recycled, the rinse water is usually continuously discharged. This wastewater stream may contain debris (straw, cigarette butts, caps, etc.) which can clog the screens on the drain holes leading to overflow of canals or channels.
- Bottle washing wastewater volume is 2-6 m^3 per 10,000 bottles

3.2.2 Wastewater from the Water (Supply) Treatment Plant

The inspector should be aware that in most cases, the wastewater from the water (supply) treatment plant is discharged directly and not conveyed to the WWTP. While this wastewater stream may not be polluted, it is important to inspect this wastewater stream for obvious contamination (turbidity or color).

Since the wastewater from the water (supply) treatment plant is likely to have a high dissolved solids concentration (due to the application of treatment chemicals), a quick test of electro-conductivity (EC) using the portable meter would verify EC value and give an indication of total dissolved solids (TDS) concentration. This is important if the wastewater from the water (supply) treatment plant passes through agricultural areas or is ultimately discharged to a water body used for irrigation.

The volume of wastewater generated by the water (supply) treatment plant is typically 5-10% of product water volume.

3.2.3 Characteristics of Wastewater from Bottling and/or Canning of Beverages

BOTTLE WASHING

- Wastewater Volume: 2 ~ 6 m³ per 10,000 Bottles
- BOD5 <400 ~ 800 mg/l
- COD <1,000 ~ 2,000 mg/l
- pH pH 10 ~ pH 12
- TSS200 ~ 500 mg/l

BOTTLING / CANNING

- Process Wastewater: 3 ~ 5 m³ per 10,000 Bottles
- BOD5 <600 ~ 2,800 mg/l
- COD 1,000 ~ 4,500 mg/l
- pH pH 5.0 ~ pH 9.5
- TSS<200 ~ 500 mg/l
- Color <150 ~ 500 PCU
- CIP Wastewater Refer to SYRUP Production Data

DAIRY (MILK CANNING and ICE CREAM)

- Process Wastewater: 1.0-2.5 m³ per Metric Ton
- BOD5 <1,000 ~ 3,000 mg/l
- COD 1,000 ~ 8,000 mg/l
- pH pH 5.0 ~ pH 9.5
- TSS<200 ~ 500 mg/l
- Color <150 ~ 500 PCU
- Fats, Oil, & Grease (FOG) <200 – 800 mg/l
- CIP Wastewater Refer to SYRUP Production Data

4. WASTE MANAGEMENT

4.1 Waste Minimization

Syrup or Concentrate Production

- Eliminate blind ends and sharp turns in piping (CIP)
- Improve blending / mixing effectiveness
- Prevent spills and leaks
- Use high shear mixers for dissolving sugar

Water Treatment

- Jar test to optimize chemical dosing program
- Ultrafiltration and/or Reverse Osmosis may be better than Chemical Treatment

Bottle Washing

- Increase caustic solution concentration
- Filter rinse water and caustic wash solution to re-use

Bottling or Canning

- Calibrate filling machines to avoid over- & under-filling
- Adjust production speed to reduce breakage, spills
- Reduce water spray rate for lubrication (of conveyors) and cooling

5. WASTEWATER TREATMENT

5.1 Introduction

Since this is a food industry, most of the pollutants present in the wastewater from the beverage industry is organic in nature. Hence, they are readily biodegradable.

Syrup or concentrate production usually generates small quantities of wastewater. However, provisions must be made to accommodate unexpected or unplanned discharge of highly contaminated (or polluted) off-spec or expired finished products or partially processed products or raw materials. Since these events are unpredictable, an overcapacity of 20-25% may be appropriate. In any case, the concentrated wastewater should be very slowly dosed into the regular wastewater stream to avoid overloading the wastewater treatment plant.

The schematic process flow diagram shown in Figure 5 below shows a typical conventional treatment processes suitable for a bottling plant in the beverage industry wastewater.

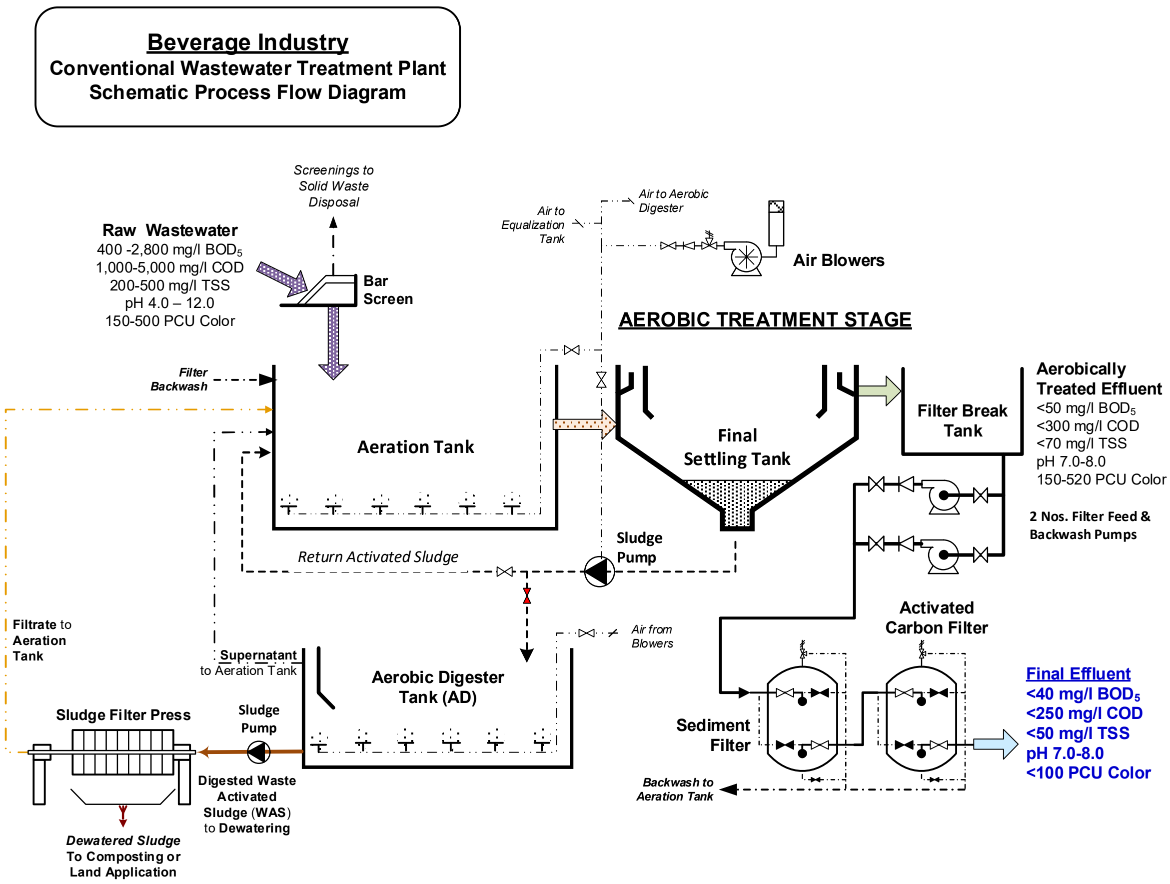

Figure 5 Conventional Treatment Plant for Beverage Industry Wastewater

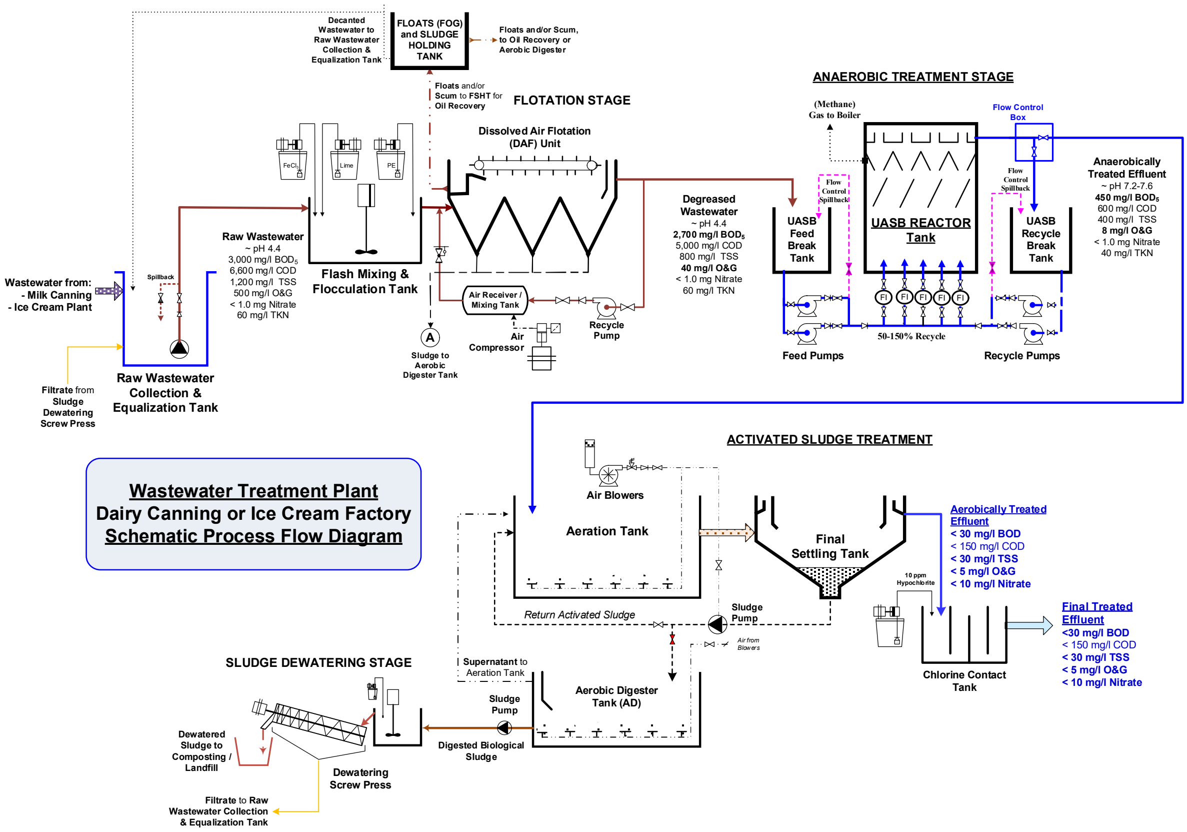

Figure 6 Wastewater Treatment Plant for Dairy Industry Wastewater

5.2 Physical Treatment Processes

Physical treatment processes rely on physical properties of contaminants to effect treatment. Physical treatment processes are best suited for the removal of discrete solids from water because they are effective and very economical, especially in terms of cost per unit quantity of pollutant removed.

5.2.1 Screening

Wastewater from a returnable bottle beverage bottling plant contains large suspended solids such as straw, bottle caps, and cigarette butts which may interfere with the operation or function of downstream treatment units. Manually cleaned bar screens are the most commonly used screening device due to the large size of the solids to be removed.

The size of screening equipment is based on the flow rate, size of openings, and solids load. The effectiveness or degree of removal of solids is also dependent on these factors and varies considerably from less than 30% to more than 70%.

5.2.2 Flotation (Oil and Grease Removal)

Dairy or milk raw materials and products have high fat content in the wastewater may inhibit biological treatment processes. For diary or ice cream factory wastewater, dissolved air flotation (DAF) is required to effectively remove fats, to a level that is no longer inhibitory to biological treatment processes.

Other forms of flotation (plain or induced by fine air bubbles) may be inadequate in lowering the concentration of fats, oil, and grease (FOG) to a level that is no longer inhibitory to biological treatment processes. Aside from the conventional method of dissolving compressed air in recirculated clarified water, dissolved air mixture may be formed by cavitation. Cavitation air flotation simplifies the dissolved air system by replacing the recirculation pump, air compressor, air-water mixing tank, and pressure reducing and flow control valves with a single mixer-like cavitation air flotation unit.

Flotation systems typically include dosing of coagulating agents to promote agglomeration of the fats, feathers, and suspended solids into flocs. The size of the flotation area is dependent on the instantaneous feed flow rate which is usually the pump flow rate and rise rate of the solids. The rise rate of flocs in DAF systems is typically 3-5 m/hr. Flotation can remove more than 80% of suspended solids and approximately 30-50% of BOD.

5.3 Chemical Treatment Processes

5.3.1 Conventional Chemical Treatment

Since the wastewater from the beverage industry contains mainly organic pollutants, biological treatment processes are most commonly used. However, chemical treatment processes which rely on (usually, inorganic) chemical reactions to remove or destroy pollutants may be resorted to for difficult to remove color. For wastewater from the beverage industry, chemical treatment is mainly used to remove or reduce color through pH adjustment, precipitation, coagulation, and oxidation-reduction reactions. Treatment of the wastewater with chemicals will cause the precipitation or coagulation of the food coloring and agglomeration of flocs or suspended solids and precipitates. Chemical treatment to remove color may be applied before or after biological treatment.

Adjustment of pH, precipitation, and coagulation may take place in separate reaction tanks or simultaneously in a single reactor tank. Flocculation normally takes place in a separate reaction tank. After precipitation, coagulation, and flocculation, the pollutants, now in floc form, are separated by gravity sedimentation in conventional settling tanks or clarifiers or in inclined, parallel plate or tube settlers. The sludge which now contains the (color) pollutants removed from the wastewater is discharged and dewatered prior to ultimate disposal as solid wastes. Chemical treatment can be very effective in removing or reducing inorganic pollutants including food coloring but has a less effect on BOD or COD.

While there are many chemicals used in wastewater treatment, the most common include alum, ferric chlorides and other iron salts, lime, caustic soda, hydrochloric acid, and sulfuric acid. Polyelectrolytes are used as flocculant aids. Due to the wide variety of food coloring, the correct types and combinations of treatment chemicals and their optimum dosages are best determined by conducting jar tests on the actual wastewater streams.

Conventional chemical treatment can remove more than 90% of the color but BOD or COD reduction is minimal, often less than 10%.

5.4 Biological Treatment Processes

5.4.1 Activated Sludge Process

Biological treatment processes make use of living organisms (mostly microorganisms) to effect treatment. The *activated sludge* treatment process is an aerobic, suspended-growth system. It is the most common biological treatment process because of its high BOD reduction efficiency, stability, reliability, and ease of operation.

The activated sludge treatment process consists of an aeration tank and a (final or secondary) settling tank. Wastewater flows into the aeration tank where biologically active sludge recycled from the (final or secondary) settling tank is mixed with the influent wastewater. The activated sludge microorganisms consume the organic pollutants (measured as BOD_5 and COD) which serve as their food or substrate, and convert them to harmless carbon dioxide, water, and additional cell mass. An aeration system provides the oxygen required for the degradation of the organic pollutants and the mixing energy to keep the activated sludge flocs in suspension.

Activated sludge treatment process can reduce BOD by over 90-95% and suspended solids by 80-90%.

While many factors affect the performance of an activated sludge treatment system, one of the most important is the ratio of food (BOD) to microorganism or food to mass (F:M) ratio. A food to mass (F:M) ratio of 0.05 – 0.15 kg BOD5/day/kg microorganisms will consistently produce treated effluent BOD_5 concentrations below 20 - 30 mg/l and effluent suspended solids concentrations below 30 – 50 mg/l.

5.4.2 Alternative Aerobic Biological Treatment Processes

Alternative aerobic biological treatment processes include sequencing batch reactors (SBR), trickling filters, rotating biological contactors (RBC), and membrane bioreactors (MBR).

Sequencing batch reactors (SBR) are a variation of the conventional activated sludge system. Treatment takes place in a single tank, unlike the two-tank arrangement of the conventional activated sludge system. Treatment is undertaken in batches going through the different stages of filling, aeration / reaction, settling or solids separation, and discharge or decanting of the treated effluent. Provisions have to be made to accommodate the influent wastewater during the different stages (except filling). In most cases, a holding or equalization tank is used or a twin tank arrangement is provided wherein one tank cycles through the treatment while the other reactor tank accumulates the influent raw wastewater. SBRs attain similar treatment efficiencies as activated sludge treatment plants. Although they can be operated manually, SBRs usually require automation and motorized or pneumatically operated valves. SBRs consume more energy than activated sludge treatment plants of the same capacity.

Trickling filters are a form of attached growth or fixed film biological treatment systems. In fixed film processes, microorganisms that consume the organic material (food or BOD) grow as *slime* on fixed media.

As the wastewater flows over the slime or biomass, (soluble) organic wastes are adsorbed and consumed by the microorganisms. Oxygen from air diffuses through the thin layer of wastewater to the microorganisms. As the slime layer builds up, clumps slough off or detach from the media. The material that sloughs off, called *humus*, flows with the wastewater and is separated from the treated wastewater in the secondary clarifier or settling tank (or filter). The main advantage of trickling filters (and other fixed film treatment systems) is their low operating costs.

Rotating biological contactors (RBC) are another type of attached growth biological treatment with low operating energy consumption. In contrast to trickling filters wherein the media do not move, the media in RBCs are discs partially submerged in the wastewater that rotate around a shaft. The rotation alternately exposes the slime layer to the food (organic wastes) when submerged and oxygen when exposed to the air to effect treatment.

It is important to note that attached growth treatment processes, such as trickling filters are more effective on soluble organic pollutants and less so on particulate or suspended solid pollutants. For this reason, trickling filters need primary clarifiers or similar pre-treatment units to be effective.

Since wastewater from beverage factories contain mostly soluble organic pollutants with low concentrations of suspended solids, attached growth treatment systems are well suited for the treatment of beverage factory wastewater. Properly sized and operated, attached growth treatment systems can attain BOD reduction efficiencies of 80-90%. The suspended solids concentrations of the treated effluent of attached growth treatment processes like trickling filters are often higher than those of the effluent of suspended growth treatment processes like activated sludge process.

Membrane bioreactors (MBR) are aerobic, suspended growth treatment systems similar to activated sludge treatment plants where the secondary clarifier or settling tank is replaced with a (semi-permeable) membrane such as ultrafiltration or microfiltration membranes which are usually installed in the aeration tank. This system eliminates the secondary settling tank resulting in a more compact system. The membrane is also several times more effective in removing suspended solids (mainly the activated sludge flocs) than settling tanks to produce very low suspended solids concentrations in the effluent. The membrane system also allows the retention of higher concentrations of biomass or activated sludge, further improving BOD reduction efficiencies.

MBRs can produce effluents with less than 10 mg/l BOD_5 and less than 10 mg/l TSS (total suspended solids). Depending on the type and material of the membrane, it may also be able to remove some types of color dyestuff.

The membranes in MBRs are sensitive to fouling from mineral and biological deposits which reduce flux and increases the pressure required to maintain the desired flux. This results in higher energy requirements to operate and the need for frequent cleaning. As a result, MBRs are more costly operate than the more conventional biological treatment systems as well as being more costly to construct.

5.4.3 Anaerobic Treatment

Anaerobic treatment is generally applied on high BOD strength wastewater and organic sludges. Anaerobic processes take place in the absence of oxygen. In biochemical reactions, oxygen generally acts as electron receptor in the process of extracting energy from the organic material. In the absence of free oxygen, other chemical species such as nitrates and sulfates can serve as oxygen donors in *anoxic* reactions. In the absence of even such oxygen donors, other compounds, generally complex organic compounds, serve as electron receptors.

One great advantage of anaerobic treatment systems is the low energy consumption, or in many cases, net energy yield (from the methane gas generated). Their disadvantage is the much slower reaction rates which generally translates to longer reaction (holding) times and larger tanks.

In general, anaerobic treatment processes are cost effective when the influent BOD concentration is 2,000-3,000 mg/l or higher. Anaerobic treatment processes can attain BOD reduction efficiencies of more than 75-90%. However, due to the high BOD concentration of the influent, the effluent of anaerobic treatment systems needs polishing treatment (usually by aerobic processes) to attain compliance with discharge standards.

The biochemical oxygen demand (BOD) of raw wastewater from beverage industry very rarely exceeds 2,000 mg/l. Hence, anaerobic treatment systems are rarely used in treating wastewater from the beverage industry.

5.5 Tertiary Treatment Processes

5.5.1 Introduction

Sometimes, primary treatment (physical and chemical treatment processes) and secondary treatment (biological treatment processes) may be inadequate to attain full compliance with discharge standards, especially for color when treating wastewater from beverage industry. To further improve effluent quality to attain compliance, tertiary treatment methods may be used.

5.5.2 Ultrafiltration

Depending on the type of membrane and type of food coloring, ultrafiltration with or without chemical pre-treatment (for precipitation and coagulation) may suffice to remove color and residual pollutants. Like MBRs which use membranes, the product water of ultrafiltration is of very high quality (very low color, BOD, etc.).

The retentate or reject from ultrafiltration contains the pollutants that were removed from the feed water. Since the pollutants are concentrated in the retentate, it needs to be treated. If the wastewater or effluent treatment plant includes a chemical treatment stage, the retentate is best returned to the chemical treatment stage for further treatment. Otherwise, the retentate is returned to the headworks of the wastewater treatment plant.

5.5.3 Activated Carbon Filtration

Activated carbon filtration is a simpler and less costly method of removing color from secondary effluent of treatment plants for wastewater from the beverage industry. Tertiary filtration consists of a sand filter and an activated carbon filter. The sand filter removes residual suspended solids (from secondary treatment) to prevent plugging of the downstream activated carbon media which would reduce its adsorption and treatment capacity. The activated carbon filter removes the color particles as well as some organic matter and inorganic substances. In some cases, activated carbon adsorption may also further reduce residual COD.

The adsorptive ability and capacity of activated carbon is dependent on the raw material from which it is made as well as the type of color bodies (food coloring and natural color of juices) present in the wastewater being treated. These are best determined by adsorption (isotherm) tests on actual wastewater samples.

5.5.4 Chemical Decolorization

A simpler method for removing or reducing residual color from beverage industry treated effluent is treatment with strong oxidizing agents. Decolorization by chemical oxidation only requires a chemical solution metering system and is easier to install and operate. In many cases, chlorination using sodium or calcium hypochlorite solution will suffice to reduce color to attain compliance. Alternatively, hydrogen peroxide may also be used. The effectiveness of these oxidizing agents and their optimal dosages are best determined by jar tests on the actual effluent to be treated.

5.6 Effectiveness of Various Treatment Processes

SYRUP or CONCENTRATE PRODUCTION

Chemical Treatment

- Neutralization pH 6.5-8.0
- Precipitation, Coagulation
    - **Color <150 PCU**
    - **TSS < 50 mg/l**

Activated Sludge, SBR, Trickling Filter

- TSS<30 mg/l
- BOD <30 mg/l
- COD <100 mg/l

Activated Carbon Filtration

- Color <100 PCU
- COD <100 mg/l

BOTTLING or CANNING
Chemical Treatment (With Bottle Washing Wastewater)
- Neutralization pH 6.5-8.0
- Precipitation, Coagulation
    - **Color <150 PCU**
    - **TSS < 50 mg/l**

Activated Sludge, SBR, Trickling Filter
- TSS<30 mg/l
- BOD <30 mg/l
- COD <100 mg/l

Activated Carbon Filtration
- Color <100 PCU
- COD <100 mg/l

DAIRY (MILK CANNING and ICE CREAM)
Chemical Treatment (Including Flotation)
- Neutralization pH 6.5-8.0
- Precipitation, Coagulation, Sedimentation or Flotation
    - **FOG <50 mg/l**
    - **TSS < 50 mg/l**

Anaerobic Digestion (such as UASB)
- FOG <10 mg/l
- TSS<100 mg/l
- BOD <300 mg/l
- COD <600 mg/l

Activated Sludge, SBR, Trickling Filter
- FOG <5 mg/l
- TSS<30 mg/l
- BOD <30 mg/l
- COD <100 mg/l

WATER TREATMENT
Chemical Treatment
- Neutralization pH 6.5-8.0
- Precipitation, Coagulation TSS < 50 mg/l

Filtration
- TSS<30 mg/l

NOT usually treated

BOTTLE WASHING
Chemical Treatment
- Neutralization pH 6.5-8.0

Treated with BOTTLING Plant Wastewater

添付資料 14　　Guideline on Textile Factory Inspection

Industrial Inspection and Water Pollution Control Guidelines
TEXTILE PROCESSING INDUSTRY

Industrial Inspection and Water Pollution Control Guidelines
TEXTILE PROCESSING INDUSTRY

Table of Contents

1. INTRODUCTION

1.1 Rationale

This industrial (water) pollution control guideline for the textile industry was prepared under the ***Project for Effective Implementation of EIA and Pollution Control through Capacity Development of Ministry of Environment in the Kingdom of Cambodia*** to enhance the enforcement capacity of environmental inspectors and officers by providing industry specific technical information on (water) pollution sources, characteristics, and treatment methods in the textile industry.

1.2 Textile & Garments Industry

The Textiles and Garments Industry sector makes up 32,8% (2017 est.) of the Gross Domestic product (GDP) of Cambodia. The Textile and Garments industry sector comprises about 80% of the GDP of the industry sector. The textile and garments industry sector has an estimated 663 factories of which 520 manufacture garments, 83 make footwear, and the balance produce bags. This industry sector employs an estimated 800,000 Cambodians, of which, 80% are women.

The textile and garments industry sector (excluding footwear and leather/animal gut articles) contributed 65.5% of the total exports in 2018.

2. TEXTILE MILLING AND PRODUCTION

2.1 Dry Processes

2.1.1 Spinning

Spinning refers to the process of twisting together of fiber to form yarn or thread. Broadly speaking, spinning includes preparatory steps such as cleaning of the fibers to remove dirt, impurities, and contaminants; carding to produce an even and aligned mass of fibers; twisting to form the yarn; and winding of the yarn into spools. Natural fibers may come from natural vegetable (cotton, sisal) or animal (wool, silk) sources while synthetic fibers are man-made. In general, natural fibers tend to be short while synthetic fibers may be produced in very long lengths.

Spinning is a dry process; although, certain materials, such as sizing may be added to improve strength, abrasion resistance, and texture of fibers and to reduce friction. The fibers, especially synthetic fibers, may also be treated with anti-statics and lubricants for trouble-free spinning.

2.1.2 Weaving and Knitting

Weaving is a method of producing cloth or fabric by interlacing two (2) sets of yarns or threads at right angles. Knitting is another method of producing cloth or fabric by creating multiple, interconnected loops of yarn from continuous lengths of yarns or threads.

Both weaving and knitting are dry processes which do not generate wastewater discharges. However, the yarn may be treated with sizing, anti-statics, and/or lubricants, similar to spinning.

2.2 Wet Processes

2.2.1 Pre-Treatment

The unfinished (meaning not yet bleached or dyed) woven or knitted cloth or fabric (also called "*greige*") is pre-treated to remove dirt, natural or added impurities, sizing, and other treatment chemicals used during spinning and weaving or knitting. Pre-treatment involves desizing, scouring, bleaching, mercerizing (mainly for cotton yarn and fabric), and washing.

Desizing involves impregnating the yarn or fabric with the desizing agent, allowing the desizing agent to degrade or dissolve the sizing from the fabric, and finally washing off the contaminants. Desizing agents include enzymes, oxidizing chemicals, acids, detergents, and water.

Scouring is used to remove (natural or added) oils and waxes and other impurities from the yarn or fabric to render it more hydrophilic or water-absorbent and cleaner. Scouring involves a high temperature and use of chemicals such as caustic soda (sodium hydroxide), detergents, and surfactants. Fabric or yarn made of certain types of fibers like wool may require the use of solvents.

Bleaching is the process by which color (and possibly, also odor and other impurities) is removed from the fabric or yarn to whiten it. Bleaching allows dyeing with lighter colors and a more even color dispersion. Bleaching uses strong oxidizing agents (usually for natural fibers) or reducing agents (usually for synthetic fibers). Optical whiteners or brightening agents may be applied afterwards to further enhance the white brightness.

Mercerizing is the process of treating cellulosic fiber (usually, cotton but also applied on hemp and linen though less frequently) with caustic soda (sodium hydroxide) to cause the fibers to swell and increase luster and the surface area of the fibers and thereby, their affinity to dyes and color fastness.

At the end of the pre-treatment stage (or in between individual process steps), the yarn or fabric is thoroughly cleaned by washing water and detergents and/or surfactants to get rid of the pre-treatment agents applied and contaminants removed in the pre-treatment stage.

2.2.2 Conventional Dyeing

Dyeing is the process of imparting color to yarn or fabric by the application of dyes. Dyes are dissolved, usually in water, to form a liquor or dye bath. The yarn or fabric is immersed in the dye bath. The dye molecule attaches to the surface of the fibers by physical absorption or by chemical bonding. As the yarn or fabric remains soaked in the dye bath, the dye penetrates deeper into the fibers and eventually align with and become fixed to the long fiber molecules. The best dyes do not lose color from washing or exposure to light. Ideally, all the dye molecules attach firmly to the fibers. In reality, a fraction of the dyes in the dye bath will not fix on (attach to or bind with) the fibers and becomes part of the effluent of the dyeing process where the dyes impart color of the wastewater.

There are many types of dyes – direct, acid, basic, disperse, mordant, and vat dyes. Natural dyes come from sources such as flowers, fruits, and other plant parts or from insects and animals or from minerals. Synthetic dyes are man-made.

Aside from the dyes, other chemicals such as acids, alkali, and salts are used to enhance the effect of the dyes and to fix them more firmly to the fibers.

There are several methods of dyeing depending on the materials to be dyed and the dyes use. Yarn or fabric may be dyed in batches or continuously; although, batch dyeing is more common. Whole, finished garments may also be dyed but this is not a common practice.

After dyeing, the yarn or fabric is rinsed and neutralized, then washed with detergents. Finishing formulations such as softeners may be applied to obtain desired characteristics of the finished yarn or fabric. The yarn or fabric is then spun and heat dried to produce the finished dyed yarn or fabric.

2.3 Textile Printing

Unlike conventional dyeing which imparts only a single color on the whole mass of yarn or fabric, *textile printing* or *textile printing* can impart multiple colors at several local sites and with specific designs or patterns. Textile printing is usually to done on fabric rather than on yarn. In textile printing, the dyes are applied using rollers, blocks or plates, and/or silk screen or stencils with the desired designs or patterns. Fixing agents or mordants may be applied before, during, or after the designs or patterns are printed on the fabric, depending on the printing methods and dyes used.

Preparation of the printing rollers, blocks or plates, and/or silk screen or stencils with the desired designs or patterns is a process separate from the actual textile printing but may be done in the same textile mill. Preparation of rollers often involves use of corrosive and hazardous chemicals to etch the pattern or design on the rollers. Fabrication of the rollers such as by photoengraving generates wastewater.

2.4 Garment Washing

2.4.1 Regular Washing

The production of ready-to-wear garments and apparels is a major sub-sector of the of the Cambodia textile industry. Production of garments, apparel, and other finished textile goods uses dyed fabric and yarn as raw material. While the garments or apparels are not dyed before, during, or after sewing, the sewn garments are washed, treated with softeners and other agents, dried, pressed, and packed. This is similar to laundry operation but typically on a much larger scale and with limited but similar types of garments. Regular washing removes dirt and other contaminants. The wastewater or effluent from regular washing of garments contains dirt, soaps or detergents, fabric softeners, and sometimes, dyes washed off from the fabric.

2.4.2 Stone Washing, Acid Washing

Stone washing is a process to impart a worn out look on new garments and/or to soften and make more flexible stiff fabrics such as denims and canvas. The new garments are placed in large, horizontal washing machines with pumice stones which batter the fabric to soften and upbraid the fabric. In addition to the detergents, the used wash water contains fine pumice or stone powder.

Acid washing is a variation of stone washing in which chlorine solution is added to intensify the whitening or worn out appearance. Despite the name, it does not involve the use of acids.

As an alternative or supplement to pumice and chlorine solution, enzymes are also used to obtain the desired worn out look. The use of enzymes reduces the amount of water used in the stone washing process as well as the suspended solids (such as pumice powder) and other contaminants (upbraided fibers and dyes).

3. WASTEWATER GENERATION

3.1 Wastewater Sources

3.1.1 Wet Processes - Washing, Bleaching, Dyeing, and Finishing Operations

Spinning, weaving, and knitting are basically "dry" processes which do not generate liquid discharges or wastewater. However, a protective, adhesive coating (sizing) is usually applied on the spun yarn surface in preparation for weaving or knitting in order to improve weaving or knitting efficiency.

For many types of fabric, especially cotton, the fabric or cloth is singed to remove loose fibers thereby reducing pilling and tendency to soil and improving surface texture and dye bonding. Although singeing is technically part of the finishing operations, it does not generate any wastewater. On the other hand, large quantities of wastewater are generated in the washing, bleaching, dyeing, and finishing operations with practically each step generating wastewater or effluent.

3.1.2 Wastewater Sources in Conventional Dyeing

To prepare yarn or cloth for use in making garments and other textile products, it is washed to remove impurities, bleached to remove undesirable color, dyed to the desired color, and finished by washing and applying various formulations to obtain the desired quality.

A schematic process flow diagram of the pre-treatment stage showing the steps that generate wastewater or effluent is presented in
Figure 1 below.

Many textile mills operate on a batch basis. This means that many of the process steps are performed in the same vat or tank. Referring to the schematic process flow diagram of the pre-treatment stage, the process steps desizing, scouring, and/or bleaching and subsequent wash and rinse and/or neutralize and rinse may be done in a single vat or tank. Wastewater may be discharged during and after each process step.

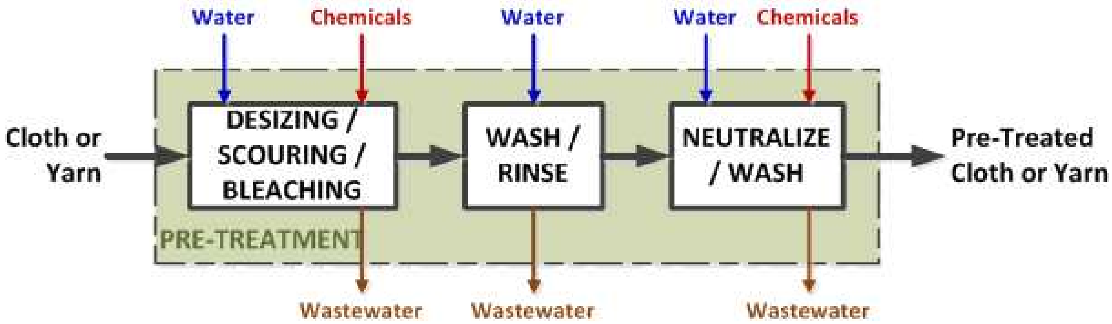

Figure 1 Schematic Process Flow Diagram of Pre-Treatment Stage

The schematic process flow diagram of the dyeing and finishing stage showing the steps that generate wastewater or effluent is presented in Figure 2 below.

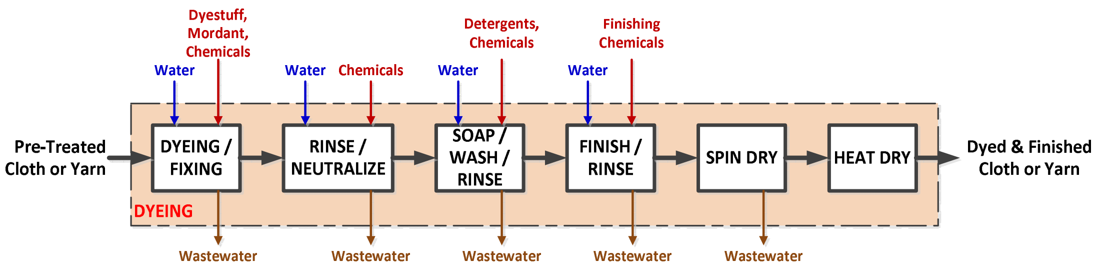

Figure 2 Schematic Process Flow Diagram of Dyeing and Finishing Stage

As with the pre-treatment stage, the process steps in the dyeing and finishing stage, actual dyeing and fixing of dyes, rinsing and neutralization of the chemicals used in dyeing, washing with soap, detergents and/or other formulations, and applying finishing chemicals and rinsing may also be done in a single vat or tank. Wastewater may be discharged during and after each process step.

In case some or all of the process steps are done in separate vats or tanks, the wet yarn or fabric will drip liquid or wastewater dragged out of the first vat or tank while it is transported to the next vat or tank. Floor drains on the route between vats or tanks should collect and convey the drag out wastewater to the effluent treatment plant.

In the dyeing and finishing stage, spin drying, and heat drying are done in other equipment. The transport of the wet dyed and finished fabric or yarn will often result in drips, spills, and leaks on the floor on the route to the spin dyers. This wastewater stream on the floor should be collected and treated prior to discharge. Transport of the spin-dried fabric or yarn is not likely to generate wastewater.

While drain water from spin dryers may be directed to canals, spills and leaks frequently occur on the floor of the spin dryer section. Hence, floor drains should collect the wastewater for conveyance to the effluent / wastewater treatment plant.

For continuous processes, the drains from vats or tanks are often closed pipes routed directly to drainage canals or pipes which may not always be readily visible. The sewer or piping plan for the wastewater or effluent streams is needed to identify the routes of these sources of wastewater or effluent.

Often overlooked sources of wastewater associated with dyeing are the dye preparation room and laboratory. While the dye preparation room is usually kept dry, highly concentrated dye solutions and rinse or wash water may be disposed of from this room. Likewise, the laboratory may discharge relatively small amounts of wastewater which may be highly contaminated. In both cases, the sewer drains serving the dye preparation room and the laboratory should be connected to the industrial wastewater sewer system to ensure that the wastewater discharged from these sources are properly treated prior to disposal.

3.1.3 Wastewater Sources in Textile Printing

In terms of wastewater sources, the main difference of textile printing from conventional dyeing is the addition of the preparation of the printing rollers, blocks or plates, and/or silk screen or stencils with the desired designs or patterns to the dyeing process. While this is a distinct process from the dyeing process itself, preparation of rollers, plates, and others is often done in the same textile mill. The type and sources of wastewater in the preparation of the rollers, plates, silk screen, and/or stencils depend on what material they are being made of and how they are made.

The schematic process flow diagram of the textile printing and finishing stage showing the steps that generate wastewater or effluent is presented in Figure 3 below.

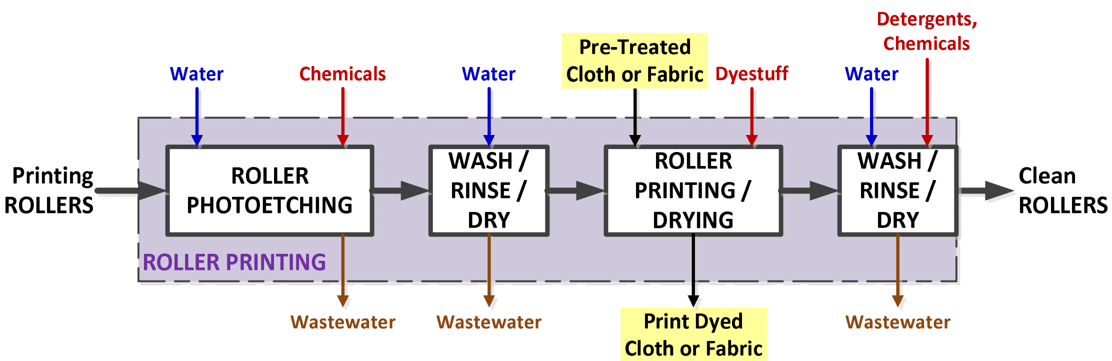

Figure 3 Schematic Process Flow Diagram of Textile Printing and Finishing

In the case of print rollers or plates, many are fabricated using photoengraving techniques which etch designs on a (usually copper) substrate (roller or plate). The roller or plate is first coated with a photoresist and then exposed to strong light shining through a pattern or screen with the prepared design or image. Areas exposed to light harden. A solvent then washes away soft photoresist from the unexposed area, to uncover the pattern or design on bare metal (substrate). The plate or roller is then bathed in (or sprayed with) the etching solution to create the pattern or design on the plate. The plate or roller is then washed to remove the photoresist and etching solutions and then dried. The roller or plate is now ready to use for textile printing. After completion of a production run, the plates or rollers are cleaned, sanded, and re-used to create new designs and patterns.

Textile printing is more often a continuous and mechanized rather than batch and manual process. As such, it generates less wastewater. The dyes used are often thickened to minimize spreading due to absorption and/or capillary action. If multiple colors or dyes are to be printed, multiple rollers or plates are also used, one for each color or dye.

After designs or patterns are printed, the fabric is dried and the printed dye or color is cured and set or fixed by steam or hot air. The dyed fabric is then washed and finished similarly to conventionally dyed fabric.

3.1.4 Characteristics of Wastewater from Textile Dyeing and Finishing

N.B. The following data on the characteristics of wastewater from textile dyeing and finishing are derived from Philippine textile industry. The data have to be validated to determine if they are applicable to the Cambodia textile industry.

Table 1 Specific Wastewater Generation Rates in Dyeing and Finishing

- **Quantity:**
  - **Average:** **125 liters/kg cloth or yarn**
  - **Maximum:** **160 liters/kg cloth or yarn**
  - **Minimum:** **60 liters/kg cloth or yarn**
  - **Benchmark:** **60 liters/kg cloth or yarn**
- **Quality:**
  - **Average:** **35 gm BOD_5/kg cloth or yarn**
  - **Maximum:** **>60 gm BOD_5/kg cloth or yarn**
  - **Minimum:** **15 gm BOD_5/kg cloth or yarn**

Table 2 Significant Pollution Parameters in Dyeing and Finishing Wastewater

- **Color**
- **pH**
- **5-day Biochemical Oxygen Demand (BOD_5)**
- **Chemical Oxygen Demand (COD)**
- **Total Suspended Solids (TSS)**
- **Heavy Metals:**
  - **Lead**
  - **Chromium**
  - **Copper** (*e.g.*, roller printing)
- **Salinity / Electroconductivity**

3.1.5 Wastewater Sources in Garment Washing

Regular Washing: Washing of (sewn, ready-to-wear) garments is similar to typical laundry operations except for the larger, industrial scale. The main source of wastewater from garments washing is the washing machine. Washing with detergents, rinsing, draining, treatment with softeners and other property enhancers, and spin drying usually takes place in the same machine. These washing machines drain wastewater directly to the drainage canals or sewer pipes leading to the effluent treatment plant. Spills and leaks rarely occur in garments washing operations.

Stone washing makes use of pumice to obtain the worn-out look and to soften garments. Hence, wastewater from stone washing contains pumice solids in addition to the detergents and fibers. Due to their density, the pumice solids tend to settle in the wastewater canals and pipes.

Acid washing adds chlorine (not acid) solution to the pumice in stone washing to achieve an even whiter and more worn out appearance. The wastewater from acid washing may contain residual chlorine and chlorination by-products in addition to the usual contaminants present in wastewater from stone washing.

If enzymes are used to supplement or replace pumice and chlorine, excess enzymes will end up in the wastewater. However, use of enzymes will reduce the volume of wastewater generated and contaminants in the wastewater such as pumice solids and fibers.

3.1.6 Characteristics of Wastewater from Garment Washing

N.B. The following data on the characteristics of wastewater from garments washing are derived from Philippine textile industry. The data have to be validated to determine if they are applicable to the Cambodia textile industry.

Table 3 Specific Wastewater Generation Rates in Garments Washing

- **Quantity:**
  - **Average:** **55 liters/kg laundry**
  - **Maximum:** **80 liters/kg laundry**
  - **Minimum:** **25 liters/kg laundry**
  - **Benchmark:** **20 liters/kg laundry**
- **Quality:**
  - **Average:** **15 gm BOD_5/kg laundry**
  - **Maximum:** **30 gm BOD_5/kg laundry**
  - **Minimum:** **10 gm BOD_5/kg laundry**

Table 4 Significant Pollution Parameters in Garments Washing

- **Color**
- **pH**
- **5-day Biochemical Oxygen Demand (BOD_5)**
- **Chemical Oxygen Demand (COD)**
- **Total Suspended Solids (TSS)**
- **Chlorination By-Products**
- **Salinity / Electroconductivity**

4. WASTE MANAGEMENT

4.1 Waste Minimization

- Process Optimization
  - Reduce Liquor Ratio (in Jigger / Vats)
  - Change from Overflow Rinsing
    - Batch or Stepwise Rinsing
    - Continuous Countercurrent Rinsing
  - Replace Chlorinated Solvent Carriers
  - Use HOT Water for Rinsing
  - Improve Hydroextractors (Spin Dryers)
- Substitution
  - Biodegradable Detergents
  - High Fixation Efficiency and Non-Toxic Dyestuff
  - Mineral instead of Organic Acids
  - Hydrogen Peroxide instead of Chlorine Products
- Recycling and Re-Use
  - LAST Rinse as FIRST Rinse in Next Batch
  - Re-USE of Alkali (Mercerization) after Filtration
- Cleaner Technology
  - Continuous Rinsing instead of Batch Rinsing
  - Computerized Color Matching

5. WASTEWATER TREATMENT

5.1 Introduction

Considering the wide variety of significant pollution parameters in textile industry wastewater, its treatment requires several types of treatment processes. The schematic process flow diagram shown in Figure 4 below shows a comprehensive range of conventional treatment processes suitable for textile industry wastewater.

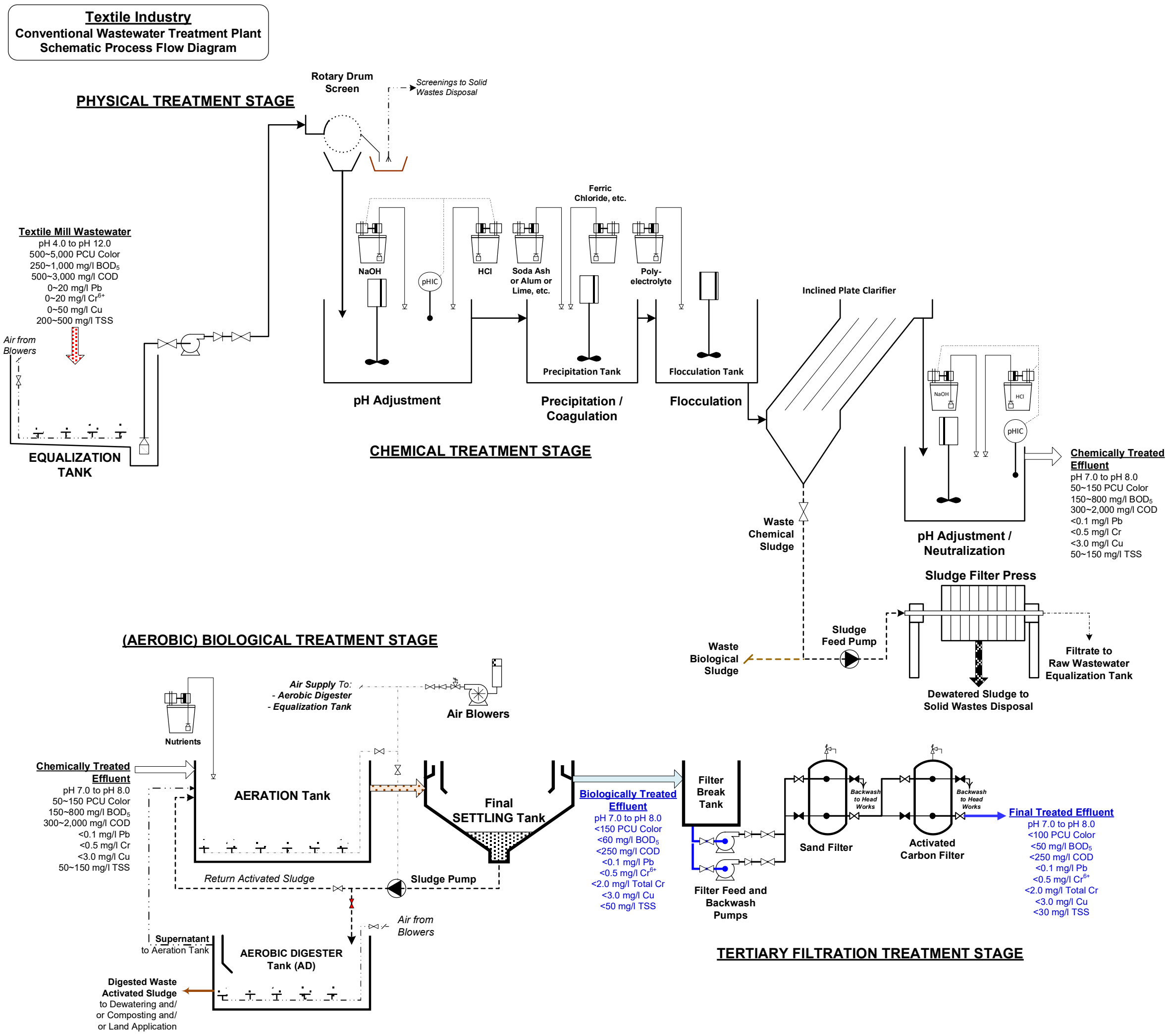

Figure 4 Conventional Treatment Plant for Textile Industry Wastewater

5.2 Physical Treatment Processes

Physical treatment processes rely on physical properties of contaminants to effect treatment. Physical treatment processes are best suited for the removal of discrete solids from water because they are effective and very economical, especially in terms of cost per unit quantity of pollutant removed.

5.2.1 Equalization

Treatment of wastewater from textile mills depends on the types of yarns or fabrics, dyes, and finishing chemicals used. Textile mills rarely process only a single type of fabric or yarn and dye with a single dye of specific color. In fact, the type of yarn or fabric and the colors and types of dye can vary on a batch by batch or production line by production line. Hence, the wastewater or effluent treatment plant must be able to effectively treat highly variable volumes of wastewater with varying characteristics. It is, therefore, important to equalize the volume and characteristics of the textile mill wastewater to be treated in order to minimize the variations in quantity and quality. The first treatment process of a wastewater or effluent treatment plants of textile mills should be equalization.

The working capacity of the equalization tank may be determined from the instantaneous flow rates and flow patterns. In the absence of reliable, actual flow rate data, the working capacity of the equalization tank should be equal to the average daily flow if feasible. Alternatively, the working volume of the equalization tank may be based on the total volume of wastewater if the largest tanks of each production line are simultaneously dumped.

Due to the high degree of contamination and the presence of suspended solids, the equalization tank is usually aerated to minimize putrefaction of the organic pollutants which causes odor problems. Aeration also serves to mix the contents of the equalization tank to attain uniform conditions.

5.2.2 Screening

Wastewater from the textile industry contains suspended solids which may interfere with the operation or function of downstream treatment units. Of special concern are the fibers which tend to form strings which wrap around equipment. Rotary drum screens are the most appropriate type even though mesh type screen have higher capture efficiency because rotary drum screens are less prone to blinding or plugging from strings and are self-cleaning. Alternatively, static hyperbolic screens are also reasonably effective and more resistant to blinding than mesh screens. Unlike rotary drum screens, static screens need to be manually scraped for effective removal of screened solids.

The size of screening equipment is based on the flow rate, size of openings, and solids load. The effectiveness or degree of removal of solids is also dependent on these factors and varies considerably from less than 30% to more than 70%.

5.2.3 Flotation

Since most of the fibers are light, dissolved air flotation (DAF) or other forms of flotation can be effective in removing fine fibers and other solids not caught by screening. Aside from the conventional method of dissolving compressed air in recirculated clarified water, dissolved air mixture may be formed by cavitation. Cavitation air flotation simplifies the dissolved air system by replacing the recirculation pump, air compressor, air-water mixing tank, and pressure reducing and flow control valves with a single mixer-like cavitation air flotation unit. Since DAF systems are expensive and chemical treatment can remove the fine fibers and suspended solids, the flotation is not usually appropriate or cost effective for the treatment of textile industry wastewater.

Flotation systems typically include dosing of coagulating agents to promote agglomeration of the fibers and suspended solids into flocs. The size of the flotation area is dependent on the instantaneous feed flow rate which is usually the pump flow rate and rise rate of the solids. The rise rate flocs in DAF systems is typically 3-5 m/hr. Flotation can remove more than 80% of suspended solids and approximately 30-50% of BOD.

5.3 Chemical Treatment Processes

5.3.1 Conventional Chemical Treatment

Chemical treatment processes rely on (usually, inorganic) chemical reactions to remove or destroy pollutants. For wastewater from the textile industry, chemical treatment is used to remove or reduce color, suspended solids, and dissolved pollutants through neutralization, precipitation, coagulation, and oxidation-reduction reactions. Treatment of the wastewater with chemicals will cause the precipitation or coagulation of pollutants, agglomeration of suspended solids, and precipitates.

Neutralization, precipitation, and coagulation may take place in separate reaction tanks or simultaneously in a single reactor tank. Flocculation normally takes place in a separate reaction tank. After precipitation, coagulation, and flocculation, the pollutants, now in floc form, are separated by gravity sedimentation in conventional settling tanks or clarifiers or in inclined, parallel plate or tube settlers. The sludge which now contains the pollutants removed from the wastewater is discharged and dewatered prior to ultimate disposal as solid wastes.

Chemical treatment can be very effective in removing or reducing inorganic pollutants including toxic heavy metals (such as copper, chromium, and lead), color dyes, and suspended solids but has a less effect on BOD or COD.

While there are many chemicals used in wastewater treatment, the most common include alum, ferric chlorides and other iron salts, lime, caustic soda, hydrochloric acid, and sulfuric acid. Polyelectrolytes are used as flocculant aids. Due to the numerous possible combinations of fibers, yarns, fabrics, dyes, softeners, finishing formulations, and dyeing methods, the correct types and combinations of treatment chemicals, including polyelectrolytes, and their optimum dosages are best determined by conducting jar tests on the actual wastewater streams.

Even when there is an adequately large equalization tank, the types and combinations of chemical that are effective in treating the wastewater may vary frequently. It is, therefore, necessary to have several chemical dosing systems. With experience and the use of simple jar testing techniques, the wastewater treatment plant operator can effectively and successfully attain compliance with effluent standards by adjusting chemical dosing regimens if multiple chemical dosing systems are provided.

Conventional chemical treatment can remove as much as 90% of suspended solids and approximately 30-50% of BOD or COD.

5.3.2 Electrocoagulation

An electrocoagulation reactor consists of an anode of aluminum and a cathode of an inert material, most commonly, iron, across which is applied a direct current voltage. The aluminum metal in the anode dissolves as aluminum cations while at the cathode, hydroxide is formed. These react with pollutants to form precipitates which are removed by settling. Hydrogen gas is also formed at the cathode. The fine bubbles of hydrogen gas can attach to suspended solids particles to float them out. Electrocoagulation is more effective than conventional chemical treatment methods especially in removing difficult to treat contaminants such as emulsified oil, hydrocarbon solvents, and heavy metals. In addition, electrocoagulation produces much less sludge than conventional chemical treatment. Although still relatively more expensive, it may be suitable for specific applications in the treatment of wastewater from the textile industry.

5.4 Biological Treatment Processes

5.4.1 Activated Sludge Process

Biological treatment processes make use of living organisms (mostly microorganisms) to effect treatment. The *activated sludge* treatment process is an aerobic, suspended-growth system. It is the most common biological treatment process because of its high BOD reduction efficiency, stability, reliability, and ease of operation.

The activated sludge treatment process consists of an aeration tank and a (final or secondary) settling tank. Wastewater flows into the aeration tank where biologically active sludge recycled from the (final or secondary) settling tank is mixed with the influent wastewater. The activated sludge microorganisms consume the organic pollutants (measured as BOD_5 and COD) which serve as their food or substrate, and convert them to harmless carbon dioxide, water, and additional cell mass. An aeration system provides the oxygen required for the degradation of the organic pollutants and the mixing energy to keep the activated sludge flocs in suspension.

Activated sludge treatment process can reduce BOD by over 90-95%, suspended solids by 80-90%, and oil by 50-80%.

While many factors affect the performance of an activated sludge treatment system, one of the most important is the ratio of food (BOD) to microorganism or food to mass (F:M) ratio. A food to mass (F:M) ratio of 0.05 – 0.15 kg BOD5/day/kg microorganisms will consistently produce treated effluent BOD_5 concentrations below 20 - 30 mg/l and effluent suspended solids concentrations below 30 – 50 mg/l.

5.4.2 Alternative Aerobic Biological Treatment Processes

Alternative aerobic biological treatment processes include sequencing batch reactors (SBR), trickling filters, rotating biological contactors (RBC), and membrane bioreactors (MBR).

Sequencing batch reactors (SBR) are a variation of the conventional activated sludge system. Treatment takes place in a single tank, unlike the two-tank arrangement of the conventional activated sludge system. Treatment is undertaken in batches going through the different stages of filling, aeration / reaction, settling or solids separation, and discharge or decanting of the treated effluent. Provisions have to be made to accommodate the influent wastewater during the different stages (except filling). In most cases, a holding or equalization tank is used or a twin tank arrangement is provided wherein one tank cycles through the treatment while the other reactor tank accumulates the influent raw wastewater. SBRs attain similar treatment efficiencies as activated sludge treatment plants. Although they can be operated manually, SBRs usually require automation and motorized or pneumatically operated valves. SBRs consume more energy than activated sludge treatment plants of the same capacity.

Trickling filters are a form of attached growth or fixed film biological treatment systems. In fixed film processes, microorganisms that consume the organic material (food or BOD) grow as *slime* on fixed media. As the wastewater flows over the slime or biomass, (soluble) organic wastes are adsorbed and consumed by the microorganisms. Oxygen from air diffuses through the thin layer of wastewater to the microorganisms. As the slime layer builds up, clumps slough off or detach from the media. The material that sloughs off, called *humus*, flows with the wastewater and is separated from the treated wastewater in the secondary clarifier or settling tank (or filter). The main advantage of trickling filters (and other fixed film treatment systems) is their low operating costs.

Rotating biological contactors (RBC) are another type of attached growth biological treatment with low operating energy consumption. In contrast to trickling filters wherein the media do not move, the media in RBCs are discs partially submerged in the wastewater that rotate around a shaft. The rotation alternately exposes the slime layer to the food (organic wastes) when submerged and oxygen when exposed to the air to effect treatment.

It is important to note that attached growth treatment processes, such as trickling filters are more effective on soluble organic pollutants and less so on particulate or suspended solid pollutants. For this reason, trickling filters need primary clarifiers or similar pre-treatment units to be effective. The presence of fibers which can form strings in the wastewater from the textile industry can contribute to clogging of the trickling filter media or the RBC discs. Properly sized and operated, attached growth treatment systems can attain BOD reduction efficiencies of 80-90%. The suspended solids concentrations of the treated effluent of attached growth treatment processes like trickling filters are often higher than those of the effluent of suspended growth treatment processes like activated sludge process.

Membrane bioreactors (MBR) are aerobic, suspended growth treatment systems similar to activated sludge treatment plants where the secondary clarifier or settling tank is replaced with a (semi-permeable) membrane such as ultrafiltration or microfiltration membranes which are usually installed in the aeration tank. This system eliminates the secondary settling tank resulting in a more compact system. The membrane is also several times more effective in removing suspended solids (mainly the activated sludge flocs) than settling tanks to produce very low suspended solids concentrations in the effluent. The membrane system also allows the retention of higher concentrations of biomass or activated sludge, further improving BOD reduction efficiencies.

MBRs can produce effluents with less than 10 mg/l BOD_5 and less than 10 mg/l TSS (total suspended solids). Depending on the type and material of the membrane, it may also be able to remove some types of color dyestuff. As such, the treated effluent of MBRs may be suitable to re-use in the textile mill.

The membranes in MBRs are sensitive to plugging by stringy solids such as those present in wastewater from the textile industry. Hence, effective primary treatment to remove suspended solids is necessary if MBRs are to be used in treating wastewater from the textile industry.

The membranes in MBRs are sensitive to fouling from mineral and biological deposits which reduce flux and increases the pressure required to maintain the desired flux. This results in higher energy requirements to operate and the need for frequent cleaning. As a result, MBRs are more costly operate than the more conventional biological treatment systems as well as being more costly to construct.

5.4.3 Anaerobic Treatment

Anaerobic treatment is generally applied on high BOD strength wastewater and organic sludges. Anaerobic processes take place in the absence of oxygen. In biochemical reactions, oxygen generally acts as electron receptor in the process of extracting energy from the organic material. In the absence of free oxygen, other chemical species such as nitrates and sulfates can serve as oxygen donors in *anoxic* reactions. In the absence of even such oxygen donors, other compounds, generally complex organic compounds, serve as electron receptors.

One great advantage of anaerobic treatment systems is the low energy consumption, or in many cases, net energy yield (from the methane gas generated). Their disadvantage is the much slower reaction rates which generally translates to longer reaction (holding) times and larger tanks.

In general, anaerobic treatment processes are cost effective when the influent BOD concentration is 2,000-3,000 mg/l or higher. Anaerobic treatment processes can attain BOD reduction efficiencies of more than 75-90%. However, due to the high BOD concentration of the influent, the effluent of anaerobic treatment systems needs polishing treatment (usually by aerobic processes) to attain compliance with discharge standards.

The biochemical oxygen demand (BOD) of raw wastewater from textile industry very rarely exceeds 2,000 mg/l even when processing natural fiber such as silk and wool. As such, anaerobic treatment systems are rarely used in treating wastewater from the textile industry.

5.5 Tertiary Treatment Processes

5.5.1 Ultrafiltration

Sometimes, primary treatment (physical and chemical treatment processes) and secondary treatment (biological treatment processes) may be inadequate to attain full compliance with discharge standards, especially for color when treating wastewater from textile industry. To further improve effluent quality to attain compliance, tertiary treatment methods may be used.

Depending on the type of membrane and type of dyes, ultrafiltration with or without chemical pre-treatment (for precipitation and coagulation) may suffice to remove color and residual pollutants. Like MBRs which use membranes, the product water of ultrafiltration is of very high quality (very low color, BOD, etc.). Thus, one advantage of ultrafiltration is the possibility of re-using treated effluent in the textile mill. However, because of the low cost of water supply and the current abundance of water, using ultrafiltration to enable reuse of the product water may not be financially viable.

The retentate or reject from ultrafiltration contains the pollutants that were removed from the feed water. Since the pollutants are concentrated in the retentate, it needs to be treated. If the wastewater or effluent treatment plant includes a chemical treatment stage, the retentate is best returned to the chemical treatment stage for further treatment.

5.5.2 Activated Carbon Filtration

Activated carbon filtration is a simpler and less costly method of removing color from secondary effluent of treatment plants for wastewater from the textile industry. Tertiary filtration consists of a sand filter and an activated carbon filter. The sand filter removes residual suspended solids (from secondary treatment) to prevent plugging of the downstream activated carbon media which would reduce its adsorption and treatment capacity. The activated carbon filter removes the color particles as well as some organic matter and inorganic substances. In some cases, activated carbon adsorption may also further reduce residual heavy metal concentration.

The adsorptive ability and capacity of activated carbon is dependent on the raw material from which it is made as well as the type of color bodies (dyes) present in the wastewater being treated. These are best determined by adsorption (isotherm) tests on actual wastewater samples.

5.5.3 Chemical Decolorization

A simpler method for removing or reducing residual color from textile industry treated effluent is treatment with strong oxidizing agents. Decolorization by chemical oxidation only requires a chemical solution metering system and is easier to install and operate. In many cases, chlorination using sodium or calcium hypochlorite solution will suffice to reduce color to attain compliance. Alternatively, hydrogen peroxide may also be used. The effectiveness of these oxidizing agents and their optimal dosages are best determined by jar tests on the actual effluent to be treated.