Initial Environmental Examination

April 2017

Myanmar: Third GMS Corridor Town Development Project

“Mon State”

Prepared by SAFEGE International Department for the Asian Development Bank. This initial environmental examination is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature. Your attention is directed to the “terms of use” section on ADB’s website.

Contents

SAFEGE Ingénieurs Conseils

Figures

Tables

Abbreviations & Acronyms

3Rs	Reduce, Reuse, Recycle
AAGR	Annual Average Growth Rates (Population)
ADB	Asian Development Bank
AH 1	Asian Highway 1
APCF	Asia Pacific Carbon Fund
BATNEEC	Best Available Techniques Not Entailing Excessive Costs
BOI	Thai Board of Investment
BOI	Thai Board of Investment
BOO	Build - Own - Operate
BOOT	Build–Operate–Own–Transfer
C:N	Carbon-Nitrogen (ratio)
cap	Capita (= 1 person)
CBO	Community-Based Organization
CBP	Capacity Building Program
CC	Climate Change
CDIA	Cities Development Initiative for Asia
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CH_4	Methane
CO_2	Carbon Dioxide
CPCS	Centre for Peace and Conflict Studies
DDI	Domestic Direct Investment
DFR	Draft Final Report
DHSHD	Department for Human Settlement Housing Development (DUHD)
DMF	Design and Monitoring Framework
DUHD	Department of Urban Housing Development (MOC)

EA	Executing Agency
EA	Environmental Assessment
ECC	Environmental Compliance Certificate
ECD	Environmental Conservation Department
EIA	Environmental Impact Assessment
EHS	Environment, Health and Safety
EMP	Environmental Management Plan
EWEC	East – West Economic Corridor
FDI	Foreign Direct Investment
GAD	General Administration Department
GHG	Greenhouse Gas
GMS	Greater Mekong Sub-Region
GNP	Gross National Product
GoM	Government of Myanmar
HDPE	High Density Polyethylene
IA	Implementing Agency
IEE	Initial Environmental Examination
IFI	International Finance Institution
INC	Initial National Communication
IPNS	Integrated Plant Nutrient System
ISWM	Integrated Sustainable Waste Management
JICA	Japan International Cooperation Agency
m^3	cubic meter
MaT-DAC	Mawlamyine Township Development Affairs Committee
MaT-DAO	Mawlamyine Township Development Affairs Office
MoECAF	Ministry of Environment Conservation and Forests
MoNREC	Ministry of Natural Resources and Conservation (ex-MoECAF)
MHA	Ministry of Home Affairs
MMK	Myanmar Kyat

MOA	Ministry of Agriculture
MOC	Ministry of Construction
MOE	Ministry of Energy
MOSB	Myanmar Offshore Supply Base
MRF	Material Recovery Facility
MS-DA	Mon State Development Affairs
MS-DAC	Mon State Development Affairs Committee
MS-DAO	Mon State Development Affairs Office
MSE	Micro- and Small enterprises
MSG	Mon State Government
MS-GAD	Mon State General Affairs Department
MST-DAC	Mon-State Township-level Development Affairs Committees
MSW	Municipal Solid Waste
MTDC	Mawlamyine Town Development Committee
MW	Megawatt
NAPA	National Adaptation Programs of Actions
NECC	National Environmental Conservation Committee
NEDA	Neighbouring Countries Economic Development Cooperation Agency, Ministry of Finance, Thailand
NGO	Non-Government Organization
NMSP	New Mon State Party
NPK	Nitrogen, Phosphorous, And Potassium
NSAG	Non-State Armed Groups
ODA	Overseas Development Assistance
PCU	Project Coordination Unit
PET	Poly-ethylene Terephthalate
PIU	Project Implementation Units
PPP	Public–Private Partnership
PPTA	Project Preparatory Technical Assistance
SEZ	Special Economic Zone
SLEDP	Strategic Local Economic Development Plans

SPC	Special Purpose Company
SPS	Safeguard Policy Statement
TA	Technical Assistance
TAO	Township Administration Office
UMTA	Union of Myanmar Travel Association
UNDP	United Nations Development Programme
WOP	Water Operator Partnership (WOP)
WWTP	Waste Water Treatment Plant
YCDC	Yangon City Development Committee
YHT	Yangon Heritage Trust

EXECUTIVE SUMMARY (ENGLISH)

The Third GMS Corridor Town Development Project focuses on the town of Mawlamyine in Mon State. The Project intends to significantly improve the environmental conditions in Mawlamyine and the quality of life of its population through the improvement of water supply and solid waste facilities.

Water supply is presently insufficient in terms of serviced areas, service duration, quantities supplied and water quality. The Project beneficial impacts are the followings:

- Improvement of the water supply efficiency by the improvement of KhinPonChong reservoir water resource mobilisation;
- Improvement of public safety through the construction of a water treatment plant based on rapid sand filtration process with disinfection by chlorine;
- Improvement of water supply security by increasing the water supply storage capacity through (i) the construction of a new 4,000 m^3 new water storage, located next to the proposed water treatment plant and (ii) the rehabilitation of the 3 existing storages of Kan Thone Kan;
- Improvement of distribution networks and extension over the whole town of Mawlamyine (except the 12 wards in the North that would be managed by Thai Tap Water Company);
- Improvement of quality of life and reduction of public health risks related to water.

Solid waste management is a major environmental issue in Mawlamyine where only 50% of the solid wastes are collected at present. The remaining 50% are dumped all over the city where the waste either decay with unpleasant smells and proliferation of insects or is burnt by the residents with emission of unpleasant and dangerous smokes as materials like plastics are also burnt. The collected waste is disposed in a large dumping site where it is regularly burnt in dry season and from where untreated leachates are discharged into the surface water bodies. Large quantities of waste are dumped into the storm drainage networks, clogging the drains and creating localized flooding during the rainy season.

The solid waste component beneficial impacts include:

- Improvement of quality of life and public health by (i) increasing the collection rate of solid waste in the city and (ii) improving collection points facilities;
- Improvement of storm drainage efficiency by reducing the amount of waste dumped in the drains and clogging the system;
- Optimization of waste transport costs to landfill by the construction of a transfer station;
- Reduction of water pollution load by improved collection rate and construction of a sanitary landfill with leachate collection and treatment;
- Reduction of air emissions and particularly GHG through (i) construction of a composting plant on the landfill site and (ii) collection of landfill gas and flaring;

- Improvement of waste recycling efficiency resulting in secondary beneficial environmental impacts through significant avoidance of GHG emission;
- Reduction of public health risk particularly among the population of waste pickers through the construction of an incinerator facility for the treatment of medical waste from the several hospitals and clinics and presently disposed in the dumping site without any precautionary measure.

The proposed acquisition of private land (3.7 acres or 1.5 ha) to build the future sanitary landfill near MuYong Village in Kyaikmayaw is only involving agricultural land. Then it will affect no household.

The only affected households are the wastepickers living in the existing dump site area that will be closed. Details regarding their affectation are available in resettlement plan report.

The buildings heritage in Mawlamyine is represented by Mon buildings dating from several centuries ago up to the British colonial era, with most of the latter in very poor condition. The project intends to stimulate the rehabilitation of such buildings with the objectives to:

- improve the general urban landscape and city beautification;
- stimulate the returns from the development of tourism;

None of the building heritage Project components requires land acquisition as the proposed pilot study is located on Mon Government land and involves mostly internal works with some paving of an outside courtyard.

None of the Project components involves significant forest clearing or encroachment into wetland or other conservation area.

The project will support innovation with the construction of the first composting plant in Myanmar, attached to the landfill and will equipped the proposed new landfill with a system of gas collection and flaring. When compared with the situation without project, the solid waste component of the Third GMS in Mon State shall reduce the annual emissions of GHG from generated waste by more than 42,000 t CO_2-eq/year in 2020 and even by 132,000 t CO_2-eq/year in 2040 when compared to a situation without Project. From 2016 to 2040, the reduction of cumulated GHG emissions shall be reduced by more than 2 million tons CO_2-eq.

The IEE also considered climatic trends at the national, regional and local scale in Myanmar and more specifically in Mawlamyine for which long term climatological data is available. Both temperature and rainfall show increasing trends in Mawlamyine along the last 50 years of observations, in line with MONREC trend analysis for Mon State. Annual rainfall increased by 500 mm over a 50 years period, or a raise of about 100 mm/decade. The month of July shows the highest raise during the 50 years period, about 300 mm, followed by May with 120 mm. Other months are almost stable or show only slight increase.

Temperature also increased over the same period. The average annual maximum temperature rose by 1.1°C over the last 48 years, or an increase of about 0.23°C per decade, a value significantly higher than what is considered in the Mon State (0.14°C increase per decade). July and November are the months showing the highest raise over the period, about 2°C. According to IPCC, sea level rise could reach 0.82 m by the end of the century. The present project considers a safety over-elevation of 1 meter as a design criteria for concerned project components, to avoid long term flooding risk.

The results of AWARE were considered in the preparation of the IEE Report. In this connection, climate change and natural hazards considerations had been incorporated in the IEE. AWARE was used by ADB to undertake an initial climate risk screening exercise. The results had rated the project as MEDIUM RISK and have identified flooding and landslide as a high level risk factor as the project is located in a region which has experienced recurring flood events in the recent past. However, the effective risk level is dependent on local geographical factors. On this basis, due to the location of Mawlamyine in a flat or smoothly undulating area, the risk for landslide may be considered as low. Mawlamyine experiences infrequent flooding mainly localized next to the Thanlwin River which may affect the strand road, but hardly more of the urban area as the elevation raises quickly by several meters. None of the Project sub-component is localized in flood prone area. The WTP, located next to the KhinPonChong reservoir is designed to be higher than the maximum elevation of water in the reservoir. The Project components shall not be affected or put at risk by climate change.

A screening carried out during the Interim phase of the Project confirmed that environmental impacts raised by the project were either very beneficial or mainly related to the risks of nuisances during the construction phase and easily controllable by appropriate construction site supervision and conventional mitigation measures. Consequently, the proposed categorization of the Project was B, involving the preparation of the present IEE. The conclusions of the present report confirm this initial categorization as category B Project.

Aside from the several and undisputable beneficial impacts of the Project in Mawlamyine, some potential risks of limited impacts are still to be considered should the management program anticipated be deficient:

- Appropriate operation and maintenance of the incinerator, particularly of the furnace temperature and of the stacks filters is required to ensure no hazardous air contamination results from the process. The EMP recommends long term monitoring of air emissions as part of the routine O&M activities.
- Most of the anticipated environmental and social impacts are related to nuisances which may happen during the construction activities. Because of the project located in an urban environment, risk of nuisances is higher: traffic congestion, temporary alienation of access, temporary disruption of community facilities, noise and engine gas and dust release may temporarily disturb the nearby communities. However, recommendations formulated in the present EMP combined with a solid environmental contractual framework and an effective inspection and supervision of construction sites will definitely reduce these risks to acceptable levels.

The EMP also emphasizes the low level of consideration for occupational health and safety (OHS) in Myanmar but also in Mawlamyine nowadays. Construction sites generally ignore safety signals, personal or collective protections for workers, safety belts, EHS awareness training, public safety measures for activities in populated areas etc. This situation is not compliant with the EHS requirements of international lending organisations as the ADB. For that reason, the EMP emphasises (i) the need for EHS capacity building for MTDC, the PMO and the PIU staff, (ii) the need for very strict and detailed EHS specifications for the tender documents and (iii) the need for strict EHS enforcement through monitoring of construction activities.

EXECUTIVE SUMMARY (MYANMAR)

- (i) 4000 m3 (ii)
- Chlorine

50% 50%

[illegible] -

(i) [illegible]

(ii) [illegible]

- [illegible]
- [illegible] Station [illegible]
- [illegible]
- Composting Plant [illegible] (ii) [illegible] ([illegible]) [illegible]
- [illegible]
- [illegible]

[illegible] -

- [illegible]
- [illegible]

[illegible]

Composting Plant

2020 42,000 t Coz-eq / year 2040 132,0000t Co2-eq / year 2016 2040

IEE

500 100 300 120

48 1.1 □C 0.23 □C 0.14 □C 2 □C IPPC 0.82 1

IEE AWARE AWARE AWARE ADB

(C& M activities)

(EMP)

EMP

EMP EHS

□□□ □□□□□□□□□□□□□□□□□□□□□□□□□□□□
□□□□□□□□□□□□□□□□□□ □ □□□□□□ □□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□□□□
□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□ □□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□
□□□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□□□□□□
□□□□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□ ADB □□□□□□□□□□□ □□□□□□□□□□□□□□□□
□□□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□ □□□□□□□□□□□
□□□□□□□□□□□□□□□□□□ EMP □□□□□□ (i) MTDO , PMG □□□□□□□□ PIO □□□□□□□□□□□□□
□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□□□□□□
□□□□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□□□□□□□□□ (ii)
□□□□□□□□□□□□□ □□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□ EMS
□□□□□□□□□□□□□□□□□□□□□ (iii) □□□□□□□□□□□□□□□□□□□□ EHS □□□□□ □□□□□□□□□□□□□
□□□□□□□□□□□□□□□□ □□□□□□□□ □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□
□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□□□□□□ □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□

1 INTRODUCTION

1.1 Project Categorization

A preliminary screening exercise of the proposed Project components, based on the latest applicable Rapid Environmental Assessment (REA) Checklists proposed by the ADB (REA Urban Development, REA Water Supply, REA Sewage Treatment and REA Solid Waste Management), was initially carried out by the ADB in June 2014. The screening was updated in 2015 and presented in the Project Interim Report (August 2015) and led to the following conclusions:

- The Project will provide major improvements regarding urban environment and quality of life of the residents;
- Projects components are not anticipated to significantly affect water, soil or air quality in the Project area;
- No detrimental impacts are anticipated on the long term. Most critical period will be the construction period, as many of the works will occur in densely urbanized areas. However, impacts can be strongly minimized, even avoided if good environmental practices are integrated in the Construction EMP and in the EHS specifications for construction contractors, and effectively enforced on sites through a solid and efficient monitoring. These requirements are described in the present IEE-EMP.
- The Project will have limited land acquisition and resettlement implications, as most of the project components have already been designed in order to avoid/minimize land acquisition and resettlement.

Applicable ADB REA Checklists are presented in **Appendix 3**.

Considering (i) the major beneficial impacts on the urban environment of Mawlamyine, (ii) the anticipated limited environmental impacts from the Project components and (iii) the limited potential impacts on land acquisition and resettlement, the present Project was classified as an ADB category. This categorization has been confirmed during the preparation of this IEE as discussed later.

This IEE is complemented (i) by a Resettlement Plan (RP) to address in details land acquisition and resettlement issues and (ii) by a full EMP encompassing construction and operation period with a particular focus on the construction period, recognizing that many of the construction activities will be located within sensitive urbanized areas.

Considering the Burmese environmental regulations, the study level also complies with the regulatory requirement of the draft EIA Procedures (6^{th} edition).

1.2 Purpose of EIA/IEE

This report gives an account of the Environmental Impact Assessment (EIA) of the proposed Third GMS Corridor Towns Development Project. The EIA was conducted as part of the Project preparation with the following purposes:

- To ensure the environmental soundness and sustainability of the project;

- To support the integration of environmental as well as climate change and natural hazards considerations into the project decision-making process;
- To identify early potential impacts and risks arising from the proposed Project components on the physical, biological, socio-economic and cultural environment;
- To identify measures to avoid, minimize, mitigate or compensate for adverse impacts and enhance positive impacts, and
- To lead to overall environment improvements in the project area of influence.

The present EIA was carried out in compliance with the Safeguard Policy Statement (SPS, June 2009) of the Asian Development Bank (ADB) and with reference to the Draft Procedure for Environmental Assessment (6th edition) prepared by the Burmese Government under the 2012 Environmental Conservation Law.

1.3 Report Organization

The Initial Environmental Examination follows a conventional layout for this type of report and integrates an Environmental Management Plan (EMP).In addition to this introduction the reader will find the following sections in this report:

- The Executive Summary;
- This introduction with the project rationale (Section 1)
- The applicable Institutional and Regulatory Framework (Section 2);
- The description of the proposed Project components (Section 3);
- The Baseline Situation (Section 4);
- The Impact Analysis (Section 5);
- The Alternative Development options (Section 6);
- The Public Consultation activities (Section 7);
- The Grievance and Redress Mechanism proposed (Section 8)
- The Environmental and Social Management Plan (Section 9)
- Conclusions & Recommendations (Section 10)
- Appendices (see separate volume)

2 POLICY, INSTITUTIONAL & LEGAL FRAMEWORK

2.1 Myanmar Environmental Laws, Regulations and Standards

2.1.1 HISTORICAL BACKGROUND

National Commission on Environmental Affairs (NCEA) was formed in 1990 with the purposes of setting environmental standards and creating environmental policies for utilizing natural resources and controlling environmental pollutions. It was organized as a division under the Ministry of Foreign Affairs in April 1992. NCEA has adopted a National Environmental Policy (NEP) in 1994 to ensure the incorporation of environmental concerns in planning for economic development. The NEP emphasizes "the responsibility of the State and every citizen to preserve its natural resources in the interest of present and future generations". In 2005, NCEA was transferred under the Ministry of Forestry.

The Ministry of Forestry was upgraded in September 2011 as the Ministry of Environmental Conservation and Forestry (MOECAF) and then Ministry of Natural Resources and Conservation (MONREC) in 2016, the focal and coordinating agency for the overall environmental management in Myanmar

The Environmental Conservation Department (ECD), one of the six departments under the MOECAF is responsible for implementing National Environmental Policy and to manage natural resources conservation and pollution control on water, air and land. The main ECD responsibilities include:

- Development of legislation related to environmental regulations, guidelines and procedures;
- Coordination of environmental conservation activities;
- Development of plans on climate change mitigation and adaptation, on desertification control and ozone layer protection;
- Preparation of national report in relation with international agreements.

When the MOECAF was created, the NCEA disappeared and its members were transferred to the ECD. The National Environmental Conservation Committee (NECC) was then established in April 2011 by ECD which selected representatives from most Ministries to participate to this committee.

On March 17th, 2016, the newly seated Pyihtaungsu Hluttaw announced an important reorganization of the Union Ministries, reducing the overall number from 36 ministries to 21. A total of 10 ministries have been merged. The Ministry of Environmental Conservation and Forestry (MOECAF) has been merged with the Ministry of Mines (MOM) to create the new **Ministry of Natural Resources and Environmental Conservation (MONREC).**

2.1.2 BACKGROUND OF LAWS AND REGULATIONS

Myanmar has already legislation and regulations which relate to natural environmental aspects dating prior to its independence. For instance, the Forest Act and the Burma Wildlife Protection Act have been enacted respectively in 1902 and 1936 for the sustainability of the forest products. Amended versions of such earlier act and newly promulgated one give a perspective on the existing legal and administrative framework concerning the environmental affairs in Myanmar.

The Myanmar Agenda 21 was formulated in 1997 in response to the call of the Earth Summit to develop national strategies to implement the Global Agenda 21. The Myanmar Agenda 21 made recommendations for the drafting and promulgation of a framework law which can further promote the integration of environmental and developmental concerns in the decision making processes of the country.

Present major laws and regulations with relation to environmental management are summarized in **Table 2-1**.

Table 2-1: Applicable Environmental, Health and Safety (EHS) Laws & Regulations in Myanmar

Laws and Regulations	Year	Purpose/Description
Environmental Conservation Law	2012	This law provides the basis for the conservation and protection of the natural environment of Myanmar including the marine environment. The ECL provides the common principles of environmental conservation and for other environmental laws and policy. The Environmental Conservation Committee (ECC) within the Ministry of the Natural Resources and Environmental Conservation (MONREC) was formed to oversee implementation, enforcement, and further development of the ECL including providing education and assistance to government agencies and proponents with the requirements of the ECL. The ECC also plays a lead role in managing environmental disputes.
Myanmar Environmental Conservation Rules	2014	These place responsibility on the Government to establish and adopt the necessary programs for the conservation and enhancement of environment, protection, control and reduction of pollution in environment, and conservation. Articles 52, 53 and 55 of the Rules states that all Projects and Project expansions undertaken by any ministry, government department, organization, corporation, board, development committee and organization, local government or authority, company, cooperative, institution, enterprise, firm, partnership or individual (and/or all Projects, field sites, factories and businesses including expansions of such Projects, field sites, factories and businesses identified by the Ministry, which may cause impact on environmental quality and are required to obtain Prior Permission in accordance with Article 62 of the Rules) having the potential to cause Adverse Impacts, are required to undertake IEE or EIA or to develop an EMP, and to obtain an ECC from MONREC.

Laws and Regulations	Year	Purpose/Description
Environmental Impact Assessment Procedures	2015	The EIA procedures state that all projects undertaken by a ministry, government department, organization, corporation, board, development committee, local government or authority, company, cooperative, institution, enterprise, firm, partnership or individual that could cause significant adverse environmental or social impacts are subjected to screening for either an IEE or EIA, and ultimately require an Environmental Compliance Certificate (ECC) from MONREC before being allowed to proceed. The EIA process involves (i) screening, (ii) scoping for EIA, (iii) EIA/IEE preparation and review, (iv) EIA/IEE approval, and (v) appeal. The procedures include project categorization which helps determining whether such project or activity will be required to conduct an IEE, an EIA or an EMP. The article 13 of the procedures states that the appropriate public consultation is required through all phases of the IEE and EIA. Regarding the Resettlement and Indigenous People, in the article 7, chapter 2 of the procedures states that projects that involve Involuntary Resettlement or which may potentially have an Adverse Impact on Indigenous People shall comply with specific procedures separately issued by the responsible ministries. Prior to the issuance of any such specific procedures, all such Projects shall adhere to international good practice (as accepted by international financial institutions including the World Bank Group and Asian Development Bank) on Involuntary Resettlement and Indigenous Peoples.
Conservation of Water Resources and Rivers Law	2006	To conserve and protect the water resources and rivers system for beneficial utilization by the public; to protect environmental impacts for the abuse use of water resources. Law strictly prohibits disposal of engine oil, chemical, poisonous material and other which may cause damage, or dispose of explosives from the bank or from a vessel.
Forest Law	1992	The Forest Law, 1992 highlights forest protection, environmental and biodiversity conservation, and extended set-up of the permanent forest estates (PFE) and protected areas system (PAS). It provides opportunities for the promotion of private sector involvement in reforestation and timber trade, and decentralizes management responsibilities. It encourages community participatory approach in managing forest resources, particularly to satisfy the basic needs of the rural people. It demonstrates a shift from the concept of revenue generation and restriction to motivation and share of management responsibility with people.
Protection of Wildlife and Wild Plants	1994	To protect wildlife, wild plants and conserve natural areas, to contribute towards works of natural scientific research, and to establish zoological gardens and botanical gardens.

Laws and Regulations	Year	Purpose/Description
and Conservation of Natural Areas Law		The Law highlights habits maintenance and restoration, protection of endangered and rare species of both fauna and flora, establishment of new parks and protected areas, and buffer zone management.
National Environmental Policy	1994	To ensure sound environmental policies in the utilization of water, land, forest, mineral resources and other natural resources in order to conserve the environment and prevent its degradation.
Law of Mon State Development Affair	2012	It provides information on the policy, regulations on the solid waste management and drainage facilities management, and includes supervision of construction, renovation and extension of a building.
Law of Kayin State Development Affair	2013	It provides information on the policy, regulations on the solid waste management and drainage facilities management, and includes supervision of construction, renovation and extension of a building.
Protection and Preservation of Cultural Heritage Regions Laws	1998	To implement the protection and preservation policy with respect to perpetuation of cultural heritage that has existed for many years; to protect and preserve the cultural heritage regions and the cultural heritage. New project in such sensitive areas is required to get prior approval from the Culture
The Underground Water Act	1930	This Act provides the requirement for systematic use of ground water toward sustainable purpose.
Public Health Law	1972	For promoting and safeguarding public health and to take necessary measures in respect of environmental health.
Prevention and Control of Communicable Diseases Law	1995 Revised in 2011	The Law highlights the functions and responsibilities of health personnel and citizens in relation to prevention and control of communicable diseases. It also describes measures to be taken in relation to environmental sanitation, reporting and control of outbreaks of epidemics and penalties for those failing to comply. The law also authorizes the Ministry of Health to issue rules and procedures when necessary with approval of the government
Factory Act	1951	For effective management in every factory for disposal of waste and effluent, and matters on health, cleanliness and precaution against danger.
Agricultural Land Law	2012	To protect the rights of the people working on the farmland
National Biodiversity Strategy and Action Plan	2012	The NBSAP acts as the major guiding document for planning biodiversity conservation in the country, following its goal to provide a strategic planning framework for the effective and efficient conservation and management of biodiversity and natural resources based on greater transparency, accountability and equity.
Myanmar Investment Law	2012	This Law makes sure not to cause environmental pollution or damage in accord with existing laws in respect of investment.

LAWS AND REGULATIONS	YEAR	PURPOSE/DESCRIPTION
Myanmar Investment Rules	2013	The Myanmar foreign investment rules contain several elements dealing with environmental protection, including: Art. 33. Proposals for economic activities that are considered capital intensive by the Commission, and that are prescribed to undergo environmental impact assessment by the Ministry of Environmental Protection and Forestry have to be submitted along with Environmental and Social Impact Assessment. Art. 54. The promoter or investor shall: (a) comply with Environmental Protection Law in dealing with environmental protection matters related to the business; Art. 123. If it is scrutinized and found out that the investor has carried out business that causes environmental pollution or has not taken action to minimize environmental pollution at the land for which he is entitled to lease or use, or if it is scrutinized and found that the work carries out causes nuisance to the persons who reside around such place due to noise or by culture and if relevant persons officially object, the Commission may terminate the lease or tendering right to use after making necessary inquiry. Art. 125. The investor, for operating any business, does not have the right to lease and develop the following lands: (a) religious lands; (b) cultural heritage and natural heritage regions designated by relevant Ministries; (c) lands restricted for Union defence and security; (d) lands under litigation; (e) lands restricted by the State from time to time; (f) lands where exists place or building which may cause situations such as impact on public environment noise, pollution, impact on culture within urban residential area due to the business of the investor.
National Sustainable Development Strategy	2009	This strategy concerns the sustainable management of natural resources, integrated economic development, and sustainable social development.
Conservation of Water Resources and Rivers Law (2006)	2006	This Law aims to conserve and protect the water resources and river systems for beneficial utilization by the public, to smooth and enhance safety of waterways navigation along rivers and creeks, to contribute to the development of State economy through improving water resources and river systems, and to protect environmental impact.
Enacted Laws related to Labour and Safety	Mainly 2011-2016	Laws and Rules applicable for the construction and operation of the projects: Labour Organization Law & Rules (2011) Settlement of Labour Dispute Law & Rules(2012) Edited Settlement of Dispute Law(September, 2014) Social Security Law (2012) Social Security Rule (2012) Minimum Wages Law (2013)

Laws and Regulations	Year	Purpose/Description
		Minimum Wages Rule Employment and Skill Development Law Leave and Holiday Law (1951) Amended Law for Leave and Holiday Law 1951(July 2014) Payment of Wages Law (Jan 2016)

2.1.3 APPLICABLE ENVIRONMENTAL STANDARDS

In December 2015 MONREC released Myanmar Environmental Quality (Emission) Guidelines. The guidelines cover both water and atmosphere emissions related to a wide range of production industries. Most of the proposed standards refer to the Environmental, Health and Safety Guidelines of the IFC (2007). Concerning treated wastewater discharges (Section 1.2), proposed standards refer also to IFC EHS guidelines. Emission guidelines related to leachate discharges from municipal solid waste landfills and emissions from incinerators are presented in following Tables. With respect to drinking water standards the MONREC guidelines refer to the National Drinking Water Guidelines recently introduced by the National Water Council and based on WHO Guidelines and Standards for drinking water.

Table 2-2: Emission Quality Standards applicable to treated municipal wastewater effluents

Parameter	Unit	Maximum Concentration
Biological oxygen demand	mg/L	30
Chemical oxygen demand	mg/L	125
Oil and grease	mg/L	10
pH	S.U.	6-9
Total coliform bacteria	MPN[a]/100 ml	400[b]
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a] MPN = Most Probable Number

[b] Not applicable to centralized, municipal wastewater treatment systems

Table 2-3: Emission Quality Standards applicable to leachate from municipal waste landfills

Parameter	Unit	Daily Maximum	Monthly Average
5-day Biochemical oxygen demand	mg/l	140	37
Ammonia	mg/l	10	4.9
Aniline		-	-
Arsenic	mg/l	-	-
alpha Terpineol	mg/l	0.033	0.016
Benzoic Acid	mg/l	0.12	0.071
Chromium (total)	mg/l	-	-
Naphthalene	mg/l	-	-
p-Cresol	mg/l	0.025	0.014
pH	S.U.	6-9	6-9

Phenols	mg/l	0.026	0.015
Pryridine	mg/l	-	-
Total suspended solids	mg/l	88	27
Zinc	mg/l	0.2	0.11

2.1.4 NATIONAL EIA REQUIREMENTS AND FRAMEWORK

In accordance with the recommendations of the 2012 Environmental Conservation Law, MONREC has prepared a procedure for the Environmental Assessment (EA) of development projects. This procedure is still in a draft form (version 42 latest) but is already virtually enforced by MONREC.

From the information gathered from the draft procedure, the PPTA Consultant has prepared a tentative flowchart depicting the various stages of the procedure and the formal review/approval steps by MONREC.

MONREC should be solicited 3 times during the preparation process of a local EIA/IEE:

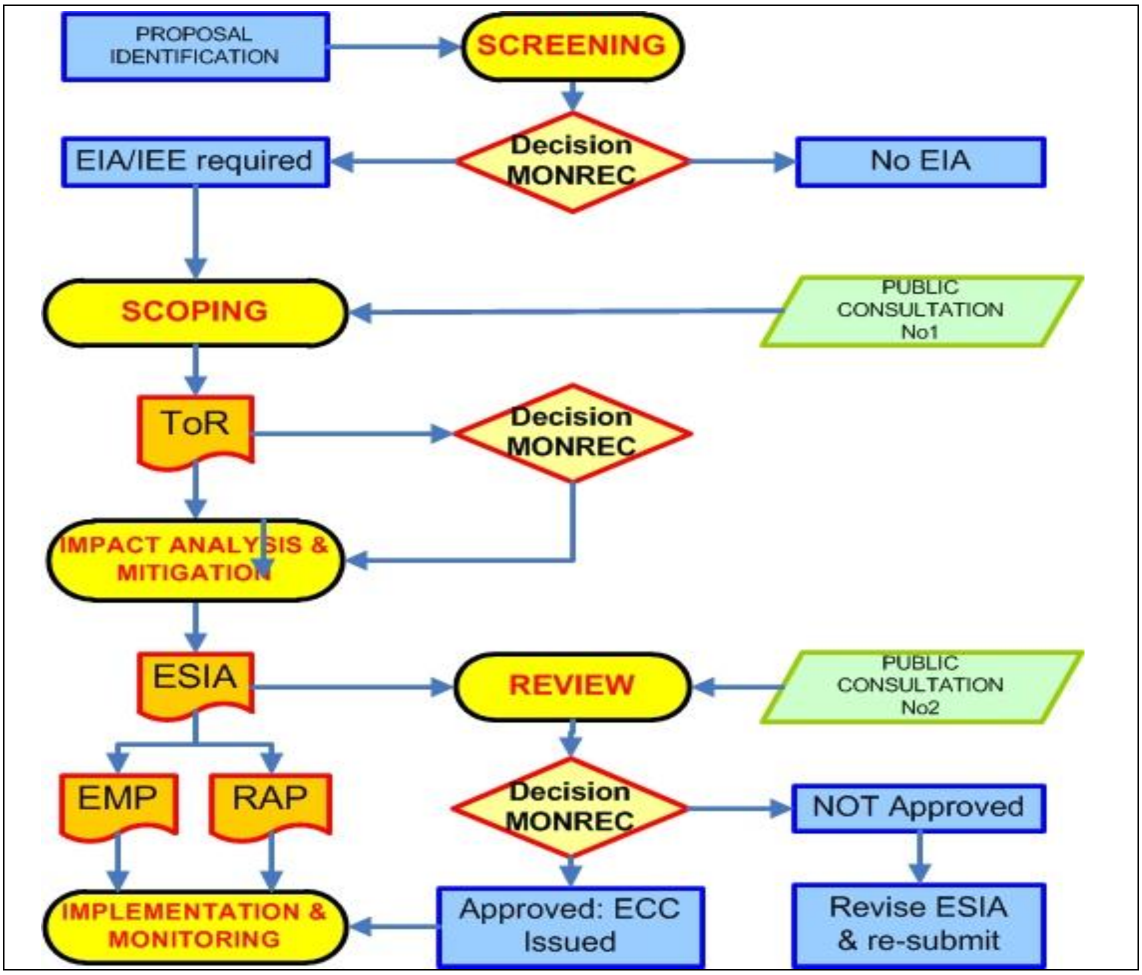
- at project proposal stage (screening), to decide if EIA or IEE is required or not
- before the start of the EIA study to approve (i) the Terms of Reference for the EIA and (ii) the qualification of the Consultant proposed for carrying out the EIA;
- at submission stage of the EIA draft report for comments and then issuance of the ECC.

Two public consultations are also considered. This process, as shown in **Figure 2-1** is quite comparable with ADB requirements regarding the EA main process stages.

In parallel to the preparation of the IEE documentation by the PPTA Consultant for ADB, it is required by the national procedure on EA that a local EIA report is submitted to MONREC. In order to avoid delay in the eventual implementation of the project, the required EA steps have been undertaken by the Executing Agency in parallel with the progress of the PPTA IEE, benefiting fully from the work done by the PPTA Consultant.

In terms of report content, the EIA requirement for Myanmar covers both environmental and social while for ADB SPS, these come separately in the EIA/IEE for environment and the RAP (and other types of documents) for the social aspects (baseline, resettlement, livelihood restoration). Compilation of information for reporting to MONREC relied on these documents from PPTA.

Figure 2-1: Draft Process for Environmental Assessment in Myanmar



Source: PPTA Consultant based on Myanmar EIA Procedures
Note: ECC=Environmental Compliance Certificate

Table 2-4: Coordination between ADB and MONREC requirements

Steps in Myanmar EA Procedure	Links with ADB PPTA EIA/IEE	Schedule
Submission of Project proposal	Project proposal to be submitted to MONREC by the Proponent (MSG) must be based on the final list of project components approved by proponent following PPTA Interim report and workshop	MONREC is required within 15 days of receiving a project proposal to perform screening and determine the type of environmental assessment (EIA, IEE or none) required.
Preparation of EIA Scoping and ToR	ToR may partly rely on the ADB ToR related to the Environmental and Social tasks of the PPTA, and be complemented as necessary by any	MONREC is required to provide decision on firm's qualification within 7 days, and to provide approval of scoping and EIA ToR within 15 days

Steps in Myanmar EA Procedure	Links with ADB PPTA EIA/IEE	Schedule
	issue identified during the public consultation activities. Project proponent must appoint a consultant registered/qualified to prepare scoping and ToR.	upon submission of documents by proponent
Preparation of EIA report	Preparation of the EIA/IEE report will be based on the EIA/IEE and RAP reports prepared by the PPTA Consultant.	Report preparation to start when PPTA EIA/IEE is submitted to or approved by ADB
Public Consultations	Myanmar EA procedure requires 2 public consultations. ADB SPS requires minimum of 2 consultations for category A project (with full EIA) and minimum 1 for category B (with IEE)	Public consultation activities of PPTA Consultant to be fully considered in EIA report for MONREC

In order to achieve the proposed project implementation plan, the timeline for securing the applicable MONREC approval are as **Table 2-5**:

Table 2-5: Timeline for MONREC Approval

Activities	2016				2017			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Detailed design								
Procurement of goods and services								
Permits and Clearances								
Scoping and Approval of TOR (with MONREC)								
Local EIA Preparation (from ADB IEE)								
MONREC approval								

2.1.5 INTERNATIONAL TREATIES

Myanmar has also made commitments to the following international agreements and protocols on environmental, social, safety and occupational issues as shown in **Table 2-6**.

Table 2-6 International Agreements on Environment, Social and Safety

International Agreement	Date of Signature	Date of Ratification	Date of Membership	Cabinet Approval	Relevance to Project
United Nations Framework Convention on	11/06/1992	25/11/1994 (Ratification)	-	41/94 (09/11/1994)	Yes (GHG reduction)

International Agreement	Date of Signature	Date of Ratification	Date of Membership	Cabinet Approval	Relevance to Project
Climate Change, New York, 1992 (UNFCCC)					
Convention on Biological Diversity, Rio de Janeiro, 1992	11/06/1992	25/11/1994 (Ratification)	-	41/94 (09/11/1994)	Yes but limited as urban environment
International Tropical Timber Agreement (ITTA), Geneva, 1994	06/07/1995	31/1/1996 (Ratification)	-	-	No
Vienna Convention for the Protection of the Ozone Layer, Vienna, 1985	-	24/11/1993 (Ratification)	22/2/1994	46/93	No
Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal, 1987	-	24/11/1993 (Ratification)	22/2/1994	46/93	No
London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, London, 1990	-	24/11/1993 (Ratification)	22/2/1994	46/93	No
The Convention for the Protection of the World Culture and Natural Heritage, Paris, 1972	-	29/4/1994 (Acceptance)	-	6/94	Yes in Mawlamyine

International Agreement	Date of Signature	Date of Ratification	Date of Membership	Cabinet Approval	Relevance to Project
United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and / or Desertification, Particularly in Africa, Paris, 1994 (UNCCD)	-	02/01/1997(Accession)	02/04/1997	40/96 (4-12-96)	No
Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington, D.C., 1973; and this convention as amended in Bonn, Germany,1979 (CITES	-	13/6/1997 (Accession)	11/09/1997	17/97 (30-4-97)	No
ASEAN Agreement on the Conservation of Nature and Nature Resources, Kuala Lumpur, 1985	16/10/1997	-	-	-	No
Cartagena Protocol on Biosafety, Cartagena, 2000	11/5/2001	-	-	13/2001 (22-03-2001)	No
ASEAN Agreement on Transboundary Haze Pollution	10/06/2002	13/3/2003 (Ratification)	-	7/2003 (27-02-2003)	No
Kyoto Protocol to the Convention on Climate Change, Kyoto, 1997	-	13/8/2003(Accession)	-	26/2003 (16-07-2003)	Yes

International Agreement	Date of Signature	Date of Ratification	Date of Membersh ip	Cabinet Approval	Relevance to Project
Stockholm Convention on Persistent Organic Pollutants (POPs), 2001	-	18-4-2004 (Accession)	18/7/2004	14/2004 (01-04-2004)	No
Sendai Framework for Disaster Risk Reduction, UNISDR, 2015	-	-	2015	-	?

2.2 ADB Environmental Safeguards Policy

In 2005, the Asian Development Bank embarked on a review process of its three safeguard policies on the environment, involuntary resettlement and Indigenous Peoples. The 2009 Safeguard Policy Statement (SPS) is the result of this four-year process. NGO Forum on ADB's network members was heavily involved in monitoring and commenting the review process.

The new Safeguard Policy Statement (SPS) became effective in January 2010. It replaced the ADB's previous separate policies on each of these areas: Policy on Indigenous People (1998), Involuntary Resettlement Policy (1995) and Environment Policy (2002). Key documents related to the new Policy include:

- ADB, 2009. Safeguard Policy Statement, Manila.
- ADB, 2012. Environment Safeguards, a Good Practice Sourcebook, Draft Working Document, Manila.

The standards contained in the ADB's SPS have far-reaching impacts. They determine the ADB's environmental and social obligations for its annual and rising lending volume and influence emerging national legal frameworks in Asia. Due to the Bank's increasing support for private sector operations, the Safeguard Policy Statement also determines how private financing, supported by the ADB, operates in Asia.

The overarching statement on ADB's Commitment and Policy Principles (Chapter V) says that the ADB's safeguards have the following objectives (SPS, p 15): i) avoid adverse impacts of projects on the environment and affected people, where possible; ii) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible; and iii) help borrowers/clients to strengthen their safeguard systems and develop the capacity to manage environmental and social risks.

2.2.1 GENERAL REQUIREMENTS

The Policy Delivery section (Chapter V B, paras. 53–64) lists general requirements that the ADB is obliged to follow in regard to: project screening and classification, information disclosure, consultation and participation, due diligence, monitoring and reporting, local grievance redress mechanisms and the Bank's Accountability Mechanism.

- Project screening and classification: The Policy stipulates that the ADB will undertake project screening as early as possible to i) determine the significance of adverse impacts; ii) identify the level of assessment and institutional resources required; iii) determine disclosure requirements (para. 50).
- Information disclosure: In line with the ADB's Public Communications Policy, the Policy requires (para. 53) that for environment Category A projects, draft environmental impact assessments must be posted on the ADB's website 120 days before project approval. For draft environmental assessment and review frameworks, draft resettlement frameworks and/or plans and draft Indigenous Peoples planning frameworks and/or plans, the Policy only stipulates that these documents must be provided by the borrower/ client and posted on ADB's website before project appraisal, as follows: i) final or updated environmental impact assessments and/or initial environmental examinations, resettlement plans, and Indigenous Peoples plans upon receipt (by the ADB), and ii) environment, involuntary resettlement and Indigenous Peoples monitoring reports submitted by borrowers/clients during project implementation upon receipt (by the ADB).
- Consultation and participation: The general provisions on consultation and participation are mostly phrased as aspirations. The Policy states that the ADB "is committed to working with borrowers/ clients to put processes of meaningful consultation and participation in place." Meaningful participation is defined as: i) beginning early in the project preparation stage and being carried out on an on-going basis throughout the project cycle; ii) providing timely disclosure of relevant and adequate information that is accessible to affected people; iii) being free of intimidation and coercion; iv) being gender inclusive and responsive; and v) enabling the incorporation of all relevant views of affected people and other stakeholders in decision-making (para. 54).
- Due diligence and review of safeguard assessments and plans: Due diligence refers to the ADB's process of assessing safeguard issues through field visits and desk reviews as well as through examining relevant safeguard documents (such as environmental impact assessments, resettlement plans, Indigenous Peoples' plans). Through its due diligence processes, the ADB confirms that all potential environmental and social risks are identified. If they cannot be avoided, it ensures that appropriate mitigation measures are identified (SPS, para. 56).
- Monitoring and reporting: The monitoring obligations are merely required to be "commensurate with the project's risks and impacts". For highly complex and sensitive projects, the ADB requires the borrower/client to "engage an independent advisory panel" (SPS, para. 57).
- Local grievance redress mechanisms: The Policy requires the borrower/client to set up and maintain a grievance redress mechanism at project level (SPS, para. 59). This mechanism does not replace the ADB's accountability mechanism, but is intended to solve grievances at the local level. Affected people can also take complaints to the ADB's Accountability Mechanism. The Accountability Mechanism Policy merely requires complainants to demonstrate that they have sought to address their complaint with management.

2.2.2 ENVIRONMENTAL REQUIREMENTS

More precisely as environment aspects are concerned, the objective of the Policy is to "ensure the environmental soundness and sustainability of projects and to support the integration of environmental considerations into the project decision-making process" (SPS, p. 17). The main Environmental Safeguard requirements are the followings:

- **Categorization and information disclosure:** The Policy uses a categorization system to reflect the significance of a project's potential environmental impacts. "A project's category is determined by the category of its most environmentally sensitive component, including direct, indirect, cumulative, and induced impacts in the project's area of influence" (SPS, para. 50). Final or updated EIAs and/or initial environmental examinations must be made available upon receipt on the ADB's website. The following categories exist:
  - **Category A**: significant adverse environmental impacts that are irreversible, diverse or unprecedented. Category A projects requires a full-scale Environmental Impact Assessment (EIA). A draft EIA, including the Environmental Management Plan, must be made available on the ADB's website at least 120 days prior to Board approval.
  - **Category B**: less adverse environmental impacts that are site specific, few of which are irreversible, and mitigation measures that can be designed more readily than for Category A projects. Category B projects require an initial environmental evaluation.
  - **Category C**: minimal or no adverse environmental impacts. Category C projects require further environmental assessment actions/documents.
  - **Category FI**: projects involving ADB funds to, or through, a financial intermediary. Category FI projects require an Environmental and Social Management System.
- **Assessment process:** Environmental impacts must be determined in consultation with affected people and concerned non-government organizations (NGOs). For category A projects, the borrower/client is required to undertake an assessment of options that looks at alternatives to the project's location, design, technology and components. The options assessment will also examine the "no project" alternative. The borrower/client must present the rationale for selecting the particular project details, including a cost-benefit analysis that takes into account environmental costs and benefits of the various alternatives considered (SPS, Appendix 1, para. 4).
- **Type of impacts:** The types of impacts related to the environment include physical, biological, cultural and socioeconomic impacts. These can relate to occupational health and safety; community health and safety; vulnerable groups; gender issues; and impacts on livelihoods and physical cultural resources (SPS, Appendix 1, para. 5).
- **Project site/scope:** The project site covered by the environmental safeguard provisions in the Policy is defined as: "the primary project site(s) and related facilities that the borrower/client (including its contractors) develops or controls, such as power transmission corridors, pipelines, canals, tunnels, access roads, borrow pits and disposal areas, and construction camps". This definition also includes: associated facilities that are not funded as part of the project, but "whose viability and existence depends exclusively on the project"; "areas and communities potentially affected by cumulative impacts from further planned development of the project"; and predictable impacts caused by the project "that may occur later or at a different location" (SPS, Appendix 1, para. 6).
- **Transboundary impacts:** The environmental assessment process must identify potential transboundary effects, such as air pollution and increased use

or contamination of international waterways. It must also identify global impacts, such as the impact of greenhouse gases and impacts on endangered species and habitats (SPS, Appendix 1, para. 7).

- **Environmental planning and management:** If environmental impacts are identified, the borrower/ client is required to prepare an environmental management plan describing how potential impacts and risks will be addressed (SPS, Appendix 1, para. 12).
- **Consultation and participation, grievance mechanism:** The consultation process and grievance mechanism process follows the same provisions as laid out in the general requirements (see above) (SPS, Appendix 1, paras. 19 and 20).
- **Reporting and monitoring:** The Policy states that "the extent of monitoring activities will be commensurate with the project’s risks and impacts" (SPS, Appendix 1, para. 21). For Category A projects, the borrower/client is required to retain qualified external experts or qualified NGOs to verify its monitoring information. The minimum requirement is semi-annual report during construction for projects with significant impacts and which become annual during operation. For other projects, periodic reports are required. Monitoring reports must be posted in a location accessible to the public (SPS, Appendix 1, paras. 21 & 22).
- **Unanticipated environmental impacts:** If unanticipated impacts occur during project implementation, the borrower/client is required to update the environmental assessment and environmental management plan or prepare a new assessment and plan (SPS, Appendix 1, para. 23).
- **Biodiversity conservation and sustainable natural resource management:** This section (SPS, Appendix 1, paras. 24 – 49) contains requirements regarding the following issues: modified habitats; natural habitats; critical habitats; legally protected areas; invasive alien species; management and use of renewable resources;
- **Pollution prevention and abatement** (resource conservation, energy efficiency, waste, hazardous materials, pesticide use and management, greenhouse gas emissions);
- **Health and safety** (occupational health and safety and community health and safety); and
- Physical cultural resources (SPS, Appendix 1, para. 24).

3 PROJECT DESCRIPTION

3.1 Project Proposals for Mawlamyine

The Project in Mon State concerns 3 main components related to water supply improvement, solid waste management and cultural heritage conservation. The project components are presented in Error! Reference source not found..

Figure 3-1: Proposed Third GMS Project Components in Mawlamyine

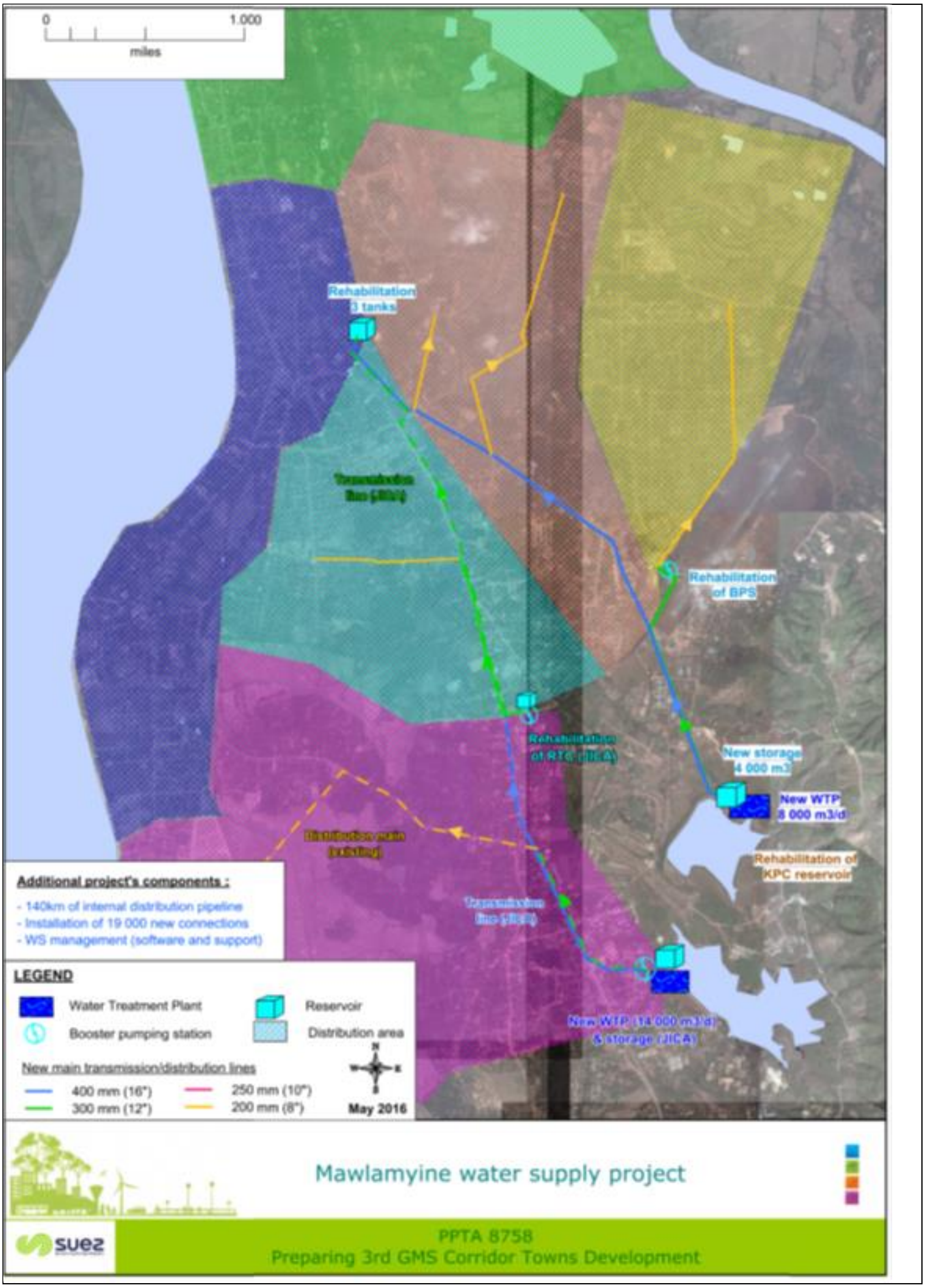
3.2 Water Supply project

The proposed project consists of four major elements as depicted spatially on **Error! Reference source not found.**.

- Rehabilitation of the KhinPonChong dam and creation of a new treatment plant. Rehabilitation of the KPC dam recognises that this forms part of the unique cultural heritage of Mawlamyine and will therefore be undertaken to preserve the main features of the existing dam most notably the existing intake structure. The treatment plant would have a capacity of 8,000 m3/day. The process would include remineralisation, rapid sand filtration, disinfection and sludge treatment.
- Rehabilitation and extension of the existing storage facilities (3 Tanks Reservoir) and creation of a new storage facilities at KhinPonChong (4,000 m3);
- Transmission lines and distribution lines including 13 km of transmission lines and main networks (diameters from 200-400 mm) and 140.2 km of distribution system (including tertiary networks < 100 mm). The project would also include a fund to finance approximately 19000 new connections.
- Improved Operation & Management covering asset management, GIS, billing and customer management, NRW control. These latter aspects will be procured as part of a management contract.

The outline designs of the proposed networks have been analysed using hydraulic modelling techniques. The results demonstrate that maximum velocities and pressures are acceptable for both the short and long term requirements.

Figure 3-2: Proposed Water Supply Project in Mawlamyine

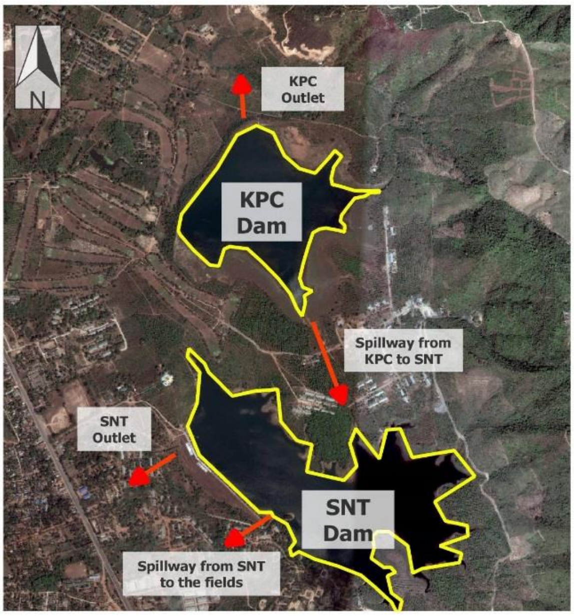


3.2.1 EXISTING WATER RESOURCES

In terms of the existing public water supply, Mawlamyine is served by three distinct resources namely:

- Water from the KhinPonChong reservoir created in 1904 together with an old distribution system which is still supplying 24/7 water by gravity to the main storage reservoirs and thereafter distributing to parts of the city;
- A newer reservoir, ShweNatTaung reservoir which supplies by pumping to the main storage reservoirs in the downtown area;

Figure 3-3: View of existing reservoirs and interactions



Main characteristics of the two reservoirs are summarized in the table below:

Table 3-1: Main characteristics of the reservoirs

Reservoir	Type	Construction date	length of the dam (m)	Maximum storage capacity (m3)	Current use	Managed by
KhinPonChong	Earth dam	1904	1200	3.08 M	Public and private water supply	Mawlamyine TDC
ShweNatTaung	Earth dam	1996	460	6.47 M	Public and private water supply Irrigation	Irrigation Department

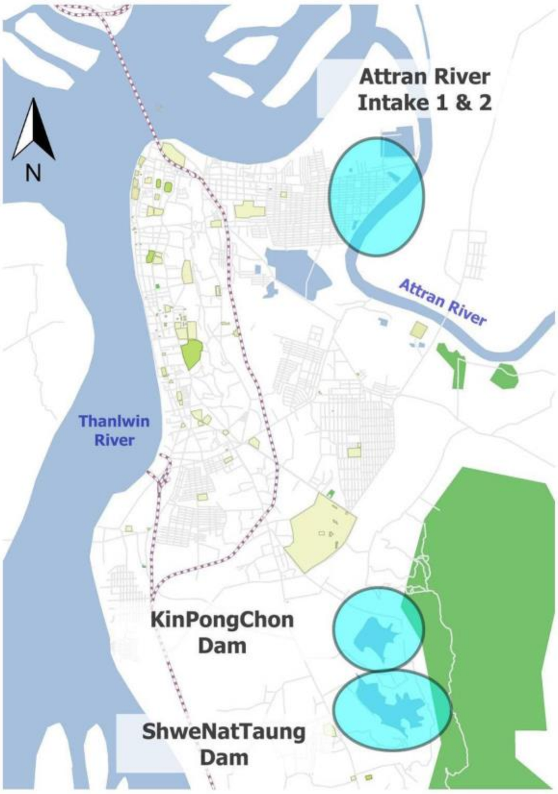
Reservoir	Catchment area (km²)	Max level (mASL)	Min Level (mASL)	Spillway elevation (mASL)	Water surface at spillway level (km²)	Remark
KhinPonChong	1.78	39.1	32	39.1 (+0.7)*	0.54	No resource protection plan No regular monitoring
ShweNatTaung	2.35	36.6	20.6 (intake level)	33.5	0.63	No resource protection plan

**Spillway level is regularly increased by TDC (see hydrological report in appendix of FSR)*

***Given the age of these structures little details are available concerning the design of these structures.*

Two water intakes from the Attran River, which shall be replaced in the future by one intake and associated treatment plant under a proposed PPP (see chapter 3.2.4).

Figure 3-4: View of existing resources in Mawlamyine



Inhabitants supplement these water resources via shallow groundwater (tubewells and wells), rainwater during rainy season and also via bottled water and boxer trucks.

Existing information concerning the quality of these resources is extremely sparse. To supplement this the PPTA Consultant undertook a series of measurements during September 2015. The main findings of these surveys are summarised below:

- The KhinPonChong water resource presents a very low mineralisation (EC=22.5 µS), which is in line with its origin: only rain water with a limited run-off due to the small size of the catchment, so with limited opportunity to be enriched with soil minerals. Organic pollution is low, in relation to the small size of the catchment and the absence of major pollution sources. All parameters are compatible for its use as drinking water after treatment. Similar conclusions apply to the ShweNatTaung dam water quality.
- The high salinity of tube well N°1 located along the Thanlwin river bank reflects the influence of the sea and the salinity of the water in the estuary. Turbidity and TSS values are high for underground resources, probably reflecting the inappropriate design of the tube wells or the fine sediment at the level of the pumping. All wells are contaminated, as a result of discharges from septic tanks representing the predominant sanitation system of Mawlamyine.
- Turbidity of the Attran river intakes is high and also there is evidence of salinity related to the proximity of these intakes to the Thanlwin estuary. The turbidity of water from Attran intakes 1 and 2 is reduced by sedimentation in ponds before

reaching the households. This is the only purification process in Mawlamyine water supply system.

-

OPTION ANALYSIS AND CONCLUSION

In terms of water resources the following different sources have been considered, in accordance with above information:

- Groundwater;
- Surface water dams and reservoirs;
- Surface water from the Attran River

With regard to groundwater, available information indicates that this is either polluted by septic tank effluents (shallow groundwater) or saline (deeper tubewells). Given also the limitation with respect to yield, existing resources should be discontinued.

Turning to possible dams/reservoirs, we have not considered the development of new dams/reservoirs but focused on identifying existing dams which could be eventually used for domestic water supply. Available hydrological information would indicated that the water resources of the ShweNatTaung are abundant and not limiting due to the large storage capacity and catchment basin. Resources in the KhinPonChong appeared to be more limited especially at the end of the dry season and also in relation to known leakages associated with this reservoir. Nevertheless, this resource is strategic due to its quality, elevation and location. Hydrological analysis of the dam has been performed looking at different scenarios, as presented in Water Supply Appendix 1.2. Main results indicate that considering the present project described hereafter, 8 000 m3/d could be abstracted safely throughout the year.

The current Attran intakes are close to the Thanlwin estuary. Studies undertaken by the PPTA Consultant indicate that these resources are highly likely to be saline in the short to medium term related to changes in the upstream hydrological regime (linked to operation of future dams) and also due to the sea level changes. In addition being located downstream of the main city, these intakes are subject to pollution from both wastewater systems and solid waste leachate discharges. In order to abstract water from the Attran river, intake should be implemented upstream of the city, preventing salinity and urban pollution.

Finally, it has to be noticed that none of the resources has a protection plan for environmental protection purpose as well as preservation, to prevent from pollution or undesirable/illegal uses.

3.2.2 DESCRIPTION AND ANALYSES OF THE PRESENT SITUATION

CONTEXT

The Township of Mawlamyine is the capital of Mon State and is located at the estuary of the Thanlwin (Salween) River, one of the longest rivers of Myanmar. Mawlamyine Township comprises 28 urban wards and 13 rural villages with a total population of 289,388 inhabitants as recorded by the 2014 Census. The largest ethnic group in Mawlamyine according to the General Administration Department (GAD) data is the Bamar whereas the Mon comprise the third largest group in the township, most of whom live in rural areas of the township. Annual rainfall average over the period 1965-2014 (50 years) period is 4864 mm of which 82% falls from June to September, the 4 wettest month of the South-west monsoon.

The 2014 census records the sources of drinking water and water for other uses as reported by households in Mawlamyine. Mawlamyine data indicates a high use of bottled/purified water in the city compared to general bottle water consumption in the State. In addition, Mawlamyine residents rely more heavily on tap water/piped water and tubewells than other state residents although protected wells/springs are an important source of non-drinking water in general.

Concerning water borne sanitation, almost 95% of the population of Mawlamyine has access to improved toilet facilities (sealed latrines 92% and flush toilets 2%). Only a small portion of the population (<5%) does not have access to sanitation facilities. In the main urban area, septic tanks and sealed latrines are emptied by trucks with septage disposed near to the existing landfill.

According to the Mon State Health Dept., dengue outbreaks are a common occurrence with reported cases ranging between 8 cases in 2000 and 1114 cases in 2001 with reported deaths at zero in some years to a high of 9 (2001). The general incidence of dengue ranges between 138 (2011) with another spike of 819 cases in 2013. In addition, the GAD figures identify tuberculosis as having the highest prevalence, followed by diarrhoea and malaria.

ORGANIZATION AND GENERAL INFORMATION

The provision of urban environmental services in Mawlamyine Town is the responsibility of the Mawlamyine Town Development Committee (MTDC) which covers a service area of 28 wards with a total urban population of 253 734.

Residents of Mawlamyine City are getting water from different resources:

- ✓ **Water supply system managed by TDC comprises several facilities based on surface water which includes both reservoirs and river.**
- ✓ **Private tubewells (among them are some unregistered/illegal ones),**
- ✓ **Public wells and communal taps**
- ✓ **During the dry season water is supplied with water boxer (2.7-3.6 m3) through and out the city**

Most of households have elevated water tank, ground water tank or drums as water storage for 2 to 3 days usage and this is the practice throughout the country.

The original piped water supply system was constructed under the British Empire based on the use of KhinPonChong Dam supplying 3 tanks reservoir and then the city area under gravity conditions. Since then, the water supply system has been significantly reinforced in order to increase the coverage of the city with the inclusion of:

- ✓ **Shwe Nat Taung reservoir and distribution system including RTC reservoir**

- **Attran 1 & 2 systems distributing water from the river for the northern part of the city : two surface treatment plants based on sedimentation process**

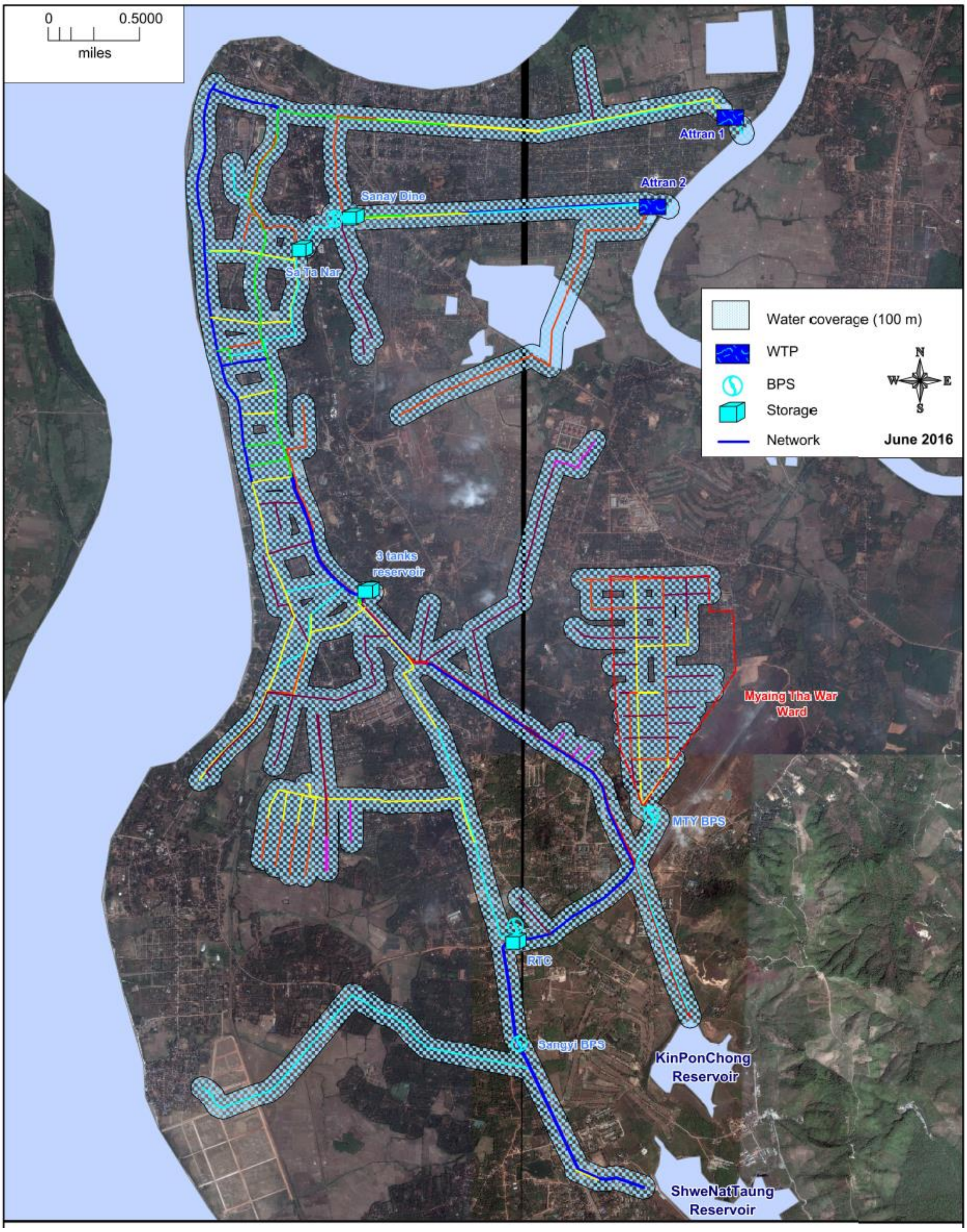
During this period, the main network has also been extended significantly, in order to improve the coverage in the city, particularly in the Northern and Southern areas. Indeed, the network length has increased to nearly 110km as on date.

It is supposed that nearly 26% of Mawlamyine urban population which means nearly 50 000 inhabitants are supplied through the public network. The number of water meters is currently 9 250.

The current coverage of the water supply system is presented in the figure below based on the maximum distance of 100m from the distribution network. The overall covered area is nearly 14km².

Besides, it has to be noticed that water supply in MyaingThaYar Ward is managed by a ward committee, getting water from KhinPonChong reservoir.

Figure 3-5: Map of water supply system and coverage in Mawlamyine



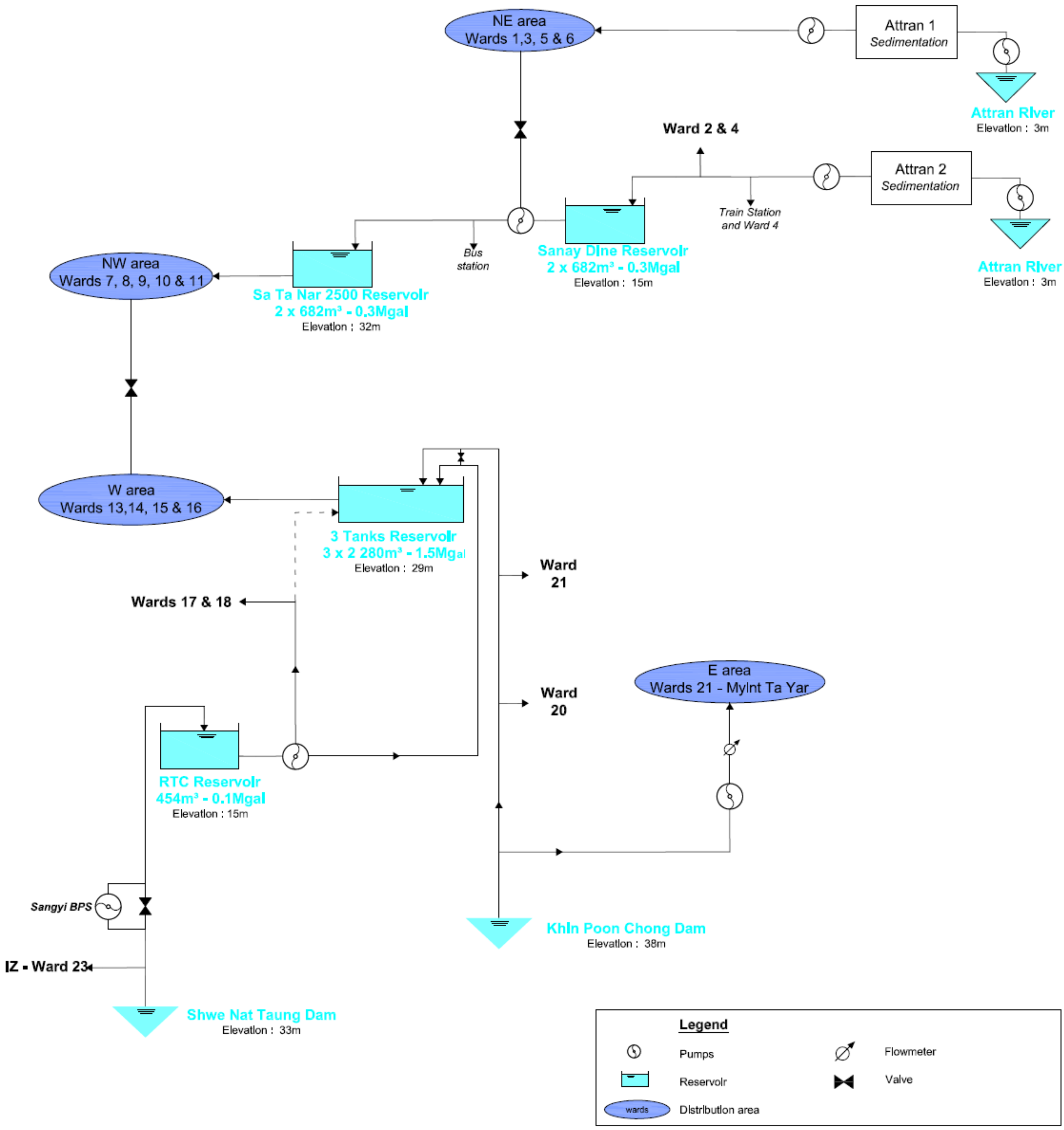
KEY FIGURES

- Service area coverage : about 14 km²
- 26% of the population covered with piped water
- Unsteady functioning with intermittent supply for some areas
- About 50 000 people supplied with nearly 9 250 installed water meters
- 2 reservoirs : KhinPonChong and Shwe Nat Taung
- 2 Treatment plants and intakes on the Attran River
- Amount of supplied water : ~ 25 000 to 30 000 m3/d
- 107 Km pipe lines : -
  - Transmission& distribution mains: 16 km
  - Internal network :91 km
- 4 storage : RTC, 3 tanks Reservoir, SanayDine and SaTaNar
- 3 booster pumping stations : RTC, SanayDine and Maing Tha Yar
- 10 000 m^3 storage => 8 to 10 hours autonomy of current production
- NRW : >80**%** (estimation including commercial losses)
- No treatment apart from sedimentation process

DESCRIPTION OF THE SYSTEM

The figure below summarizes the functioning of the existing water supply system and distribution areas. In addition, description of the existing facilities is presented in Water Supply Appendix 1.3, together with additional information of the existing system (functioning hours, quality analysis from TDC…)

Figure 3-6: Flow diagram of the existing system



ANALYSIS OF THE SYSTEM

The main conclusions regarding the water supply system in Mawlamyine as included in the complementary modelling report (Water Supply Appendix 2) are as follows:

- **Production & treatment**: None of the existing facilities treat the water apart from natural sedimentation process. Hence, only raw water is distributed with regular presence of bacteria. The age of some facilities, limited capacity and lack of maintenance limit their use in the immediate future. The existing dams are a major asset since they benefit from a significant elevation and good water quality. Water from the dam has the advantage to have a low turbidity throughout the year compared to the Attran river sources.

- **Transmission & Storage**: some transmission lines, especially from KhinPonChong Dam, are in very bad condition due to their age (nearly 100 years) and material (grey cast iron). In addition, many of these lines are now under-sized in relation to increasing demand of the service area. Hence, rehabilitation as well as strengthening shall be undertaken to ensure the transfer of future water production.

Concerning the storage and focusing on the southern area in connection with the project's boundaries two reservoirs exist:

- RTC reservoir presents a limited capacity, leakages and overflow as indicated by the measurement campaign. Accordingly, the rehabilitation of this key facility shall be considered, as well as the rehabilitation and resizing of the pumps.
- 3 tanks reservoir is a strategic facility located close to the downtown area and functioning under gravity. Available storage capacity is considerable with 1.5 Mgal (~ 6 800m^3). Separation into 3 different tanks allows higher flexibility. However, due to its age (nearly 80 years old), the reservoir should be rehabilitated and secured. Existing connexions appear to be also in bad conditions because of the age of the installation and lack of maintenance.

In the northern area two tanks are used to distribute the water from the Attran River. Attran 2 supplies the tank of SanayDine, from which water is pumped to the distribution system (North West Area) and to the second storage of SaTaNar. This second tank is operating under gravity condition to supply the northern part of the downtown area.

Table 3-2 : Reservoirs' description

	Volume (m3)	Description	Elevation (m)	Distribution Area
3 tanks	6 820	3 similar square ground tanks	29	Wards 13 to 16
RTC	450	Ground tank	15	Wards 17&18 and 3 tanks
SanayDine	1365	2 similar ground tanks	15	Wards 1 to 6 (with Attran 1&2)
SaTaNar	1365	2 similar ground tanks	32	Wards 7 to 11
TOTAL	**10 000**	-	-	-

- **Distribution:** Existing distribution network represents a total length of nearly 90km with the oldest cast iron pipes laid almost 100 years ago in the downtown area. Presently, the number of connections estimated to be around 9 250, mainly equipped with poor quality water meters with questionable accuracy. The coverage for the urban area is quoted as only 27%. Clearly rehabilitation of the existing network is necessary together with improvement of service coverage.

Table 3-3 : Length of network

Length (km)	Ø < 80	Ø 80	Ø 100	Ø 150	Ø 200	Ø 250	Ø 300	Ø 400	Total
Transmission lines	-	-	-	-	-	-	10.7	5.3	**16**
Distribution lines	1.9	18.1	15.9	21.4	17.6	7.1	8.9	-	**90.9**
Total	**1.9**	**18.1**	**15.9**	**21.4**	**17.6**	**7.1**	**19.6**	**5.3**	**106.8**

- **Operation and management**: limited human and technical resources have been identified. As a consequence, a lack of planning is noticeable as well as the absence of NRW management. Indeed, both commercial and physical losses are high, with a total amount of NRW estimated at over 70%. Specific focus on NRW is presented in the following chapter. In addition, limited capacity does not allow a sufficient maintenance and operating of the facilities.

3.2.3 FOCUS ON NRW

NRW IN MAWLAMYINE

Based on available data and measurements a tentative water balance has been established during the study. Accuracy of the analysis remains highly limited due to the lack of accessible data of the system and some assumptions were necessary to perform the water balance. Nevertheless, it is clear that the amount of NRW is extremely high with a large share of real/physical losses.

Table 3-4: Tentative water balance for Mawlamyine

<table>
<tr><td rowspan="7">System Input Volume
30 000 m^3/d</td><td rowspan="4">Authorized Consumption
7 931 m^3/d</td><td rowspan="2">Billed Authorized Consumption
2 931 m^3/d</td><td>Billed Metered Consumption
2 580 m^3/d</td><td rowspan="2">Revenue Water
2 931 m^3/d
10%</td></tr>
<tr><td>Billed Unmetered Consumption
381 m^3/d</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
5 000 m^3/d</td><td>Unbilled Metered Consumption
0 m^3/d</td><td rowspan="5">Non – Revenue Water
27 069 m^3/d
90%</td></tr>
<tr><td>Unbilled Unmetered Consumption
5 000 m^3/d</td></tr>
<tr><td rowspan="3">Water Losses
22 069 m^3/d</td><td rowspan="2">Commercial losses
800 m^3/d</td><td>Unauthorized Consumption
500 m^3/d</td></tr>
<tr><td>Customer metering inaccuracies
300 m^3/d</td></tr>
<tr><td>Physical losses
21 269 m^3/d</td><td>Leakage on mains
Leakage and overflows at storages
Leakage on services connections up to the customer metering</td></tr>
</table>

The level of billed consumption or revenue water is very low. Unbilled authorized consumption cannot be defined precisely but is estimated to be high with a large use of "free water" for institution, monasteries and administrative buildings. Besides, commercial is likely to be significant due to the oldness and poor quality of water meters and possible billing errors in absence of proper customer data base.

On the basis of these estimates the tentative leakage index is estimated at 253 m3/d/km or 2900 l/day/connection. These figures confirm a very high level of NRW. Translating them using the chart below and giving the low pressure of the system, it can be appreciated that the system is in Category D corresponding to "Very inefficient use of resources" there is clearly therefore significant further room for improvement to bring losses down to around 150-200 l/connection/day, thereby liberating a precious amount of water of spare production capacity.

Figure 3-7: Categorization of Water Company Performance in terms of NRW

Technical Performance Category		ILI	Real Losses in Litres/Connection/Day (when the system is pressurised); at an average pressure of:				
			10 m	20 m	30 m	40 m	50 m
Developed Countries	A	1 - 2		< 50	< 75	< 100	< 125
	B	2 - 4		50 - 100	75 - 150	100 - 200	125 - 250
	C	4 - 8		100 - 200	150 - 300	200 - 400	250 - 500
	D	> 8		> 200	> 300	> 400	> 500
Developing Countries	A	1 - 4	< 50	< 100	< 150	< 200	< 250
	B	4 - 8	50 – 100	100 - 200	150 - 300	200 - 400	250 - 500
	C	8 - 16	100 - 200	200 - 400	300 - 600	400 - 800	500 - 1000
	D	> 16	> 200	> 400	> 600	> 800	> 1000

A Further loss reduction may be uneconomic unless there are shortages

B Possibilities for further improvement

C Poor leakage management, tolerable only if resources are plentiful and cheap

D Very inefficient use of resources, indicative of poor maintenance and system condition in general

Source: World Bank Institute NRW Training Module 6: performance Indicators

3.2.4 OTHER PROJECTS

JICA PROJECT: PHASE 1 & 2

JICA's project is part of an overall JICA loan agreement with the Union of Myanmar covering several towns, including Mawlamyine. This project in Mawlamyine is proposed to include 2 phases. This paragraph describes the scope of work based on available data and documents.

First phase of the project consists in a 1M US$ loan which aims to increase the production capacity. This project is supposed to include two main components:

- Creation of a new production facility near ShweNatTaung dam which outflow is set at 3.12 Mgal/d (~ 14 000m3/d) using Slow Sand Filter Process. This project consists in intake structure from ShweNatTaung Dam, the WTP using slow sand filters and the associated storage.
- Implementation of a transmission line from RTC to 3 Tanks Reservoir: it is proposed to lay a 300mm pipe (PVC) between the two facilities.

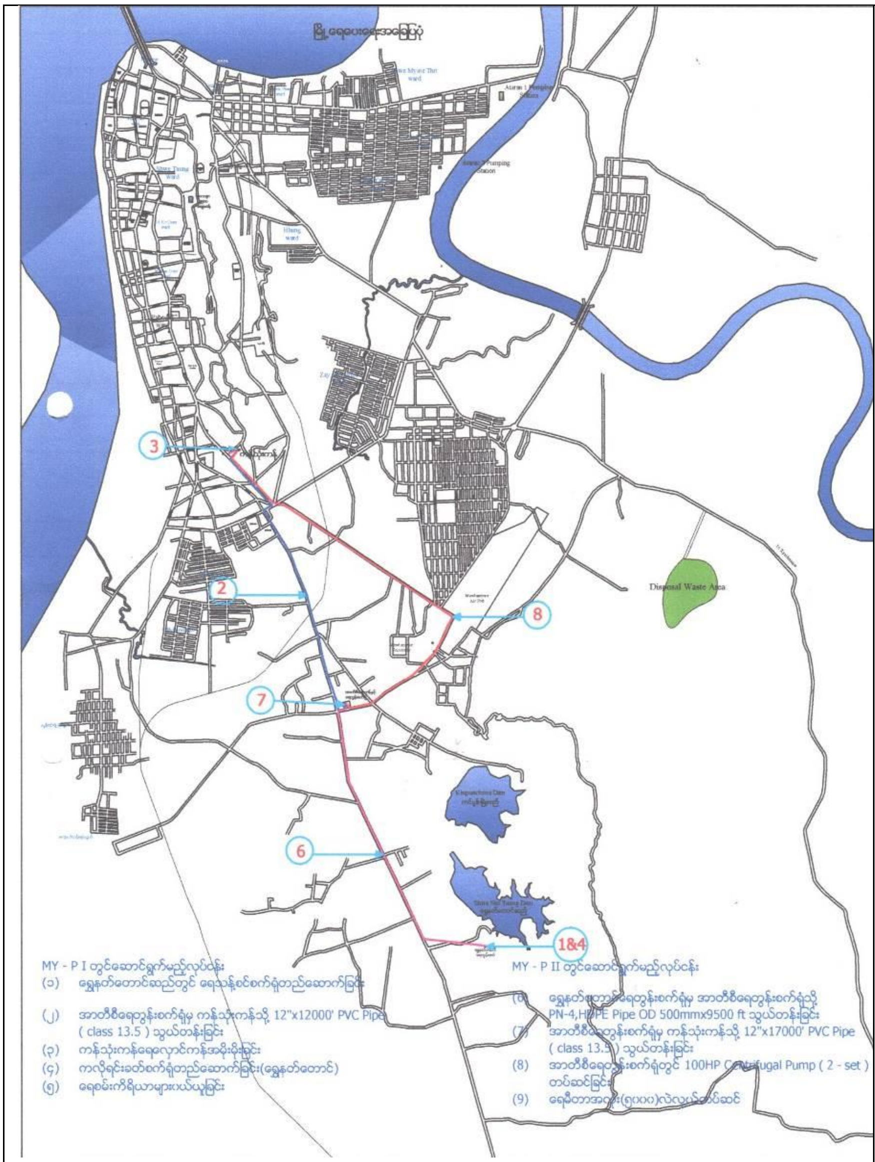
Besides some rehabilitation works of 3 tanks reservoir are also planned, including the construction of a roof.

In addition, a second phase is planned by JICA which is supposed to complement the functioning of ShweNatTaung system (the following components are currently under discussion between TDC, DUHD and JICA, and have not been approved yet):

- Implementation of a transmission line from SNT to RTC Reservoir: it is proposed to lay a 400mm pipe between the two facilities.
- Renewal of RTC pumping station and reservoir and extension of the storage
- Installation of 5 000 water meters
- Implementation of an additional pipeline from RTC to 3 tanks Reservoir: it is proposed to lay a 300mm pipe between the two facilities.
- Main distribution line for RTC distribution area (250mm) to wards 17 &18

Consequently, the overall project would cover the entire system from SNT and provide up to 14 200m3/d to the western part of the city, including 3 tanks reservoir. Overall scope of the project has been summarized in the following map (source TDC). However, it has to be noticed that at this stage, final scope of Phase 2 has not been approved yet.

Figure 3-8: Components of proposed JICA's project – phase 1 & 2 *(source TDC)*



PHASE 1

1. SNT Water Treatment Plant & Reservoir.
2. Transmission line from RTC to 3 Tanks
3. Construction of a Roof at 3 tanks reservoir.
4. Chlorination plant
5. Equipment

PHASE 2

6. Transmission line from SNT to RTC
7. Renewal of RTC BPS
8. Transmission line from RTC to 3 tanks
9. Renewal of 5000 water meters

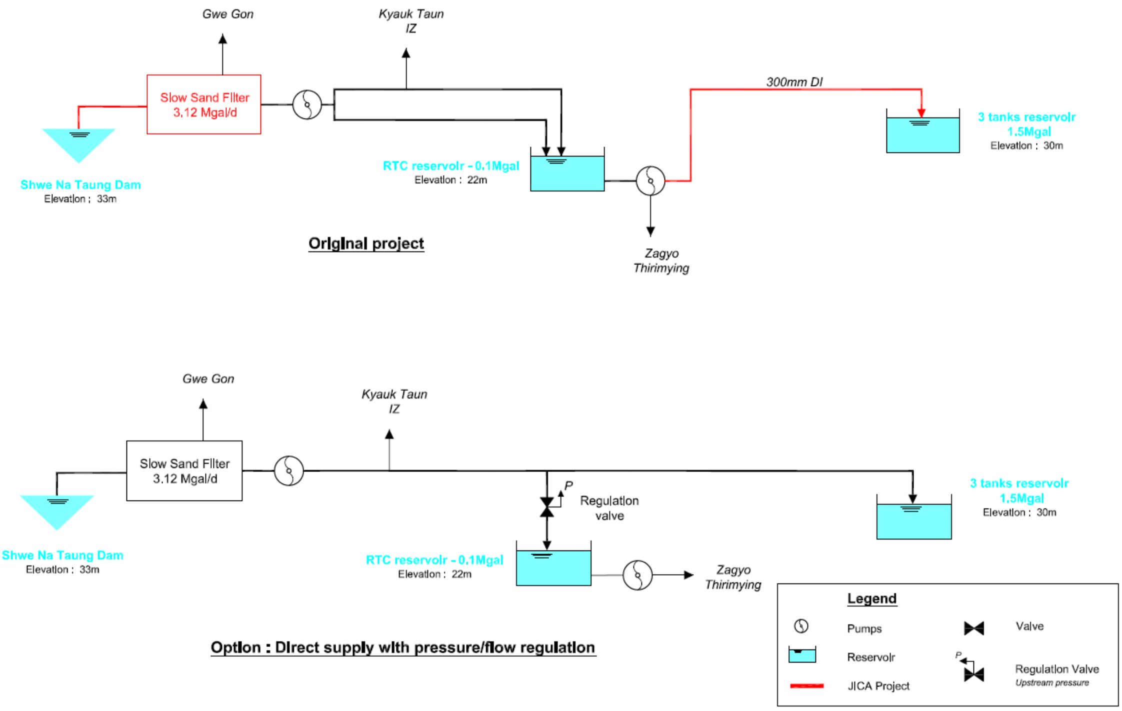
In addition, it is proposed to install a main distribution line (250mm) from RTC to wards 17&18.

Comments : *While reviewing the design associated with these projects few comments have been made to ensure the overall consistence and adequacy since the systems as a whole need to function together. All components of the proposed project are necessary and consideration of the ShweNatTaung system as a whole is fundamental.*

Firstly it is clear that proposed theoretical production of 14 200 m3/d (or 3.12 Mgal/d) is necessary to cope with the water demand. Treatment process relies on slow sand filtration which appear to be adequate but questionable in some aspects (high capital expenditure, land requirements, specific operating…). Considering a usual velocity in the filter of 0.2 m/h and 20h/d functioning, production volume would require a filtration surface not less than 3 500m² or 0.85acre (while available documents suggest an filtration surface of 8 filters x 21 m x 14 m = 2350 m², notwithstanding the fact that 2 of the 8 filters are assumed to be spare ones). It is also reminded that slow sand filtration is a specific biological treatment which needs a skillful operating different from rapid sand filtration (which operation is usually assisted by automatic devices). Regarding the chlorination process, use of similar process for all treatment facility would ease the overall operation of the system and procurement of chemicals. Besides, it is noticed that the issue of low mineralization of the raw water is not addressed in the design.

Regarding the distribution, it seems consistent to have different independent distribution areas used as DMAs (as explained hereafter and presented on Figure 3-11), including one for each following areas: ShweNatTaung, RTC and 3 tanks. Under this consideration, storage and pumping infrastructure should be designed accordingly. Indeed, water would then be directly distributed to the surrounding area of ShweNatTaung from the new WTP facility which would require sufficient storage for both transfer to RTC and 3 tanks, and distribution. Accordingly, a storage capacity of nearly 4 000m^3 would appear adequate (approximately 25% of the daily production capacity). Actual capacity of the storage currently under construction appears much lower.

Besides, transmission system from ShweNatTaung to RTC and 3 tanks reservoirs is a key components. Current plan would supply from WTP to RTC from which water would be transferred again to 3 tanks. Opportunity to have a direct supply from WTP to 3 tanks with a connection to RTC (equipped with a regulation system) would lower energy consumption (only one pumping) and reduce the pressure on RTC which storage capacity is highly limited. The following flow diagrams describes both functioning:



Water Supply project Mawlamyine - JICA's Proposal

The proposed ADB project described hereafter will need to function in a complementary manner to the one financed by JICA. The scope of works of the two projects has been studied in details to prevent from overlapping. In particular, ShweNatTaung system (production, storage and transmission) will be under JICA's project whereas ADB project will include the distribution (network and connections).

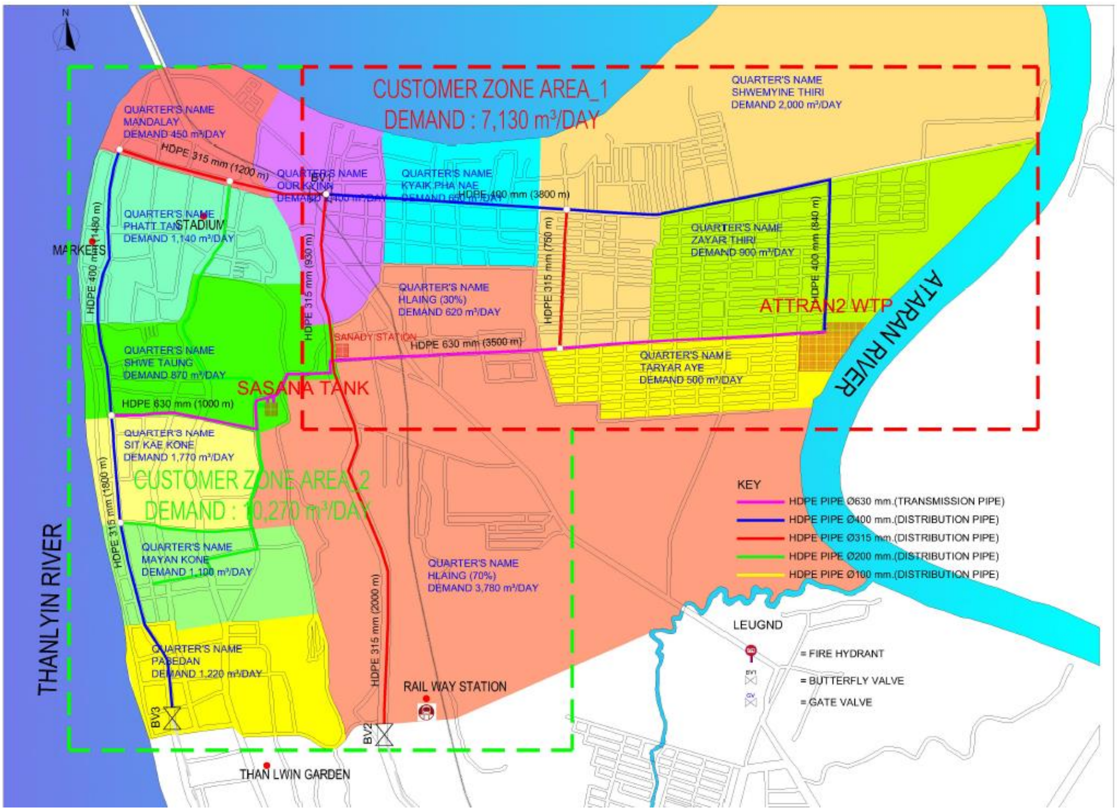
PPP PROJECT WITH THAI TAP WATER COMPANY (TTW)

A PPP project from Thai Tap Water Company is currently being studied. This projects aims to construct a new WTP in the North-Eastern part of the city and replace existing facilities Attran 1&2. The project area would cover the 12 northern wards of Mawlamyine (see figure Figure 3-9).

The proposed project includes:

- Construction of a WTP using rapid sand filter process together with clarifiers and chlorination. Overall capacity is proposed to be 30 000m3/d with expandable structure to reach 40 000m3/d.
- Clear water tank (3000m3) and BPS at the WTP
- Main transmission and distribution lines
- Additional storage (2000m3) for the western area

Figure 3-9: Project area of PPP project from Thai Tap Water Company *(source: TTWC)*



The proposed treatment process would consist in rapid sand filtration with a pre-treatment using clarifiers (pre-chlorination, coagulation/flocculation) and a final chlorination. This process is assumed to comply with WHO standard.

It has to be noticed that none internal distribution network neither connection are included in this project and NRW is expected to be 50%. Hence water sales are estimated to be nearly 15 000m3/d in the covered area. Consequently, volume of production is rather high with 30 000m^3/d.

Considering this PPP and under the current circumstances, it is assumed that the northern part of the city (wards 1 to 12) are covered by the PPP and is not part of the project area. Nevertheless, an alternative scenario is presented hereafter covering the eventuality where an agreement would not be reached and the PPP not push through.

leading to the definition of a water supply project.

3.2.5 WATER SUPPLY STRATEGY

The water supply project of Mawlamyine meets the following targets:

- **<u>Increase water coverage : *"Water for All"*</u>**

One of the main objectives of the project is to increase the service coverage of the water supply system in the project area together with the production. Alongside of this project, this water coverage is supposed to be completed by the PPP project for the Northern part of the city, supplying treated water from the Attran River.

The objective is to connect 75% of the urban population in short term by the end of the project. As assumed to complete the water coverage in long term (2040), it is proposed to consider 95 % of coverage for the city. At that time, almost all the population living in the urban area will be connected to the network.

According to the following table and calculation and considering the project area only, the estimated impacts of the project are following looking at population to be served by the network for the two main horizons:

- **By 2020: Nearly 120 000 inhabitants in the project area, that is to say 95 000 more than current situation with more than 19 000 expected new connections.**
- **By 2040: over 240 000 inhabitants within the urban area.**

- **<u>Continuous service : 24/7 water supply</u>**

As previously described in the diagnosis phases, the level of service is unequal in the city. Most inhabitants are supplied only few hours per day. The target is to reach a good level of service for all the citizens of Mawlamyine: a continuous water service, 24h/d and 7d/week together with an appropriate monitoring system. Besides continuous supply and pressurized network is a prerequisite to enable satisfactory water quality and prevent pollution in the network.

Reduction of NRW through the definition and application of an action plan is also a necessity to improve the quality service. It will also have an impact on the financial sustainability of the system limiting expenditures (CAPEX and OPEX) and increasing incomes.

- **Improve water quality**

A continuous service would not be completely efficient without improvement in water quality. The project proposal aims to ensure good water quality everywhere in the network from the production to the consumers' taps. Using existing assets, in particular the reservoirs, water can be easily treated and distributed. Improvements of the water quality are also highly necessary to improve public health and limit waterborne diseases. Treated water must comply with WHO and upcoming national standards in terms of quality. The table below shows objectives on treated water quality.

Table 3-5: water quality objectives

Parameters	National drinking water standard	WHO drinking water standard	Treatment objectives
Turbidity	5 NFU	< 5 NFU**	1 NFU
pH	6.5 - 8.5	6.5 - 9.5	6.5 - 8.5
Iron	1 mg/l	0,3 mg/l**	0.2 mg/l
Aluminium	-	0.2 mg/l	0.2 mg/l
Ammonia	0.02 mg/l	-	0.1 mg/l
Chlorine	2 - 10 mg/l	-	1 - 2 mg/l
E. Coli	-	0 (99%)**	0 /100 ml
Parasites*	-	-	0 /100 ml

* Gardia and Cryptosporidium ** Expected

- **Enhance resilience and sustainability of the system**

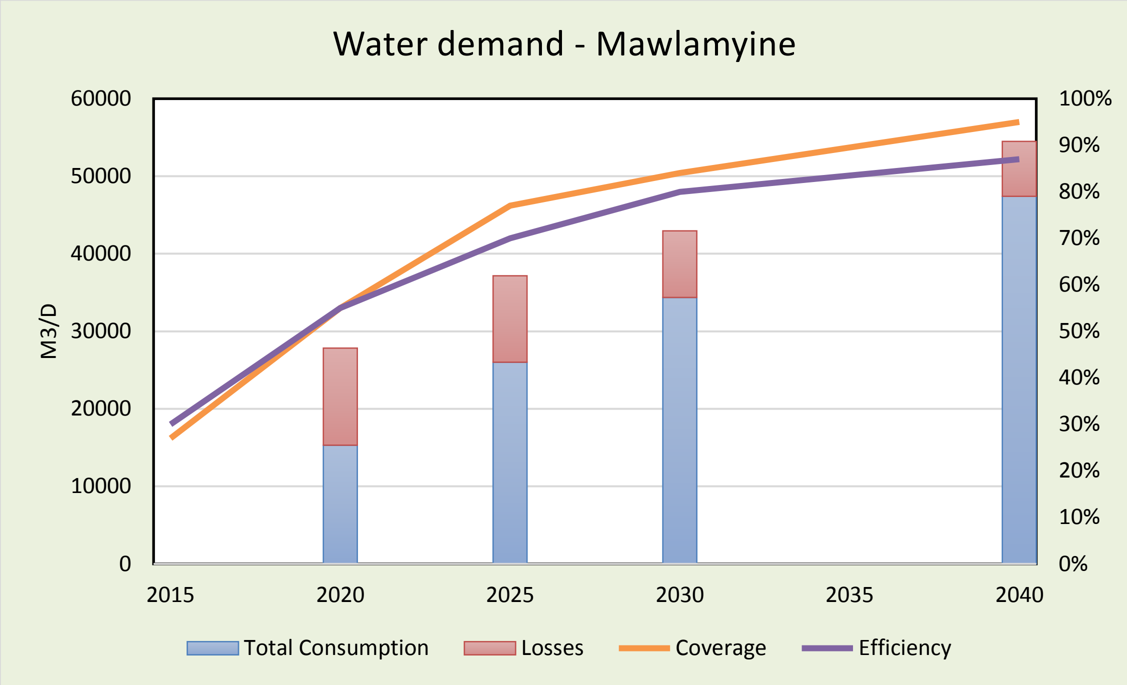
Based on existing assets, the strategy is to improve the current system with a stepwise modernization and reinforcement of the capacities. From a technical point of view the strategy is to build upon existing system with reinforcement and rehabilitation of existing assets together with new infrastructure. Furthermore improvement of the management and system will only come with a specific capacity building plan focusing on people, and with a financial strategy leading toward long term sustainability and development.

3.2.6 FUTURE REQUIREMENTS

The requirements for future water supply provision are based upon the concept plans developed by DUHD which the population is set to grow at around 2.0% per annum reaching almost 360,000 by 2025 and 485,000 by 2040. On the basis of these plans and projections, water demand for future horizons up to 2040 has been estimated covering the urban area and surrounding villages.

The projections as included in the FSR indicate a requirement of approximately 37,000 m3/day for the urban area by 2025. This would increase to almost 55,000 m3/day in the long term (2040). The way that water consumption is planned to increase together with service coverage and overall system efficiency (reduction of physical losses) is shown in **Figure 3-10**.

Figure 3-10: Mawlamyine Water Supply and Demand to 2040



Looking at the entire city and as indicated above, water supply coverage from the TDC system is planned to increase from 27% to 77% in the short term (focusing firstly on the urban area) and up to 95% in the long term. Connections will increase to 47,000 by 2025 and 86,000 by 2040. Population served will increase to almost 235,000 in the short term and 430,000 in the long term considering the accessible villages surrounding the urban area to be connected in long term. In addition water supplies will all be treated and provided continuously (i.e. 24/7 supplies).

3.2.7 OPTION ANALYSIS

The previous analysis confirmed the need for large increases in production capacity, treatment facilities (currently inexistent) and associated networks to improve service coverage in water supply together with improved operational and financial management.

As part of the interim report, two options were studied consisting of providing water supply from primarily the existing reservoirs and secondly from a combination of the reservoirs and the Attran resource. As a result of the different technical-economic analysis undertaken it was shown that separate systems for each service area was the most economic option. Indeed, the existing dams are a major asset since they benefit from a significant elevation and good water quality; water from the dam has the advantage to have a low turbidity throughout the year compared to the Attran river sources. Implementation of new production facilities able to treat water from these resources would enable to fulfil the short and medium term requirements for Mawlamyine considering the southern part of the city.

In addition, during the Interim and Final phases of the assignment further details of two associated projects presented above have been obtained allowing to refine the Project and ensure their consistency and complementarity. Consequently, it is assumed that JICA project will cover the entire production and transmission line from Shwe Nat Taung to 3 tanks reservoir, including RTC reservoir while PPP is supposed to cover the Northern part of the city (wards 1 to 12), as summarized in Figure 3-11. As mentioned previously, JICA project for Mawlamyine city includes the implementation of a new water treatment plant at ShweNatTaung dam. Theoretical capacity is supposed to be 3.12 Mgal/d, that is to say 14 200 m3/d, with possibilities for further extensions. Considering future water demand spatial distribution, implementation of this facility is highly necessary to fulfil the water need.

Further analysis of the proposed Project during the final phase of this assignment focused on the identification of an appropriate site for the intake and treatment plant at KhinPonChong and the preliminary design of the network facilities. In accordance with resource analysis, SWOT analysis and previous conclusions, it is proposed the creation of a new water treatment plant with a nominal capacity of 8 000m3/d (16h/day functioning). Capacity has been set according to the hydrological analysis of KhinPonChong. Together with ShweNatTaung system, this capacity will fulfill the water need within the project area. It has to be noticed that rehabilitation of the dam is also necessary, including measure to reduce water losses from the dam, secure and optimize the storage capacity. Produced water from KhinPonChong will supply the same areas as existing conditions plus future extensions under this project towards the Eastern part of the city.

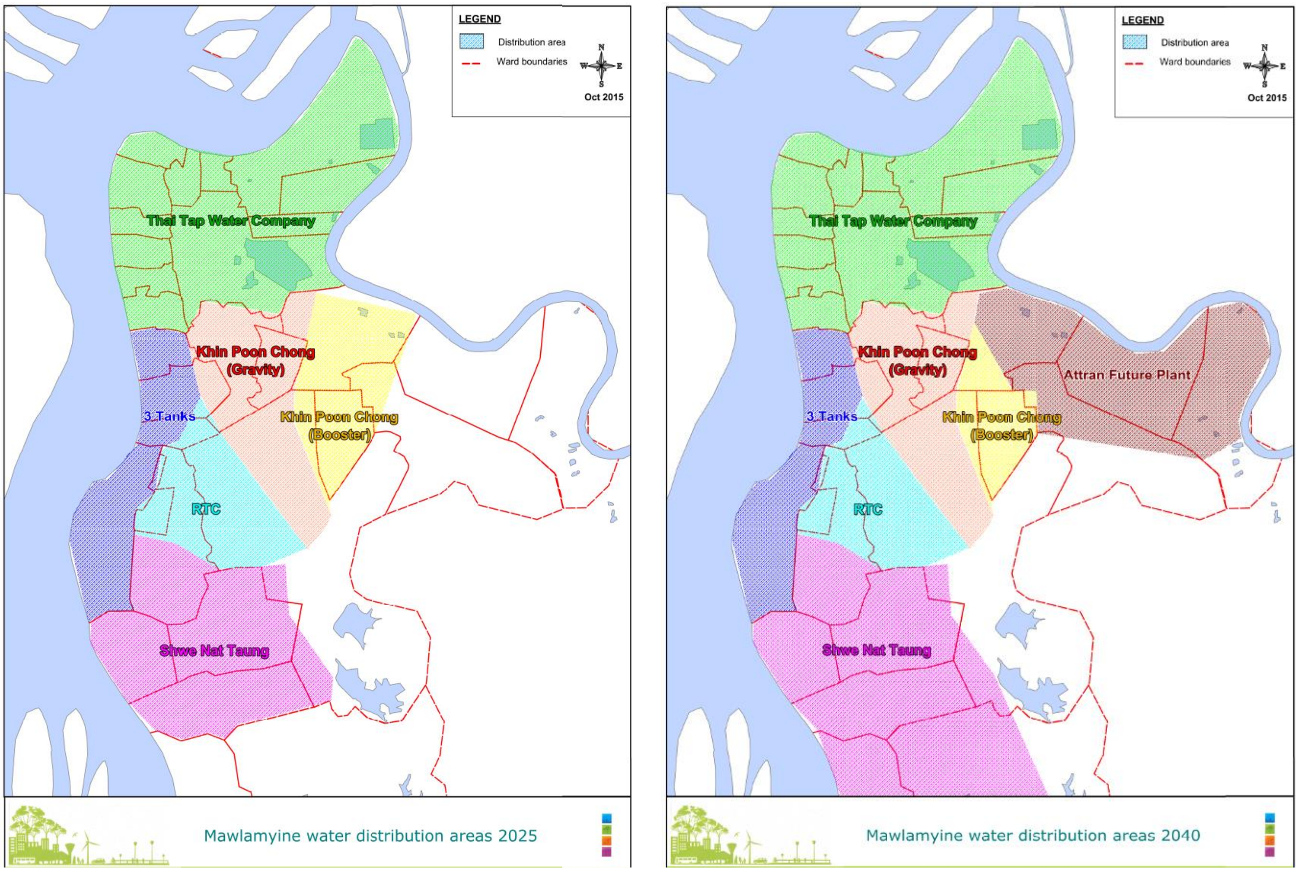
An upgrade of the storage facilities appears necessary in order to increase the autonomy of the system and to promote water supply under gravity thereby saving on operating cost. As an initial approach it is advised a minimum storage capacity of half day per distribution area or system. Consequently, sufficient storage shall be implemented at KhinPonChong. Besides, existing 3 tank reservoir presents a significant storage capacity with a strategic location allowing gravity distribution to the city center. It is proposed to keep the functioning of this key system which need to be secured and rehabilitated. This storage could be supplied from both KhinPonChong and Shwe Nat Taung systems for a higher flexibility and security purpose. Consequently two inflows will be made available according to water needs and distribution across the system: gravity flow from KhinPonChong and transfer from ShweNatTaung (BPS).

To distribute the treated water and extend the coverage, a large amount of pipe will have to be newly installed, whereas existing network will have to be rehabilitated and strengthened to ensure reliable supply in the covered areas. Installation of the internal distribution system remains in the scope of ADB project for the entire project area.

Apart from TTW area (outside project perimeter), 5 distribution areas can be identified, each of them can be easily metered as part of NRW strategy. The distribution strategy is based on the existing functioning. Among them: two are only supplied from KhinPonChong, two other from ShweNatTaung whereas both resources can supply 3 tanks area. Looking at longer term and requirements, the development of the Eastern zone will require a new distribution area which resource could be the Attran River. Whereas Shwe Nat Taung system will cover the West Southern development and extension. Related distribution areas can be identified in the figure below. In addition, interconnections between the systems would secure the overall functioning and ensure higher flexibility of the system (ex: 3 tanks reservoir shall keep available supply from both dams.

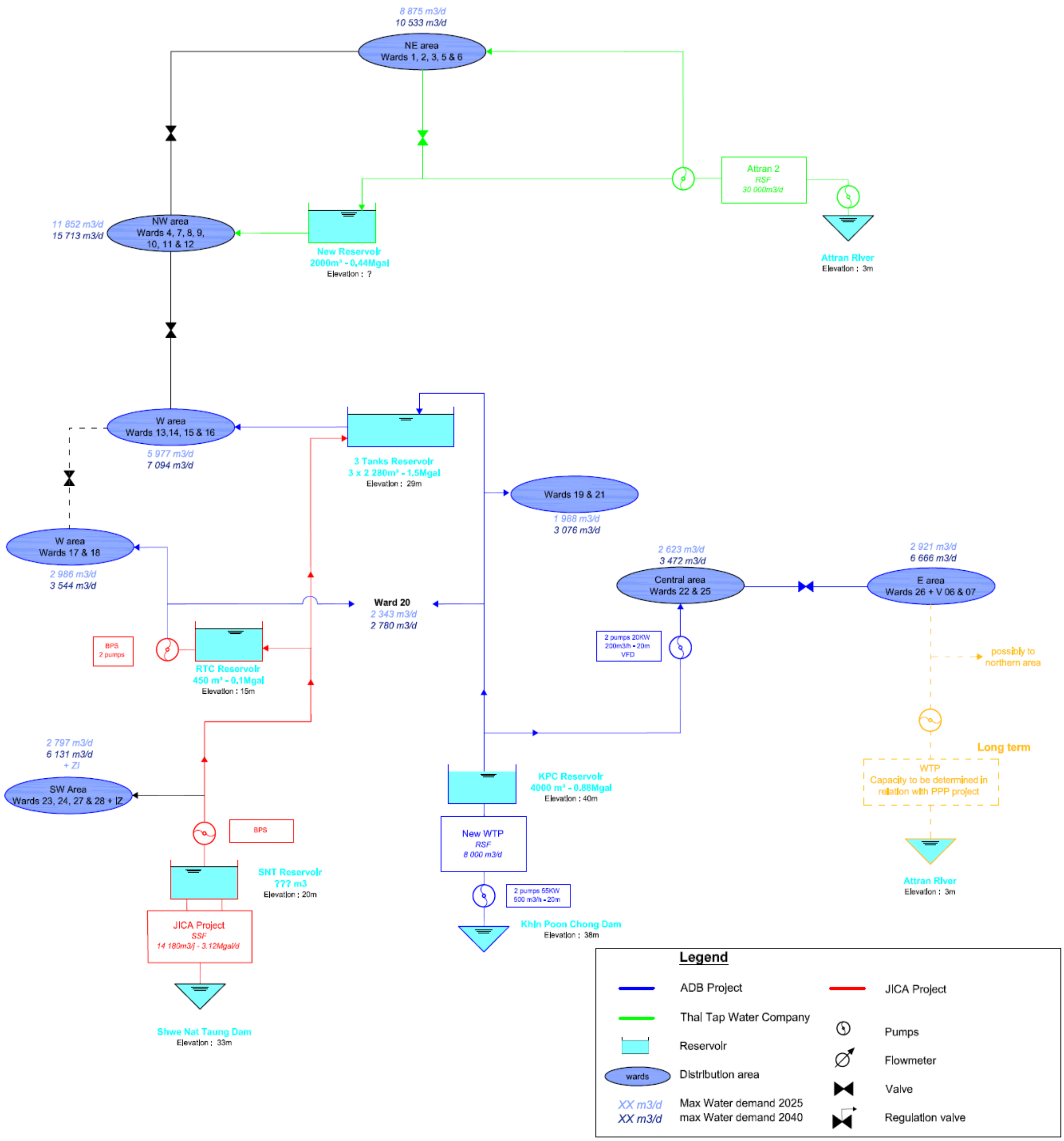
In addition, **reduction of NRW will be one of the focal point regarding both commercial and physical losses.** The objective of the proposed action plan is tackle current high level of NRW and to counterbalance in long term the entropic tendency of the losses to increase. From an existing network efficiency estimated to be 30%, it assumed that efficiency shall raise up to 70% by 2025 and 95% for longer term. Alongside with infrastructure, capacity building and new methodologies shall be implemented to reduce commercial losses in particular regarding the customer management and billing activities. This component shall be supported by the use of modern tools, particularly software & support (GIS, customer & billing management software…).

Figure 3-11: Distribution areas for short and long terms



Summary and repartition of the works of each projects are summarized in the figure below.

Figure 3-12: Mawlamyine project flow diagram



Notes

In case the PPP project is not commissioned, an alternative strategy would need to be implemented to supply the Northern area of Mawlamyine. Considering that availability of surface water from the two reservoirs is limited and would not be sufficient to cover the entire city, it is suggested to use surface water from the Attran River.

Under this consideration, a treatment facility using Rapid Sand filtration in line with the raw water quality would be necessary. Such facility would then be concomitant with long term requirements which suggest a production facility for the South-Western part of the city. Consequently, treatment facility could be constructed in short term and then extended for longer term. Nevertheless, it is strongly recommended to abstract water upstream of the city and potential effluent from the landfill. In addition of potential pollution, this would prevent from salted water intrusions toward Attran river estuary which is likely to increase in connection with climate change. On initial examination, a nearly 20 000m3/d facility would be required to be extended to 30 000m3/d for long term requirements.

Apart from production facility, it would also be necessary to implement new infrastructure building upon existing assets and facilities (SanayDine and SaThaNar tanks). This would include: storage (total 10 000m^3 for half day autonomy) and transmission towards the supplied area, as well as distribution network. Furthermore, in order to reduce NRW and ensure the sustainability of the system, it would also be recommended to apply the same strategy as the project area, implementing a NRW and asset management strategy, including renewal of some existing assets.

3.2.8 PROPOSED PROJECT

In line with previous objectives and strategy the proposed project consists of four major elements as described below.

- Production and treatment
- Increase and secure storage
- Expand distribution system
- Reduce NRW, improved Operation & Management covering asset management, GIS, billing and customer management.

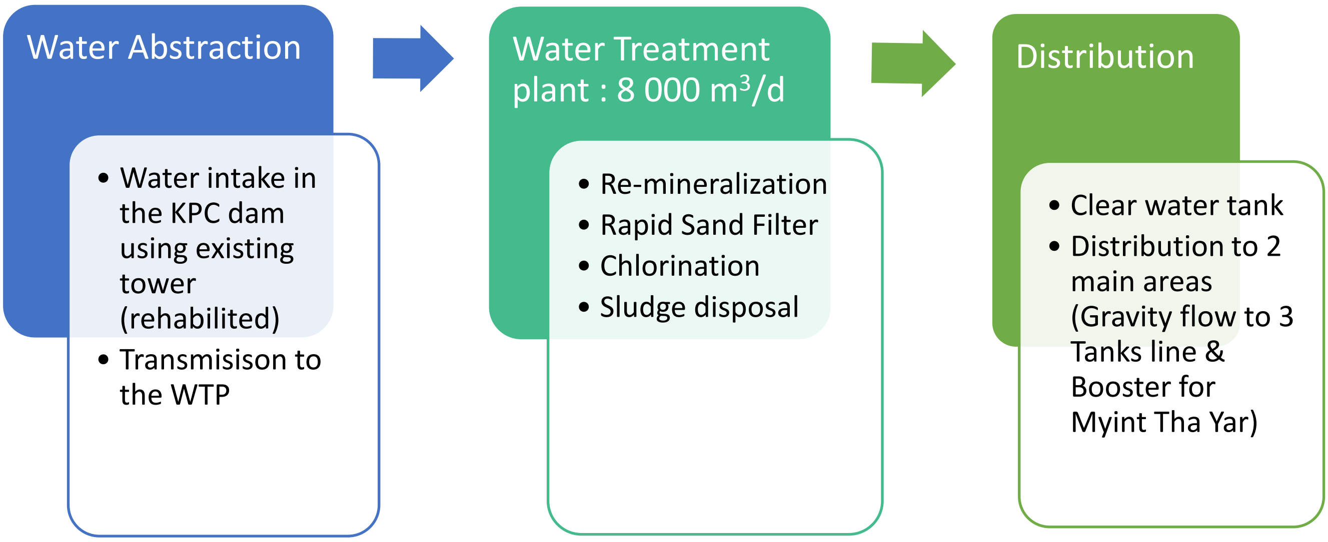
PRODUCTION AND TREATMENT

Increase production capacity is a crucial component to cope with future water demand considering the urban growth. In order to achieve this objective in a sustainable and secured manner, it is proposed to optimize and upgrade existing resources by treating the water thanks to a new water treatment plant at Kin Pong Chong, whereas ShweNatTaung system is under JICA project.

It is firstly proposed to rehabilitate the reservoir of KhinPonChong. Necessary surveys shall be conducted first to gather additional information of the dam (topography, soil analysis…). According to the results, rehabilitation of the dam should include measure to secure the infrastructure, reduce water losses and seepages and optimize the storage.

It is proposed the creation of a new water treatment plant with a nominal capacity of **8 000m3/d** (16h/day functioning). Capacity has been set according to available data regarding the hydrology of the dam considering its rehabilitation. This capacity will fulfil the water need within the dedicated area (average daily need).

Overall functioning is summarized below:



For more details, proposed treatment process consists in:

1. Water abstraction using the existing water tower which need to be rehabilitated. Intake includes the installation of pumps and transmission line to the WTP equipped with a flowmeter and pilot line to control pumps from the treatment site. The transmission line is expected to measure nearly 300 meter long with 400mm diameter pipe.

2. Re-mineralization process as a pre-treatment would be preferable since low mineralization has been identified in KhinPonChong Dam. If confirmed the adopted treatment process would need to consider this parameter in order to prevent the water supply system from possible damages due to aggressive water (corrosion and colored water, possible deterioration of DI pipes, civil work… leading to leakages). Different process could be used is re-mineralization is necessary depending on detailed chemical composition of the water (for instance: injection of CO_2 + lime).

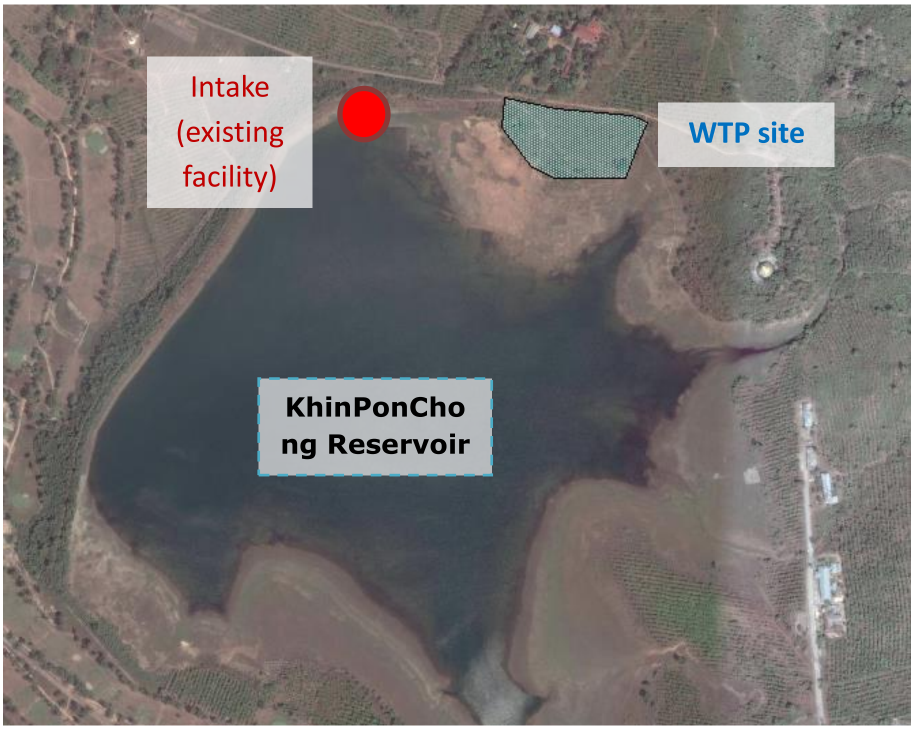
3. Filtration step with a battery of 3 open type gravity sand filters (alternatively pressurized filters could be considered), with the associated backwash, air scour and control facilities. Filters are upstream and constant level type and each of them will be equipped with one independent filter control system (easier operation). Using rapid sand filters, depth of sand shall not be less than 0.9 m (exclusive of all supporting layers). The filter media will be hard grain silica sand, having a NES (Nominal Effective Size) between 0.9 mm and 1.2 mm and a UC (Uniformity Coefficient) below 1.8. An overall filtration surface of nearly 60m² would be necessary (3 x 20m²).

4. Final chlorination into a clear water tank prior to distribution mainly for its microbial disinfection power. Disinfection could be based on different process to produce chlorine with a possibility to have a common production for all WTP (use of chlorine bleach or chlorine gas, or production on site with electro-chlorination…). Chlorine, whether in the form of chlorine gas or sodium hypochlorite, dissolves in water to form hypochlorous acid ($HOCl$) and hypochlorite ion (OCl^-).

5. Transmission under gravity conditions

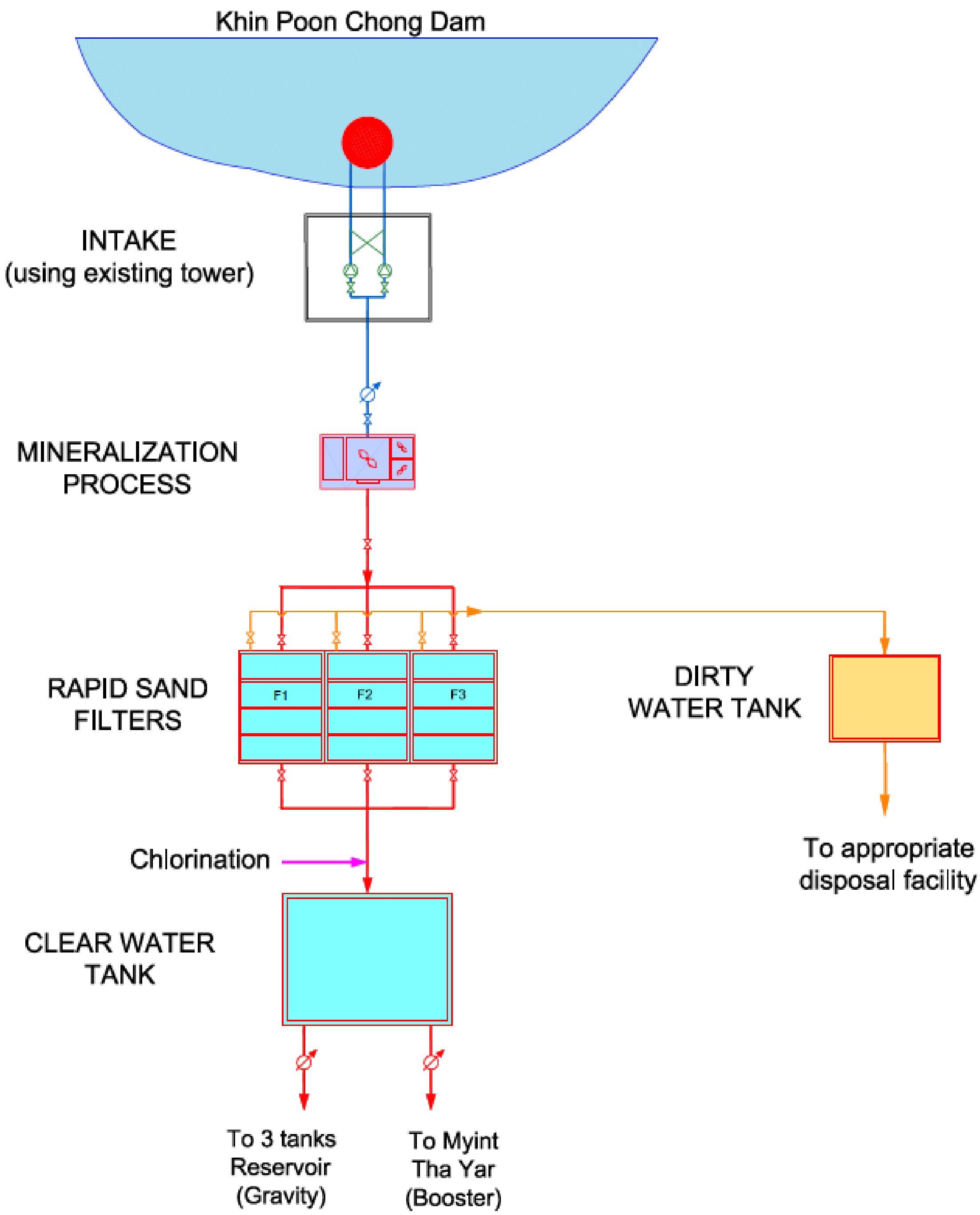
The new facility will also include buildings and annex devices, in particular: operation building, electricity buildings, chlorination plant, air production… In addition, sludge resulting from filters washing will have to be properly disposed. Nevertheless, the amount of sludge is expected to be limited due to the low raw water characteristics.

Figure 3-13 : Site location of WTP



The proposed process is able to ensure an appropriate water quality and relatively easy to operate since it can be assisted and automatic. It is a compact and robust system able to treat a large amount of water in a limited space. In connection with the low turbidity of the raw water, coagulation/flocculation and use of chemicals would not be required. The process diagram below shows the global system which is proposed.

Table 3-6: Mawlamyine KPC system



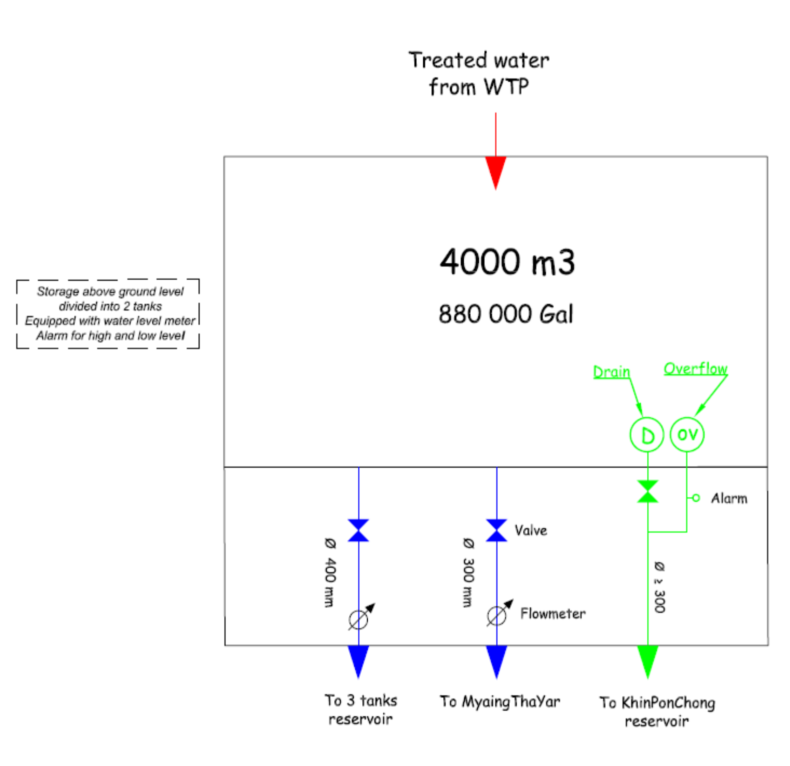
Finally, protection plan will have to be set up introducing protection perimeters and environmental policy around the water resources, in particular the 2 reservoirs. Such plan will serve multiple purposes: prevent pollution, control water usage, centralization of data (hydrologic and climatic information) updating estimates of water resource availability, adoption of an integrated water management approach and possibility to develop action plan for water conservation and promote public information.

STORAGE

In line with previous considerations treated water storage capacity needs to be increased. The following components are proposed to cope with the objectives and requirements:

- Construction of a new reservoir for the new WTP at KhinPonChong with a storage capacity of 4000m3 (i.e. 0.88 Mgal). This capacity corresponds to half of the daily treatment capacity and is necessary to ensure the good functioning of the system under gravity conditions and supply the peak demand. This facility should be constructed next to the WTP and above the ground (elevation > 40m) to enhance gravity flow and prevent under-pressure from groundwater along the dam. To ease operation and regular cleaning, this storage should be divided into two compartmented tanks. Geotechnical analysis on this site will be required for both WTP and storage. Finally, each outlet will be equipped with flowmeter (x2).

Figure 3-14: general layout of KhinPonChong storage



RC 4000m³ storage

Metallic 2500m³ storage

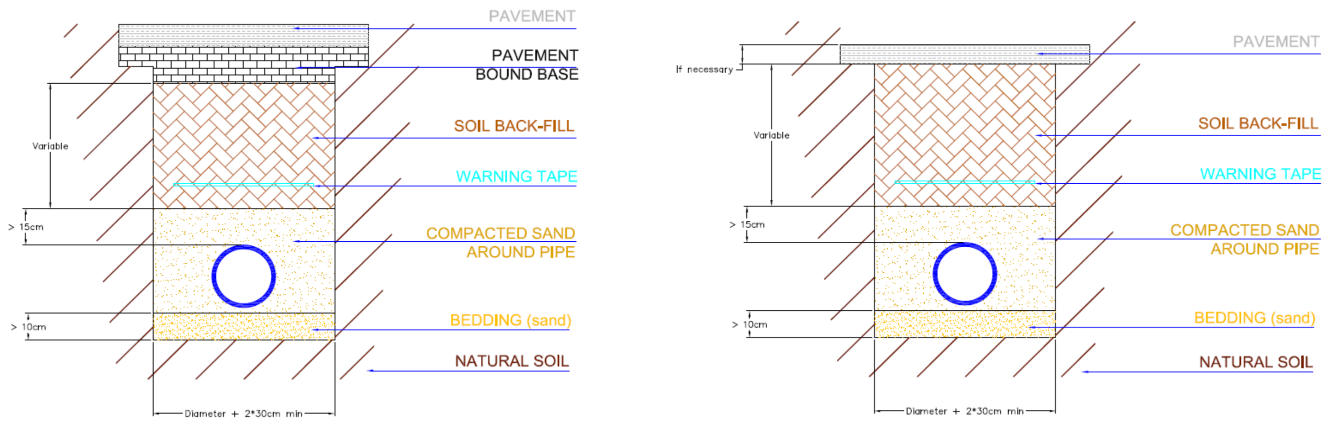
- Rehabilitation of 3 Tanks reservoir which capacity is sufficient in regard with its distribution area (>1 day autonomy) and benefit from sufficient head to supply most of downtown area. Works shall ensure the quality of treated water and secure the facility. It has to be notices that a roof is already under construction at the time of this report production. Hence, it is suggested to improve drainage system, refurbish the tanks and connections (inlets/outlets), secure the site with fences and install measurement equipment (water level sensor, alarm…).

DISTRIBUTION

To distribute treated water and increase water coverage, a large amount of pipeline will be newly installed. The network is organized and structured based on the main distribution lines from which some need to be strengthened or replaced. The outline designs of the proposed networks have been analysed using hydraulic modelling techniques. The results demonstrate that maximum velocities and pressures are acceptable for both the short and long term requirements. Results of this analysis are presented in Water Supply appendix 2.

Pipelines will generally be installed using trench method. A specific care will be given for the installation of pipeline to prevent leakages and premature wear. Consequently, pipeline will be installed according to international standards as presented in the typical trench drawing below. Nature of backfilling can depend on the soil condition and quality. Furthermore, typical drawings for pipe and equipment installation are presented in Water Supply Appendix 1.6.

Figure 3-15: Pipe installation and trench description



Typical trench drawing
National / AH Roads

Typical trench drawing
Secondary Road

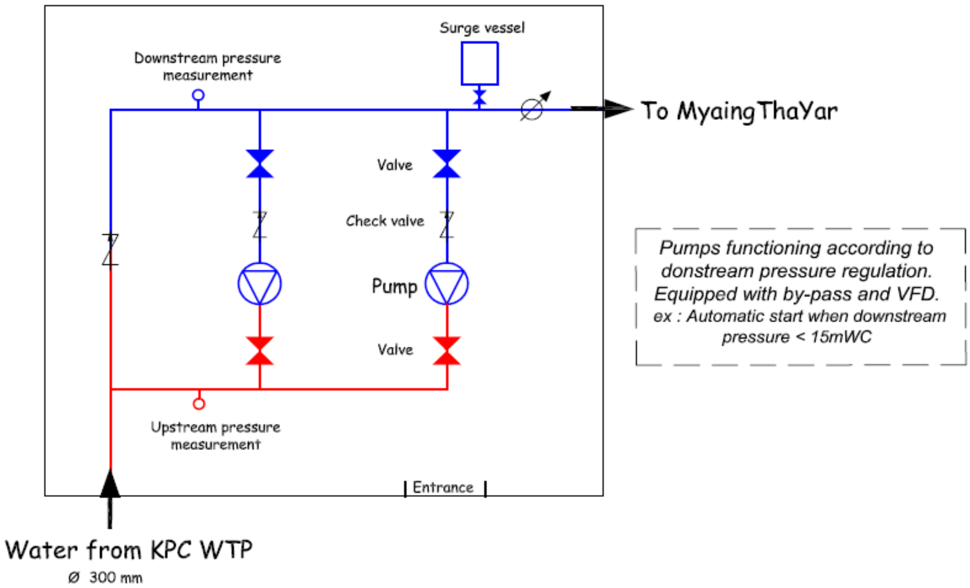
- **Transmission and main distribution**

In order to meet increasing water demands and future extensions, strengthening of both transmission and main distribution pipes and laying of new main distribution lines is proposed. This shall also permit to finally achieve equitable distribution of water supply and to limit head losses. This network will consist of pipelines from 200mm diameter up to 400mm and has been sized based on system modelling looking at medium and long terms requirements. This structural network includes:

- Replacement of old transmission line from KhinPonChong to 3 tanks reservoir. Following the existing route a new 400mm pipeline is proposed. The corresponding longitudinal profile is following:

- Replacement and strengthening of MyaingThaYar main distribution line with a 300mm pipeline. Strengthening of this line will limit the head losses and ensure a suitable supply and pressure to MyaingThaYar ward. Existing BPS may become optional due to higher static head. Nevertheless, it is proposed to include its rehabilitation in the project to have the possibility to increase pressure if necessary, especially during peak demand and/or for medium term. Existing BPS could be rehabilitated implementing a new booster with downstream pressure control (variable frequency drive) and by-pass. In case connections are made upstream of MyaingThaYar (in particular supply to military camp), relocation of the BPS at the production point (next to the tank) could be considered.

Figure 3-16: General layout of MTY BPS



- Some new main distribution lines 200mm to cover the wards #19 to #22.

Proposed total length of new transmission and main distribution network per diameter is as following, location is presented in the summary map below. In regards with the strategic importance of this structural system and local constraints, it is proposed to install ductile iron pipeline.

Table 3-7: Length of transmission and main distribution lines

	200 mm	250 mm	300 mm	400 mm	TOTAL
Length (m)	5 570	0	2 230	5 160	12 960

Besides, some existing main distribution lines recently installed will be used even if some may need to be strengthened for long term requirements. And it has to be reminded that an additional transmission lines will be installed from ShweNatTaung system under JICA project.

- **Internal distribution**

As presented previously, it is proposed to increase the network coverage step by step, based on the population forecasts and future water demand 77% by 2025 and 95% by 2040 (long term). Consequently, the length of internal network to be installed for the project area by 2025 is estimated to be nearly 140km, in addition of existing distribution network (~ 53km) among which many pipes are likely to need renewal. Then, the proposed breakdown of pipe length per size for Mawlamyine is following:

Table 3-8: Length of internal distribution network

Diameter (mm)	≤ 80mm	100 mm	150 mm	200 mm	TOTAL
Breakdown	40%	35%	20%	5%	**100%**
Length (km)	56	49	28	7	**140**

At this stage, for durability and economic considerations, it is proposed to install ductile iron pipeline; alternatively HDPE could be considered for internal network.

Following map is a draft design of tentative future internal distribution network which shall be further detailed during the next steps of the Project:

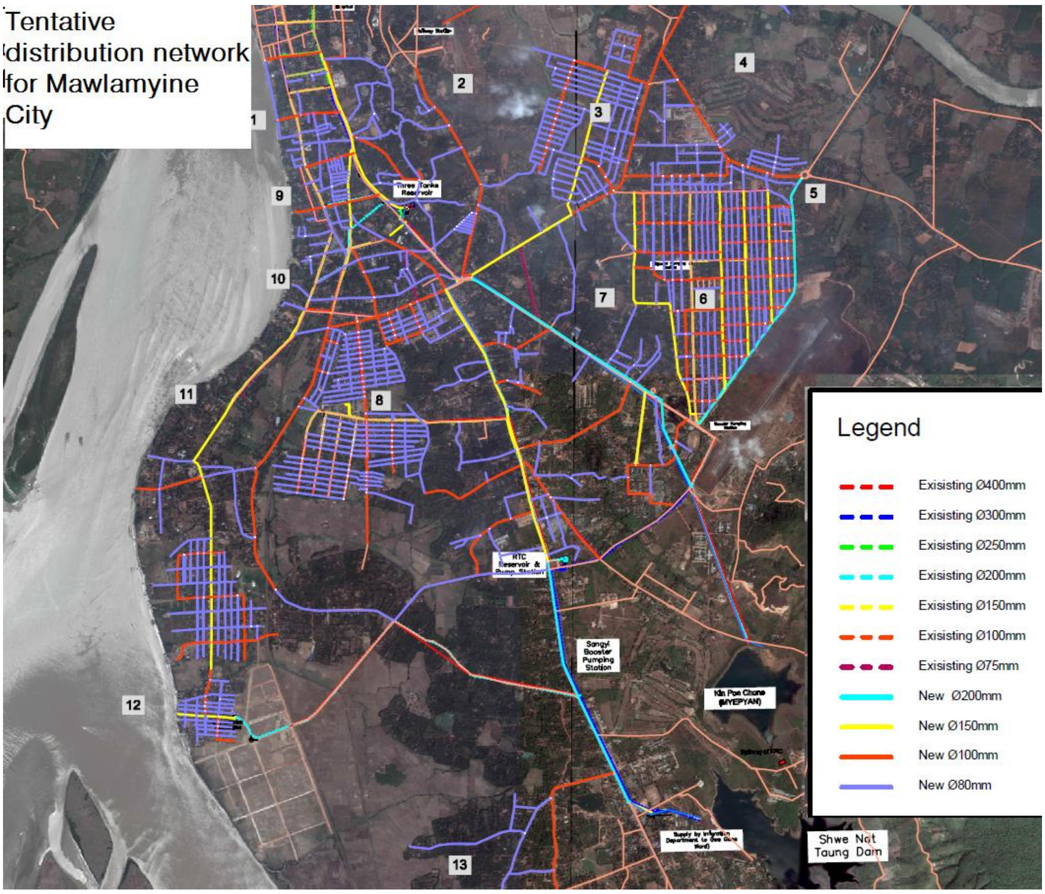


Figure 3-17 : Tentative drawing of Mawlamyine future internal distribution system

Together with the coverage extension and distribution network installation, new connections will be made. The number of new connections is estimated to be nearly 19 160 by 2025 assuming that 24 200 households will be connected in the project area (47 300 for the entire city). New connections shall be implemented according to international standards with a define procedure (material, maximal, length, registration…), and equipped with high quality water meters: certified class B or ideally class C.

NRW STRATEGY

It is proposed to have a full strategy to fight, control and reduce losses, from a macro scale to a household level, according to the objectives presented above. It is based on:

- The quantification of losses,
- The localisation of leakages,
- The proposition to start an asset management plan.

Control of leakages cannot be permanently maintained if leakage detection is not accompanied by an asset management plan. Indeed, part of the network infrastructure is aging since oldest part of the network is nearly 100 years old. Consequently, it is proposed the rehabilitation of 50 % of the existing network in the project area (that is to say around 26 km pipes). This is a first step to implement an asset management plan that must be tracked and used in the future.

3.3 Solid Waste Project

At the moment the waste collection and disposal in Mawlamyine town is inadequate and create health risks, safety risks and environmental hazards for the population. This is an unacceptable situation and unsustainable and therefore needs urgent improvements. Several options have been investigated for implementation of an Integrated Solid Waste Management (ISWM) system.

The proposed new ISWM system for Mawlamyine consists of:

- Improving primary collection system in the town and secondary transport system to the landfill and composting site;
- More Efficient separation and collecting of recyclables e.g. like ferro, plastic bottles, glass, aluminium cans and paper, both through the informal sector and formal sector;
- Introducing source separating organics (SSO) system for diverting large amounts of organic waste to the new planned Composting Plant;
- Upgrading of the existing dumpsite to a Controlled Landfill with bottom liner and leachate collection and treatment.

Above measures are included in the investment plans of the town and proposed for ADB financing.

Table 3-9: Solid Waste sub-components for Mawlamyine

DESCRIPTION	SUBDIVISION	NUMBER TO PURCHASE
Primary Collection		
Small containers 240 ltr in 3 different colours for the three different separation waste streams: for each ward two collection points (28 Wards)	Green colour containers for organics; Blue colour containers for recyclables Yellow colour containers for the reject waste	56 56 56
Aluminium containers 1100 ltr for siting at small size collection points. Two different containers for separating organics and rejected waste. It is assumed that most of the recyclables are already removed by the informal sector	Aluminium container with large text on site: ORGANICS Aluminium container with large text: ONLY REJECTS WASTE Aluminium container with large text: ONLY RECYCLABLES	28 28 28
Transport containers content 3 m3 for collecting with hooklift trucks	Steel containers 3 m3 hook lift system	28
Collection trucks for above containers	Small trucks with lift system for 240 l and 1100 l containers Hook lift Truck for 3m3 steel containers	2 2
Recycling		
Formal sector: Introducing at schools, township offices and other official buildings the separation and recovery of recyclables using 3 different colour containers	recyclables ("dry waste"): 240 l containers Blue compost ("wet waste"): 240 l containers Green reject waste: 240 l containers Yellow	28 28 28
Adding aluminium containers 1,100 l at specific collection Points in town for deposit recyclables by the public	Additional Recycling containers 1100 l, 1 in each ward	28
Adding some extra 3m3 containers in the most populated wards of town	Additional containers 3m3 hook lift system in most populated wards	15

DESCRIPTION	SUBDIVISION	NUMBER TO PURCHASE
Composting		
Construction of a composting plant of 65 tons/day capacity	Sorting area Composting Pad Maturing Pad Storage Area Mechanical Equipment Area	500 m² 4,000 m² 1,600 m² 4,000 m² 2,000 m²
Landfilling		
Upgrading of existing dumpsite into a controlled landfill with bottom liner and leachate collection over 16.8 ha including 5 cells (only 1 cell constructed under this Project Phase, others scheduled in 2024, 2028, 2032, 2036)	Landfill Infrastructures area (access, office, storage) Environmental monitoring wells Weighbridge 50 tons Bulldozer 248 HP Small 4x4 drive truck tractor	14.6 ha 2.2 ha 6 1 1 1
Leachate treatment: anticipated production is 23,000 m3 per sub-cell during 5 months of wet season	Recirculation into landfill passive evaporation from holding ponds in dry season. On-site physical & biological treatment	3000 m² pond and leachate treatment plant

Source: PPTA Consultant, Solid Waste FSR, 2015

Total CAPEX is estimated at 14 million USD for the first phase of project implementation.

Required labour is estimated as 18 employees for landfill operation and 14 employees for compost plant operation. Total OPEX for waste collection, controlled landfill, compost plant and medical waste treatment is estimated at 460,000 USD/year.

3.3.1 DIAGNOSIS SOLID WASTE MANAGEMENT

COLLECTION

- Mawlamyine Town Development Committee (MTDC) provides solid waste collection services to 23 of the 28 wards (covering about 90% of the total population).
- The MTDC has only 7 waste vehicles for 23 Wards and they have no possibility to include the other 5 wards to incorporate in the SWMS (Solid Waste Management System). Normally waste is collected twice/week.
- Assuming a population of 258,809 with a waste generation of 0.55/kg/capita/day, results in about 142 ton/day. Initial observations estimate that about 50% of waste is collected and dumped at the designated dump site.

For instance, Nhaing Tae Ward is not covered by solid waste collecting system of Mawlamyine Town and the community had to deal with their own waste management system. Mostly they dump the waste into the stream near the village which flows into the Attran River. This small stream flows in the north of the ward, while the Attran river flows north-east of the ward. The households away from the stream and from Kyaikmayaw road burn their waste on the street or on their yard.

Inadequate and uncontrolled waste disposal causes groundwater pollution, unpleasant odour and air pollution by unauthorised burning of the waste, drain clogging and spreading of mosquitoes. This has a negative impact on the city's health and environment.

- While the majority of the city is generally kept well clean, there are often accumulations of solid waste in drains which are washed down to the sea front and accumulate near to the promenade area.
- Most of the activities are operated by MTDC, but there is one ward (MyaingThaYar) which is actively undertaking a community based collection system.

Cleansing Program executed by the Cleansing Department

Sweeping, collecting and transporting the waste from roads and streets in the townships is by four means:

- Daily determined sweep routes, collection routes, and the garbage carried by hand to "carry" waste bins; every morning sweeping duties are done by 41 workers. The daily workers from the Market Department do their cleansing duties inside and outside market places in evening sessions.
- **Door to door collection:** Bell ringing and collecting of waste in the town area is an effective and systematic way of waste collection system. By hearing the bell ringing, the community know easily that the waste collection truck is coming into the streets; they can prepare for the disposal of their waste to the waste truck in time.

Figure 3-18: People queuing at bell ringing dumper venue

- **Cart and trash bin collection points**: Collecting of waste from the waste collection tanks, waste bins and waste carts kept for waste collection in the selected streets. Some carts are hitched to a jeep and sent directly to the dump site. Users throw their waste on the ground until the cart is back to the collection point. The other carts are emptied by labourers into dumper truck.

Figure 3-19: Waste Collection points (big one with Cart and small one with trash bin)

- Waste from town parks, town landscapes, town areas cleaning plan, daily collected by truck.

In each garbage truck one driver and three workers are assigned. In the morning section waste from waste collection tanks, waste bins and waste carts are collected and disposed to the dump site. In the afternoon and evening section the waste will be collected via the bell ringing system.

Markets Cleansing Program executed by the Market Department

The MTDC Market & Slaughter House Department have their own cleansing program according to **Table 3-10**.

Table 3-10: Markets Cleansing Program Mawlamyine

No.	Name of Market	Address	Collecting System
1.	No (1) Market	PhetTan Ward Lower Main Street	Between 5-8 p.m direct loading, 3 ton waste truck, 1 trip every day
2.	No (2) Market	PhetTan Ward Lower Main Street`	Between 5-8 p.m direct loading, 3 ton waste truck, 1 trip every day
3.	MyineYaDaNar Market & Vegetable Market	PhetTan Ward Upper Main Street	Between 5-8 P.M direct loading, 3 ton waste truck, 2 trips every day
4.	MinGaLar Market	SitKaeKone Ward Upper Main Street	Between 5-8 p.m direct loading, 3 ton waste truck, 1 trip every day, Small market ½ load truck

No.	Name of Market	Address	Collecting System
5.	ThiriMyine Market	ThiriMyine Ward Shwe Street	(15' x 10') Waste collection tank, between 5-8 P.M, 3 ton waste truck, 1 trip every day
6.	DaingWunKwin Market	Kyaikene Ward Lower Main Street	(15' x 10') Waste collection tank, between 5-8 P.M, 3 ton waste truck, 1 trip every day
7.	ShweMyineThiri Market	ShweMyineThiri Ward Lower Main Street	Waste collecting system bell ringing & direct loading to the truck, 1 trip every day
8.	ThanLwin Market	BoKone Ward Lower Main Street	Waste collecting system bell ringing & direct loading to the truck, 1 trip every day
9.	MaungNgaing Market	MaungNgaing Ward Lower Main Street	Waste trailer kept for waste collecting, early morning every day one trip waste trailer plus waste truck
10.	PharOut Market	PharOut Village	(20'x20') Waste collection tank. Alternate 3 days one truck one trip
11.	MyaingThaYar Market	MyaingThaYar Ward ThaMeinBaYan Street	(15'x10') Waste Collection Tank. Alternate 3 days one truck one trip

Cleansing Program by the Communities in Wards

MyaingThaYar Ward, which is situated within the area covered by the cleansing program of MTDC, has its own community solid waste system with one garbage truck. The MTDC Cleansing Section collects only waste from the outer parts of the MyaingThaYar Ward. The inner parts of the Ward areas are collected by the ward community itself with its own garbage truck and transported to the dump site.

Existing Recyclable Waste Operators in Mawlamyine

The existing recyclables waste traders in Mawlamyine, considered the 'informal sector' for recyclables are shown in **Table 3-11**.

Table 3-11: Mawlamyine Recyclables Waste traders

Materials Type	Recyclable Means
Paper-Newsprint Paper exercise books	Sent to Mawlamyine Industrial Zone. They are mixed and grind and made it to pulp, and made it to paper again. Some as tissue papers.

Materials Type	Recyclable Means
Metal (iron) Metal (hard) (Car Engines and so on) Metal (soft) (Aluminium pots and so on) Metal (Copper) (Coils from electric wires)	Iron are directly sent to MyaungDaKar Industrial Zone, in MhawBi Township, Yangon Region. Sent to SawBwarGyi Gone, Yangon Region Sent to SawBwarGyi Gone, Yangon Region. Sent to SawBwarGyi Gone, Yangon Region. If the coils were burnt less value, if not burnt higher value.
Cardboard containers	Sent to ShwePyithar Industrial Zone, Yangon Region. Then mixed, grinded and made to pulp rolls.
Rubber slippers	Coloured rubber slippers are bought and sent to Yangon. (No black rubber slippers!). Made to plastic pallets for other usage.
Batteries	Sent to SawBwarGyi Gone.
Glass bottles (Myanmar liquor Co. use their own branded bottle. Other brand bottles (e.g. oil and fish sauce bottles)	Sent to Yangon for further recycling Recycled by the companies brand
Other brand bottles	overseas liquor bottles are not traded

The recyclable wastes were not only traded from Mawlamyine Town. The traders get also recyclables from Mudon, Kyaikmayaw, Yae and Dawei.

DUMPSITE

Solid waste is dumped at a site to the east of the main city and upstream of the two river water supply intakes as shown on **Figure 3-20**. There is a clear risk of contamination of these water resources by leachate from the dump site.

Figure 3-20: Dumpsite location in Mawlamyine

Burning of waste takes place at the dump site to reduce waste volumes; this is a clearly a health hazard to the waste pickers and also is a matter of complaints from the nearby village (MuYaung Village) and the Sports Academy. During the site visit (May 2015) the dump area was completely covered in smoke (Figure 3-21).

Figure 3-21: Leachates and waste burning at the dumpsite Mawlamyine

On the dumpsite there are 8 to 10 waste pickers / scavengers as shown in Figure 3-22. Several individuals collect directly some types of recyclables and arrange their own transport (for recycling) to Yangon by truck.

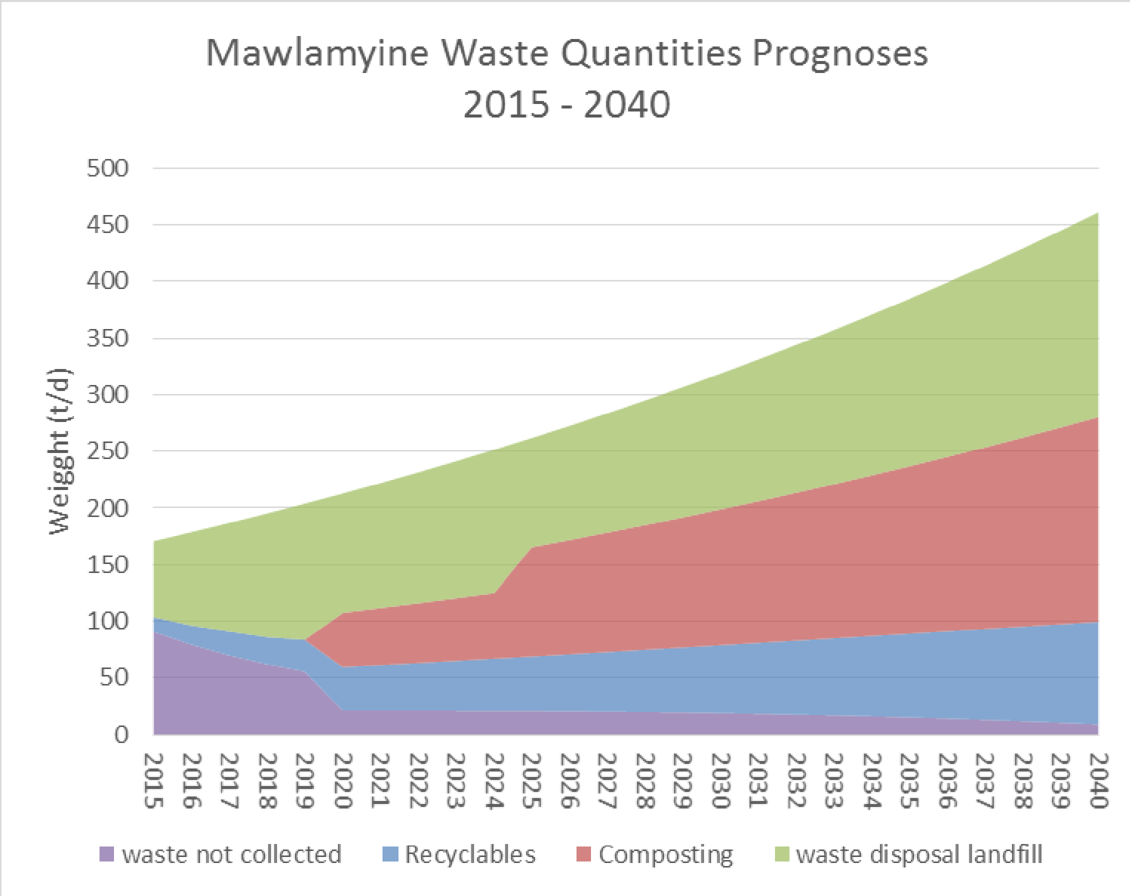
Figure 3-22: Scavengers at Mawlamyine dumpsite

Mawlamyine TDC often uses open fires to reduce the volume of waste. They try to burn only downwind of dwellings, however this is uncontrollable. Burning waste creates significant quantities of smoke (see pictures) and other fire hazards, especially when several fires lit simultaneously. Waste should not be burned anywhere, normally waste should be covered with soil once disposed. The MuYaung Village and Sports Academy, which are close to the Dump Site area, are complaining about the smoke and smells of the open fires from the dumpsite.

3.3.2 SOLID WASTE PROJECTIONS & STRATEGY

The graph in **Figure 3-23** shows the quantities (in tonnes per day) in Mawlamyine with separation of recyclables and biodegradable waste from the total waste generated for the next 25 years.

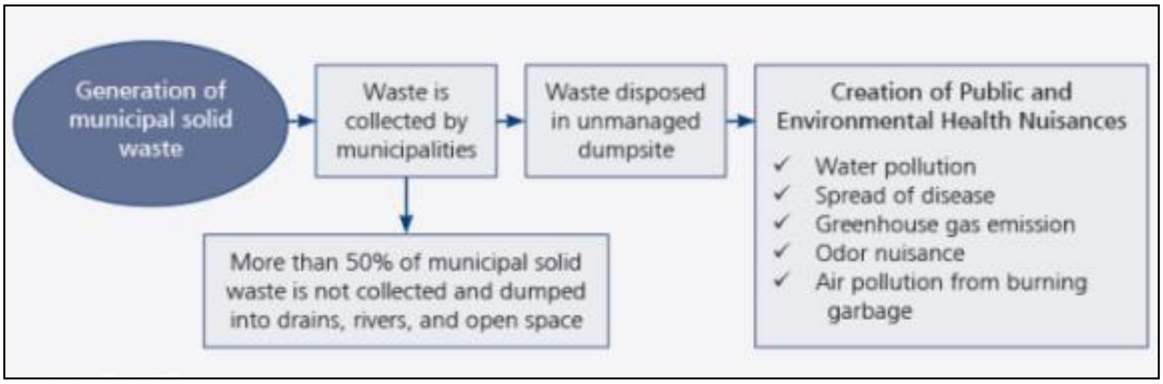
Figure 3-23: Current and Prognosis Waste Generation and Treatment



3.3.3 SCENARIOS

The previous paragraphs showed the existing solid waste situation and the future challenges as shown in **Figure 3-24**.

Figure 3-24: Typical Scenario of Solid Waste Management



At the moment, waste collection is not done appropriately, transport and disposal is at a low level and disposal of waste is not acceptable at uncontrolled dumpsites with open fires and no treatment or prevention of leachate, with potential pollution of the groundwater and water supply sources.

Also the financial struggle for the municipalities related to the waste management is also a constraint for further development in this sector. The waste collection fees are paid directly by each household and usually apply to collection only. The fees are generally not enough to cover the solid waste system's upstream costs.

To change the existing scenario with about 50% of uncollected waste and disposal of the waste in unmanaged dumpsites the following scenario as shown in **Figure 3-25** is proposed.

Figure 3-25: Proposed Scenario of Solid Waste Management

The above scenario can be implemented through the following:

- Launching a long Term **Strategy**
- Launching a **Vision**
- Establishing **Targets**
- Introduction of an **Integrated Sustainable Waste Management** Plan.

3.3.4 STRATEGY

STRATEGY

A Strategy is about the future, about thinking about the place of waste management and urban environmental health over the longer term. This project has a planning period of 25 years, from 2015 till the year 2040.

Part of a strategy is an Action Plan which covers actions to be implemented the first five years.

Many countries have, or are in the process of developing, national policies and sector strategies on waste management. These policies typically set out needs and priorities, key areas of focus and sectoral targets for the nation as a whole, and provide a national framework for regional/local Strategic Solid Waste Management (SWM) Plans.

One of the Strategy's Aspects: the "Waste Management Hierarchy", a top-down level of how to manage municipal solid waste is shown in Figure 3-26. As shown in the figure, the 3Rs of "Reduce, Reuse and Recycling" formulate the most preferred options and the most part of the hierarchy, because the main goal of solid waste management is reducing and eliminating adverse impacts of waste materials on human health and environment to support economic development and better quality of life.

Figure 3-26: Waste Management Hierarchy

TARGETS

The Main Target for SWM is:

> **"to keep the city clean and sanitary by removing waste from the living areas and disposing of it in an environmentally acceptable manner"**

This main target is more specific subdivided into short - & medium term targets and long term targets which are presented in **Table 3-12**.

Table 3-12: Targets for the Short, Medium and Long Term

Short & Medium Targets
• expand collection service to 95% by 2020 by using an efficient collection system • Implement a controlled landfill site for disposal

• Promotion of waste volume reduction (3Rs)
• Provide a Solid Waste Management financial base based on new fee collection system
• Strengthening of Institutional set-up
• Strengthen public sanitary education, public awareness and community participation
• Introduction of private-sector participation
Long-Term Targets
• Expand collection service to 98% by 2025 by using an efficient collection system
• Implement a **sanitary** landfill disposal
• Continuous Promotion of waste volume reduction to nearly zero waste
• Provide a sustainable SWM financial base
• Continuous Strengthen public sanitary education, awareness and community participation
• Expansion of private-sector participation (PPP)

The target levels for environmental improvement for solid waste management are shown in Table 3-13, with a minimum level, comfortable level and an all amenities level, which means that all facilities are in place and functioning plus good governed solid waste management.

Table 3-13: Target Levels of Environmental Improvement SWM

1	Minimum Level	To collect all generated solid waste within a service area on a regular basis (at least once a week) and disposal at controlled landfill site.
2	Comfortable Level	To collect all generated solid waste within a service area on a regular basis (minimal twice a week) and disposal at sanitary landfill site.
3	All Amenities Level	To have all facilities in place to collect all generated solid waste within the township on a regular basis and to treat the collected waste adequately then dispose of the remnants.

At the moment, the minimum Level requirements are not met, because only about 50% of the generated waste is collected (although on a regular base twice/week) and the minimum level for disposal at controlled landfill sites is far behind, even not existing, at the moment. All waste is dumped in open dumpsite without any protection.

Therefore the project has to start to achieve Level 1: Minimum Level initially, and the subsequent levels 2 and 3 for the Medium - and Long-Term.

3.3.5 INTEGRATED SOLID WASTE MANAGEMENT (ISWM)

COLLECTION

The collection system is at the moment inadequate, only about 50 -55% is collected. To reach the Minimum Target Levels of Environmental Improvement Solid Waste Management for collection, additional collecting measures have to be implemented.

To maximize the Waste Collection, the following measures are proposed:

- Modernize waste collection means (primary collection)
- Establish a high rate of sorting, separation
- Improve waste transportation to disposal site (secondary collection)

The actions undertaken are presented in the table below.

Table 3-14: Proposed Collection Improvement actions

Collection	Weaknesses	Action required
Primary collection in the Wards	works more or less properly when tariff / fee structure has been implemented	no action short term (except collection fees to be established)
Source Separation at Primary collection level	Not present at the moment, highly recommended to implement separation at source to collect less mixed waste biodegradables	Supply of different (colour) containers for different sorting, e.g. one container for dry recyclables, one container for wet recyclables (compost) and one container for the remaining fractions
Secondary collection	Township level and transport to disposal site: no sufficient vehicles and collection points	investment in additional collection vehicles and collection containers, implementation of collection points at several areas in the Towns

PRIMARY COLLECTION

Source Separating Collection Containers

Many public works departments assume that, in tropical countries, it is necessary to collect waste every day. Even in hot climates, where containers are appropriate for the volume and type of waste, this can often be reduced to two or three times per week, and sometimes, in combination with separation of organic waste, to once per week. This makes collection more affordable, while maintaining an acceptable hygiene standard.

Several containers will be used, examples shown in **Figure 3-27**, each with a different purpose, such as dry recyclables, organic waste and residual waste. Designing and modernizing a collection system also involves optimizing routing, and will probably involve reducing the frequency of collecting each type of waste. The goal is to increase efficiency.

Collection Vehicles

Collection can be done in several ways, using small carts manual, small tractor or small truck or more sophisticated means as full automatic hydraulic compressor trucks.

The main practical advantage of compactor collection trucks is that they can compress waste to smaller volumes (if compressible). In most countries in South-East Asia, more than half of the waste is organic and dense, inert materials, or bulky wastes, which are not compressible.

Normally compacting trucks are large trucks and they might be too wide for the streets in the towns. Compactor trucks use more fuel than standard trucks.

Figure 3-27: Examples of waste collection bins 240 and 1100 litres

SECONDARY COLLECTION

Secondary collection is the collection from collection points to the Landfill site location. This is normally executed with larger waste containers (>3m3) and larger transfer trucks with large containers (12m3 or more), as shown in Figure 3-28, which can be placed at several collection points (CP) in the town.

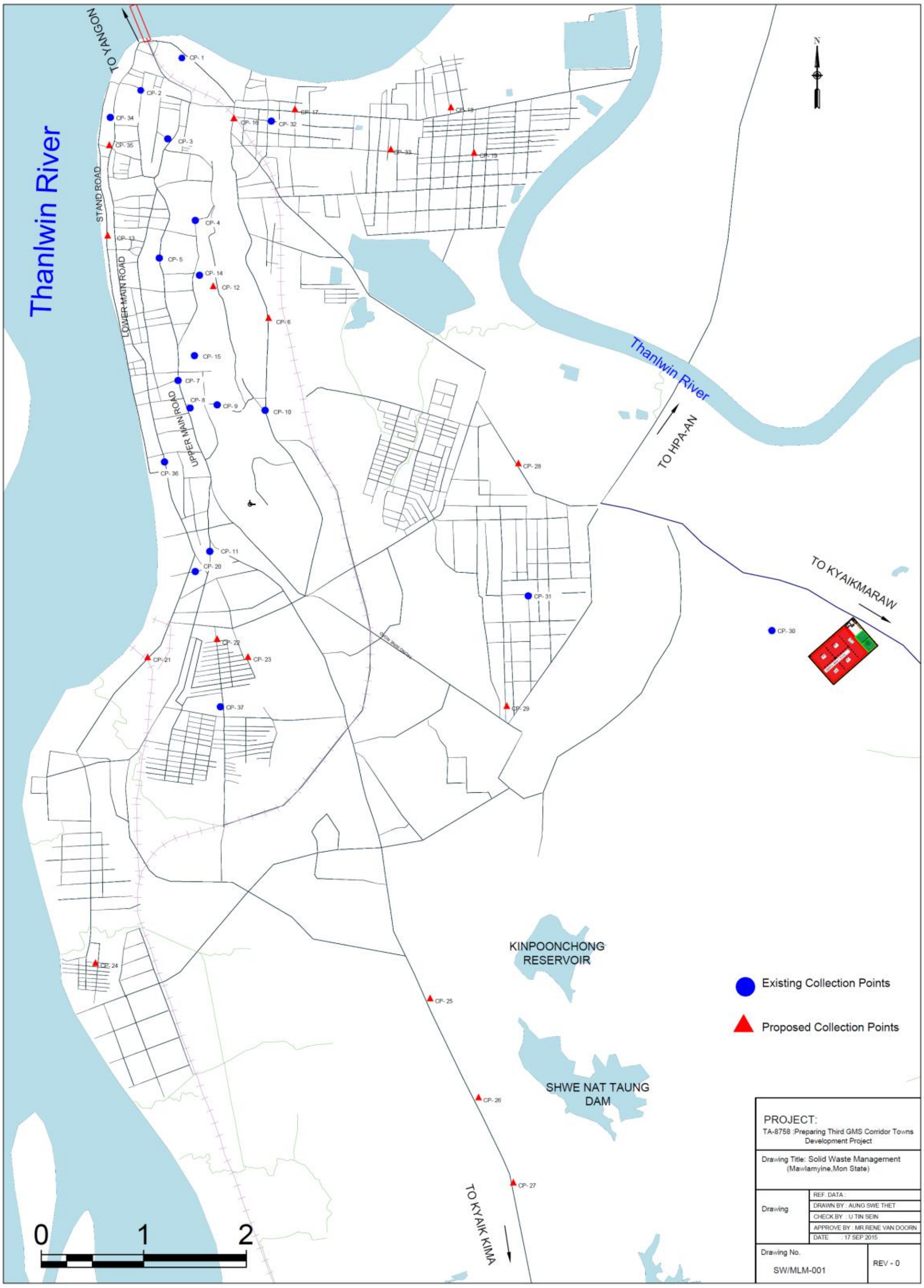
Figure 3-28: Examples collection containers 3 & 6 m^3 hook-lift system

To transfer these containers a hook-lift system is a very efficient way to lift and transport these containers with examples of hook-lift trucks shown in Figure 3-29.

Figure 3-29: Example of Hook Lift trucks

The location of the existing collection points and proposed ones is indicated on **Figure 3-30** (details in Appendices).

Figure 3-30: Map with Collection Point location



TRANSFER STATION

Transfer stations are used for further transport of the primary collected waste to the Landfill, the Compost Plant or Recycling Company. The primary collected waste, compost and recyclables are tipped in much larger containers, $12m^3$ or $15m^3$, and transported with a larger Hook-lift Truck (sometimes with a trailer for very large distances, e.g. >25km) to the dedicated final sites.

The economic viability of a transfer station depends on the critical distance of the solid waste system:

- The net distance from each ward centroid to the dump site in Kyaikmayaw is estimated based on the main road network as described in Figure 3-31 below. The wards are located between 1.5 and 12 km far from the dump site. The further wards are located near Mawlamyine Bridge or on the way to Mudon.
- Then the critical distance is calculated based on the formula:

$$Critical\ distance\ (km) = \frac{\sum distance * Waste\ collection\ (tons\ per\ day)}{\sum Waste\ collection\ (tons\ per\ day)}$$

The waste collection is estimated 47% of total waste generation in 2014 and 98% in 2040.

The waste quantity per ward is adjusted by adding the waste generated by markets in downtown area (as detailed in Table 3-10, there are 10 markets in downtown area and one market in PharAuk village), estimated to 28 t/d in 2015 and 77 t/d in 2040.

Based on the result detailed on Table 3-15, the critical distance is **Cd = 671/78 = 8.6 km.** The Critical distance is similar in 2014 and 2040 because growth rate is assumed as constant through the years. Even by assuming a higher growth rate in the South near Mudon, the critical distanced remains under 10 km. Some studies include traffic factor to the critical distance. In Mawlamyine the traffic is relatively fluid and would not affect SW trucks pattern.

Classic dumpers of 7 to 10 m3 capacity are usually economically interesting when critical distance is below 15 km. In Mawlamyine the critical distance is below 10 km. The wards are located less than 12 km far from the future landfill.

Then there is no specific need for a transfer station creation in downtown area.

Note: In addition to the cost consideration, several factors are disadvantaging the transfer station option:

- A lack of available public space, especially in the centroid of Mawlamyine wards which is located in downtown area;
- A reluctance from neighbourhood regarding a potentially noisy and smelly facility;
- Difficulties for driving a long-haul truck in downtown area.

Figure 3-31: Main SW collection routes in Mawlamyine

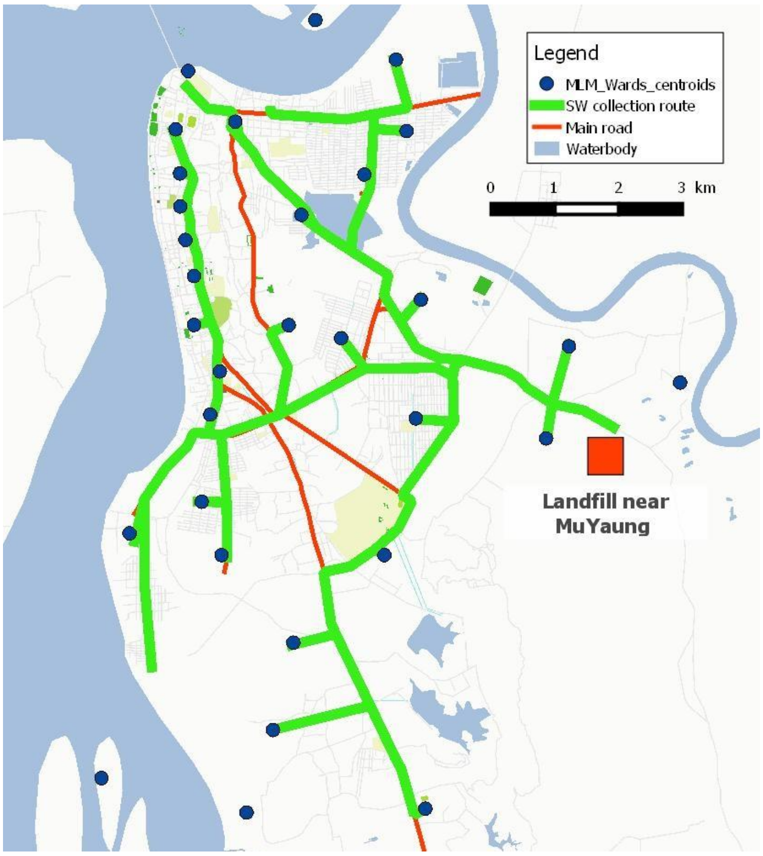


Table 3-15: Critical distance calculation for Mawlamyine Wards

Ward	Name	Distance to landfill (km)	Pop 2015 ratio Census	Waste collected 2015 (t/d)	Distance x Waste collection
1	Zayar Thiri	7.9	10912	2.75	22
2	Thar Yar Aye	6.7	5919	1.49	10
3	Shwe Myaine Thiri	8.9	23862	7.33	65
4	Hlaing	6.4	24429	6.16	39
5	Kyaik Pa Nae	9.3	7792	3.28	30
6	Auk Kyin	8.2	10350	2.61	21
7	Mandalay	9.3	5346	1.35	13
8	Hpet Tan	12	13965	7.45	89
9	Shwe Taung	11.4	10320	2.60	30

Ward	Name	Distance to landfill (km)	Pop 2015 ratio Census	Waste collected 2015 (t/d)	Distance x Waste collection
10	Sitke Gone	10.8	8088	3.35	36
11	Mayan Gone	10.3	4999	1.26	13
12	Papae Tan	9.7	5543	1.40	14
13	Bo Gone	9.1	7782	3.27	30
14	Maung Ngain	8.1	8876	3.55	29
15	Kwin Yet	7.4	12229	3.09	23
16	Mupon	9.3	10735	2.71	25
17	Thiri Myaine	8.8	13472	4.71	41
18	Thiri Mangalar	8.4	6322	1.60	13
19	Myae Ni Gone	7.6	7360	1.86	14
20	Zay Kyo	6.4	15530	3.92	25
21	Zay Yar Myaine	5	3265	0.82	4
22	Myaine Thayar	4.2	10758	4.02	17
23	Kyauk Tan	11.2	8029	2.03	23
24	Naung Kha Yi	11.4	6233	1.57	18
25	Ngan Tae	4.4	5340	1.35	6
26	Chauk Mile	1.6	4489	1.13	2
27	San Gyi	8.8	1399	0.35	3
28	Gwe Gone	10.9	5516	1.39	15
	Total	**233.5**	**258 860**	**78 t/d**	**671**

3.3.6 RECYCLING

INFORMAL SECTOR

Waste management systems in the cities of many developing countries could not be managed without the informal sector: waste pickers, scrap collectors, traders and recyclers.

This sector is often not officially recognised and acknowledged, yet its members contribute significantly to the waste management of cities, by collecting, sorting, processing, storing and trading waste materials in the recycling value chain.

The informal recovery of recyclables from the solid waste system reduces overall solid waste management costs for municipalities. If material is recovered through door-to-door collection by the informal sector, this material no longer needs to be collected, so all expenses – collection, transport and disposal – are reduced according to the amount that is recovered.

At the moment the Informal collection of recyclables in the town works good and at no costs for the municipality, therefore no further action required in this sector.

FORMAL SECTOR

There is no Formal collection of recyclables by the municipality. As mentioned before the informal sector works well and there seems no need to further collect recyclables. However, the today's informal collection rate of about 17% can be improved to 20% through the Formal Sector.

A higher separation can be implemented by introducing at schools, township offices and other official buildings the separation and recovery of recyclables using 3 different colour containers for:

- recyclables ("dry waste")
- compost ("wet waste")
- remaining fractions

At the same time when this recyclables recovery system is introduced the compost fraction will also be separated which will benefitting the municipality cleansing department at the same time. The Recycling Chain as practised in many countries all over the world is shown in Figure 3-32.

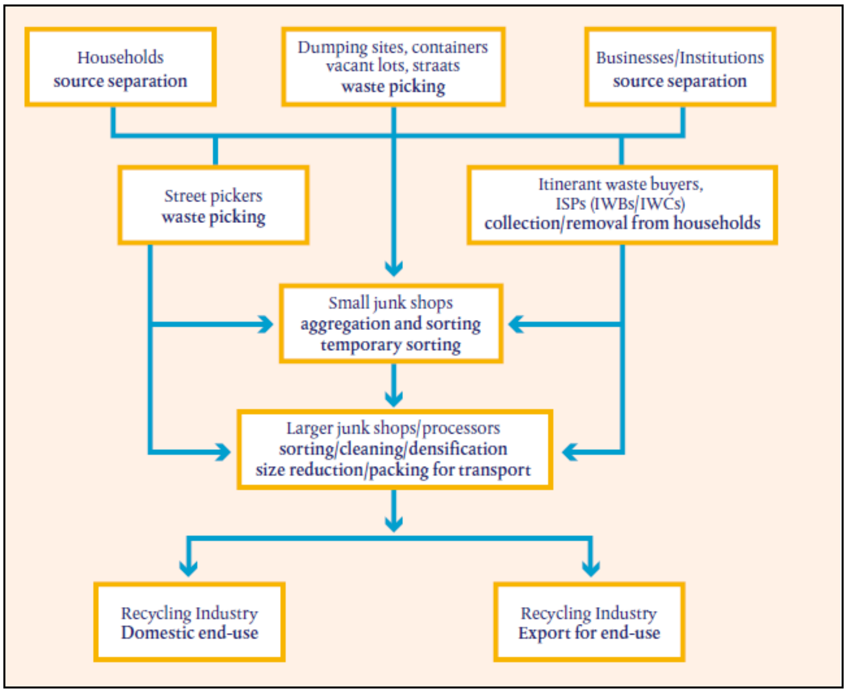
In this project it is envisaged to purchase 240 l and 1,100 l containers dedicated for separation of the recyclables.

There is a common misconception that recycling can finance, or provide income to support, new solid waste activities. Unfortunately, this is generally not the case, for several reasons. First, those materials that are profitable are probably already being recycled by the private informal sector. Examples of this kind of recycling include collecting cardboard from shops, collecting and selling ferrous and non-ferrous metals, and buying bottles and cans from households. The existence of informal recycling initiatives is at this moment well organised in town.

In most developing countries, 15-20% of the waste generated is managed by the informal sector, providing financial and environmental benefits to municipalities.

This schedule can easily be implemented in Mawlamyine, in addition to the existing 'informal' recycling system. As described before, there is already a thriving informal sector for recyclables collection.

Figure 3-32: Recycling Supply Chain



(Source: Adapted from Marchand 1998)

To keep this sector active and increase the amount of recycling materials, the following measures shown in Table 3-16 are proposed.

Table 3-16: Proposed Recycling Improvement actions

Collection	Weaknesses	Action required
Informal collection of recyclables	Works good at the moment and at no costs for the township, however public is not actively participating and health risk for collectors	Public awareness promotion for recycling and providing sanitary health & safety equipment for the informal sector
Formal collection of recyclables	At the moment not present	Introducing at schools, township offices and other official buildings separation in 3 different (colour) containers for: a) recyclables (“dry waste”) b) compost (“wet waste”) c) remaining fractions

Micro - and small recycling businesses buy materials that have been extracted from waste containers, collected from households or bought from businesses. They sell these to medium and large recyclers, called ‘dealers’ or ’traders’, who, in turn sell them to end-user industries.

3.3.7 COMPOSTING

At the moment there are no composting activities in the project town. To implement composting, the following options are proposed.

Table 3-17: Proposed Composting Actions

Options	Action Required
Backyard composting in the peri-urban areas of the town and for houses with large gardens	Introduce Instruction and Awareness Programs for backyard composting Introduce incentives for lower collection fees for those households participating (they generate less volume of waste to be collected!).
Composting facility at the location of dumpsites/landfills	Implementation of a Composting Plant with extension options for future capacity growth (modular system). This can be done in combination of upgrading existing landfills or construction of new landfills (see next paragraph)

Composting will be a major achievement in the Municipal Integrated Solid waste Management System. A detailed description of composting and composting Plant is provided in the next section with several options analysed and presenting the best option selected.

"One of the most promising solutions for Waste Reduction"

3.3.8 SOLID WASTE TREATMENT AND DISPOSAL

GENERAL ISSUES

With a new sanitary waste treatment and disposal site, it is almost certain that disposal costs will rise. This is more than a municipality generally can afford, and this means that closure of a local landfill in many cases lead to regionalization of disposal sites.

Regionalization requires new institutions to manage it, and these new institutions require financial tools and a basis on which to raise investment funds and manage operational costs.

A regional landfill treatment and disposal will serve a larger number of municipalities with different political colours and so has a risk of creating conflicts of interest of a political and/or financial nature. Questions and conflicts arise like who is responsible for the landfill, and how is it paid for.

Also there is lots of room for conflict about where the landfill will be sited, and resolving this conflict can cost a great deal of time.

Although regionalization of landfill sites is in many cases the best economical option (economies of scale), this is not further considered feasible for this project implementation.

SOLID WASTE TREATMENT OPTIONS AND WTE

In general there are three main Municipal Solid Waste treatment options:

- Incineration with WtE (Waste to Energy);
- composting and landfilling combination;
- landfilling with biogas production from mixed waste and energy production (WtE, Waste to Energy).

A general description of these 3 main disposal options is given in Table 3-18.

Table 3-18: Main Solid Waste Disposal Options

	Technology	Description	Remarks
1	Incineration and WtE (Waste to Energy)	The waste in developing countries, particularly in South Asia, is characterized by a significantly higher density and moisture, mainly organic waste with low caloric values (700–1,000 kilocalories). Given these physical and chemical characteristics of waste in the region, incineration - which is ideal for dry matter with high caloric value - is not a suitable option. In 1987, for example, a 300 tons/day incineration plant was established in Timarpur, Delhi. The project, which was expected to produce 3.75 megawatts (MW), failed, and ultimately shut down in 1990 due to the high volume of refuse with low caloric value. Incinerators require sophisticated flue gas treatment, which are expensive and require intense operation &maintenance and continuous air quality controls.	The South Asian Association for Regional Cooperation (SAARC) Dhaka Recommendation on Waste Management (October 2004) agreed that incineration, as well as unproven technologies such as plasma, should not be considered as an option for the treatment of Municipal Solid Waste of low caloric value and high environmental pollution potential. Another disadvantage is the high investment costs and high operational costs. Further high skilled operators are required for the daily operations.
2	Composting of Organics and landfilling of remaining rejects	The organic component of municipal waste generated in developing countries is greater than in developed economies, comprising well over 50% in these countries. In that context, biological treatment, compost-ing in particular, can help recover and transform organic waste into soil conditioners and fertilisers. These processes reduce GHG emissions by sequestering biogenic carbon in the soil, improving its physical properties, adding nutrients, and reducing the need for pesticides.	Biological treatment and recycling of this bulk organic fraction at a lower cost makes these methods a more suitable option for developing municipal economies in South Asia. A (smaller) landfill is still required for proper disposal of the remaining waste fractions.
3	Landfilling with Biogas production and WtE (Waste to Energy)	Engineered landfill, rather than open dumping, also contributes to Green House Gas mitigation. Landfilling refers to disposal sites where waste is placed in lined sections, where it degrades while producing biogas; CO2 and methane with further possibilities for energy recovery. Landfill processes can be controlled in order to stimulate the biogas reactor. The main output of a modern landfill system is electricity pro-duction from the combustion of biogas, with an average energy efficiency of 35%.	Many of the landfill-related Biogas projects are less ambitious; they are offering controlled flaring rather than the utilisation of energy potential. This is especially the case with smaller sized landfills, like to be implemented in Mawlamyine. Further a landfill Gas-to-Electricity Plant has to be constructed with large Gasholders, which means

		The CDM (Clean Development Mechanism; introduced under the Kyoto protocol) enables countries, to invest in emission-reduction projects in developing countries and to use the associated emission-reduction credits towards achieving their own targets, as a supplement to their domestic GHG reduction actions	high investment costs and high skilled operators required. The electricity produced should be sellable to a third party, the electricity company, which requires intense communication with the company and secure connection to the network.

CONCLUSION

- Option 1: As presented above, Incineration is not being appropriate for the project Towns project and is not further considered an option for this project.
- Option 3: Landfilling with Biogas production: this option is not further considered feasible to the fact that the size/capacity of the projected landfill is too small for generation enough biogas for economical electricity generation, which means the biogas has to be flared on-site without any revenues.
- Option 2: Composting of Organics with landfilling of remaining rejects is the best option for the 3 project towns. Also the SAARC countries (South Asian Association for Regional Cooperation) agree to encourage establishing community-based segregation at source, separate collection, and resource recovery from wastes with particular focus on composting.

Recommendation:

"Implementation of a Composting Plant with a final Controlled Landfill for the remaining rejects". The following sections will describe the Composting Plant and the Controlled landfill in more detail.

3.3.9 COMPOSTING PLANT

INTRODUCTION TO COMPOSTING

The physical composition of solid waste of the developing countries consists mostly of organic matter, which is biodegradable. To reduce reliance on landfill as a disposal route, biological treatment is increasingly becoming adopted as a standard requirement for the vast majority of biodegradable wastes.

Controlled Composting differs significantly from the decay process that occurs in nature; it is monitored and controlled, aerobic conditions are maintained, and it includes a high-temperature phase (e.g., above 55 degrees Celsius [°C]) that reduces or eliminates pathogens and weed seeds. Conversion rate per ton of organic waste to compost is approx. 25%.

Climate is a natural force which may cause failure of a composting project (e.g. by heavy rainfall saturating the composting windrows). Such climatic condition may pose a threat, which means adjusting the technology e.g. by roofing the composting site and providing a drainage system.

The major aim of composting is to achieve benefits for the entire solid waste management system by improved landfill management and reduced quantities of waste to be disposed of at the landfill.

Another effect is much lower emission of methane which is a major greenhouse gas due to anaerobic condition in the dump sites.

Many factors influence which organic waste collection programs and processing technologies should be implemented, a/o the community's waste diversion targets, the desired level of convenience for the users, processing facility site location, commitments to greenhouse gas (GHG) reductions, and costs.

The importance of these factors helps to determine which technologies are most appropriate, such as a separate collection system, which composting technology system e.g. aerobic system or an anaerobic digestion (AD) system, or a combination of both.

Determining the size of the processing facility is another key consideration, which is heavily dependent on the types and quantities of compostable materials (feedstocks) diverted through the collection program, as well as the location of the proposed processing facility.

Backyard Composting: It is not expected that a large volume of organics will be diverted from this waste streams, however every m3 which has not to be collected, is less collection required for the municipality.

GREENHOUSE GAS (GHG)

When mixed municipal solid waste (MSW) is sent to a landfill, the organic matter generates greenhouse gas (GHG) emissions. Anaerobic decay of these materials in a landfill leads to the generation of methane, which in turn is released to the atmosphere if there are no controls in place.

GHG reductions can be realized when organic waste is diverted from landfills to composting or Anaerobic Digesting (AD) facilities and processed under controlled conditions. MSW organics buried in a landfill break down anaerobically and produce landfill gas that consists primarily of methane (CH_4). Methane is a potent GHG, with approximately 25 times the global warming potential of carbon dioxide (CO_2), making landfills a significant contributor to GHG emissions. Methane also has a relatively short atmospheric lifetime (of about a decade), as compared to carbon dioxide (which remains in the atmosphere for centuries). Due to this short atmospheric lifetime, reducing emissions of methane and other "short-lived climate forcers" has the ability to slow the rate of near-term climate change.

The environmental benefits of diverting organic materials from landfill include reduced methane emissions (a potent greenhouse gas), and decreased leachate quantities from landfills.

Recycling organic matter to the soil is a part of carbon cycling, an emerging and important environmental issue. Organic waste is recognized as an important organic matter resource and has numerous beneficial attributes.

Diverting one ton of food waste through composting or anaerobic digestion reduces GHG emissions by approximately one ton of CO_2 equivalent compared to landfilling.

SOURCE SEPARATION ORGANICS (SSO)

The successful diversion of biodegradable wastes from landfill relies on the separation of these wastes at source. Whilst the biodegradable fraction can be extracted from mixed wastes, this is laborious and produces a contaminated product. Separation at source offers the opportunity of a high-quality clean feedstock for composting and the prospect of an uncontaminated product.

The most labour-intensive and tedious task of the composting process is waste separation. It can be facilitated if households of the community agree to segregate the waste, putting biodegradable (or "wet") waste into a different container from the one used for other wastes. If at-source segregation is being considered, this will require an intensive publicity and follow-up campaign in order to achieve a satisfactory degree of segregation.

A very intensive publicity campaign involves meetings with householders, presentations in the wards, campaigns in schools and public offices, and advertisements in newspapers and on television and radio. Composting schemes tend to be popular with the local population, creating jobs and a 'feel-good' factor. Publicity campaigns promoting the scheme can emphasise these key points.

The following three activities will raise the awareness of the community:

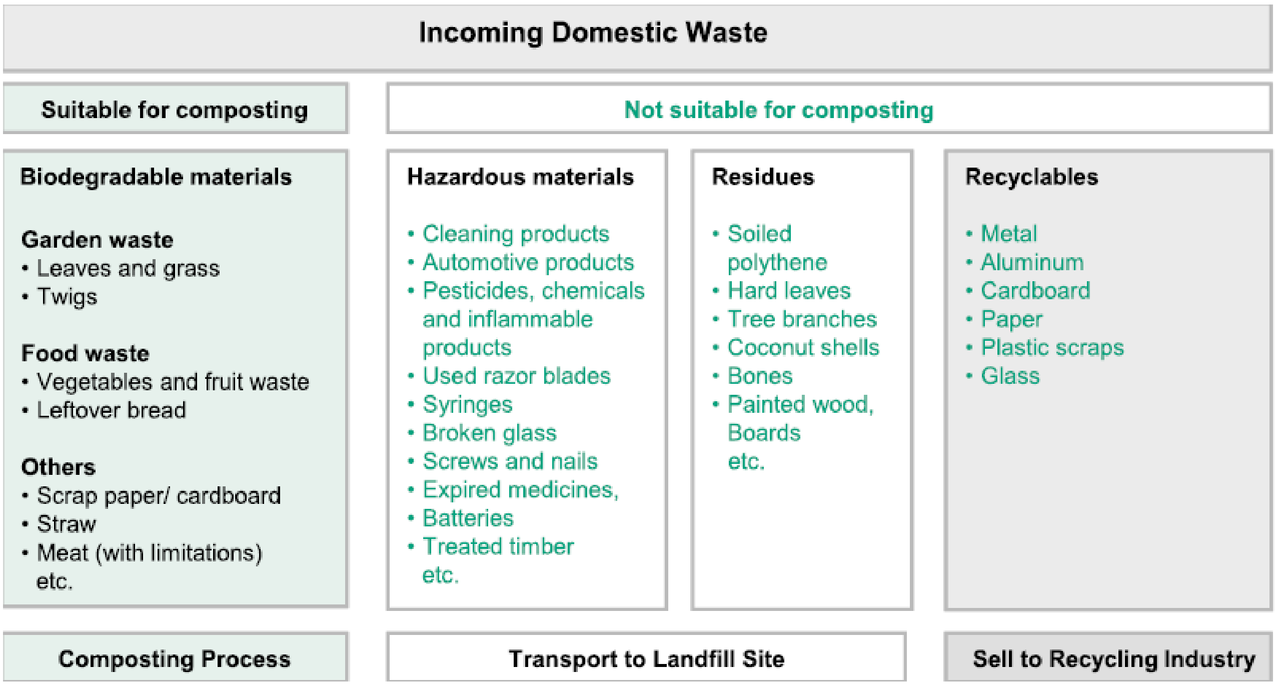
- Prepare and distribute leaflets among the households describing the benefits of source segregation and guidelines helping residents to differentiate between inorganic and organic waste;
- Affix posters with basic information to the collection trucks;
- Organise open-house events, inviting the community to the composting plant. Explain on site why source segregation greatly contributes to enhancing the operation of the composting plant.

If households are willing to segregate their waste at source it saves a tremendous amount of time and costs for the composting scheme. Moreover, it increases the quality of both biodegradable waste and recyclables.

Hence, the main goal should be the introduction of source segregation of waste in households. Residential source-separated compost programs, which include food scraps, soiled paper, and yard trimmings, are well established and successful in many countries around the world.

The separation of municipal solid waste is shown in Figure 3-33.

Figure 3-33: Source Separation of Municipal Waste



Source: Sandec composting organic waste 2006

COMMUNITY COLLECTION SITES

Source segregation can be achieved by the municipality to provide several smaller drop-off sites located at a neighbourhood level throughout the community. This allows sites to be located closer to waste generators, making them more convenient to use. Theoretically, the higher level of convenience results in higher participation rate and a greater diversion rate.

These neighbourhood sites typically consist of waste container, such as 2 to 4 m^3 commercial waste containers. The collection containers must be animal-and insect proof because of the food waste included. A typical container is shown located in Figure 3-34.

Figure 3-34: Containers for Source Separation of Organics

The containers must be emptied frequently (e.g., two to three times per week) to prevent them from overflowing and becoming unsightly, and to prevent odours.

Depending upon the style of container, community depot sites can be located at municipal facilities (e.g., parks, sports fields, parking areas) or at the sides of roads with appropriate shoulders for safe access.

KERBSIDE COLLECTION PROGRAMS

Kerbside collection of organic waste from residential sources can significantly increase diversion rates by making the service more convenient; thus, increasing program participation and capture rates. In established programs with regular weekly service, consistent participation rates of 80 to 90%, and diversion rates of 75%, are achievable.

Although kerbside programs can increase diversion rates, they come at a substantially higher cost than maintaining and operating community collection sites. Costs for kerbside collection programs vary depending on the frequency of collection, the number of households, and the distance to/from processing facilities.

There are also variations in the type of trucks that are used for kerbside programs: single-compartment versus dual-compartment trucks, and manually loaded trucks versus trucks with automated lift arms. The choice of truck depends on collection schedules and frequency, what materials are being collected, and the destination of the materials. Also these trucks are more expensive than normal collection trucks.

CART-BINS BASED COLLECTION PROGRAMS

Collection of organic wastes, garbage, and recyclables using standardized, wheeled carts is becoming more commonplace.

Cart-based collection programs for organics eliminate many of the problems associated with plastic-bag-based collection, and when combined with automated or semi-automated collection trucks, allow for increased collection productivity.

Bins for organics are available in a number of sizes, ranging from 50 to 360 litres (L). Popular bin sizes used in organics collection programs are 120, 240, and 360 L. Smaller bins (i.e. 50 and 80 L) can be collected manually. Larger bins require the use of automated or semi-automated lifting arms on the collection truck. A 240 L waste bin I shown in Figure 3-35.

Figure 3-35: Typical 240 litre collection waste bin

RECOMMENDATION

In the town the existing house-to-house collection and the bell ringing system is working relative appropriate. To improve the system for separate collection of organics the options mentioned before are compared in the Table 3-19 with the advantages and disadvantages of each collection system.

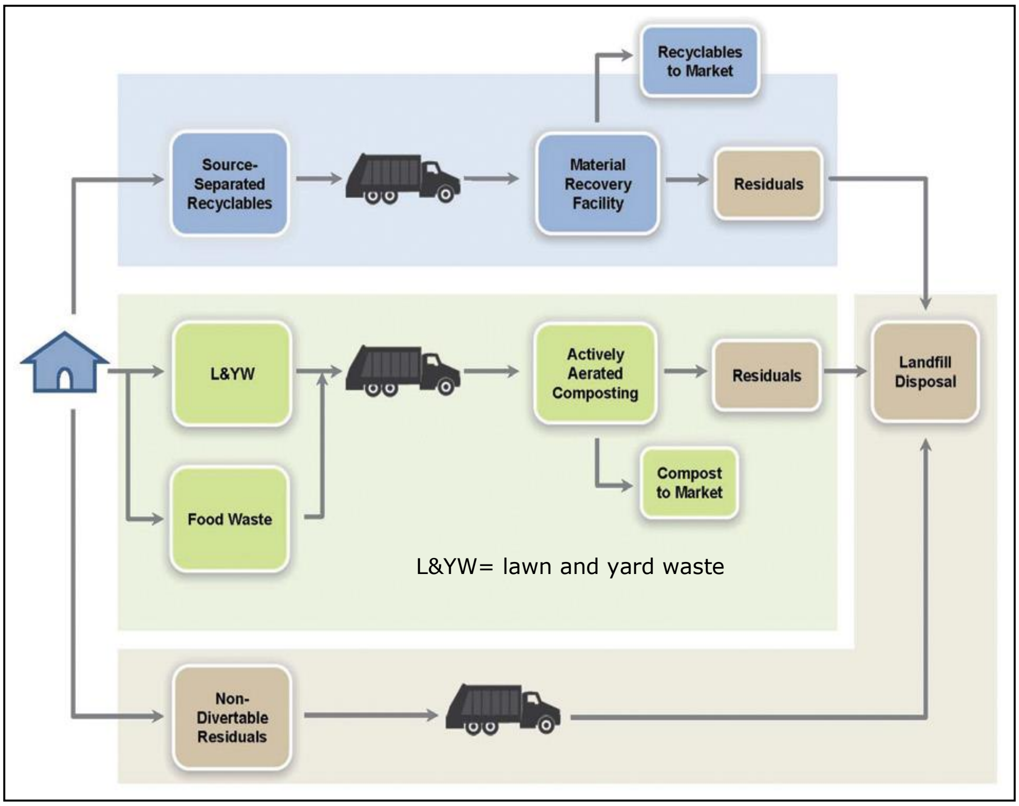
Table 3-19: Option Analyses SSO collection systems

System	Advantages	Disadvantages
Community collection sites	Simple to implement Easy for population to divert their waste Low investment costs Easy for collection trucks	Population has to be acquainted with bringing their waste to these points Keep the area clean is important as people spoil waste next to the containers
Kerb-side collection	High separation rate Convenient for the population	High investment cost due to special trucks and large amount of waste bins
Card-bins based collection system	High separation rate Convenient for the population	High investment cost due to special trucks and large amount of waste bins

The options 2 and 3 are more expensive, difficult to implement without large public awareness campaigns and requires also shifting of the cleansing department collectors. Therefore it is recommended to implement option 1: community collection sites in the town; it is the less costly option, simple to implement and can easily be further improved over the years as the population will get acquainted with source separation.

In order to reduce the costs of long distance transport, the waste will be transferred from the collection vehicles into large container trucks, located at different areas of the town, the Transfer Stations. These large container trucks carry the waste to the composting plant and landfill as shown in Figure 3-36.

Figure 3-36: Collection and Transport in SSO Waste System



COMPOSTING PLANT

Introduction

A composting plant comprises an operation area and a "green" buffer zone. The buffer zone, formed by a belt of bushes and trees surrounding the operation area, improves the visual appearance of the composting plant and the adjacent landfill area.

The operation area is divided into different zones. It contains space for waste unloading and sorting, composting, maturing, sieving and bagging of the compost, including storage space for compost. These zones must be arranged so as to ensure efficient workflow of the composting process. Additional space should be allocated for an office and sanitary facilities for the workers.

On-site water supply is a basic infrastructural requirement on a composting site. Since it is used for hygienic purposes and for watering the compost heaps, a reliable water supply should be ensured. Sanitary installations, such as toilets and washing facilities, are essential. After handling waste and compost, the workers should wash and change their clothes before leaving the workplace.

Composting operations should be conducted under a roof to protect the compost piles from excessive rain and sun. Simple light structures with steel – or concrete supporting poles can be used to support the roof.

The sorting area consists of a sealed concrete surface where the waste is sorted into organics, inorganic recyclables and rejects. The sealed surface facilitates cleaning after sorting is completed. Since the waste delivered may be high in moisture, the area should be slightly sloped (1%) to avoid leachate ponding. A drainage system collects leachate and cleaning water to be reused for watering the compost.

Conveyor belts are installed and operated for internal transport of the organics streams.

Rejects will be disposed of at the adjacent landfill and recyclables (small amount because most are already removed from the waste before) will be stored in a separate area to be collected by the recycle companies.

Electricity supply is essential preferable 3-Phased 380V. An energy-efficient lighting system should be fitted to set a good example of energy conservation and to reduce operational costs.

The roads for waste delivery and pickup of residues should be well maintained and easily accessible throughout the year.

It is recommended to employ the today's waste pickers from the existing dumpsite at the composting facility.

Processing Technologies

A number of technologies and techniques have been developed and refined, ranging from simple and inexpensive, to complex, highly mechanized, and automated solutions.

First there are two distinctive technologies:

- I: Aerobic Process; further subdivided into two options:
  - A) Passively aerated
  - B) Actively aerated
- II: Anaerobic Digestion (AD) Process

The following considerations are given is selecting the best option for source separated organics treatment in Mawlamyine:

- Separated Organic waste includes leaves, yard waste (L&YW), and food waste ("wet" waste);
- Excluded is the option with "co-digesting" in anaerobic digestion system of a Waste Water Treatment Plant (WWTP); at the moment there is no WWTP in the three towns;
- Technology II: Anaerobic Digestion (AD) of Source-Separated Organics (SSO) from the municipal solid waste (MSW) stream is a relatively new technology. It is a very sophisticated technology with special expertise required. Systems as "high solids stackable", or "high solids slurry" and "liquid wet low solids" systems are already in use, however with high investment and operational costs and the need of highly skilled operators. The "AD" option is not further considered for the three towns (only applicable if it will be a DBO-project (Design-Build-Operate) by third parties if interested).
- The focus should not be on energy electricity production (too small quantities available, small plants), but main outcome should be high quality compost.

Following the considerations mentioned above, Technology I, Aerobic Processes, both A) Passively aerated, and B) Actively aerated, will be further investigated to select the best option for Mawlamyine. Table 3-20 provides an overview of the available techniques of composting systems.

Table 3-20: Proposed Composting Techniques to be further analysed

Passively aerated	Actively aerated
Static pile	Aerated static pile (ASP)

Bunker	Enclosed ASP tunnels
Windrow	Containerized ASP
Turned mass bed	Channel
Passively Aerated Windrow (PAW)	Agitated bed
	Rotating drum

The following section and Table 3-21 provides a brief overview of the composting methods and technologies outlined in Table above. These are suitable for facilities with capacities ranging from a few hundred tonnes to tens of thousands of tonnes per year (tpy).

Table 3-21: Overview Passive Aeration Composting Techniques

	Static piles	Bunkers	Windrows	Turned mass bed	PAW
Typical capacity tpy	< 10,000	< 5,000	< 50,000	15,000 to 50,000	< 10,000
Food waste included	no	no	yes	yes	yes
Typical active composting time	2 to 3 years	2 – 6 weeks	3 – 12 months	3 – 12 months	1 – 2 years
Post processing process	curing	curing	curing	curing	curing
Relative space requirements	High	Medium to high	Medium to high	Medium to high	high
Fuel consumption equipment	Low to medium	Low to medium	high	high	Low to medium
Leachate quantity	low	low	low	low	low
Construction cost	low	low	Low to medium	Low to medium	low
O&M cost	low	low	Low to medium	Low to medium	low

From the above table it can be concluded:

- Composting time longer than 1 year is not feasible: this eliminates two options 'static piles' and PAW (passive aerated windrows);
- Food waste composting when not included is not feasible: this eliminates two options: 'static piles' and 'bunkers';

- Capacities less than 10,000 tpy are not feasible, especially for the longer term with extension and higher quantities; capacity should be above 10,000 tpy, which means elimination of options of 'static piles', and 'bunkers' and 'PAW'.

Remaining two options with passively aeration technology: 'windrows' and 'turned mass bed'. However these options require still long active composting times, 3 to 12 months, which means consequently large surface areas should be available.

Actively aerated technologies have significantly shorter active composting times than passively aerated systems and consequently require less surface areas.

The "actively aeration technologies" are shown in Table 3-22.

Table 3-22: Overview Active Aeration Composting Techniques

	ASP (positive aeration)	ASP (covered)	Tunnel system (=enclosed ASP)	In-Vessel System	Channel	Rotating drum
Typical capacity (tpy SSO)	1 000 to greater than 100,000	1 000 to greater than 100,000	10 000 to greater than 100,000	500 to 50,000	15 000 to 100,000	1 000 to greater than 100,000
Typical active composting time	2 to 6 weeks	3 to 8 weeks	2 to 4 weeks	2 to 4 weeks	2 to 4 weeks	2 days to 1 week
Aeration method	Aeration fans	Aeration fans	Aeration fans	Aeration blowers, aeration lances	Aeration fans and mechanical agitation	Aeration fans and mechanical agitation
Post processing requirements	Curing	Curing	Curing	Curing	Curing	Further Composting and curing
Relative space requirements	Low to medium	Low to medium	Low	Low	Low to medium	Medium to high
Electricity consumption	Medium	Low to Medium	Medium	Medium	Medium to High	High
Leachate/condensate quantity	Low	Low to medium	Medium	Medium	Low	Low
Construction cost	Medium	Medium	High	Medium to High	Medium to High	High
O&M cost	Low to medium	Low	Medium to High	Medium to High	Medium	Medium to High

Note: ASP= Aerated Static Piles

From above table it can be concluded:

- Composting time all within a range no longer than 8 weeks maximum, however the option of a "Rotating drum" requires additional composting and curing time;
- For cost comparison, two options "Tunnel System (enclosed ASP)", and "Rotating drum" have higher construction costs and medium to high O&M Costs.
- ASP systems (Aerated Static Piles) are very flexible to future changes in capacities tpy, easy extension possible when area is available;
- Further details for 1) Aerated Static Piles ASP (positively aeration), and 2) ASP (covered), 3) "In-Vessel System" and 4) "Channel' will be compared below to obtain the best option.

Four options will be described below:

- Aerated Static Piles ASP (positive aeration);
- Aerated Static Piles ASP (covered);
- In-Vessel System;
- Channel composting system.

Ad 1) Aerated Static Piles ASP (positive aeration)

Aerated static pile: compostable materials are placed in large piles which are aerated by drawing air through the pile or forcing air out through the pile.

The advantages and disadvantages of the ASP system are shown in Table 3-23.

Table 3-23: Aerated Static Piles advantages and disadvantages

Advantages	Disadvantages
Pile configurations and height result in reduced space requirements	Slightly higher capital cost for forced-aeration equipment
Use of negative aeration can help avoid odour problems	Over-aeration can remove moisture
Smaller surface area relative to windrows reduces impacts of weather and rain infiltration	Feedstock pre-processing requires a higher degree of care; feedstocks must be well mixed and properly sized and moistened
Significantly shorter active composting times than passively aerated systems	More operator skill required to manage aeration systems
	Aeration systems generally require three-phase electrical supply

Ad 2) Aerated Static Piles ASP 'covered'

The difference with "ASP covered" system with "ASP positive aeration" is the tarp covers installed over the piles. The tarp covers generally protect the pile from infiltration of precipitation, reduce evaporative loss of water from the compost pile, reduce vector attraction, and in some cases help to control odours and volatile organic compound emissions.

Covered ASP systems are usually designed with an active composting time of three to eight weeks.

Feedstocks are injected into tubes as they are unrolled using a special piece of equipment that also places one or two flexible plastic aeration pipes in the bottom of tubes. When the pods are filled, the ends are sealed, and the pipe(s) in the base are connected to a positive aeration system. When the composting is complete, the plastic tubes are cut open, and the materials are removed.

This option 2 is essentially an upgrade system from option 1, it is possible to start with installation of option 1 and upgrade later to the option 2. However, option 2 is more labour intensive and therefore needs more staff and extra costs for the tarp covers with regular replacement (higher OPEX).

Ad 3) In-Vessel system

In-vessel composting occurs within a contained vessel, enabling the operator to maintain closer control over the process in comparison with other composting methods.

In-vessel in “vertical plug-flow” systems, the bio solids and bulking agent mixture is introduced into the top of the reactor vessel and compost is discharged out the bottom by a horizontally rotating screw auger.

Air is introduced in these systems either from the bottom and travels up through the composting mass where it is collected for treatment or through lances hanging from the top of the reactor.

In-vessel technology is more suitable than other composting technologies in suburban and urban settings because the system allows for containment and treatment of air to remove odours before release.

The requirement for a relatively small amount of land also increases its applicability in these settings over other types of composting. In-vessel requires less land area but higher investment and operation costs (vessel maintenance, regular replacement of rotating screw augers, more obstructions with the aeration system) than other actively aeration technologies.

The advantages and disadvantages of the In-Vessel system are shown in Table 3-24.

Table 3-24: In Vessel Composting advantages and disadvantages

Advantages	Disadvantages
Relative small area required for the vessels	Higher capital cost for vessels construction, mechanical parts and forced-aeration equipment
aeration releases can easily be captured and treated	feedstocks must be well mixed and properly sized and moistened
Very limited impacts of hot weather and (monsoon)rains infiltration	Rotating screw auger required regular maintenance and replacement, higher maintenance costs
	More operator skill required to manage the system

Advantages	Disadvantages
	Aeration systems generally require three-phase electrical supply

Ad 4) Channel composting system

Channel systems are essentially turned windrow piles placed inside of buildings. The windrow is situated between two long, parallel, concrete walls that are 1.8- to 2.4-m high and spaced between 3- and 6-m apart.

For Channel composting system, a specific turning machine is required.

A turning machine rides along the tops of the concrete walls. The turning machine has a conveyor or rotating drum that hangs below it and physically lifts and throws the compost backwards, agitating it in the process. As the turning mechanism makes repeated passes down the channel over time, it moves the mass of material from the feed end of the channel to its discharge end.

This specific turning machine needs experienced operators. Also it has high investment and O&M costs.

The advantages and disadvantages of the Channel system are shown in Table 3-25.

Table 3-25: Channel Composting advantages and disadvantages

Advantages	Disadvantages
Usually enclosed in buildings, so a higher degree of odour control can be achieved	Medium to high capital costs
Less space required than windrow composting	Lacks flexibility in dealing with feedstock peaks(requires increasing the turning schedule)
Mechanical turning systems are elevated above the composting bed and are easier to maintain	Positive aeration results in lower indoor air quality
	Proper preparation and mixing of feedstocks and amendments is critical
	Building and facility footprints are long and narrow, which may not fit on some properties

CONCLUSION

The channel composting system is more prone to failures and has higher investment cost and O&M cost than the ASP systems. The In-Vessel system has higher investment costs and need higher skilled operators and requires more maintenance. The “ASP covered” system can still be implemented if this seems necessary when an “Aerated Static Piles ASP (positive aeration)” system has been installed.

The recommended option for composting system, taken into account the investment costs, the O&M costs, the simplicity of operation, the duration of the composting time and the available land area is the “Aerated Static Piles ASP (positive aeration)” system.

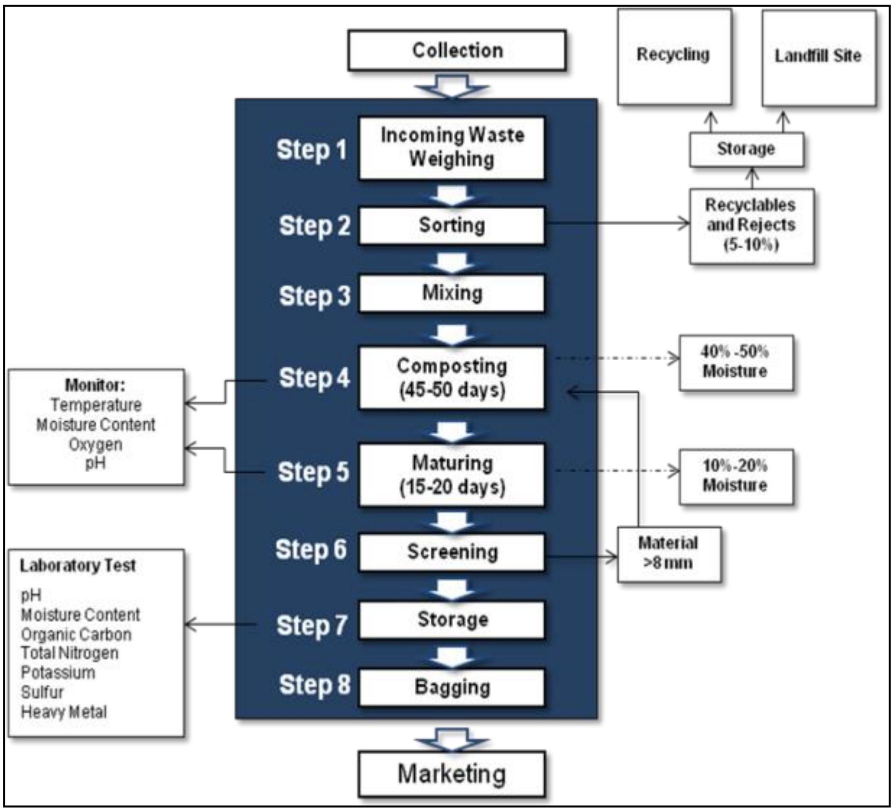
DESCRIPTION OF AERATED STATIC PILES (ASP) SYSTEM

In this technology, as shown in Figure 3-37 food waste organics and lawn–and yard waste, are collected together via the Community Collection Sites program. The materials are delivered by the transfer trucks to the composting facility where they are composted.

In the aerated static pile design option, the incoming organic stream is first pre-processed. After pre-processing, piles will be formed using a front-end loader.

The aerated static pile design option assumes, as a default, that a grid of piping lies out beneath the pre-processed stream to aerate the pile. Through blowers, sufficient air is supplied to the composting pad to aid the mixing, temperature control, and water vapour control. Finally, a layer of screened compost is often placed on top of the newly formed pile for insulation and odour control.

Figure 3-37: Flow Chart composting process and material flows



The organic wastes are delivered to the composting centre as shown in Figure 3-38. In the facility, paper and cardboard which are not already recycled, are composted in addition to kitchen and garden wastes. The composting operation can be divided into five main stages:

- **Delivery:** compostable wastes collected from the town green are delivered by transfer truck;
- **Sorting:** the sorting of waste through screening is to remove contaminants using equipment such as a trommel screens. Waste is forced into the trommel screen and separated into different size fractions and contaminants such as plastic films will be removed. A conveyor belt transport the screening further while other contaminant will be removed by handpicking (glass, plastic, etc.); further metallic wastes are removed using a magnetic separator above the conveyor belt. Then the wastes pass through a rotating 20 mm meshed screen in order to eliminate undesirable and coarse elements;

- **Mixing / Crushing:** the wastes are crushed and mixed before being conveyed to the composting pad;
- **Composting:** the organic wastes are put in the windrows, an air canal supplied by a ventilator diffuses air according to the windrow temperature in order to accelerate the composting process;
- **Maturing:** this operation lasts for about one month. The compost continues to mature until its biological activity has stabilized.

Figure 3-38: Organics loaded with Front-end loader

Maturing / Curing

Curing is an often neglected stage in the composting process. This final stage prevents the use of immature compost by allowing the compost to mature until stable. Curing occurs at lower temperatures, consumes less oxygen, generates less heat, and reduces moisture evaporation. This stage continues the aerobic decomposition of resistant compounds, organic acids and large particles, increases the concentration of humus, and allows the compost to gain disease suppression qualities (Rynk, 1992). Immature compost is an undesirable end product because it continues to consume oxygen, contains high levels of organic acids, possesses a high C/N ratio, competes for nitrogen, and can damage plant growth when used for agricultural applications.

Final Conditioning / Screening

Screening improves the final quality and appearance of the mature compost. Mechanical screening is an effective way to remove unwanted objects, recover bulking agents, and separate organics that are not completely decomposed. Screening also provides different “grades” of compost based on the particle size; coarse compost is usually returned back to the process to be further refined.

AREA DESCRIPTION

The composting area is preferably a concrete slab slightly sloped (1%) towards one side to allow excessive water from the compost heaps to flow into a drain. Along the lower end of the slab, a drainage channel for leachate collection leads to a collection point.

To operate efficiently, a composting facility must allot sufficient space to the pre-processing, processing, and post-processing compost stages as well as to the surrounding buffer zone. Typically, the bulk of the site will be occupied by the composting pad and storage area.

The total facility area comprises a tipping floor, pre-treatment area (for trommeling and shredding), composting pad, curing area, buffer zone, offices, roads, and storage of compost material and equipment.

Tipping Floor

The tipping floor design is based on an average waste height of 3.0 m, a maximum retention (storage) time of 4 a 5 days, and a manoeuvrability factor of 2.5 for a front-end loader. The tipping floor area requirements are calculated based on the daily flow rate (in tpd) and the bulk densities of each component entering the tipping floor.

Composting Pad

This is the area required for the composting and turning of organic waste compost piles. The composting pad is the largest area of the facility and the design is based on the typical geometry of the piles when regularly turned by a front-end loader. The following Design guidelines are used: provision for equipment turning clearance (manoeuvrability factor of 2.5), space between windrows (min. 2.0 m), side clearance (min. 2.0 m), windrow height (approx. 3.50 m), windrow base (max. 10.0 m), windrow crown (approx. 0.6 m), and windrows in parallel.

The organics are mixed and piled. There is no standard width or length for ASPs, as size is often dependent on site-specific requirements and land availability. For aerated static pile composting, pile dimensions can be for example:

Base width: 3.0 m - 6.0 m, Height: 1.5 m - 3.5 m, Length: 30.0 m or more.

In an actively aerated composting system, the air is distributed through the composting pile by a network of air pipes underneath the composting pile. The simplest method is a pipe-on-grade system using a set of perforated pipes that are laid out on the ground, with the compost pile built on top of the pipe system. The perforated pipe is often covered by a porous layer of woodchips or straw before the compost pile is built to improve air distribution. The perforated pipes and the porous base layer should typically be at least 2 m from the edges of the pile to prevent air from short-circuiting out the ends and sides of the pile, and to force air to pass through the material being composted, as shown in Figure 3-39.

There are several variations of in-floor systems, including covered trenches, pipe and spigot arrangements. These systems are more costly to construct but allow for quicker pile construction and tear-down, since there are no exposed pipes. They also eliminate the risk of damaging aeration piping and the need to replace pipes. Often, below-grade systems provide more efficient air delivery, which translates to reduced electrical consumption by aeration fans.

Fans are usually of the centrifugal-axial-blade type. The size of the fan or blower depends on a number of factors, including the type and porosity of material in the pile, the size of the pile, and air flow characteristics of the air distribution system.

Figure 3-39: Example outdoor composting with aeration pipes system

Leachate Flows: Generally, no significant amounts of leachate are produced in composting facilities, as long as compost is covered and the moisture content is kept near optimal values.

Wastewater reuse system: wastewater is generated during composting and the cleaning of the facility. Instead of discharging the wastewater into drains, it can be reused for new compost piles to maintain the moisture balance and enhance the decomposition process.

Front-end loader manoeuvrability factor for turning of piles; default of 2.5 is used

The following residence times will be used as default during ASP composting and curing stages of the waste stream:

For the high quality compost a 51-day compost residence time with a curing period of 30 days.

Maturing or Curing Area

At facilities that use the ASP composting system, curing activities normally take place in a separate, outdoor area. The curing areas should be located up-slope so that drainage from receiving and active processing areas does not flow into or through the curing area as shown in Figure 3-40. Curing pads should also have a slope of between 0.5 and 2% to promote drainage.

Normally curing takes place in open air windrows. However, during the monsoon rains in Myanmar it is recommended to cover the windrows with a simple roofing to avoid excessive rainwater intrusion and for the hot season to avoid too much evaporation.

The area for the curing piles is designed for a 30 days maximum storage period. The curing area needs less space compared to the composting area, about one quarter of the area of the compost pad.

Finished Compost Storage Area

Finished compost should be stored away from operating areas so that it is not contaminated by incoming feedstocks or surface water runoff from active composting and curing pads.

The treatment (for shredding and screening) and equipment storage areas were designed based on a typical footprint area of all pertinent equipment, the number of units, and a manoeuvrability factor of 2.

Area for storage of finished product: the size should take into account a storage period of ready product of max. 4 months.

The storage area should have graded surfaces (e.g., sloped at 0.5 to 2%) that promote drainage and prevent water from ponding, which can raise the product’s moisture content (and affect sales efforts) and/or result in anaerobic conditions and odours.

Figure 3-40: Windrow Layout in Curing Pad

The product storage area should also have a working surface consisting of a strong sub-base and base material that is able to support the weight of wheel loaders and trucks without rutting.

The size of product storage areas is a key consideration and is normally determined by the facility's production cycle and the demand for compost over the year.

For the surface calculation of finished compost area the following theoretical volume calculations is used (based on experiences in other countries): for every tonne of source-separated organics that is composted, approximately 0.5 tonnes of finished compost is produced.

A large volume of reject material, - about 20 % of incoming materials -, is rejected and sent to the landfill. This material may however be used as daily covering material of the waste at the landfill-front in the Cells.

Other Area Requirements

An office, sanitary buildings, repair shop and equipment parking are required.

Finally, the buffer zone is indicated with a distance of 10m from the fence/ land property area border, as shown in Figure 3-41.

A typical hangar type roof required for monsoon rains protection is shown in Figure 3-42.

Figure 3-41: Generic Lay-out of Composting Plant Mawlamyine

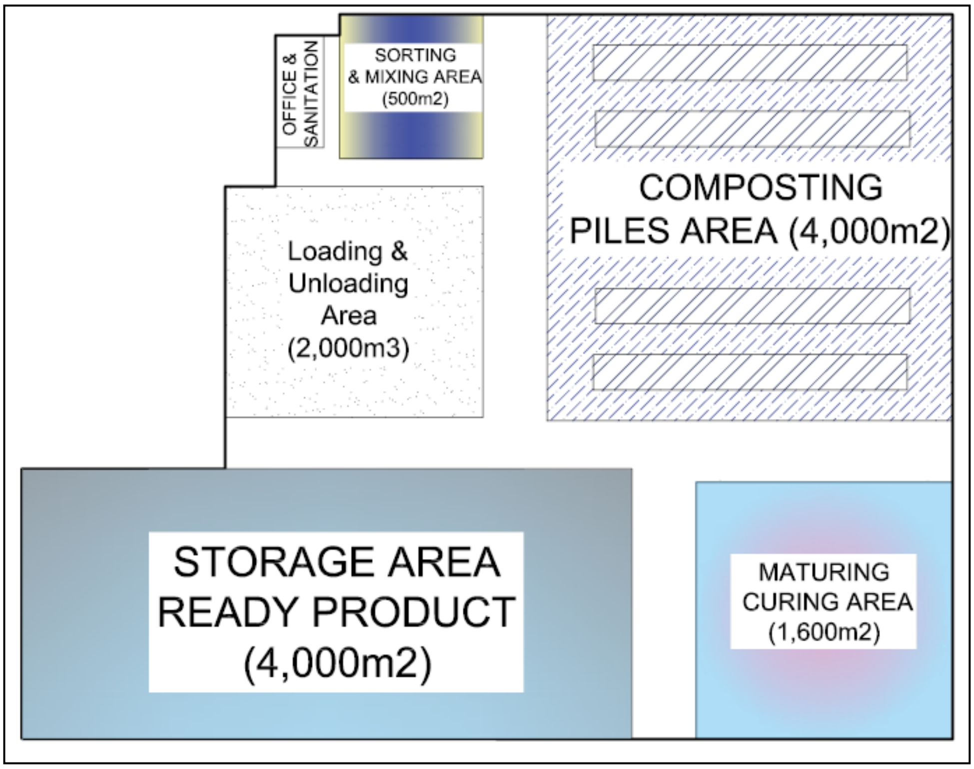
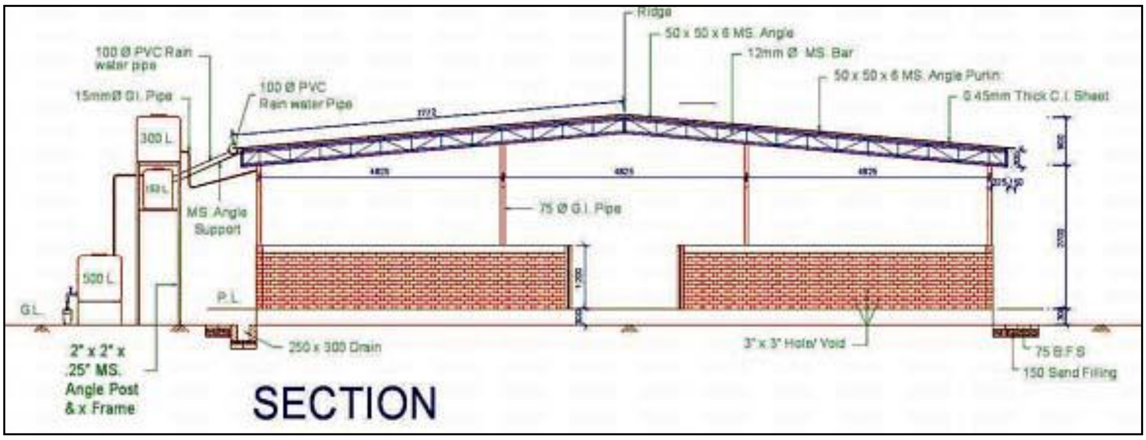


Figure 3-42: Example of Compost Cover: Hangar Type Roof



3.3.10 DISPOSAL LANDFILL

INTRODUCTION

A controlled landfill is a carefully engineered area specially built for environmentally safe disposal of wastes. The aim is to avoid any hydraulic (water-related) connection between the wastes and the surrounding environment, particularly groundwater.

A controlled landfill requires a very large area, due to the fact that it should have a life span of minimal 25 years uninterrupted disposal of municipal waste and the environmental requirements like protection of the groundwater and distances to rivers, creeks and other water courses. Next to this in the surrounding of a sanitary landfill no housing settlements are allowed because of health risks and nuisance.

UPGRADING OF EXISTING DUMPSITE

In Mawlamyine the existing dumpsite is about 2.5 ha in a 38 ha public area, large enough to upgrade this site to an environmental safe sanitary landfill site. Also the site is already in ownership of the Government which is favourable than to purchase new land elsewhere (which is difficult to find in short term, especially due to the large size and required buffer zone). The site is far enough from town, about 10 km and there are no housing in the surrounding areas. However, during implementation of this PPTA project, in December 2015 MSG started building apartment blocks at a distance of 300 m from the landfill site boundary. Conform the EPA (Environmental Protection Agency) International Regulations, a distance of 500 m should be used as Buffer Zone (see Box next page); however the Government of Myanmar has no regulations set for this area but it is foreseen that they will follow these Environmental regulation in the near future. It is highly recommended to stop further more apartment constructions in the dedicated Buffer Zone.

Minimum buffer distances at municipal solid waste and general waste landfill facilities:

- 500 m to residential development, rural townships and highways or arterial road networks.
- A lesser buffer may be acceptable where it is considered compatible with the surrounding area and land uses so that there will be an effective buffer of 500 m between the landfill and any sensitive or incompatible land use.

To enable a more sustainable mode of operation at the existing dump site in Mawlamyine it is proposed to:

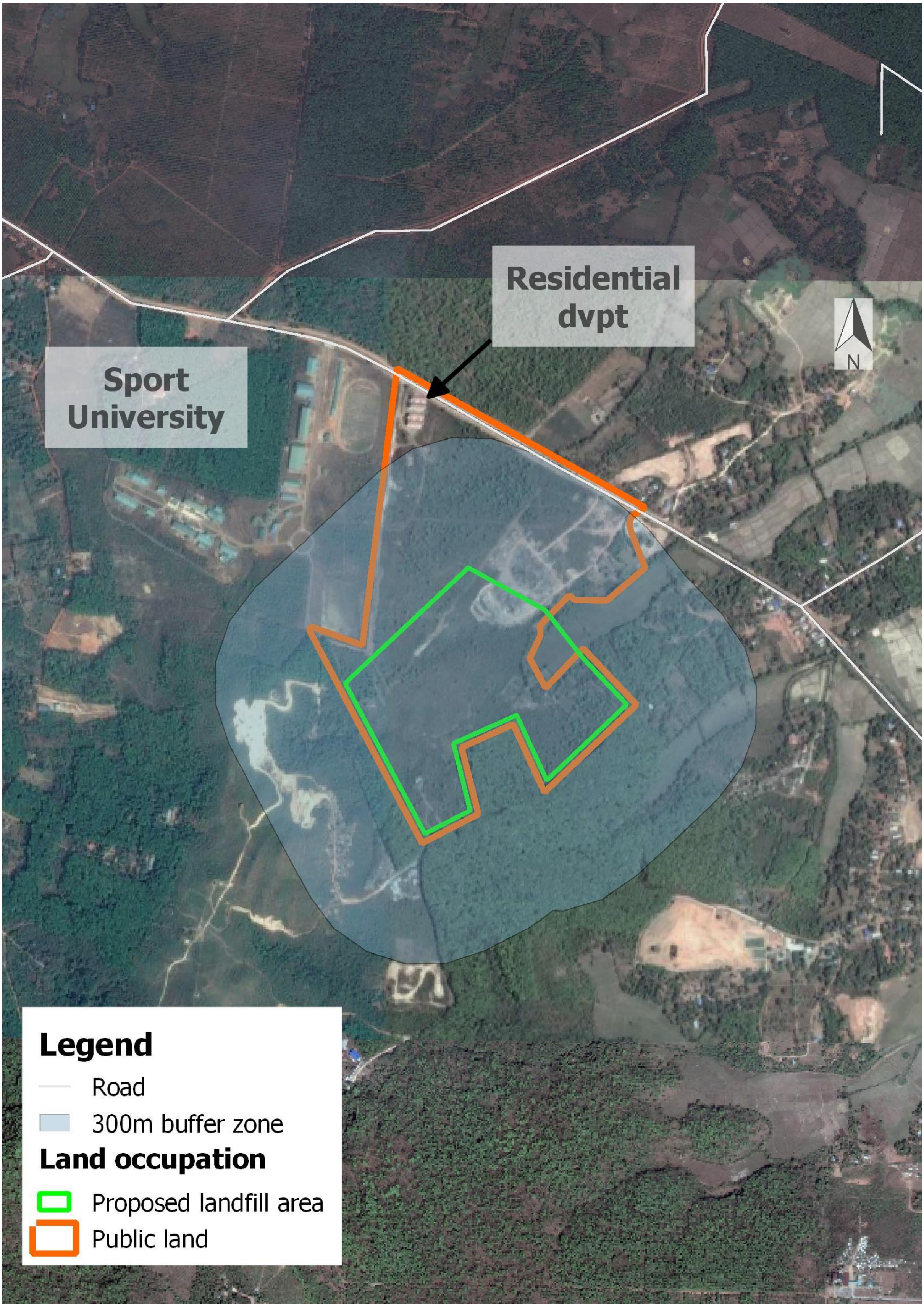
- move the existing solid waste into one confined area. This waste will be removed to landfill cell I as soon as the first landfill cell has been completed;
- To build a first landfill cell with 5 year life span capacity, separated in 5 sub-cells to facilitate the hydraulic flow of leachates;
- introduce a managed landfill concept;
- to prepare a part of the site for Composting Plant area;
- to purchase small pieces of land to make a more sizable landfill site location (more rectangle size, is easier and much more economical for construction than a "spaghetti-size" area.)

The location of the existing dump site and proposed landfill area is shown on Figure 3-43.

Design of the proposed landfill will include clay lining, groundwater monitoring, planned cell development, leachate collection and storage, surface water management, and regular covering of waste and controlled waste picking. A separate area for medical waste will be provided with a small incinerator with shed for infectious waste.

The sanitary landfill will be fenced to control the access.

Figure 3-43: Mawlamyine Proposed Landfill and Existing Dump Site



There are three critical elements in a controlled landfill:

i) a bottom liner,

ii) a leachate collection system,

iii) a final cover.

Landfill bottom liners are made of high density polyethylene (HDPE) to avoid any leakage of leachate into the soil. An HDPE liner is minimal 1.5 mm thick and is normally installed by a specialist supplier to 'welt' the sheets together. Normally an HDPE liner is delivered on rolls of 7.00m width with a length of 140m. The liner shall be a composite barrier having 1.5 mm HDPE or equivalent having permeability less than $1*10^{-7}$ cm/sec. The water table should be at least 2 m below the base clay or amended soil barrier layer.

The liner system should also be applied on side slopes. To install the HDPE liner, it should be kept out of sunlight otherwise it will be damaged through the action of ultraviolet radiation (Figure 3-44).

Figure 3-44: Liner system of Controlled Landfill

Leachate is water which is contaminated by contacting the wastes. It seeps to the bottom of a landfill and is collected by a system of pipes (Figure 3-45). The pipes laid along the bottom capture the contaminated water (leachate). The pumped leachate is treated at a leachate treatment unit, see further for details of leachate treatment.

Figure 3-45: Leachate collection system of controlled Landfill

To reduce the leachate volume, the disposed waste should be covered daily with soil to avoid rainfall intruding the landfilled waste.

Leachate control

Even with good operational practices and surface water controls, most landfills will generate leachate. This leachate must be managed so as to prevent contamination of groundwater and surface water. Leachate management is best accomplished through the installation of a landfill liner and the installation and operation of an engineered leachate collection/conveyance system.

Leachate Treatment options in this project include the following:

- Recirculation back into the landfill;
- Passive evaporation to the atmosphere (often through holding ponds or storage lagoons)
- On-site physical and biological treatment.

The sequence as mentioned above will be utilized for the treatment of leachate, this depending on the rainfall/day. The first option is practicable with low to normal rainfall, after which the second option will be applied.

The on-site physical biological treatment is the last option and may be used during heavy monsoon rains when storage is not sufficient. At this stage in the project, a simple treatment unit with physical treatment (sedimentation, settling pond) and biological treatment (e.g. through surface aerators) is foreseen.

At the closure of the landfill cells after 5 years of operation, a final cover or cap over the landfill cell will keep precipitation water out (to prevent leachate formation) of the landfill. It generally consist of several sloped layers: clay or membrane liner (to prevent rain from intruding), overlain by a permeable layer of sandy or gravelly soil (to promote rain runoff), overlain by topsoil in which vegetation can root (to stabilize the underlying layers of the cover).

Environmental monitoring: Ground Water Monitoring Wells: Total to be installed numbers = 6 (1 well up-gradient of the ground water flow; 5 wells along the sides in down-gradient direction); all wells 30m away from landfill.

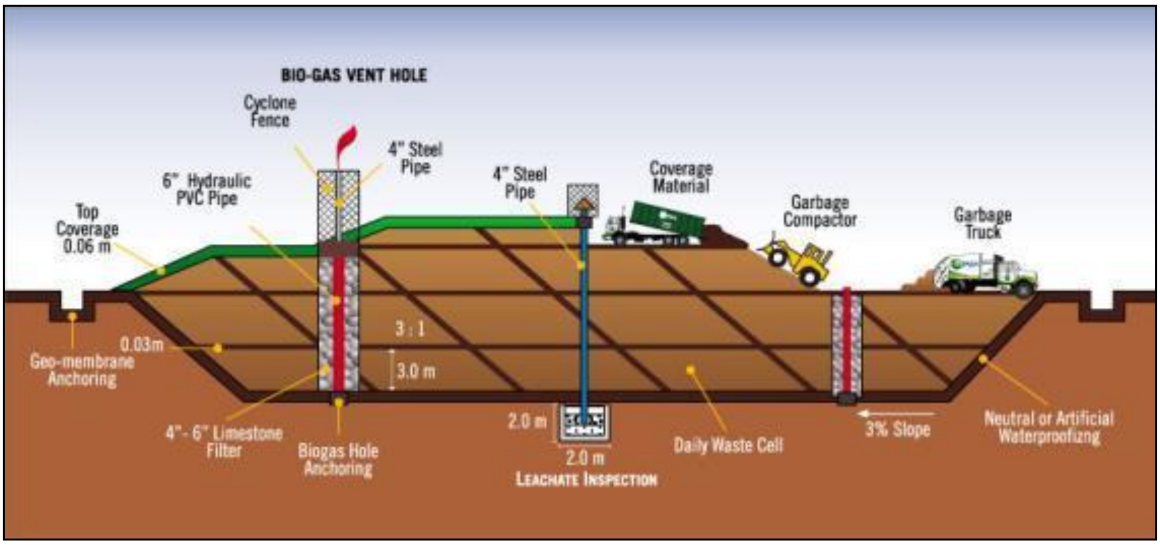
The main principles for a controlled Landfill are presented in Figure 3-46.

Note on Landfill Gas

Aerobic decomposition begins immediately after organic waste disposal in the landfill and continues until all of the entrained oxygen is low or not present anymore. This process generates landfill gas (LFG) which is harmful to the environment. The potential impacts is most significant at landfills of significant size (nominally >1Mt waste capacity). In case of mixed waste landfills, they should have LFG collection and control systems installed that are designed and operated to minimize both LFG migration and emissions. The landfill gas is either burned off in a flare, or used to generate electricity in a gas turbine.

It is however limited in this project by diverting the biodegradable waste to the compost plant and disposing in the landfill mainly inert waste with low quantities of biodegradable waste rejects. Additionally the landfill is relative small and LFG control can be achieved by passive venting, no flaring is required. However, it is important to monitor on a regular bases (e.g. once/month) if landfill gas is produced. Experiences with similar landfill systems show that no significant landfill gas is produced at inert waste landfills.

Figure 3-46: Principles for Construction of Controlled Landfill



EQUIPMENT REQUIRED FOR LANDFILLING

For daily spreading and soil covering a bulldozer is required. The bulldozer also compacts the waste, although not as the same level as a specialized Compactor Machine. In this project with a relative small landfill size, a Compactor is not required and a bulldozer has more diverse operational options compared to a compactor.

A small tractor with cart-trailer will be used for carrying on-site the daily cover material and for transport of separated waste from the compost plant and other works on-site. It is assumed that the front-end loader from the compost plant can be used for the small quantities to be loaded. A second front-end loader only for the landfill is not required during the first phases of the landfill operation. At the long term it is maybe necessary to operate an additional front-end loader. A second loader is not included in the Investment costs.

3.3.11 PRELIMINARY DESIGN

The preliminary design consists of the following sections:

- Collection Strategy
- Recycling improvement
- Composting
- Controlled Landfill

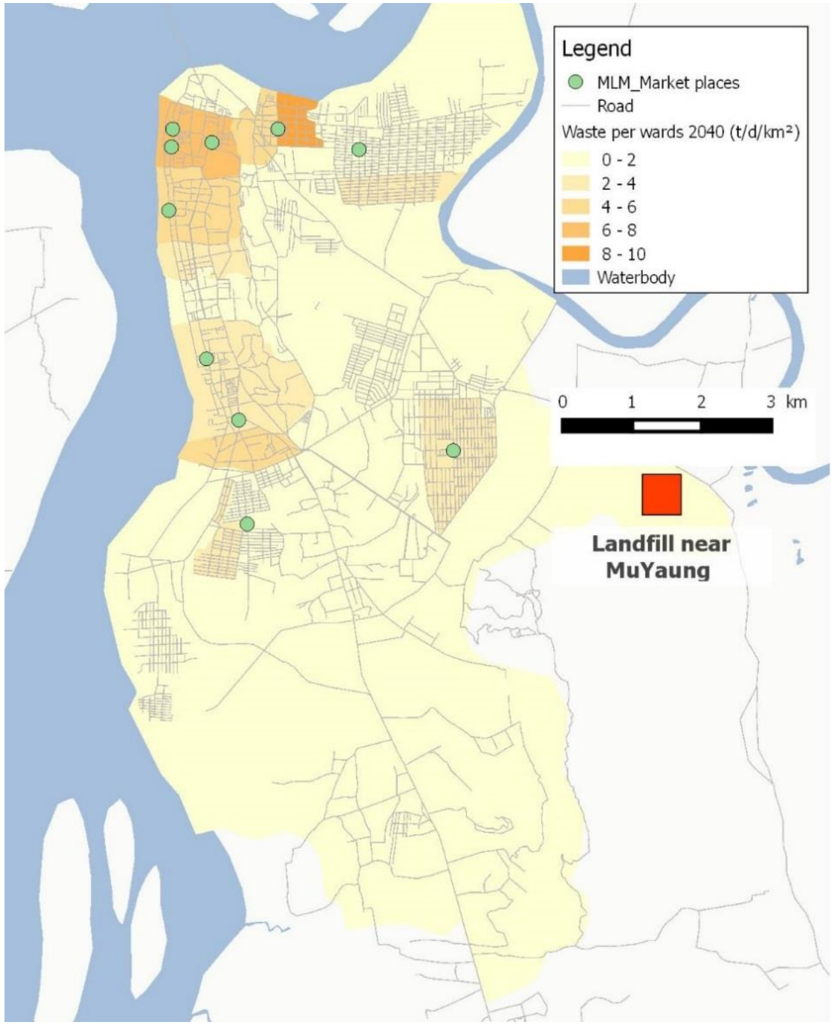
COLLECTION STRATEGY

Primary Collection trucks for a critical distance below 10 km

In parallel with the density of population, the waste generation per wards is denser in the historical area of the city. This is particularly accentuated by the presence of the main markets. The following Figure 3-47 displays a big densification of the waste generation in downtown area while wide wards in the South would remain low densified.

Five collection zones are proposed to analyse the type of truck adapted to each area.

Figure 3-47 Waste generation per ward in t/d/km² in 2015 and 2040



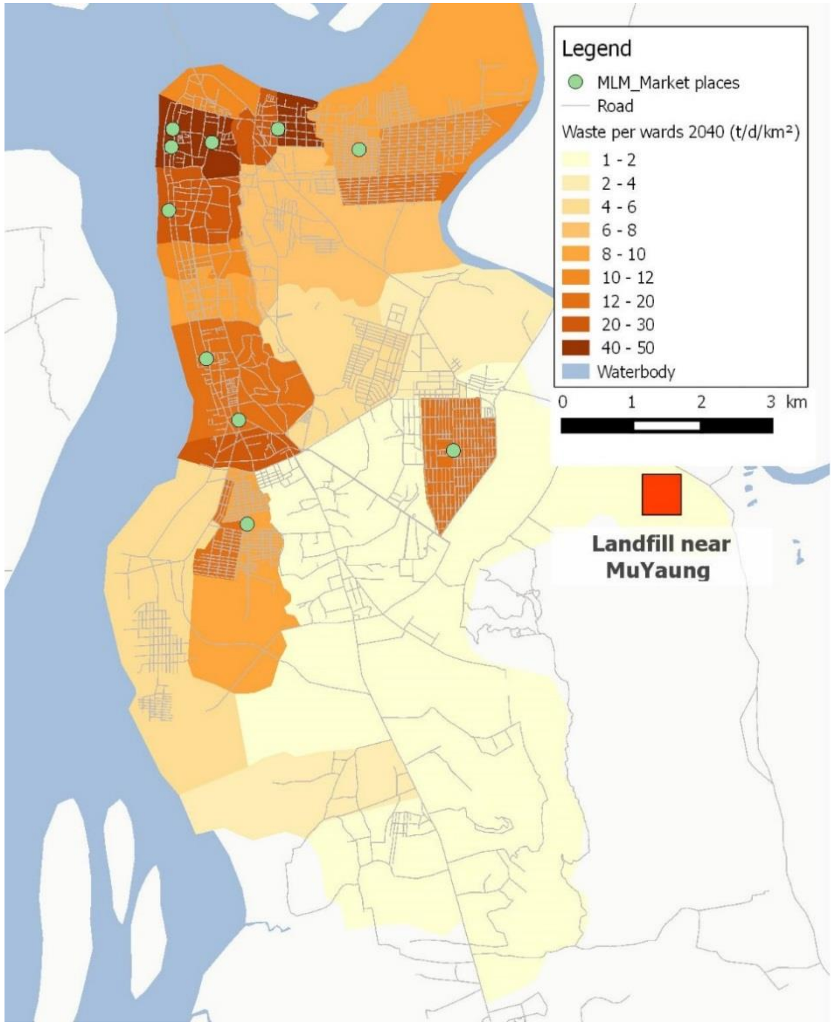
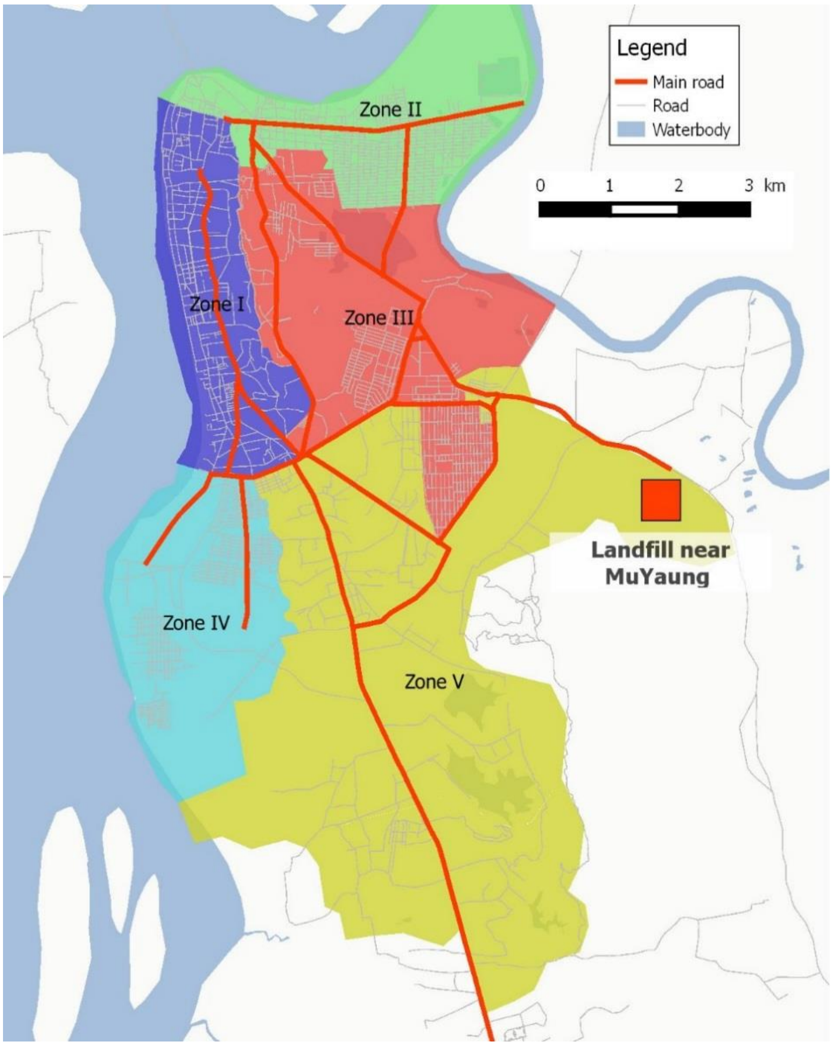


Figure 3-48 Proposed solid waste collection zones for Mawlamyine



Four type of trucks have been studied for Mawlamyine SWM with the following assumptions:

Type	Tractor	Dumper Small	Dumper Large	Compactor
Capacity (m3)	4-5	7-8	10	13-16
Compaction ratio	1	1	1	2
Average speed	12	12	12	12

Table 3-26 Number of small tractors needed to fulfill collection requirements

Tractor (cap: 4 m3)	distance to landfill (km)	trip duration (2 ways) (in h)	Maximum trips / day (working 7 h/d)	Maximum Cap/truck/d	Waste collected 2015 (t/d)	Waste collected 2040 (t/d)	Trucks needed 2015	Trucks needed 2040
Zone I	10.5	1.8	4	16	19.2	108.4	1.2	6.8
Zone II	8	1.3	5	20	26.5	149.7	1.3	7.5
Zone III	6	1.0	7	28	14.5	81.9	0.5	2.9
Zone IV	9	1.5	5	20	11.3	63.6	0.6	3.2
Zone V	9.5	1.6	4	16	8.5	48.2	0.5	3.0
						Trucks needed	**5**	**24**

Table 3-27 Number of small dumpers needed to fulfill collection requirements

Dumper small (cap: 7 m3)	distance to landfill (km)	trip duration (2 ways) (in h)	Maximum trips / day (working 7 h/d)	Maximum Cap/truck/d	Waste collected 2015 (t/d)	Waste collected 2040 (t/d)	Trucks needed 2015	Trucks needed 2040
Zone I	10.5	1.8	4	28	19.2	108.4	0.7	3.9
Zone II	8	1.3	5	35	26.5	149.7	0.8	4.3
Zone III	6	1.0	7	49	14.5	81.9	0.3	1.7
Zone IV	9	1.5	5	35	11.3	63.6	0.3	1.8
Zone V	9.5	1.6	4	28	8.5	48.2	0.3	1.7
						Trucks needed	**3**	**14**

Table 3-28 Number of large dumpers needed to fulfill collection requirements

Dumper large (cap: 10 m3)	distance to landfill (km)	trip duration (2 ways) (in h)	Maximum trips / day (working 7 h/d)	Maximum Cap/truck/d	Waste collected 2015 (t/d)	Waste collected 2040 (t/d)	Trucks needed 2015	Trucks needed 2040
Zone I	10.5	1.8	4	40	19.2	108.4	0.5	2.7
Zone II	8	1.3	5	50	26.5	149.7	0.5	3.0
Zone III	6	1.0	7	70	14.5	81.9	0.2	1.2
Zone IV	9	1.5	5	50	11.3	63.6	0.2	1.3
Zone V	9.5	1.6	4	40	8.5	48.2	0.2	1.2
						Trucks needed	**2**	**10**

Table 3-29 Number of compaction trucks needed to fulfill collection requirements

Compactor (cap: 16 m3)	distance to landfill (km)	trip duration (2 ways) (in h)	Maximum trips / day (working 7 h/d)	Maximum Cap/truck/d	Waste collected 2015 (t/d)	Waste collected 2040 (t/d)	Trucks needed 2015	Trucks needed 2040
Zone I	10.5	1.8	4	104	19.2	108.4	0.2	1.0
Zone II	8	1.3	5	130	26.5	149.7	0.2	1.2
Zone III	6	1.0	7	182	14.5	81.9	0.1	0.5
Zone IV	9	1.5	5	130	11.3	63.6	0.1	0.5
Zone V	9.5	1.6	4	104	8.5	48.2	0.1	0.5
						Trucks needed	**1**	**4**

Zone I and Zone II are the furthest zones and the weight to collect is important due to their density of population and the presence of the main markets.

As markets are generating a lot of wastes in a specific area (main containers at the corner of the markets), it is important to ensure an efficient collection by a large capacity truck such as compaction truck. The leachates rapidly generated by the important amount of organics would be properly maintained as compaction trucks are impervious.

As streets are narrow in Zone I and II, the private solid waste collection could be completed by two 7m3 dumpers in a first phase and two more in a second phase.

Zone III, IV and V will be densified according to the urban planning proposed by DUHD. However it is expected less densified areas than in historical zones I and II. Then larger dumpers would be able to work in these zone.

The truck duration is estimated 15 years corresponding to the first phase. Then the second phase must be include a truck renewal and additional trucks to face the increase of waste generation.

<table>
<tr><th></th><th colspan="3">First phase (2018 – 2030)</th><th colspan="3">Second phase (2030 -2040)</th></tr>
<tr><th></th><th>Dumper Small</th><th>Dumper Large</th><th>Compactor</th><th>Dumper Small</th><th>Dumper Large</th><th>Compactor</th></tr>
<tr><td>Zone I</td><td>1</td><td>-</td><td rowspan="2">1</td><td rowspan="2">2</td><td>-</td><td rowspan="2">2</td></tr>
<tr><td>Zone II</td><td>1</td><td>-</td><td>-</td></tr>
<tr><td>Zone III</td><td>-</td><td>1</td><td>-</td><td>-</td><td>2</td><td>-</td></tr>
<tr><td>Zone IV</td><td rowspan="2">-</td><td rowspan="2">1</td><td>-</td><td>-</td><td>2</td><td>-</td></tr>
<tr><td>Zone V</td><td>-</td><td>-</td><td>1</td><td>-</td></tr>
</table>

Improvement of collection practises

- Improve collection points, especially at the main markets. Remove mobile carts and replace them with containers.
- Improve the overall collection rate.

Improvement of the Primary collection consists of the following proposed elements:

Table 3-30: Improvement Primary Collection

Item	Description	Subdivision	Number to purchase
i)	Small containers 240 ltr in 3 different colours for the three different separation waste streams: for each	Green colour containers for organics;	56

Item	Description	Subdivision	Number to purchase
	ward two collection points (28 Wards)	Blue colour containers for recyclables Yellow containers for reject waste	56 56
ii)	Aluminium containers 1100 ltr for siting at small size collection points. Two different containers for separating organics and rejected waste.	Aluminium container with large text on site: ORGANICS Aluminium container with large text: ONLY REJECTS WASTE	28 28
iii)	Transport containers content 3 m3 for collecting with hooklift trucks	Steel containers 3 m3 hooklift system	28
iv)	Collection trucks for above containers	Small trucks with lift system for 240 ltr and 1100 ltr containers Hook lift Truck for 3m3 steel containers	2 2
v)	Compactor for market areas	16 m3 compaction truck	1

It should be noted, that each truck can transport different containers with separated organics, recyclables and reject waste. This means that the truck is not dedicated to one separate waste stream but will be used in a multi-functional way (however never mix the waste streams in one truck load or one container load).

The number of trucks is based on the first phase implementation phase Short Term till 2020. It is obvious when the new waste management systems will be fully implemented, more trucks are required. This is assumed taken place in the next Phase, Medium Term 2025 -2030.

RECYCLING

The recycling system will be further improved for higher efficiency in separating the recyclables. Two sectors are distinguished:

- Informal Sector;
- Formal Sector.

Informal Sector

To improve the informal collection sector, it is important that the today's recyclable collectors are getting familiar with the new introduced upgraded integrated solid waste management system.

Awareness campaigns, information how to deal with recyclable collection in a Healthy and Safe manner are important issues for the informal sector. To improve this behaviour regular meetings and information leaflets will be provided to the informal collection sector and the public.

It is estimated that during the implementation of this first Phase Short Term project, communication meetings and leaflets information will be provided.

Formal Sector

To improve the recyclables collection rate from about 16% to about 20%, more involvement of the Formal Sector is required. More collection will be implemented throughout the following measures:

Table 3-31: Improvement measures Recycling Sector

Item	Description of purchase or implementation	Subdivision	Number
i)	Formal sector: Introducing at schools, township offices and other official buildings the separation and recovery of recyclables using 3 different colour containers	recyclables ("dry waste"): 240 ltr containers Blue compost ("wet waste"): 240 ltr containers Green reject waste: 240 ltr containers Yellow	28 28 28
ii)	Adding aluminium containers 1100 ltr at specific collection Points in town for deposit recyclables by the public	Additional Recycling containers 1100 ltr, 1 in each ward	28
iii)	Adding some extra 3m3 containers in the most populated wards of town	Additional containers 3m3 hook lift system in most populated wards	15

Note: it is however possible to introduce small containers of 40 or 60 ltr, to be placed inside buildings especially dedicated for "dry" waste (=recyclables) and reject waste, while composting containers can be placed outside the building easy accessible for the public. These smaller containers are not estimated in this project but could easily be purchased at the municipality own initiative.

COMPOSTING

Two proposed systems will be introduced in the town:

- Backyard Composting;
- Construction of a Composting Plant.

Backyard Composting

Backyard composting will only be introduced in the peri-urban areas of the town and for houses with large gardens.

At the moment the public is not acquainted with composting. Therefore training and information is required to assist the potential house owners with backyard composting. In this project it is estimated to implement "Instruction and Awareness

Programs for Backyard composting”. This may be executed in conjunction with the recyclables awareness programs.

Construction of Compost Plant

The following main constructions are estimated for the first Phase composting of 25% of the generated waste till 2025. The design capacity is 65 tons/day. The follow-up phase to compost 40% of the waste generated is not estimated in this project as capital Investment. The capacity prognosis for this second phase is about 120 ton/day. However, extensions of the compost plant are included in the land surface areas. Purchase of Equipment is selected on 40% composting quantities, like Front-end loader, conveyor belts and trommel screens.

Some of the civil works are included in the Landfill design as they will be used for both operations. The following items are included in the landfill design and landfill cost estimate: Access Roads, Guard house and entrance, fencing around the site including perimeter roads, weighbridge and on-site gravel roads.

WORKS: The composting Plant for Mawlamyine will have the following main items to be constructed as Works:

- Construction of Sorting Area: concrete pad with drainage system
- Construction composting pad: concrete pad with drainage system
- Construction of “monsoon” cover over composting area: hangar style roof
- Construction Maturing (Curing) area, concrete pad
- Construction of Storage area ready Product: concrete based area with hangar style roof
- Offices, sanitation building, equipment and trucks storage.

SUPPLIES: Equipment to be purchased as Supplies:

- Front-end loader: 1
- Trommel screen, capacity max.15 tons/hour: 1
- Conveyor belts different lengths and width: 5
- Magnetic Ferro remover: 1
- Mixer and Grinder, max capacity 15 tons/hour: 1
- Final automatic screens <10mm

The following table presents the required areas for each part of the compost plant. The detailed calculation is presented in the Appendices.

Table 3-32: Required Areas for Compost Plant Phase 1 Mawlamyine

Compost Plant Item	Unit	Total
Design Capacity	**tonnes/day**	**65**

Compost Plant Item	Unit	Total
Sorting Area	m^2	500
Composting pad	m^2	4,000
Maturing pad	m^2	1,600
Storage Area	m^2	4,000
Subtotal	m^2	10,100
Mech. Equipment area	m^2	2,000
Total	m^2	12,100
Total ha. (/10,000m^2)	ha	1.21
Total acres (2.4691m^2)	acres	3.00

A lay-out of the compost plant is provided in the Appendices.

CONTROLLED LANDFILL

Waste quantities

For designing the capacity of a landfill, the waste quantities which will be landfilled during the life span of the landfill are calculated. The lifespan proposed of the Mawlamyine landfill is till 2040. The calculation is based on several important prognoses for the long term. It should be noted that landfill capacity values will undergo revision during operation of the landfill when waste quantities delivered at the site vary from the generation rates estimated prior to the start of landfill operations.

The following prognoses are taken into account for calculating the waste quantity going to the landfill:

- Population growth in Mawlamyine from 258,809 in 2015 to 424,603 in 2040
- Quantity per capita from 0.55 kg/c/day in 2015 to 0.9 kg/c/day in 2040
- Separation rates for composting fractions of 25% of collected wastes in 2020 to 40% of collected wastes starting in 2026;
- Recyclables recovery rate from approx. 16% of collected waste in 2015 to 20% of collected wastes in 2020;
- Collection of generated waste from 55% in 2015 to 92% in 2025 and finally to 98% in 2040.

The total rejects waste to be landfilled after the separation of the recyclables and organics from the generated waste is 1,174,000 tonnes during the lifespan of the landfill in 2040.

The calculation of the waste quantities to be landfilled is shown in Table 3-33. The complete excel sheet with the detailed quantities calculation is presented in the Appendices.

Table 3-33: Waste disposal quantities 5-years projections

Year	Population	Waste generated ton/day	Waste not collected ton/day	Recyclables ton/day	Compost ton/day	Disposal ton/day	Disposal waste ton/year
2015	258 860	171	91	13	-	67	24 500
2020	286 084	213	21	38	48	105	38 500
2025	316 172	262	21	48	96	96	35 200
2030	349 424	319	19	60	120	120	43 700
2035	386 173	385	15	74	148	148	53 900
2040	426 788	461	9	90	181	181	65 900
					Total in 25 years		**1,174,000**

The table above shows that after implementation of the first Phase of the project with improved collection system and start of the Compost Plant (with 25% composting of the collected wastes the first 5 years), the disposal quantities increases mainly due more collection of the waste in the town with a reduced amount of not-collected waste quantities. After 2025 when the second phase of Composting (to 40% of the collected waste) will be implemented, the quantities increase mainly due to population growth and higher quantities of waste generation per capita per day.

The total calculated waste for disposal in 25 years is 1,174,000 tonnes. This quantity will be disposed in several landfill cells. The required surface area and level of landfill cells is presented in the next paragraph.

LANDFILL AREA AND LANDFILL CELLS

The following quantities and area surfaces are calculated for the landfill area. The waste of the existing dumpsite will be removed to the new controlled landfill. An estimate quantity of 100,000 m3 is added to the total waste generation (existing dumpsite area is about 2.5 ha, waste level approx. 4.00 m).

Table 3-34: Total Landfill Disposal area and Landfill Cell I area

Mawlamyine Landfill Item	Unit	Total
Waste generated till 2040	m^3	1,174,000
Existing waste dumpsite estimate	m^3	100,000
Total estimate 2040 LF	m^3	1,274,000
Cover material +30%	m^3	382,200
Total Capacity LF 2040	m^3	1,656,200
Average height	m	12
Area for landfill waste	m^2	138,000

Mawlamyine Landfill Item	Unit	Total
Calculated area (trapezium shape)	m^2	146,300
Infrastructures (roads, offices etc.): 15%	m^2	21,945
Total m2	m^2	168,245
Total ha. (/10,000m2)	ha	16.80
Total in acres (2.4691m2)	acres	41.54
First CELL I		
Total number of Cells	No.	5
Percentage landfilled in Cell I	%	20
Quantity waste in Cell I	m^3	330,814
Area required Cell I:	m^2	175 x170m: 29,750
Cell I in ha.	ha	3.00
Cell I in acres	acres	7.35

See for the detailed calculation the excel sheets in the Appendices.

A controlled landfill will be constructed at the same site location as the existing dumpsite. The construction will be as described in the previous section.

Leachate Treatment

As indicated previously, Leachate Treatment in this project includes the following:

- Recirculation back into the landfill;
- Passive evaporation to the atmosphere (often through holding ponds or storage lagoons)
- On-site physical and biological treatment.

The sequence as mentioned above will be utilized for the treatment of leachate, this depending on the rainfall/day.

Capacity of a leachate storage and treatment pond by full evaporation method:

The area of a landfill Cell is 3 ha. However to ensure good leachates management and reduce storm water intrusion, it should be divided in 6 months to 1 year lifespan sub-cells. The amount of 330,000 m3 (cell I capacity including coverage) will be reached in 5 years. Then a sub-cell should have an area of 3 ha/5 = 6,000 m^2.

The leachate discharge estimate is a complex calculation involving several parameters such as rainfall, evaporation, but also waste absorption, humidity, temperature, etc.

As a first approach, it is considered here only rainfall and evaporation (source DMH data from 2011 to 2015). The estimated area under use is one sub-cell so 6,000 m².

	Average rainfall (mm/month)	Storm water volume (m3/month)	Average evaporation (mm/month)	Surface needed for full evaporation (m²)
January	5	33	125	260
February	0	1	133	9
March	24	144	170	847
April	30	180	172	1045
May	428	2569	240	10714
June	858	5147	227	22629
July	1120	6720	253	26556
August	1269	7615	291	26177
September	785	4709	270	17427
October	170	1023	146	6983
November	31	188	128	1470
December	37	222	126	1757
Calculation for a year	4759 mm/y	28551 m3/y	2283 mm/y	12507 m² (average)

Note: The above calculation is not including the surface of the leachate pond. The leachate pond should be covered by a roof in order to reduce the inflow from storm water

To conclude, a leachate removal by evaporation would involve a wide leachate pond (12 ha at least) with a covering roof.

Then a leachate treatment plant has to be considered.

Two samplings were done at the leachates outlet of the existing dump site:

- Sampling in September 2015: BOD = 160 / COD = 740
- Sampling in July 2016: BOD = 400 / COD = 900
- Both results reveal a high concentration in Iron and Nitrogen and a lower concentration in Phosphates.

However these samplings should be completed by additional samplings before designing the leachates treatment plant. In addition, the leachates production estimate should be more detailed by analysing the humidity rate in the wastes in dry and rainy season.

In a first approach, the treatment plant would have an average flow of 80 m^3/d or 2400 m^3/month or 29 000 m^3/year. During the rainy season the storm water reaches 27 000 m^3 (From May to September (5 months)) then the basin would need to accept 27 000 – (5*2400) = 15000 m^3. Including 20% of evaporation, the minimum volume of the basin is 12000 m^3.

A 4000 m² leachates pond by 3 m deep would allow a simple evaporation process in dry season and an average treatment of 80 m^3/d.

The municipal septage trucks are currently tipping wastewater into the dump site. The leachate treatment plant would be an advantage to treat both leachates and septic tanks effluents.

- WORKS: The following main structures are estimated for Works:
  - Access road, width 7.50 m for heavy trucks;
  - Perimeter fence 2.00 m high;
  - Guard house with barrier;
  - Weighbridge 40 tons;
  - On-site roads (gravel); 3.00 width;
  - Construction of landfill Cell no. I, about 330,000 ton capacity (calculation details in next paragraph and in Appendices;
  - Perimeter survey road, width 3.50 m for normal vehicles;
  - Leachate storage pond with treatment;
  - Environmental Monitoring wells; 6 pc
  - Offices and sanitary buildings;
  - Power supply and water supply connections.
- SUPPLIES: The following Landfill Equipment are required for Supplies:
  - Bulldozer 185 kW (248 HP) for transfer and compacting of waste;
  - Small 4-wheel drive truck tractor for on-site transfer of daily cover soil;

It should be taken into account, that only the first landfill Cell no. 1 will be constructed during this phase. Future landfill Cells have to be constructed according to the following scheme:

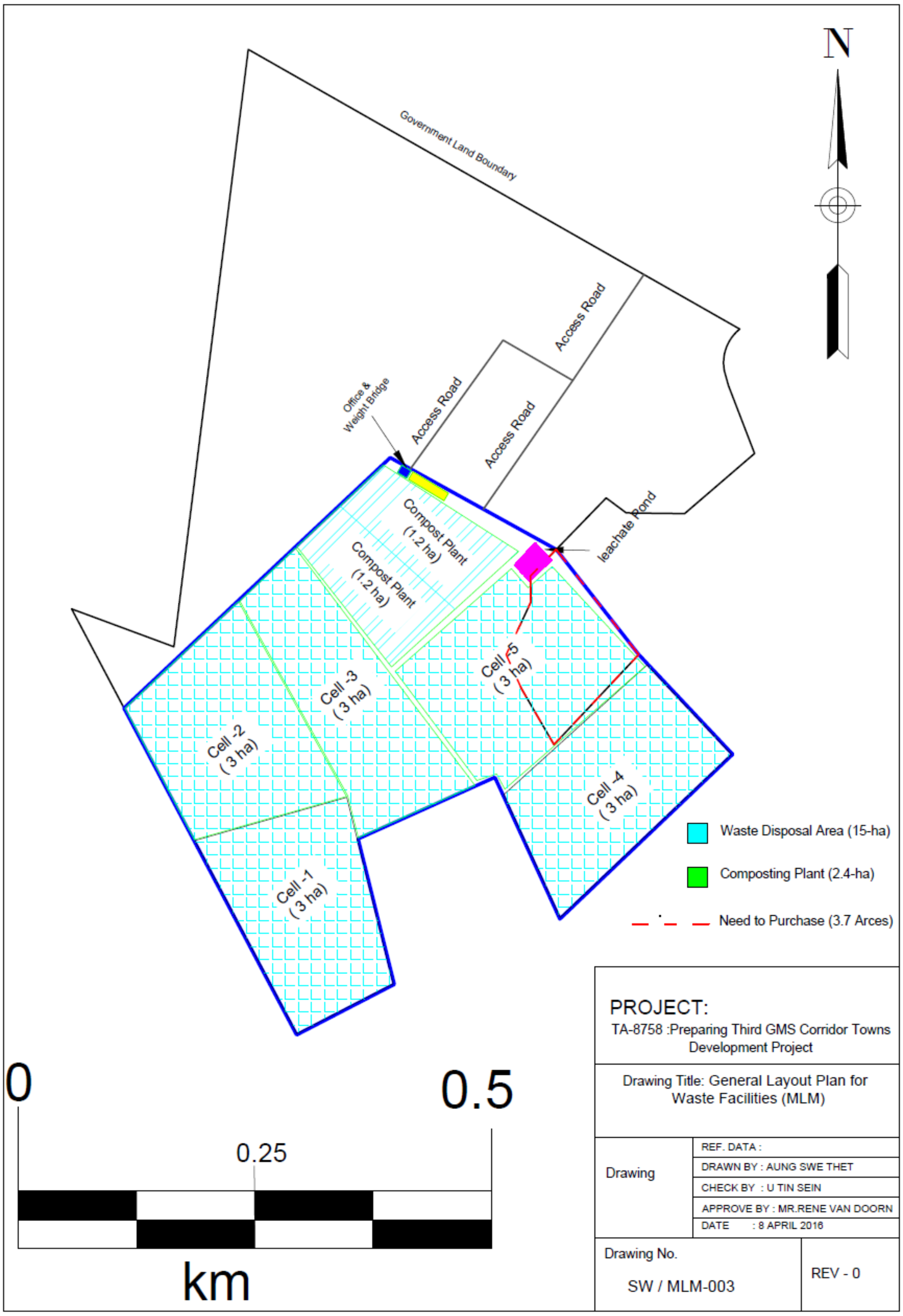
Table 3-35: Planning Construction of new Landfill Cells at Mawlamyine Landfill

Landfill Cells	Construction Year
Landfill Cell no. 1 (implemented in this project phase)	2018
Landfill Cell no. 2	2020

Landfill Cell no. 3	2025
Landfill Cell no. 4	2031
Landfill Cell no. 5	2036

It is usual that after construction of the controlled landfill with implementation of a weighbridge, much more details about quantities and materials recoveries are collected. New analyses and updates for future expansions are required on a regular basis to anticipate for measures to be taken on time.

Figure 3-49 Proposed site plan of the landfill cells and the composting plant



3.4 Cultural Heritage

Mawlamyine currently has a rich built history which many other urban centers in the region have lost in their rapid desire to move to a "modern" city. There is a short window of opportunity (perhaps 5 years) during which there is time to conserve much of this heritage and then use or convert this resource to attract tourists and create related sustainable employment directly as guides/historians and indirectly through extra generated income in hotels, restaurants and travel related businesses. Several buildings currently in government use have the potential to be converted into more efficient and more appropriate working spaces better suited to modern needs. It would certainly be a cultural disaster to lose many of the old buildings and their settings. To do so would mean that Mawlamyine would become just another Asian city with little individual character or special reason to visit.

The country's tourism industry has seen major growth in recent years, in part brought about by economic and political reforms that have made the country an attractive tourism and investment destination. Myanmar officially recorded 1.06 million and 2.04 million international arrivals in 2012 and 2013 respectively. Figures released by the Union of Myanmar Travel Association (UMTA) show that 3.08 million visitors entered Myanmar in 2014, of which 1.95 million entered at land border points.

Figures for Mawlamyine show significant annual increases from 2011 – 14 of 32% for international and 18% for local visitors.

The 2013 – 2020 Tourism Master Plan (prepared by the Ministry of Hotels and Tourism) projects that there will be 7.5 million inbound visitors by 2020. If even a small proportion of these people visited Mawlamyine it would produce a massive boost for the local economy. Many of these tourists can now be more adventurous as the country becomes considered more safe and accommodating, while many restrictions on travel have also been lifted. The completion of the upgraded road link from the Thai border at Myawaddy/Mae Sot will further encourage visitors to Mawlamyine en route to Yangon or to the new destinations opening up to the south on the way to Dawei and beyond.

Mawlamyine has a number of attributes that provide it with plenty of potential to be a major historical attraction in its own right. These include:

- Its wide range of distinctive and strategically located religious buildings including the Kyaik Thanlan pagoda (erected in 875 A.D), U Zina pagoda (3rd century B.C according to legend) and the Mahamuni pagoda (1904).
- Its connection with two famous authors, namely Rudyard Kipling (briefly in 1889) in association with the Kyaik Thanlan temple, and George Orwell (as a policeman in the 1920's) where his mother's maiden family name of Limousin is still commemorated in Lainmawzin Street;
- Its wealth of colonial secular and religious buildings, many of which are in need of significant renovation, and which are associated with Mawlamyine's position as capital of British Burma from 1826 to 1852 and then one of the busiest ports in South East Asia;
- Its relatively relaxed environment compared to the hustle and bustle of Yangon;
- Its attractive location on and views over the Thanlwin River which makes it an ideal location as a base for exploring the surrounding regional attractions (e.g. several world renowned caves and Mount ZweKabin north towards Hpa-An: and the reclining Buddha at Win Sein Taw Ya, Second World War memorials at

Thanbyuzayat, as well as the town of Kyaikkami with its Yele Paya, all south of Mawlamyine).

- The potential of Belu Kyun (Ogre Island) and its cottage industries (slates, rubber bands, smoking pipes, walking sticks, pens, bracelets, bamboo articles) which are focused on a number of small villages. The island will become more accessible once the new bridge to the mainland is constructed and once the government decides that security is not an issue to prevent visitors staying overnight in future.

Mawlamyine is currently a Neglected Attraction. The UMTA also reported that there were 19 officially registered motels/hotels in Mawlamyine with a total of 553 beds. Of the 59 recorded locations in Myanmar, Mawlamyine was 14th in the list of bed numbers, behind places such as PyinOoLwin (933 beds), Taunggyi (676) and Kalaw (636). This suggests that Mawlamyine, with the 5th largest urban population in Myanmar (2014 Census), is not currently fulfilling its full potential in attracting neither national nor international visitors.

There is concern within the country that rapid unchecked development is already harming the physical and cultural environment in sensitive areas. A recent article in Myanmar Insider (Volume 2 – Issue 16 – March 2015) noted the suspension of 5 projects in Yangon which were considered to be located too close to the city's cultural heritage, including the Shwedagon Pagoda. The Myanmar Engineering Society is to investigate if they harm the environment and the projects' continuation will be based on their report. In April 2015, the GoM released two heritage protection bills[1] that would help better protect heritage buildings and objects. The 1957 Antiquities Act has been modified and separated into these two bills in order to improve legal protection for heritage structures and heritage objects. The bills would protect "*more than 100-year-old buildings and antiquities across the country—either above or below the ground and water—that have historic, cultural, artistic, antique and archaeological values*." Penalties for damaging, removing or destroying heritage buildings and objects would be tougher than under the 1957 Act. The Protection and Conservation of Ancient Buildings Bill says anyone who destroys or damages protected buildings could face prison terms of between 1 – 7 years.

The project recognizes that it is necessary to demonstrate that heritage buildings can be used (in their current form or as a conversion) to generate/raise economic activity by using them in a more efficient and more financially viable manner. It is not enough to appeal to an owner's good will. Owners must be convinced that a heritage building can be made more valuable/useful as it is rather than any other alternative potential use following its demolition. This argument will require the aid of both inducements and controls. Inducements may well be financial, in terms of assistance (and professional advice) to repair and/or convert the building to a more beneficial use.

[1] Protection and Conservation of Ancient Buildings Bill and Protection and Conservation of Antiquities Bill

Controls might take the form of land use controls and prohibition of demolition of selected heritage buildings.

For Mawlamyine as a whole the purpose of any assistance would be to support the government's serious intention to raise the quality and future longevity of its built heritage which would then attract more visitors and investors to acquire and convert selected buildings to more economic uses (e.g. boutique hotels, restaurants and professional offices). When successful, and at some point down the line it might be appropriate for the MSG to propose the inclusion of the town as a World Heritage Site[2]. That would lead to additional worldwide interest and increase the numbers of visitors to the area.

In order to demonstrate how the Restoration Fund can be initiated and used to renovate and to make buildings more efficient and useable, the Project is proposing a pilot study based on the General Administration Department (GAD) complex in U Zina Phayar Street as depicted by the red line in **Figure 3-50**. The building is currently subject to a tender for minor renovation works including painting, roof repairs and electrical upgrading. The current Administration building was originally the Courthouse and was shown on maps dating from 1876-77. The new and current Courthouse (to the left) was a later addition, probably in the late 1800's.

SCENARIOS

Three Scenarios have been considered for the future of the GAD building as shown on **Table 3-36** : "Do Minimal"; add Mezzanine floor; and Demolish and replace with a new construction.

Table 3-36: GAD Building Scenarios Considered

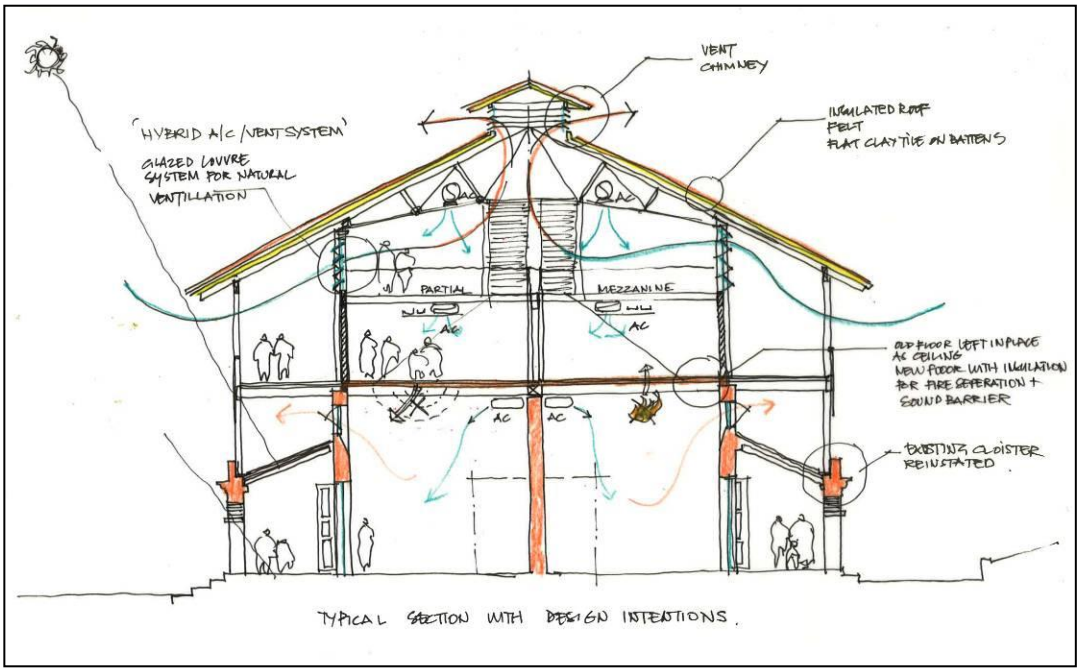
One Stop Shop - District Level		**Scenario 1 - "Do Minimal"**		**Scenario 2 - Mezzanine Rehabilitation**		**Scenario 3 - New Construction**	
		Composition	**MMK Million**	**Composition**	**Million**	**Composition**	**Million**
Description		- Rehabilitation of existing building. - Efficiency improvements to accommodate all departments, excluding Education. - Courtyard enhancements		- Rehabilitation of existing building, including mezzanine. - Efficiency improvements to accommodate all departments. - Courtyard enhancements		- Demolition of existing building. - New Building to accommodate all departments. - Courtyard enhancements.	
Total Development Cost	MMK Million	1,547,925,935	94.4%	1,679,444,735	94.4%	3,904,942,500	93.5%
Financing Cost	MMK Million	91,200,000	5.6%	98,860,000	5.6%	272,300,000	6.5%
Total Loan Amount	% of proportion	1,639,125,935	100%	1,778,304,735	100%	4,177,242,500	100%
Amount USD (at MMK 1300/USD)		**1,260,866**		**1,367,927**		**3,213,263**	
Loan interest rate	p.a.	4.0%		4.0%		4.0%	
Inflation rate	p.a.	6.6%		6.6%		6.6%	
NPV and IRR Comparison		NPV	IRR	NPV	IRR	NPV	IRR
Financial		1,491,601,052	7.9%	3,094,694,735	10.8%	107,926,990	4.1%
Economic (Threshold IRR 12%)		(19,869,203)	11.9%	725,448,807	15.6%	(1,644,460,903)	7.4%

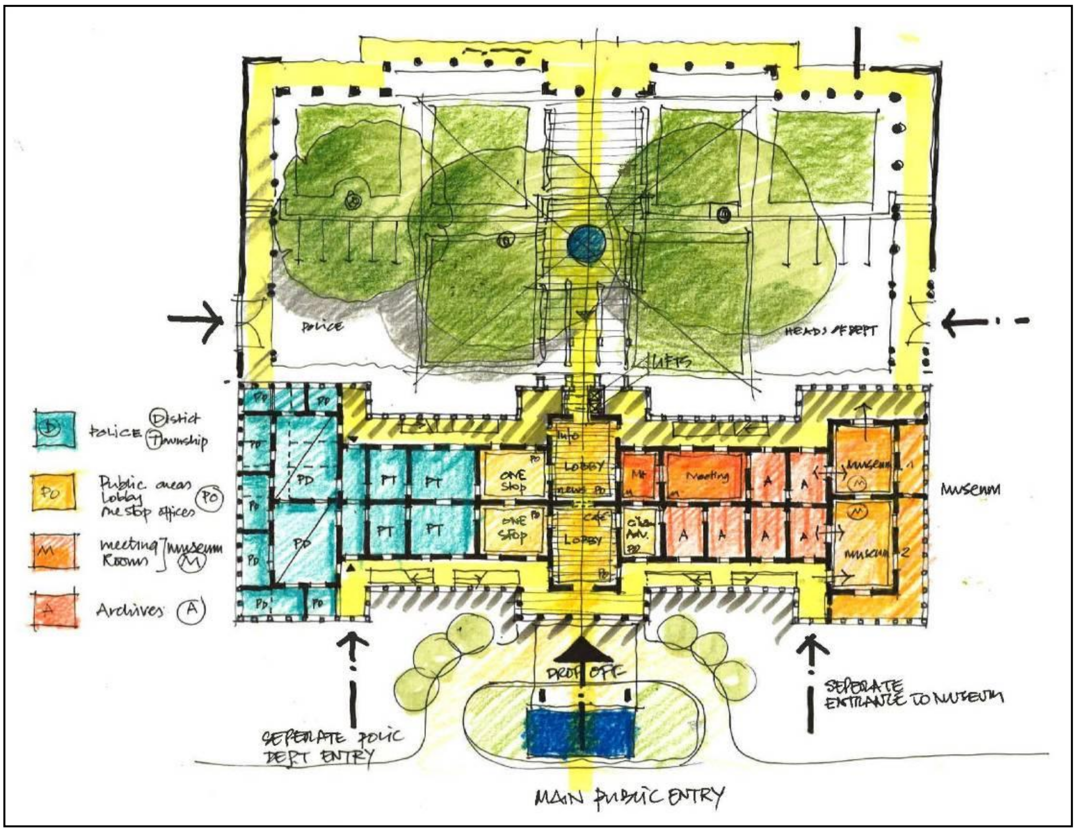
[2] The example of Levuka, an historic port town in Fiji is very similar to Mawlamyine in its history and setting although Mawlamyine has significantly more varied buildings/culture and a longer more interesting history. Levuka was granted World Heritage listing in 2013. See http://whc.unesco.org/en/list/1399 for more details.

The figures show that it would be substantially more expensive to demolish (USD 3.2 million) and rebuild the complex to incorporate the same number of people and functions compared to the preferred Scenario 2 which would add more space (USD 1.4 million). There would be little cost difference (USD 0.1 million) in a "Minimal" compared to an approach which incorporated a mezzanine floor to the second floor to provide more useable office space. A number of concept ideas as to how the complex could be designed are shown on **Figure 3-51**.

Figure 3-50: General Administration Complex U Zina Phayar Street

Figure 3-51: Concept Plan for Renovation of GAD Building (Scenario 2)





The Third GMS Project in Mon State will fund the rehabilitation of the former Court House built in the mid-1800's. The building is presently used as an Administrative Building by the GAD for Mawlamyine Township. The rehabilitation anticipates the re-organisation of the internal volume to continue to serve as a government office building. The courtyard between the building and the new courthouse will also be restored. The building is reported as being in good structural condition regarding civil works considering its age.

This pilot rehabilitation would promote best practice in heritage restoration in Mawlamyine and serve as a model for future interventions.

Figure 3-52: View of GAD building proposed to be rehabilitated under the project

View of Administration Complex U building to be rehabilitated

Same

3.5 Associated Facilities

In Mawlamyine, JICA is providing a grant for the construction of a water treatment plant (slow sand filter) for the water supplied from the Shwe Nat Taung reservoir, with the rehabilitation of a section of the pipeline between the WTP and the Kan Thone Kan storages. JICA and ADB projects are interlinked for the water supply of Mawlamyine and they must be considered as associated facilities.

An environmental and social due diligence (ESDD) has been carried out by the GMS3 TA 8758 Consultant from 16 to 30 November 2016. By the time the GMS3 PPTA final report is submitted and approved, the JICA water supply component for Mawlamyine **will be completed and will not be anymore an associated project but an associated existing facility**. As such, further steps shall now focus on GMS3 water supply component adaptation with regard to optimization of linked project operation for the full benefit of Mawlamyine Township.

The ESDD identified opportunities to improve the combined operation of the two water supply systems, in order for the city to take full benefit from the existence of two water treatment plants and to better secure 24/7 water supply quantity and quality. An interconnection between both systems shall be investigated at the time of the detailed design as well as an emergency chlorination unit at KTK storage.

Similarly, the proposed distribution area for the GMS3 project shall be adjusted as required at the start of the detailed design in order to take full consideration of the distribution area under JICA project Phase 2, not yet defined at the time of the due diligence, to avoid any risk of overlapping.

Despite its evident non-compliance with ADB SPS regarding its preparation and implementation, the JICA WS sub-component for Mawlamyine resulted hopefully in insignificant environmental and social impacts. The sub-project, therefore, does not appear to involve any kind of reputational risk to ADB funding on environmental safeguards and will not hamper the operation of the GMS sub-project.

ESDD report is attached to the present IEE as a Supplementary Document.

4 BASELINE SITUATION

4.1 Regional Geology, Soils and Seismicity

From the geomorphologic and tectonic point of view, Myanmar can be subdivided into four major tectonic provinces which are north-south trending linear belts, these are from east to west (I) Shan-Tanintharyi Block (II) Central Cenozoic Belt (III) Western Fold Belt, and (IV) Rakhine Coastal Belt. Both Mon and Kayin States fall into the eastern Shan-Tanintharyi Block (I).

Figure 4-1 illustrates that the main rock types found in Mon state are soft rocks, and Mawlamyine is mainly composed of bedrock continuously covered by at least 6 meters of alluvial deposit soils while Hpa-An area has soft rocks such as sandstone, shale, limestone and conglomerate. The rock types found around the area of Myawaddy are mainly hard rocks including limestone and dolomite, schist and granite.

Regarding soil types, Mawlamyine region mainly consist of Gleisoil which normally occurs on wide range of unconsolidated materials, mainly fluvial, marine and lacustrine sediments of Pleistocene or Holocene age (**Figure 4-2**). They are found in depression areas and low landscape positions with shallow groundwater. Red-brown forest soils, together with mountain red brown forest soils, primitive crushed stone soils are found in Southern Mon and Kayin. Lateritic soils and laterites are found at altitude below 100m above sea-level.

Figure 4-1: Geology of Myanmar

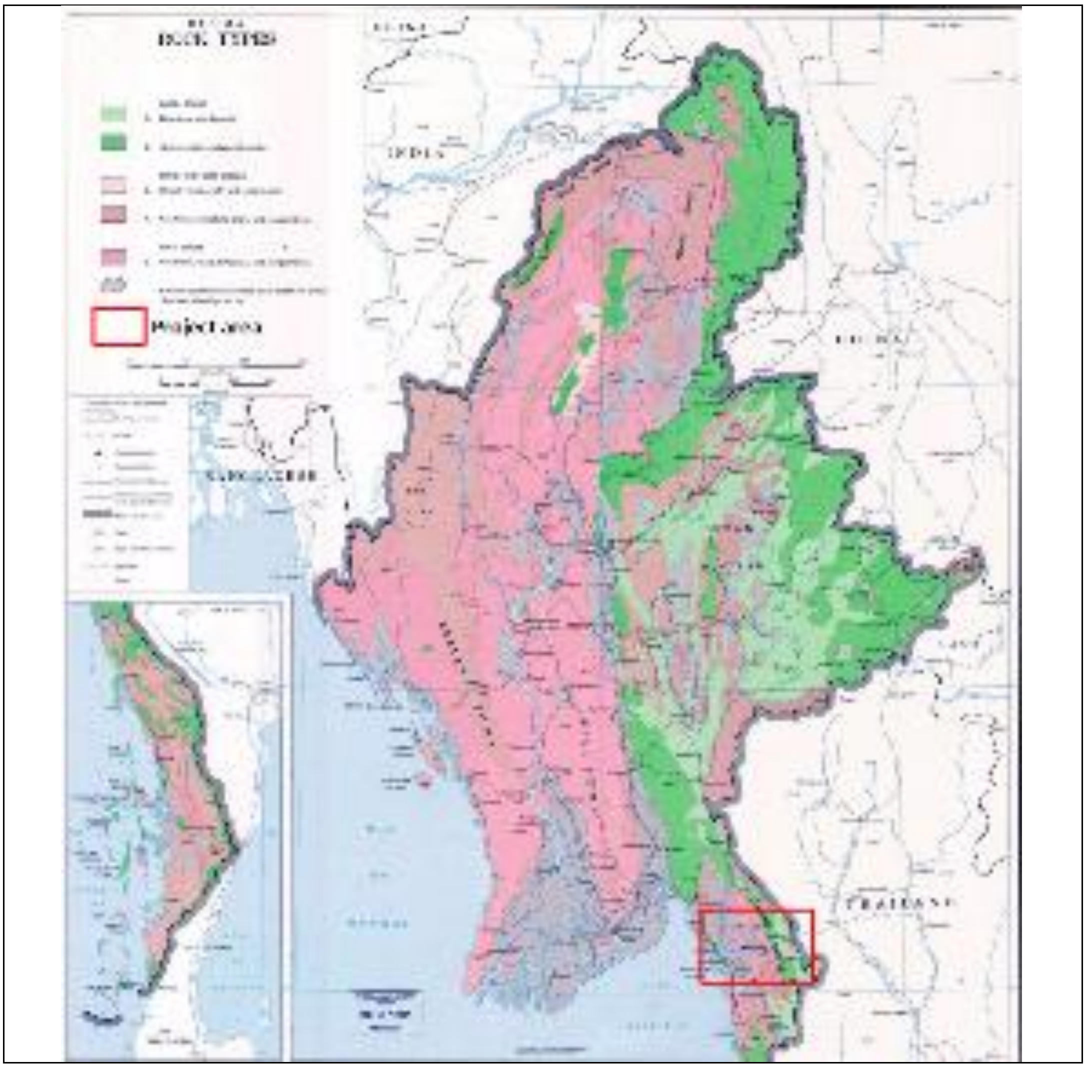
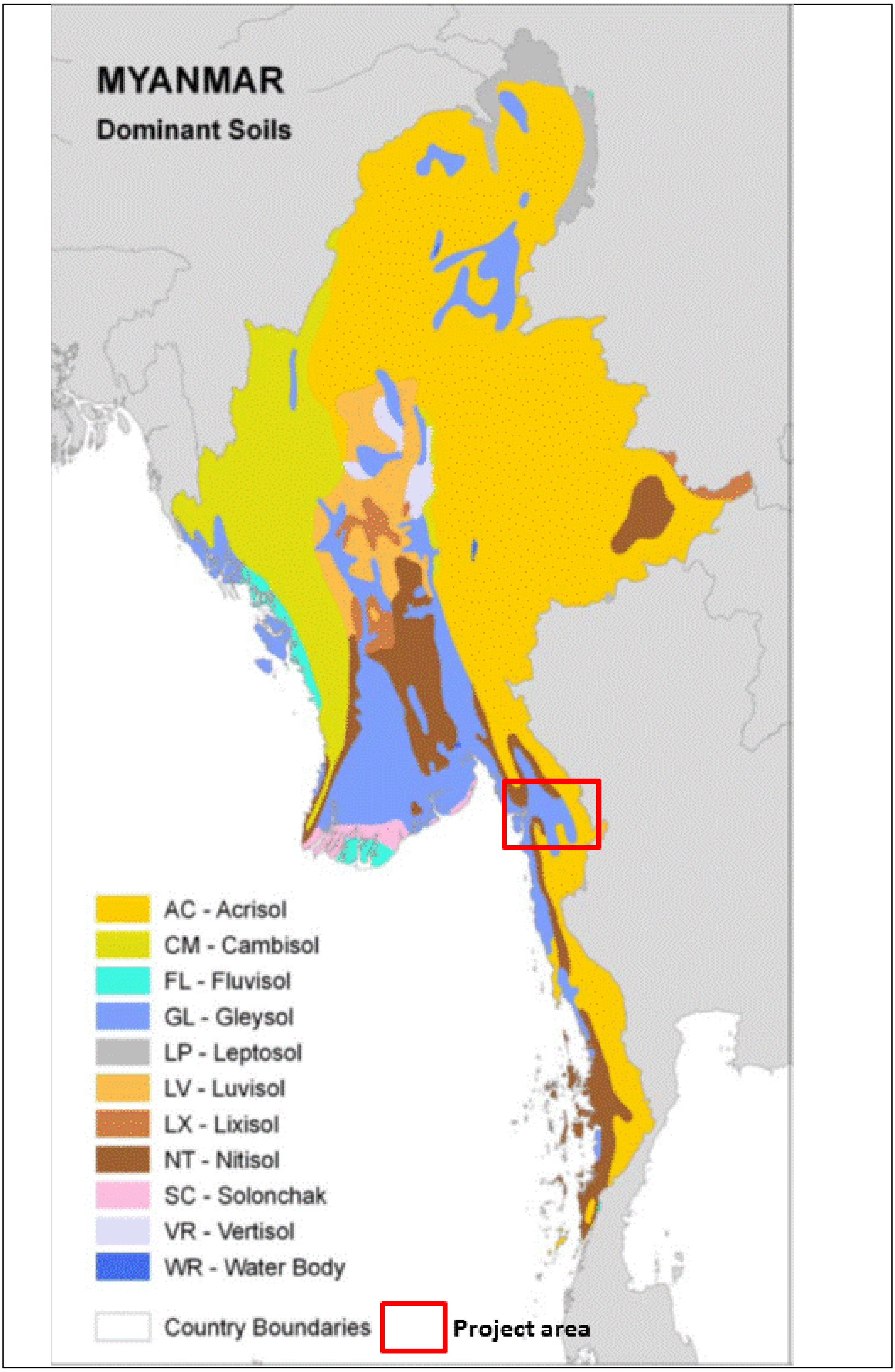


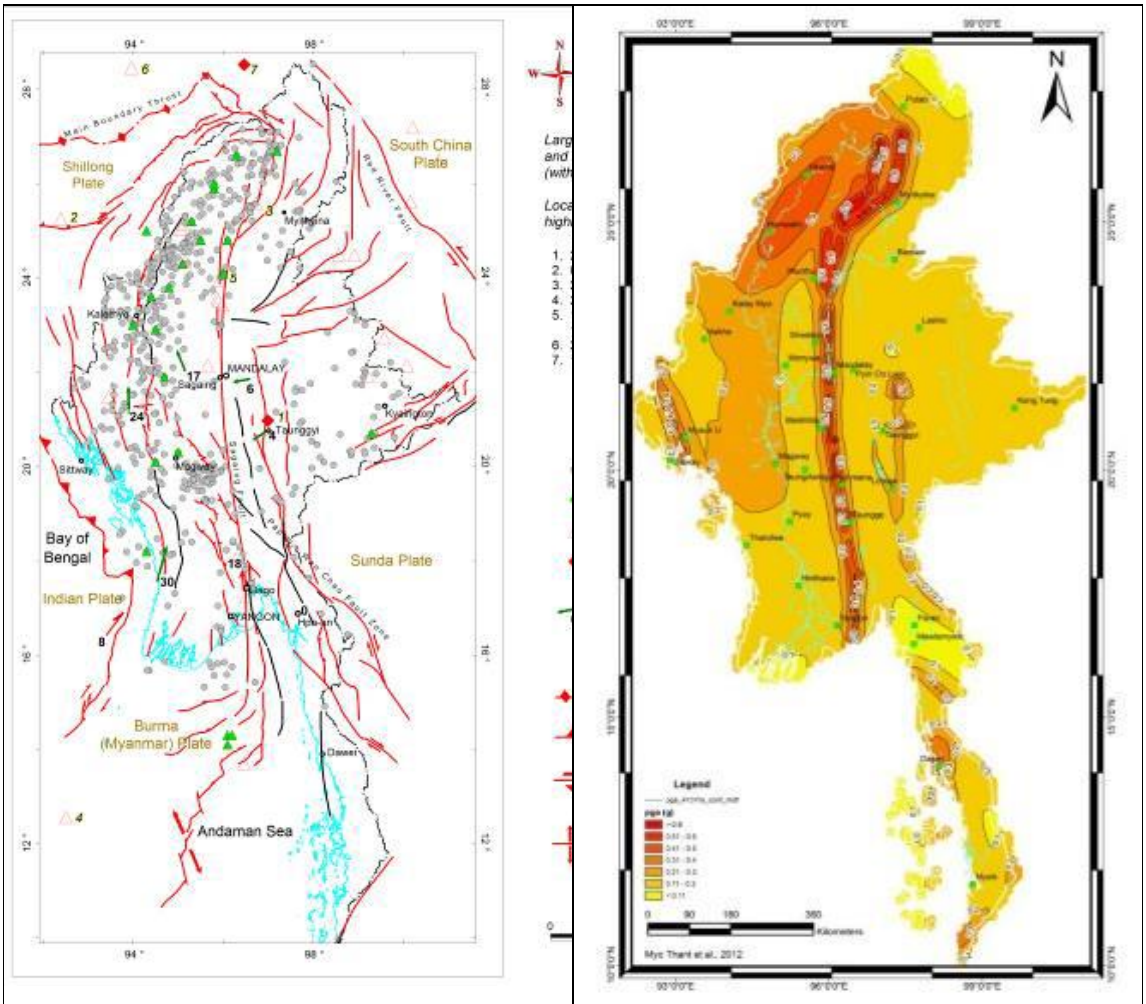
Figure 4-2: Distributions of 10 Dominant Soil Types in Myanmar



Source: FAO/NRL from Harmonized World Soil Database (HWSD) – FAO

According to the seismic zone map of Myanmar (**Figure 4-3**), Mawlamyine falls in the **low zone** with less than 0.11 PGA (Peak Ground Acceleration).

Figure 4-3: Seismic Zone Map of Myanmar



Seismotectonic map of Myanmar and surrounding regions | *Probabilistic seismic hazard map of Myanmar (Myo Thant et al., 2012)*

Source: (Hazard Profile of Myanmar 2009)

This means that the risk related to earthquake is considered as moderate and has been fully integrated into the design standards applicable to the proposed facilities.

4.2 Climate

In the Andaman Sea, four seasons are distinguished:

- The North-east Monsoon, from December to March, which brings fine cool weather and very little rainfall to the area.
- The Pre-monsoon transition period, from April to May, characterized by relatively weak and variable winds (prevailing land and sea breezes) and hot temperatures (37°C on the coast).

- The South-west Monsoon, from June to September, characterized by dense nebulosity, nearly daily drizzle interspersed with squalls, thunderstorms and heavy torrential rains along the East coast of the Andaman Sea.
- The Post-Monsoon Transition, from October to November, which is relatively similar to the Pre-monsoon transition with cooler temperatures.

Mawlamyine climatic conditions reflect these general characteristics.

4.2.1 RAINFALL

As presented on **Figure 4-4**, Mawlamyine is located within the wettest part of Myanmar, receiving in average more than 4,800 mm of rain every year.

Annual rainfall average over the period 1965-2014 (50 years) is provided in **Figure 4-5**. Average annual rainfall over the 50 years period is 4864 mm. 82% of the annual rainfall falls from June to September, the 4 wettest month of the South-west monsoon.

4.2.2 TEMPERATURE

Temperature in Mawlamyine remains high all along the year as presented in **Figure 4-6**. January is the most contrasted month with about 15°C amplitude between maximum and minimum temperature while August presents almost no difference. Average minimum monthly temperature never drops below 15°C.

Figure 4-4: General Distribution of Rainfall in Myanmar

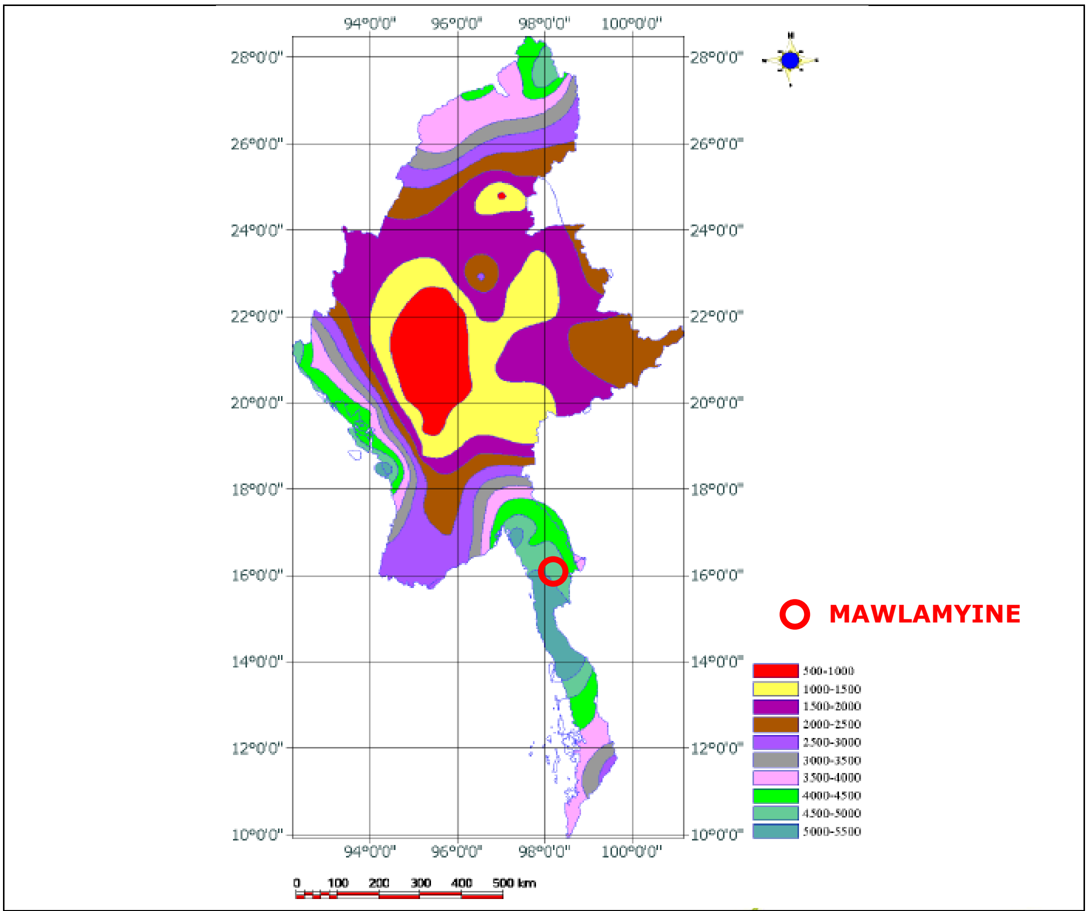


Figure 4-5: Average Annual Rainfall in Mawlamyine (Period 1965-2014)

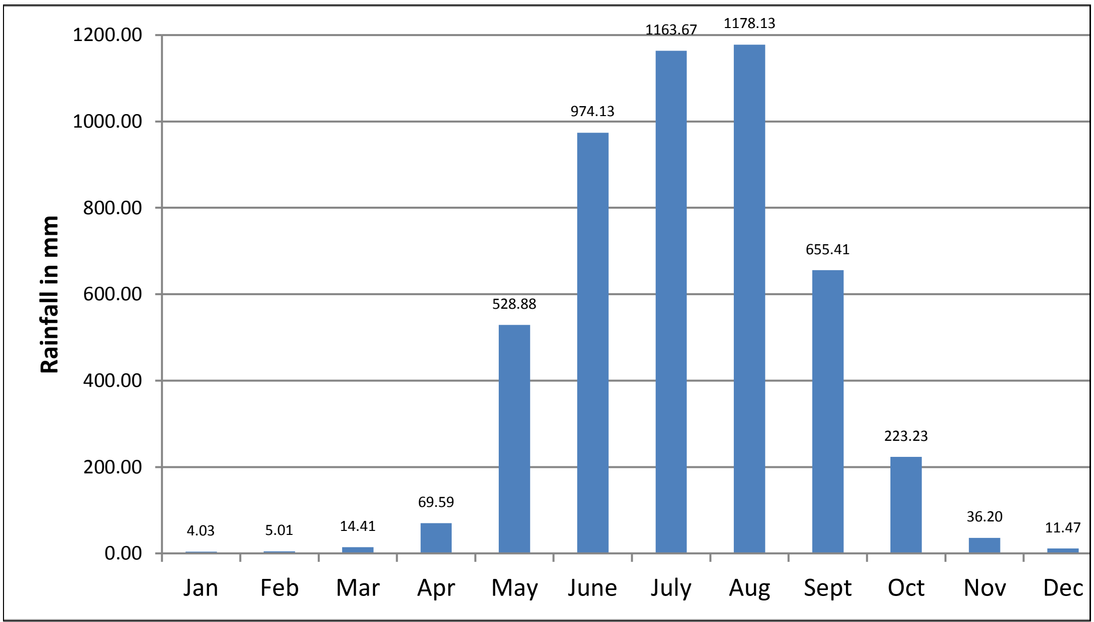
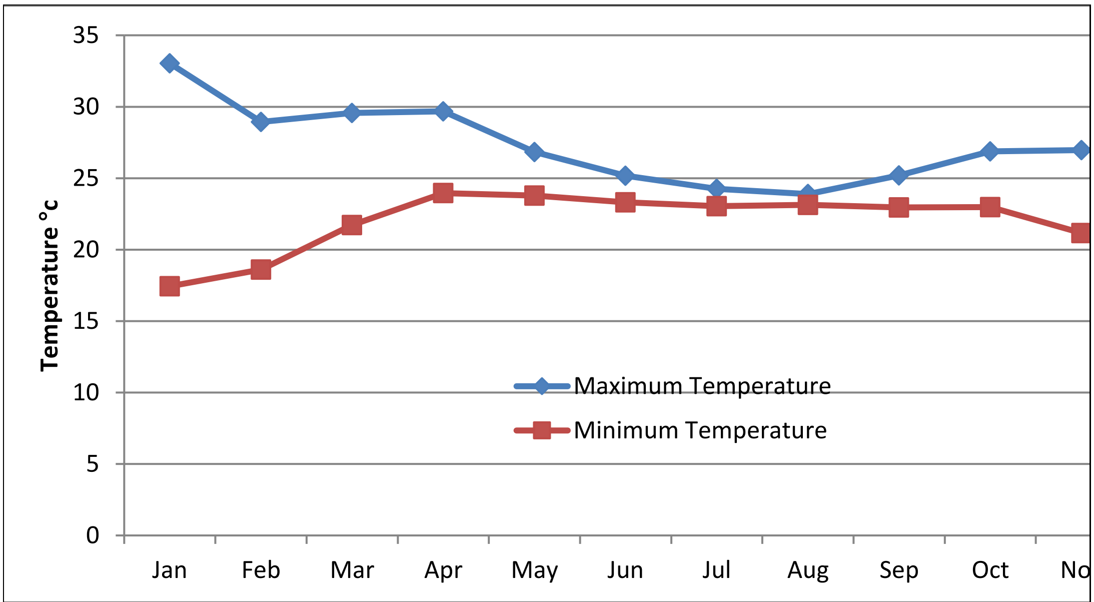


Figure 4-6: Average Annual Max. and Min. Temperature in Mawlamyine (Period 1967-2014)



4.2.3 WIND

In the morning, wind is predominantly from NE during the dry months and from SW during the wet season. In late afternoon, the wind is almost always from SW except in November and December when it stays from NE as shown in **Table 4-1**. The average monthly wind speed is moderate and doesn't exceed a maximum of 2.8 mph (or 1.25 m/s morning time in December).

Table 4-1: Average Wind Speed and Direction in Mawlamyine (2011-2015)

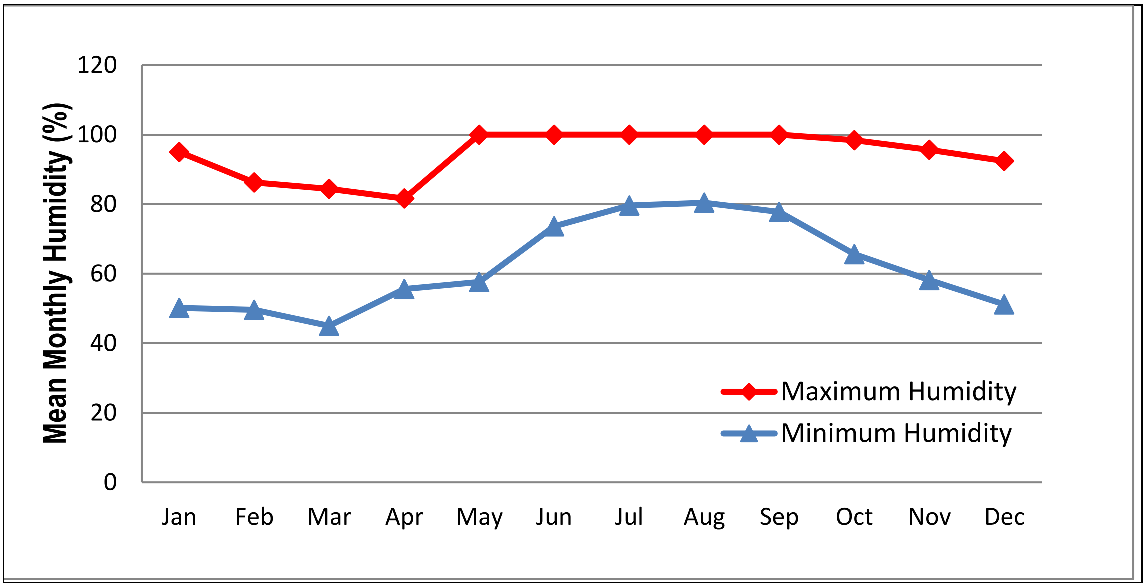
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Speed (mph) at 09:30	2.1	1.9	2.2	1.8	1.6	1.8	1.4	1.7	1.4	2.0	2.3	2.8
Direction at 9:30	NE	NE	NE	SW	SW	SW	SW	SW	SW	NE	NE	NE
Speed (mph) at 18:30	1.1	1.2	1.8	2	2.1	2.3	1.9	1.8	1.2	0.9	1.3	1.6
Direction at 18:30	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	NE	NE

Source: PPTA Consultant, 2015, data from Mawlamyine hydro-meteorological station

4.2.4 HUMIDITY

Mawlamyine has quite high humidity throughout the year by observing the 5 years data from 2010 to 2014 as shown in **Figure 4-7**. It was observed that the minimum average humidity was 45% in March and the maximum humidity reaches 100% during the wet season influence, from May to September.

Figure 4-7: Monthly Mean Humidity (2010-2014)



Source: PPTA Consultant, 2015, data from Mawlamyine hydro-meteorological station

4.3 Climate Change in Myanmar

Myanmar signed the UNFCC Convention on 11/06/1992 and ratified the convention on 25/11/1994. The country also ratified the Kyoto Protocol in 2003. Myanmar has recently submitted its Initial National Communication (INC) to UNFCCC. National Adaptation Programs of Actions (NAPA) have been prepared with the financial support of GEF/UNEP and are expected to be finalized in 2014.

4.3.1 THE NATIONAL TRENDS

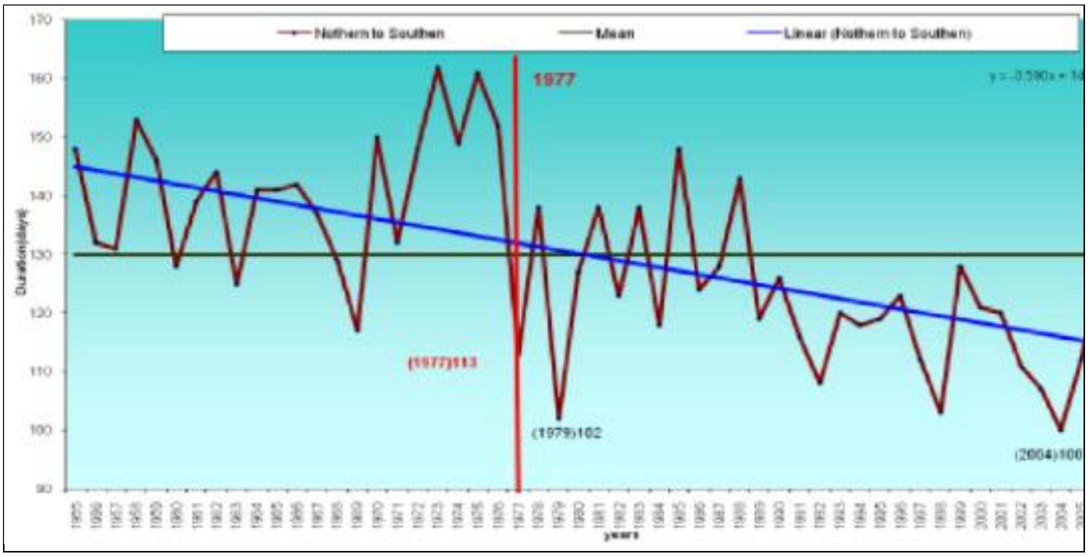
Due to its location in SE Asia and the length of its coastline, Climate Change (CC) is certainly a major concern for Myanmar. On the basis of the latest Climate Risk Index (period 1993-2012) ranking system (Global Climate Risk Index 2014, Germanwatch), Myanmar is reported as one of the most threatened country by climate change. The PPTA Consultant considers this pessimistic ranking must be interpreted carefully as it is mainly based on the losses in assets and lives during major extreme events related to climate change (typhoons and floods). The high index attributed to Myanmar results in fact, for 95% of its value, from only one event: Typhoon Nargis which killed almost 150,000 peoples in 2008. If we except this exceptional event, Myanmar appear, for 2014, not more threaten than other South Asian and South-east Asian neighbouring countries by CC.

However, Myanmar is facing progressive climate changes which threat particularly water resources and food security: Change in rainfall distribution and quantity and raise in temperature.

Figure 4-8 depicts the observed change in southwest monsoon duration: From the onset of the monsoon in Northern Myanmar until its withdrawal from the South, the monsoon duration over the last 50 years shows a significant reduction from 140-150 days in the mid-fifties to less than 120 days in 2008. Late arrival of the rain and early ending where particularly evident since the year 1977, when the duration of the rainy season dropped below 130 days, a critical limit for most cropping cycles.

According to regional information, the southwest monsoon duration has been shortened by about three weeks in northern Myanmar and one week in other parts of the country when compared to the situation observed in the fifties.

Figure 4-8: Monsoon duration (days) from onset in North till withdrawal from South (1955-2008)



Source: Some observed Climate Change Impacts in Myanmar, Dr Thin Nai Tham, Department of Meteorology and Hydrology, 2010.

Available information on climate change forecasts in Myanmar for period 2001 to 2020 anticipated:

- Slight warming of +0.5°c from June to November (rainy season) is anticipated in the whole country. During the dry season, warming will be more significant (+ 0.7 to +1.2°c) over the country, except in the delta area where temperature increase should not exceed +0.6°c.
- Only 5% increase of precipitation is forecasted for the period March-November in the whole country. During the dry season, which contributes to only 5-10% to the annual rainfall, the deficit may reach 45%, except in the delta region where dry season rain should remain normal.

4.3.2 THE SUB-NATIONAL TRENDS

Limited information has been collected so far by the PPTA Consultant at a local level. Observed temperature changes have affected some (though not all) regions to a significant degree thus far. Compared to the WMO's 1961–1990 average data, nine of the 17 state regions have observed an increase in annual temperature, two have seen decreases, and six have observed no appreciable change. Observed changes in **Kayin** and **Mon** States are provided in the **Table 4-2** presenting an analysis of records for the period 1951 to 2007 which identifies a more significant increase of temperature in Kayin State (+0.32 °C per decade) than in Mon state (+0.14°C per decade). Similarly, changes in rainfall over the same period show a decrease of 23.6 mm per decade for Kayin State while rainfall in Mon State increased by 71.57 mm per decade.

These figures have to be put into perspective with observations made in the other states of the country. Temperature increase rate in Kayin State is the highest observed in Myanmar, just followed by Lower Sagaing (0.30°c increase per decade) and Mandalay region (0.20°c increase per decade). For rainfall changes, the rainfall increase observed in Mon State is second after Upper Sagaing Region (+215.2 mm per decade) and just before Kachin State (+64.71 mm per decade). Like Kayin State, two other places observed rainfall decrease over the observation period: Bago Region (-81.08 mm decrease per decade) and Lower Sagaing Region (-17.4 mm per decade).

Table 4-2: Temperature and Rainfall Changes in Kayin and Mon States

State	Station	Mean Annual Temperature (°C)	Temp. Increase per Decade (°C)	Mean Annual Rainfall (mm)	Rainfall Change per Decade (mm)
Kayin	Hpa An	27.2	0.32	4 346	-23.6
Mon	Mawlamyine	27.1	0.14	4 816	+71.57

MOECAF, 2012, Myanmar Initial National Communication to UNFCCC

4.3.3 OBSERVED TRENDS IN MAWLAMYINE

Rainfall Historical Trend

In addition to the general assessment of CC from GCM, the PPTA Consultant carried out an analysis of Mawlamyine hydro-meteorological station monthly data, available for the period 1965-2014 (50 years), in order (i) to confirm or infirm the general trends from the GCM and (ii) provide more specific conclusions for the Mawlamyine area where the project is located. The trend over the 50 years period is identified based on the evolution of the 10 years mobile average: each point on the graph represents the average of the 10 precedent years; this approach provides a better clarity of the general trend through eliminating individual fluctuating values of each year, which reflects better the long term tendency.

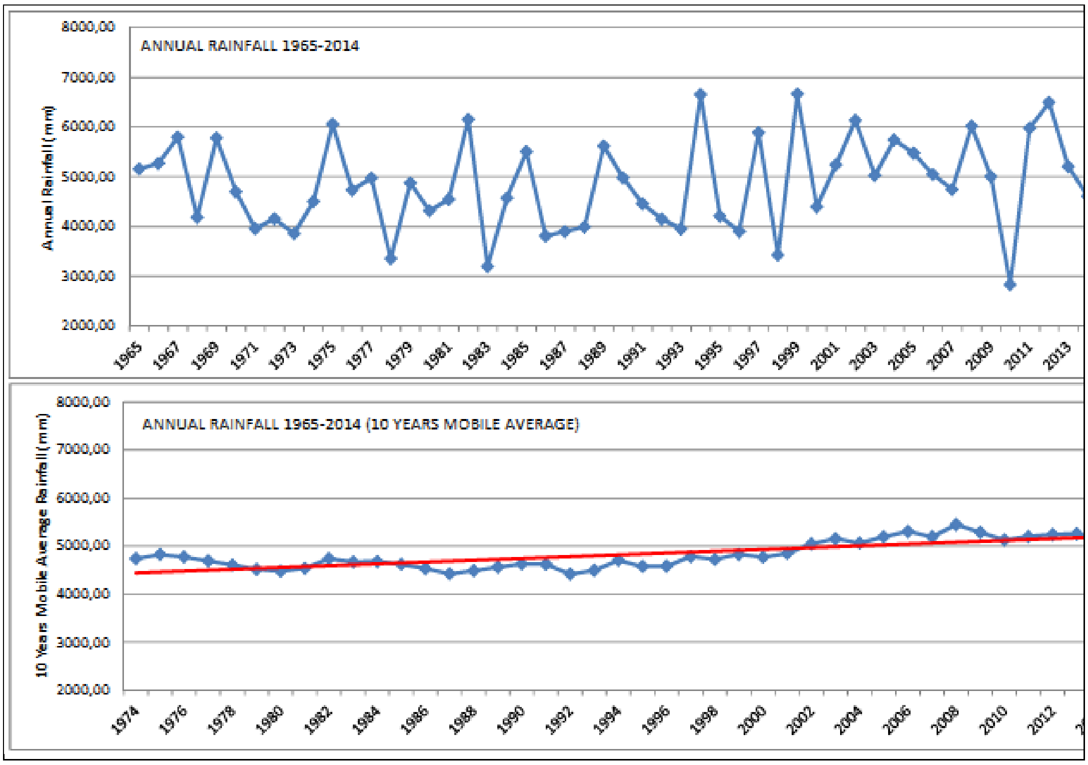
Figure 4-9 presents annual rainfall along the 50 years observation period (upper) and the same analysis but based on 10 years mobile average (lower). The 10 years mobile average clearly highlights a raising linear trend (red line) in the annual rainfall during the past 50 years, with an increase of about 500 mm/year between 1965 and 2014, or in average about 100 mm/decade.

This is in line with MOECAF estimate (UNFCCC, 2012) of an annual rainfall increase of 71.57 mm per decade for Mon State.

Figure 4-10 presents a more detailed analysis for the 6 raining months (May to October) over the observation period and based on the 10 years mobile average. In red, the resulting linear trend curve. The results lead to the following observations:

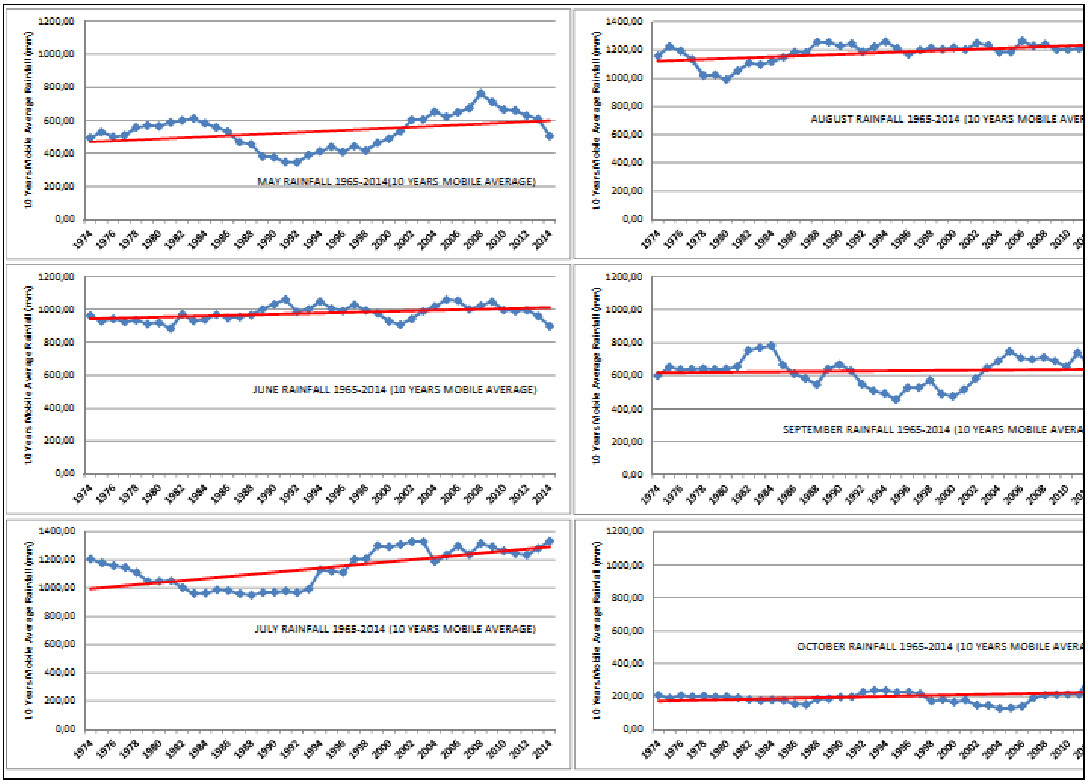
- June, September and October are rather stable with only insignificant increase over the 50 years period (increase of 50 mm in June, less for the other two months).
- The most significant increase over the 50 years in monthly rainfall is observed in May (about 120 mm) and mainly in July (almost 300 mm over the period), reflecting the general strengthening of the rainy season in the region.

Figure 4-9: Annual Rainfall Trends in Mawlamyine (Period 1965-2014)



Source: PPTA Consultant, 2015.

Figure 4-10: Monthly Rainfall Trends in Mawlamyine (Period 1965-2014)



Source: PPTA Consultant, 2015.

Temperature Trends

Data on minimum and maximum monthly temperature observed in Mawlamyine meteorological station were collected for the period 1967-2014 (48 years). Analysis performed on maximum monthly temperature is depicted in **Figure 4-11**, showing the monthly maximum temperature distribution over the period and the linear trend curve (in red).

- All the months of the year show increasing maximum temperature trends;
- July and November show the highest increase with almost 2°C;
- April and May are more stable with an increase in maximum temperature of about 0,5°C;
- The remaining months trends increase by about 1°C over the period.

The same analysis performed on the maximum annual average temperature shows an increase of about 1.1°C over the 48 years or about 0.23°C increase per decade. This value is significantly higher than the value of 0.14°C of increase by decade presented by MONREC as an average for the Mon State.

Sea Level Trends

A rise in global sea levels has been observed in recent decades, and with continued global warming temperatures, the IPCC predicts this trend to continue throughout the century. There are two primary factors affecting sea level rise relating to global warming:

- First is thermal expansion: It is estimated that approximately 60 % of the global heat energy increases are stored in the upper ocean and 30 % in ocean waters at greater depths, resulting in total oceanic absorption of 90 % of heat energy increases. As ocean waters absorb heat energy, they naturally expand, contributing to rising ocean levels.

- The second primary factor is melting ice sheets and glaciers: As the Antarctic and Greenland ice sheets melt, runoff from melting glaciers empties into the world's oceans, resulting in sea level rise.

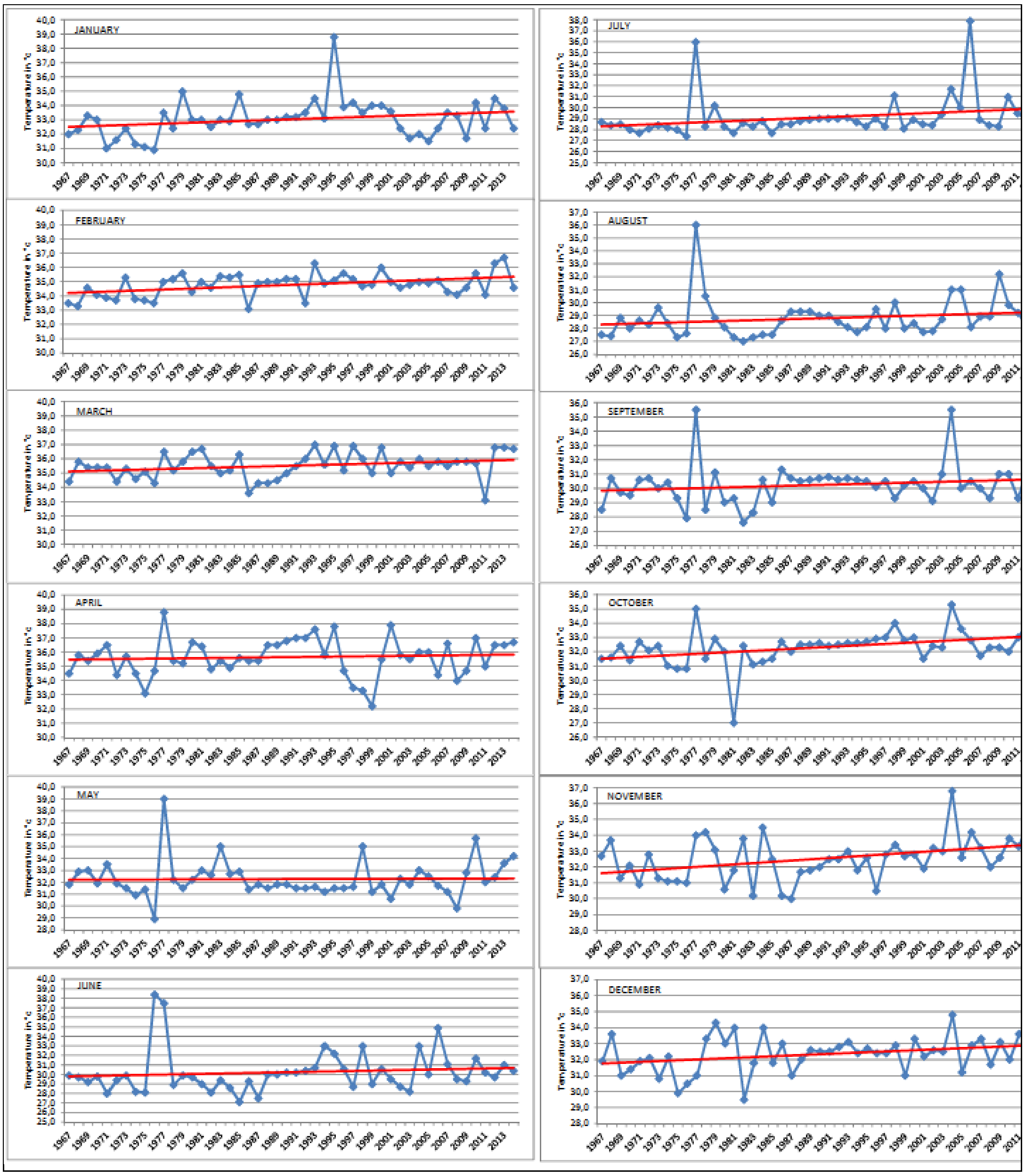
Table 4-3: IPCC Projections for Future Temperature and Sea Level Changes

		2046–2065		2081–2100	
	Scenario	Mean	*Likely* range[c]	Mean	*Likely* range[c]
Global Mean Surface Temperature Change (°C)[a]	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8
	Scenario	Mean	*Likely* range[d]	Mean	*Likely* range[d]
Global Mean Sea Level Rise (m)[b]	RCP2.6	0.24	0.17 to 0.32	0.40	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.30	0.22 to 0.38	0.63	0.45 to 0.82

IPCC, Climate Change 2013: The Physical Science Basis, 25.

The latest IPCC report also provides an assessment that it is very likely that mean sea levels rose worldwide by approximately 1.7 mm per year since 1901 (through 2010). Furthermore, the rate of rise has increased in recent decades, with an average of 2.0 mm per year since 1971 and 3.2 mm per year since 1993.

Figure 4-11: Monthly Temperature Trends in Mawlamyine (1967-2014)



Source: PPTA Consultant, 2015.

IPCC Projections for future temperatures and sea level rise are provided in **Table 4-3** according to various scenarios of CC. In order to be on the safe side, it is considered that a level rise of 0.5 m by 2065 and 1.0 m by 2100 is reasonable for planning projects in the coastal zone of Myanmar, including Mawlamyine. This value does not integrate surge raise created by low pressure tropical storms (typhoons) which already occur but are anticipated to become more frequent in the future. However, Mawlamyine is not facing directly the sea, being well protected from such phenomenon by a large island.

Conclusions

Both temperature and rainfall show increasing trends in Mawlamyine along the last 50 years of observations, in line with MONREC trend analysis for Mon State.

Annual rainfall increased by 500 mm over a 50 years period, or a raise of about 100 mm/decade. The month of July shows the highest raise during the 50 years period, about 300 mm, followed by May with 120 mm. Other months are almost stable or show only slight increase.

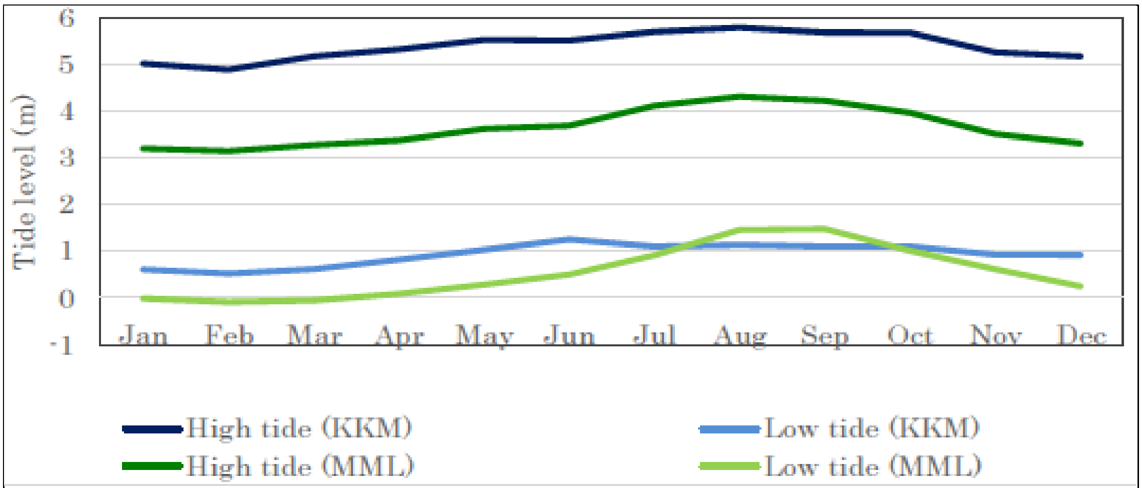
Temperature also increased over the same period. The average annual maximum temperature rose by 1.1°C over the last 48 years, or an increase of about 0.23°C per decade, a value significantly higher than what is considered in the Mon State (0.14°C increase per decade). July and November are the months showing the highest raise over the period, about 2°C. According to IPCC, sea level rise could reach 0.82 m by the end of the century. The present project considers a safety over-elevation of 1 meter as a design criteria for concerned project components, to avoid long term flooding risk. All these results are consistent with the trends generally presented by MOECAF for Mon State.

4.4 Surface Water

4.4.1 OCEANOGRAPHY

Due to the location of Mawlamyine in the estuary of the Thanlwin River, the surface water levels in the lower river system are under the influence of the sea tide. In Mawlamyine area, tide stations are located in Kyaikkami and Mawlamyine town. Average annual tide amplitude (difference between high and low tide) is approximately 4.5 m in Kyaikkami and decreases to about 3 m in Mawlamyine. Monthly tidal information for both stations in 2010 is provided in **Figure 4-12**.

Figure 4-12: Average Monthly Tide Level at Kyaikkami (KKM) and Mawlamyine (MML)



Source : Mawlamyine Port Authority

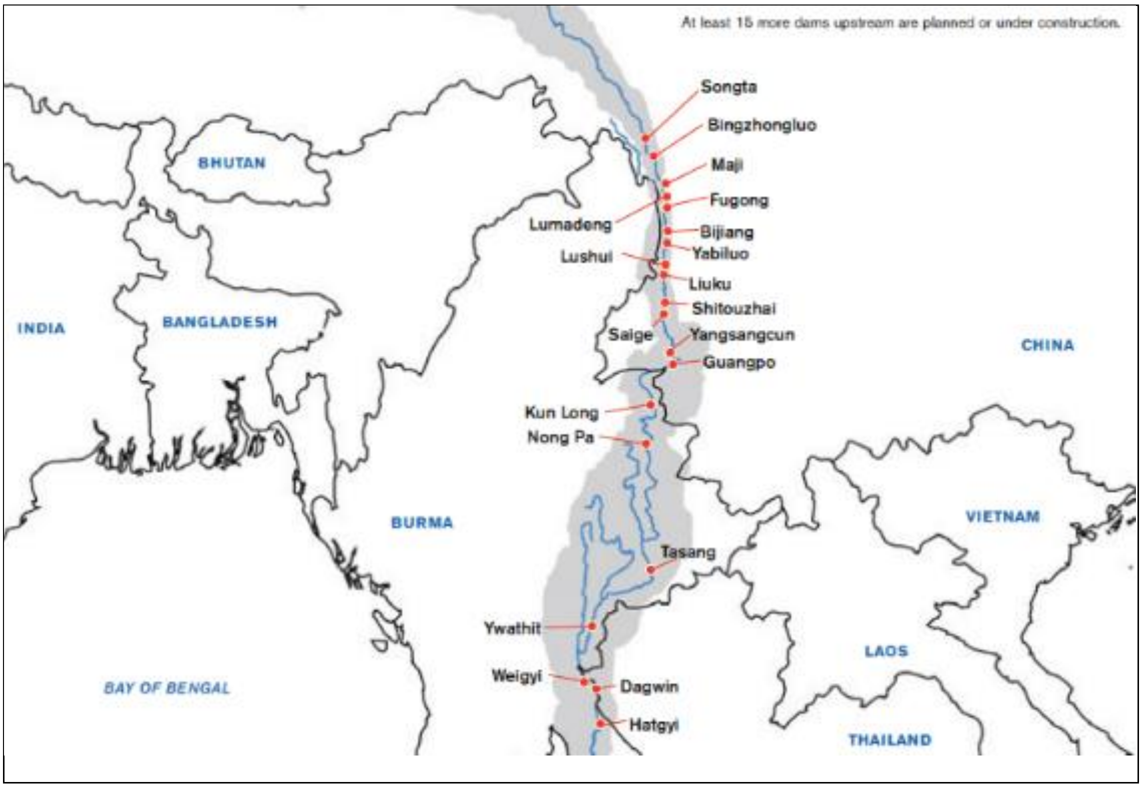
4.4.2 HYDROLOGY AND FLOODS

The Salween River is about 2,815 km long which flows from the Tibetan Plateau into the Andaman Sea in Southeast Asia. In its lower reach in Myanmar, the river is named Thanlwin River. It drains a narrow and mountainous watershed of 324,000 km² (125,000 sq mi) that extends into the countries of China, Burma and Thailand. Steep canyon walls line the swift, powerful and undammed Salween, one of the longest free-flowing rivers in the world. Its extensive drainage basin supports a biodiversity comparable with the Mekong and is home to about 7 million people. In 2003, key parts of the mid-region watershed of the river were included within the "Three Parallel Rivers of Yunnan Protected Areas", a UNESCO World Heritage Site.

Mawlamyine is located along the estuary of the Thanlwin River. *Thanlwin discharge is estimated as 157 billion m^3/year, which translates close to 5,000 m^3/s in average. Near the head of the Delta, a mean low flow of 2 300 m3/s and a flood discharge of 32,600 m3/s are reported. However, several hydroelectric projects are already identified all along the course of the river, both in China and in Myanmar, which may have drastic impact in the long term on the river hydrology.* **Figure 4-13** *presents the location of sites where potential hydropower development is identified.*

Attran River is a river of Burma (most of its course) and Thailand (its uppermost part). In Thailand, it is usually known as the Kasat River. It merges into the larger Gyaing River and Salween River near Mawlamyine. A main tributary of the Attran River is the Zami River. The Attran and its tributaries begin near the Thai-Burmese border and flow in a general north-north-west direction. The Attran River is presently used for the water supply of some areas of Mawlamyine.

Figure 4-13: ***Proposed Dams in the Salween River***



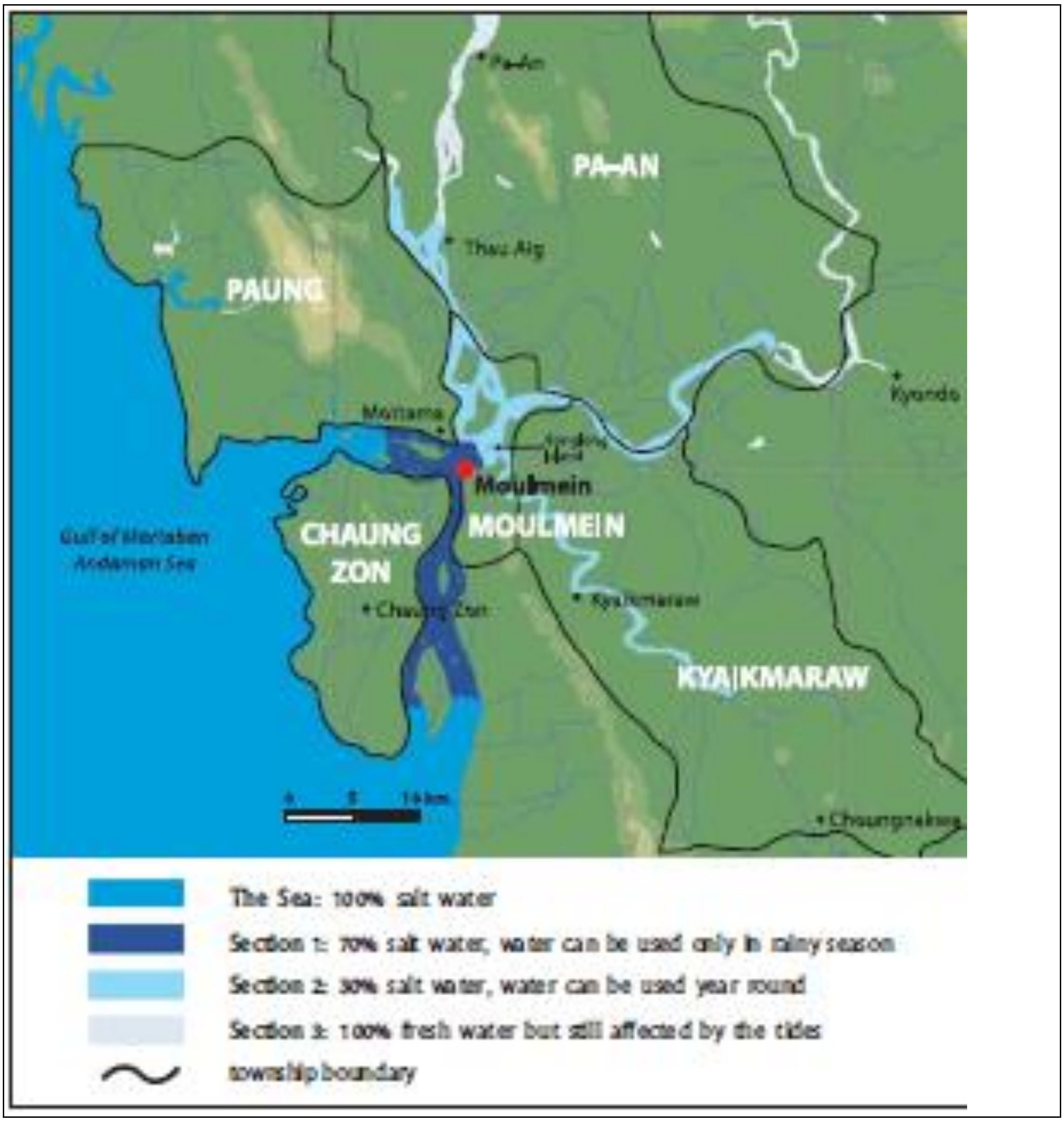
Source: Salween Watch, 13 March 2013

As described above with rising sea levels and the impact of upstream reservoirs, there is a significant risk that the saline wedge can encroach further upstream.

This has been particularly observed with respect to the estuaries of other Asian Rivers, notably the Mekong and the Brahmaputra-Ganges. At present there have been limited reporting (see **Figure 4-14**) and no attempt to simulate future saline conditions of the lower Thanlwin under different future scenarios, however, by analogy with nearby rivers the future risks can be appreciated.

For example, on the Mekong recent research generally shows that the saline wedge is expected to encroach 10 km further upstream by 2030 and 20 km by 2090 from a late 1990's baseline. While this could be used as an indication of potential future changes on the Thanlwin taking into account climate change and sea level rise, it can be appreciated that the Thanlwin is a very different river morphologically when compared to the Mekong. In addition, even in the baseline conditions, the saline wedge had already encroached significantly up certain branches of the Mekong Delta.

Figure 4-14: Existing salinity conditions (isohalines) of surface waters in the Lower Thanlwin



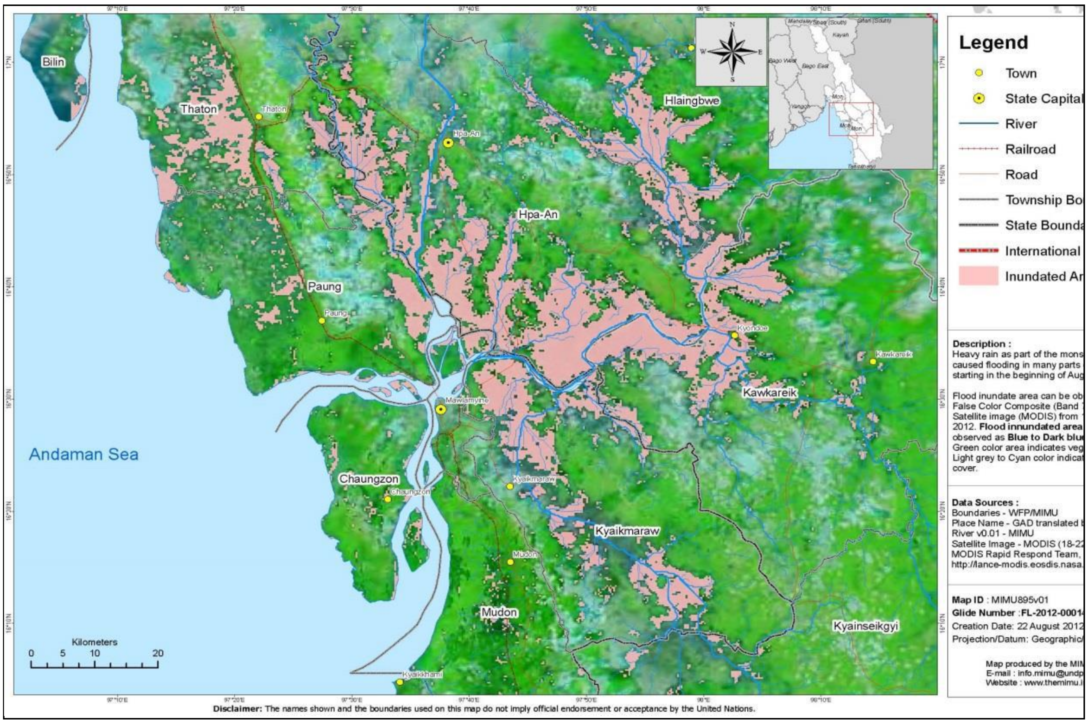
Source: Salween Watch, 13 March 2013

The floods in Southeast Myanmar could be generally classified into two types, namely: "widespread flood" and the "flash flood". Most of them occur around the middle of the southwest monsoon from June to October.

The widespread flood mainly hits the lower and middle reaches of the large rivers such as Thanlwin, Attran and Gyaing Rivers, having a catchment area larger than few thousands of square kilometres. The water levels of the downstream/middle streams of these rivers tend to gradually rise. Because of such gradual rise of river water levels, the residents have time for evacuation from the flooded zones and therefore the human damages including the death seldom occur. However, once the river water levels exceed the river bank levels, extensive and prolonged flood inundation occur. As most major urban centres are located along the downstream reach of the large rivers and are inundated over a long period, economic damages from flood tend to be huge. For this reason, most recorded major flood damages in the Southeast Myanmar result from the wide spread flood.

In contrast to the widespread flood, flash-floods tend to occur along small rivers and creeks where the peak water level rises very rapidly immediately after the heavy rainfall event. Due to such features, flash flood results into potential risk of serious human damages including fatalities. However, since flash flood is limited to limited areas and residents being well aware of the risks, the flood damages are far smaller than those of the wide-spread flood described above (Ministry of Border Affairs & JICA, 2013). See **Figure 4-15** for details of 2012 flooding.

Figure 4-15: Inundated Areas of 18-22 August 2012 Flood around Mawlamyine and Hpa-An



Source: Department of Meteorology and Hydrology, 2015

Thanlwin River tends to be the main cause of serious flood damages in Mawlamyine area. The critical level in Hpa-An (where the only control station is located) above which flood occurs is 7.50 m (staff gauge reading by the

Department of Meteorology and Hydrology). According to the records of DMH, the river water levels in the Thanlwin River exceeded the critical level seven years out of ten (period 2003-2012) and water levels above the critical level lasted for 5 to 46 days.

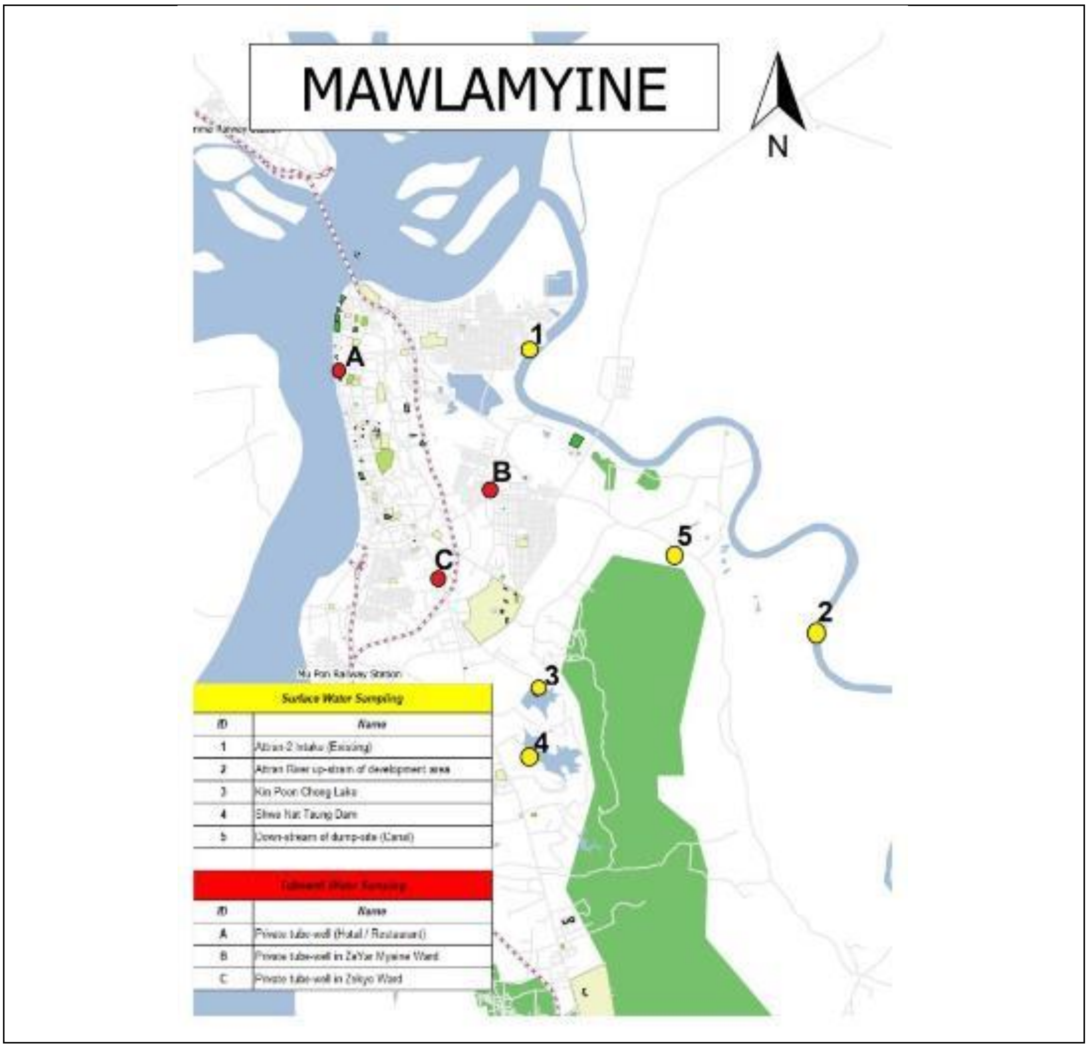
However, flood is not a major issue in Mawlamyine urban area due to the hilly topography of the city. Flooding from the Thanlwin hardly affects more than the strand road (5 m elevation) along the river bank, and not concerned by project activities. Project components are all located at an elevation >15 m.

4.5 Hydrogeology

In Mon State, groundwater is abstracted from three kinds of wells: (i) hand-dug wells (10 to 12 m), shallow-wells (25 to 50 m) and tube wells (more than 60 m) (Ministry of Border Affairs & JICA, 2013).

There is not much information about groundwater in Mawlamyine. According to the final report on Myanmar Three Cities Water Supply Management Improvement Project (Ministry of Health, Labour and Welfare of Japan, 2003), it was concluded that underground water levels in Mawlamyine tend to be low in the dry season and even depleted sometimes. Underground water abstracted from shallow wells close to the river is brackish and is hardly used for drinking purpose (ref. following section).

Figure 4-16: Sampling Locations for WQ Survey in Mawlamyine



4.6 Air Quality

There is no available information on air quality in Mawlamyine. The main issue is related to the regular burning of dry tree leaves and waste dumped in the natural drains and along streets, which releases smoke. However, due to the present limited industrial activity in the area, limited road traffic and the permanent wind blowing dominantly from the Andaman Sea, the city doesn't face presently significant problem regarding air quality.

4.7 Water Quality

The PPTA Consultant appointed a Yangon laboratory (E-Guard) to undertake a water quality survey. Sampling was carried out in September 2015. Location of water quality samplings in Mawlamyine are presented in **Figure 4-16**.

4.7.1 SURFACE WATER QUALITY

For surface water, 4 samples of surface water (samples 1 to 4) including 2 river samples (No.1 and 2), 2 lake samples (No. 3 and 4) and 1 sample of leachate from the dumpsite (No. 5) have been analysed. Results of analysis are provided in **Table 4-4**.

Table 4-4: Surface Water Quality Analysis in Mawlamyine

No.	Parameter	Unit	01	02	03	04	05
1	Temperature	°C	28.3	28.9	28.5	28.7	29.5
2	EC	µS	87.3	85.1	22.5	36.9	2210
3	DO	mg/l	6.21	6.47	6.57	7.58	1.52
4	pH		7.10	7.29	6.24	6.99	7.41
5	Turbidity	NTU	25	28	4	6	108
6	BOD	mg/l	11	< 1	6	8	154
7	COD	mg/l	< 10	< 10	< 10	< 10	737
8	TSS	mg/l	72.67	72	62.67	81	-
9	T phosphorus	mg/l	0.01	0.01	< 0.01	< 0.01	0.73
10	Phosphate	mg/l	Nil	Nil	Nil	Nil	4.26
11	Total Nitrogen	mg/l	< 0.6	< 0.6	< 0.6	< 0.6	65.24
12	Nitrate	mg/l	0.05	0.07	0.11	0.15	0.86
13	Ammonia	mg/l	Nil	Nil	Nil	Nil	45.14
14	Ammonium	mg/l	Nil	Nil	Nil	Nil	47.73
15	Total Coliforms	Cfu /100 ml	43	50	26	28	Numerous
16	Sulphate	ppm	22.87	69.35	98.6	94.81	120.27
17	Chloride	mg/l	< 1.4	< 1.4	1.07	1.42	-
18	Calcium	mg/l	14.24	15.13	3.12	6.23	-
19	Magnesium	mg/l	5.40	5.94	1.35	2.70	-
20	Sodium	mg/l	1.57	1.28	1.28	1.67	-
21	Potassium	mg/l	0.59	0.59	0.5	0.5	-
22	Alkalinity	mg/l	37	37.5	11.5	16.5	-

KhinPonChong water presents a very low mineralisation (EC=22.5 µS), which is in line with the water origin: only rain water with a limited run-off due to the small size of the catchment, so with limited opportunity to be enriched with soil minerals.

Total suspended solids value is 62.7 mg/l, which looks a bit high when compared with the low turbidity value of 4 NTU. Discrepancy between the two values may be due to the presence of few larger particles in the sample with limited effect on turbidity but with more impact on the suspended solid mass.

Organic pollution is low, in relation to the small size of the catchment still devoid of any industrial activity or of any settlement.

All parameters of KhinPonChong reservoir are compatible for its use as drinking water after treatment.

4.7.2 UNDERGROUND WATER QUALITY

For underground water, 3 samples from tubewells have been sampled and analysed as shown in **Table 4-5**.

Table 4-5: Results of the tube well water samplings in Mawlamyine

No.	Parameter	Unit	A	B	C
1	Temperature	°C	28.6	29	28.4
2	Electric conductivity	µS	1349	407	250
3	Dissolved Oxygen	mg/l	7.56	7.67	7.36
4	pH		7.13	7.49	5.87
5	Turbidity	NTU	54	22	3
6	BOD	mg/l	10	10	7
7	COD	mg/l	<10	<10	<10
8	Total Suspended Solids	mg/l	227.33	70	40
9	Total phosphorus	mg/l	0.13	0.12	<0.01
10	Phosphate	mg/l	0.31	0.21	Nil
11	Total Nitrogen	mg/l	0.84	<0.6	2.52
12	Nitrate	mg/l	0.15	0.22	1.86
13	Ammonia	mg/l	1.18	0.22	2.55
14	Ammonium	mg/l	1.25	0.23	2.69
15	Total Coliforms	Cfu /100 ml	30	28	35
16	Sulphate	ppm	200.89	124.51	91.2
17	Chloride	mg/l	302.04	6.03	40.06
18	Calcium	mg/l	148.59	64.95	17.80
19	Magnesium	mg/l	18.90	14.58	1.08
20	Sodium	mg/l	149.52	0.98	29.52
21	Potassium	mg/l	4.62	2.26	3.54
22	Alkalinity	mg/l	239.5	214	40

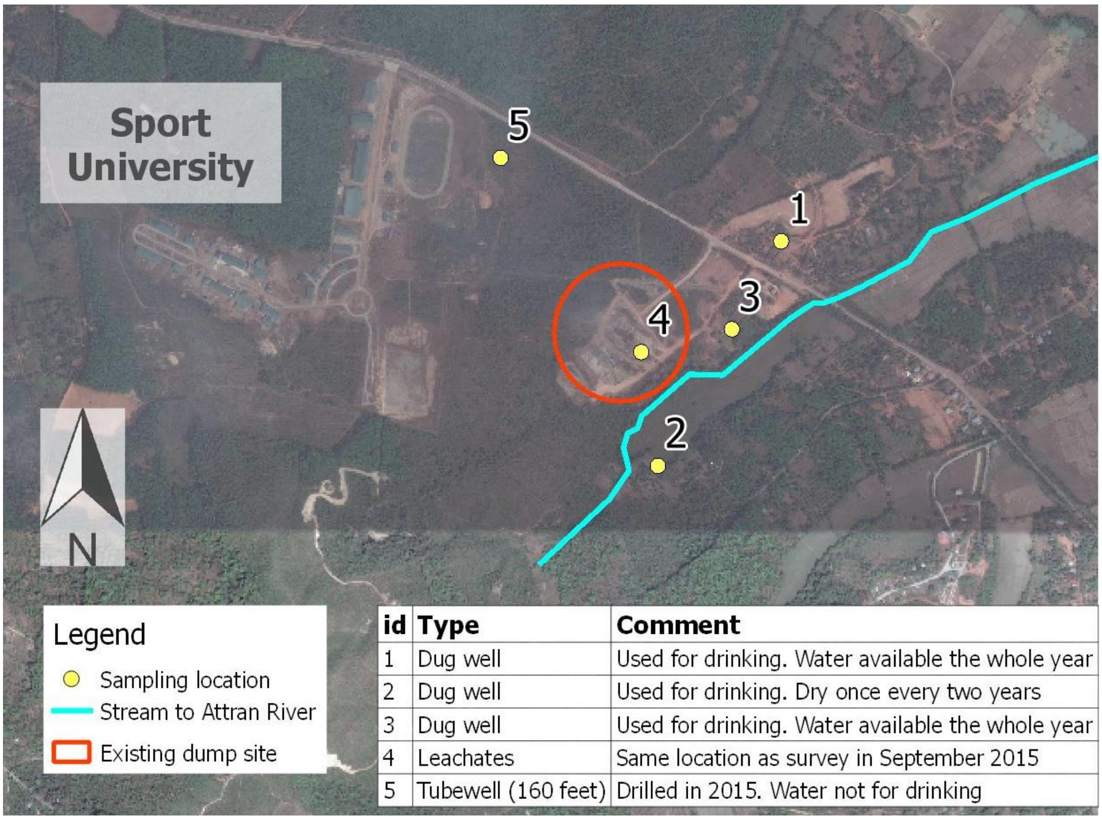
The high salinity of tube well N°1 located along the Thanlwin river bank reflects the influence of the sea and the salinity of the water in the estuary. Turbidity and TSS values are high for underground resources, probably reflecting the inappropriate design of the tube wells or the fine sediment at the level of the pumping. All wells are contaminated, as a result of the several septic tanks as the unique sanitation system of Mawlamyine.

In addition to this general baseline analysis, the PPTA Consultant has undertaken a water quality survey in July 2016 specifically in relation to potential contamination from the existing dumpsite on groundwater immediately downstream of the site. The location of water quality samplings in Mawlamyine are presented in Figure 4-17.

The aquifer flow direction is estimated from South toward North-East where Attran River flows. Then two dug wells have been selected downstream the dump site, near the main road (Sampling # 1 and 3 on the map). One dug well (Sampling #2) and one tubewell (Sampling #4) have been selected upstream the dump site.

Results of analysis are provided in **Table 4-4**.

Figure 4-17: Water quality sampling at Mawlamyine dump site surrounding wells



id	Type	Comment
1	Dug well	Used for drinking. Water available the whole year
2	Dug well	Used for drinking. Dry once every two years
3	Dug well	Used for drinking. Water available the whole year
4	Leachates	Same location as survey in September 2015
5	Tubewell (160 feet)	Drilled in 2015. Water not for drinking

With regard to these analyses the following interpretations have been made:

- For sample N°4 (landfill leachate) most of the parameters are higher than the national standards for municipal landfill leachates with high BOD (and COD although strangely this latter value is not included in the standard), TSS and other parameters; there is however no sign of heavy metal contamination in the leachate as per the previous results reported above.
- The tubewell near government houses (Sample #5) is not in regular use as the housing are not yet inhabited. It would be appropriate in the future to connect these areas to the proposed water supply project given the risk from existing and future contamination.
- **Coliforms (total and faecal):** Total coliform detected in all the samples and faecal coliforms detected in all except in Sample 2 (Upstream)
- **pH** is very low in sampling 1, 2 and 3 (pH < 6)
- **Turbidity** is higher than WHO standards in S 2, S3, S4 and S5. It is very high in S4 because sediment concentration is important in the leachates.
- **Iron** is higher than WHO standards in all the samplings. The concentration is more important upstream (S2 has 1.22 mg/l and S5 has 3.5 mg/l) than downstream (around 0.4 mg/l in S1 and S3)
- **The BOD and COD level** are quite low (except the leachates). The COD/BOD ratio is not usable as it seems the level of detection for COD measurement is 32 mg/l. At the leachate pond, COD reaches 900 mg/l while BOD is around 400 mg/l (in rainy season).
- **Fluoride** is quite high (0.5 to 1 mg/l) but still lower than WHO standards

In general, there is no specific correlation between pollution in samples downstream and upstream of the dump site although the tubewell (N° 5) exhibits water quality exceeding WHO standards for both physical and microbiological parameters

Table 4-6: Underground water quality analysis near Mawlamyine dump site

No.	Parameter	Unit	01	02	03	04	05	WHO guidelines
1	pH		5.9	5.6	5.3	7.3	7.1	6.5 – 8.5
2	Colour	TCU	Nil	10	Nil	180	30	15 TCU
3	Turbidity	NTU	4	24	6	626	52	5 NTU
4	Conductivity	microS/cm	47	22	28	9250	282	
5	Total Hardness	mg/l as CaCO3	2	4	4	840	114	500 mg/l as CaCO3
6	Calcium Hardness	mg/l as CaCO3	1	2	2	558	78	
7	Magnesium hardness	mg/l as CaCO3	1	2	2	282	36	
8	Total Alkalinity	mg/l as CaCO3	4	8	4	1210	152	
9	Phenolphthalein Alkalinity	mg/l as CaCO3	Nil	Nil	Nil	Nil	Nil	
10	Carbonate	mg/l as CaCO3	Nil	Nil	Nil	Nil	Nil	
11	Bicarbonate	mg/l as CaCO3	4	8	4	1210	152	
12	Iron	mg/l	0.33	1.22	0.42	4.86	3.54	0.3 mg/l
13	Chloride	mg/l	6	3	4	2300	3	250 mg/l
14	Sodium Chloride (as NaCl)	mg/l	10	5	7	3795	5	
15	Sulphate (as SO4)	mg/l	Nil	Nil	Nil	320	28	200 mg/l
16	Total Solids	mg/l	30	43	26	5850	219	1500 mg/l
17	Suspended Solids	mg/l	7	32	12	1230	78	
18	Dissolved solids	mg/l	23	11	14	4620	141	1000 mg/l
19	Manganese	mg/l	Nil	Nil	Nil	0.2	Nil	0.05 mg/l
20	Phosphate	mg/l	Nil	Nil	Nil	1.95	Nil	
21	Salinity	ppt	< 0.1	< 0.1	< 0.1	5.2	< 0.1	
22	Temperature	°C	25.1	25	25.1	25	25	
23	Fluoride	mg/l	0.8	1.1	0.9	0.3	0.5	1.5 mg/l
24	Lead (as Pb)	mg/l	Nil	Nil	Nil	Nil	Nil	0.01 mg/l
25	Arsenic (As)	mg/l	Nil	Nil	Nil	Nil	Nil	0.01 mg/l
26	Nitrate	mg/l	0.2	0.3	0.2	3.5	0.4	50 mg/l
27	Ammonia	mg/l	Nil	Nil	Nil	10.00	Nil	
28	Ammonium	mg/l	Nil	Nil	Nil	10.57	Nil	
29	DO	mg/l	3.8	3.4	5.2	Nil	7.2	
30	COD	mg/l	< 32	< 32	< 32	896	< 32	

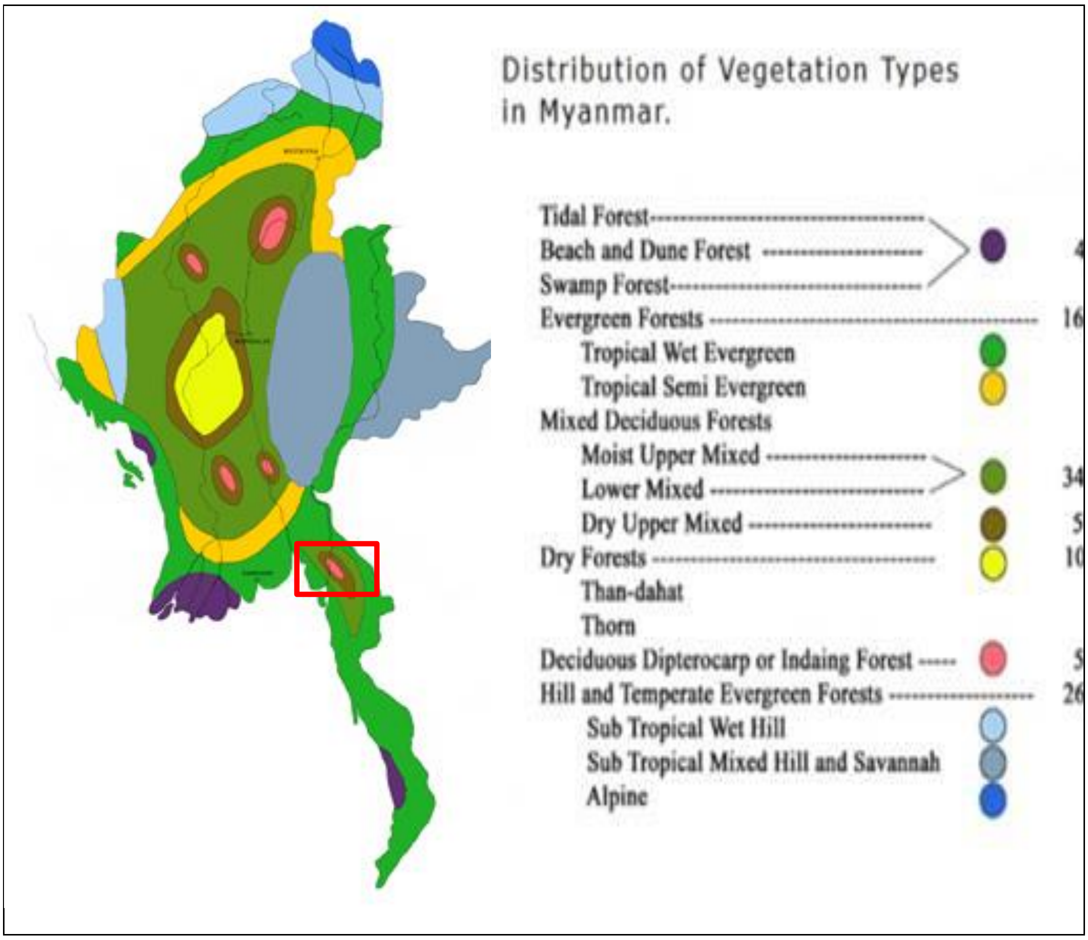
No.	Parameter	Unit	01	02	03	04	05	WHO guidelines
31	BOD	mg/l	7	9	5	390	8	
32	Cyanide	mg/l	Nil	Nil	Nil	Nil	Nil	0.07 mg/l
33	Zinc	mg/l	Nil	Nil	Nil	Nil	Nil	3 mg/l
34	Copper	mg/l	Nil	Nil	Nil	Nil	Nil	2 mg/l
35	Total Coliform Count	CFU /100 ml	4	3	3	18	8	Not detected
36	Thermotolerant (faecal) Coliform Count	CFU /100 ml	1	ND	1	7	2	Not detected

4.8 Terrestrial & Aquatic Ecology

4.8.1 NATURAL AND URBAN VEGETATION

As shown on **Figure 4-18**, there are various vegetative types ranging from Tropical Wet Evergreen, Moist Upper Mixed Deciduous forest, Lower Mixed Deciduous forest, Dry Upper Mixed Deciduous Forest, and Deciduous Dipterocarp or Indaing Forest.

Figure 4-18: Distribution of Vegetation Types in Myanmar



Source: A Checklist of the Trees, Shrub, Herbs, and Climbers of Myanmar. Contributions from the United States National Herbarium. Volume 45: 1-59

As Mon is located in the tropical climate zone with intense rains, evergreen forests (Tropical wet evergreen) and mixed deciduous forests thrive in the region of the state. Marshes grow along some coastal plains and valleys of rivers and creeks and trees such as *Dipterocarpus tuberculatus* grow on laterite-like land in areas east of Mawlamyine.

Mangroves are observed in the mouths of tidal rivers as the Thanlwin River in Mon State. According to the National Report of Myanmar on Sustainable Management of the Bay of Bengal Large Marine Ecosystem (2003), as many as 24 species of mangrove trees have been recorded along the Myanmar coastline. Genus most frequently observed include Rhizophora, Sonneratia, Avicennia, Bruguiera and Xylocarpus spp (Department of Fisheries Myanmar, 2003). In Mawlamyine area, only few mangrove trees are scattered along the banks of the Thanlwin and the Attran rivers. But these areas represent almost the upstream distribution limit of mangrove, as the salinity of the water reduces. No mangrove vegetation is observed within or close to the project component areas.

SOME MANGROVE TREES ALONG THE THANLWIN RIVER MIXED WITH DUMPED WASTE

MANGROVE TREES ALONG THE ATTRAN RIVER

The following trees and shrubs species presented in **Table 4-7** are the most common ones observed in Mawlamyine region. Most of these trees are widely distributed in SE Asia and also widely used for plantation in urban areas. None is registered as a protected species either at international (IUCN) or national levels.

Table 4-7: Species of Trees and Shrubs found in Mawlamyine region

VERNACULAR NAME (BURMESE)	SCIENTIFIC NAME
Htan pin	*Borassus flabellifer* (Arecaceae)
Da hat pin	*Tectona hamiltoniana* (Verbenaceae)
Yin Mar pin	*Chukrassia tabularis* (Meliaceae)
Shaw phyu	*Sterculia versicolor* (Sterculiaceae)
In Gyin pin	*Shorea siamensis* (Dipterocarpaceae)
Ngu pin	*Cassia fistula* (Caesalpiniaceae)
Pa Dauk	*Pterocarpus macrocarpus* (Fabaceae)
Ta Mar	*Azadirachta indica* (Meliaceae)
Bawzagaing	*Leucaena leucocephala* (Mimosaceae)
Seinban	*Delonix regia* (Caesalpiniaceae)
Tayok-saga	*Plumeria rubra (Apocynaceae)*
Magyi	*Tamarindus indica* (Caesalpiniaceae)
Kokko	*Albizia lebbek* (Mimosaceae)
Nyaung pin	*Ficus religrasa* (Moraceae)
Banda	*Terminalia catappa* (Combretaceae)
Arthaw-ka	*Polyalthia longifolia* (Annonaceae)
Swedaw	*Bauhinia monandra* (Caesalpiniaceae)
Eu-ca-lit	*Eucalyptus ovata* (Myrtaceae)
Thayat	*Mangifera indica (Anacardiaceae)*
Thiho (Cashew nut)	*Anacardium occidentale* (Anacardiaceae)
Kyun (Teak)	*Tectona grandis* (Verbenaceae)
Khayay	*Mimusops elengi* (Sapotaceae)

VERNACULAR NAME (BURMESE)	SCIENTIFIC NAME
Maniawga	*Carallia brachiata* (Rhizophoraceae)
Mahogany	*Swietenia macrophylla* (Meliaceae)

4.8.2 AQUATIC FAUNA

Very limited information is available on the fish population in the project region. Only one study on fish composition in the downstream section of Thanlwin River was carried out from May to October 2014 by the Department of Zoology, University of Mawlamyine (Than, Tun, & Htay, 2014). According to the study, 22 species were observed in the Mottama area, close to Mawlamyine. The species observed are listed in **Table 4-8**. None of these species is registered as protected either at international or national levels.

Table 4-8: Main Fish Species in Mawlamyine Region Water Bodies

VERNACULAR NAME (BURMESE)	SCIENTIFIC NAME
Nga hpe	*Notopterus notopterus* (Notopteridae)
Nga tha lauk	*Tenualosa ilisha* (Clupeidae)
Mee tan thwe	*Colia dussumieri* (Engraulididae)
Nga phan ma	*Osteobrama belangeri* (Cyprinidae)
Nga khone ma	*Puntius sophora* (Bagridae)
Nga zin yine	*Mystus vittatus* (Bagridae)
Nga nu than	*Ompok bimaculatus* (Siluridae)
Ka ka loung	*Eutropiichthys vacha* (Schilbeidae)
Nga yant gaung to	*Channa orientalis* (Channidae)
Nga yant	*Channa striatus* (Channidae)
Nga mway doh kyar	*Macrognathus zebrinus* (Mastacembelidae)
Nga mway don pyaung	*Macrognathus aral* (Mastacembelidae)
Moe nga yaung	*Arius caelatus* (Ariidae)
Pin lei nga khue	*Plotosus canius* (Plotosidae)
Nga khoo	*Clarias batrachus* (Centropomidae)
Nga si ooe	*Gerres filamentosus* (Gerrreidae)
Nga pyat khone	*Johnius coitor* (Sciaenidae)
Nga poke thin	*Otolithoides pama* (Sciaenidae)
Kabu lu	*Rhinomugil corsula* (Mugilidae)
Nga pon na	*Polynemus paradiseus* (Polynemidae)
Ka tha boe	*Glossogobius giuris* (Gobiidae)
Nga bee	*Scatophagus argus* (Scatophagidae)

No information is available on the fish population of Kin Pong Chong reservoir. According to the water supply department, no fishing activities happen on the lake where boats are not allowed. Also, very few fishes are reported because the very low level of mineralisation and nutrients of the water. Indeed, the lake is also free of aquatic vegetation and algae.

4.8.3 TERRESTRIAL FAUNA

According to the world birds database (*http://avibase.bsc-eoc.org*) Mon state records 534 bird species from which 15 species are classified as globally threatened and 1 as introduced species. However, none of these registered species have been observed in urbanized areas which are mainly represented by Passeridae and Colombidae.

4.9 Protected Areas and Species

According to Forest Department (2009), 43 protected areas exist in Myanmar. Thirty-five sites were designated from 1918 to 2010. Eight additional sites proposed from 1997 to 2008 are still under examination. The 35 designated protected areas cover approximately 42,000 km² of land, representing 6.2% of the total country area. In case of establishment of eight additional protected areas, proposed from 2001 to 2008, the area would increase 7,400 km² (1.1%), and the total area would be 49,500 km², representing 7.3% of the total land area. Two protected areas were notified in the Mon State and one in Kayin State (Mitsui & Co., Ltd, 2015).

In Mon State, there are two wildlife sanctuary named Kelatha wildlife sanctuary and Kyaikhtiyoe wildlife sanctuary (Site ID 15), respectively at 102 and 122 km from the project area. Both sanctuaries are not concerned by the project. Locations of Protected Areas are presented in **Figure 4-19**

The total numbers of reserved forest, protected areas, wildlife sanctuary in Mon State and their areas are mentioned in **Table 4-9**. None of these protection zones are located close to any of the project components.

Table 4-9: Number and Areas of Protected Areas in Mon State

State	Item	Reserved Forest	Protected Area	Wildlife Sanctuary	Total
Mon	No. of sites	15	1	2	18
	Area (ha)	184 059	15 978	18 022	218 059

Source: Statistical Yearbook 2011, Central Statistical Office, Ministry of National Planning and Economic Development, 2012

4.10 Social and Cultural Baseline

4.10.1 ADMINISTRATIVE ORGANIZATION

The division of administrative areas in Mon State follows the same dissecting arrangements as other states and regions. It starts with State which is divided down the line into Districts, Townships and Sub townships, Towns/Sub-towns, Wards/Village Tracts and Villages. The list below in **Table 4-10** shows the division of administrative areas in Mon State.

Figure 4-19: Locations of Myanmar Natural Protected Areas

The land area of the Mawlamyine township is 21 895 ha, with the widest area from east to west of seven miles and from north to south 17 miles. Mawlamyine township is bordered by Kyaikmayaw township in the east, Chaungsone township in the west, Mudon and Ye townships in the south and Hpa-An in the north. It is made up of 28 wards and 51 villages.

Table 4-10: Division of Administrative Areas in Mon State

District	Township	Towns/Sub-Towns	No. of Ward	No. of Villages
Mawlamyine	Mawlamyine	Mawlamyine	28	51
	Kyaikmayaw	Kyaikmayaw	2	171
	Chaungzon	Chaungzon	3	79
	Thanbyuzayat	Thanbyuzayat	9	95
		Kyaikkhami	6	
	Mudon	Mudon	4	56
	Ye	Ye	9	81
		Lamaing	3	59
		Khawzar	2	24
Total Mawlamyine			66	616
Total Mon State (Mawlamyine + Thaton)			86	1297

Source: UNDP Myanmar Information Management Unit

Notes: All sub-townships were upgraded to township level by the presidential order in 2013. No indication is given by the source to the division of villages between Thanbyuzayat and Kyaikkhami townships, between Thandaunggyi and Thandaung townships and also between Kawkareik and Kyondoe townships.

Administrative Officers are placed in each level of structure starting from State level down to village level. All of them are employees of General Administrative Department (GAD) under the Ministry of Home Affairs. Administrative Officer at State level has the official position of Director/Deputy Director in the department. Administrative Officer at ward or village level is however elected by constituents of wards or villages but paid monthly allowances by GAD.

4.10.2 POPULATION

Population and Ethnic Groups

According to 2014 National Census of Myanmar Total population in Mawlamyine Township is 289,388 including an urban population of 253,734 as in **Table 4-11**.

Table 4-11: Population in Mawlamyine

State/Town	Urban	Total
MON STATE	572,189	2,054,393
Mawlamyine	253,734	289,388
Thaton	55,047	238,106

Source: Census 2014 Myanmar

Table 4-12 shows the ethnicity in Mawlamyine and in the wards where the project components are being proposed.

Table 4-12: Ethnicity in Mawlamyine Township (2015)

Area	Ethnic Group									Total Ethnic Pop
	Kachin	Kayah	Kayin	Chin	Mon	Rakhine	Shan	PaO	Bamar	
Urban	17	54	2581	26	28456	209	665	20	131515	163543
Rural	17	108	2618	27	45328	215	704	24	141700	190741

Total	34	162	5199	53	73784	424	1369	44	273215	354284

Source: Township Administrative Department, 2015

4.10.3 EDUCATION

In order to provide young people with access to higher education in the region, there are a number of higher education institutions including an institute of technology, Mawlamyine Art and Science University, and one educational college producing professionals and technicians. In regards to basic education, there are 15 basic education (pre-university) high schools (branch), one basic education high school, one basic education affiliated high school and 14 basic education middle schools, 13 post-primary schools, and 120 primary schools. In terms of quality, Mon State won the first prize for best matriculation results for the education year of 2008-2009 (Chingmai University).

4.10.4 PUBLIC HEALTH

Hospitals, dispensaries and health centres are being expanded to provide health care services in Mon State. There are 4 government hospitals, 6 private clinics, 3 Rural Health centres and 12 Sub Health centres in Mawlamyine with 96 doctors, 168 nurses and 32 mid wives (2014).

4.10.5 WATER SUPPLY

In terms of existing water supply, Mawlamyine is served by three distinct resources as in **Table 4-13** namely:

- Water from the KhinPonChong reservoir created in 1904[3] together with an old distribution system which is still supplying 24/7 water by gravity to the main storage reservoirs and thereafter distributing to the main city;
- A newer reservoir, ShweNatTaung reservoir which supplies by pumping to the main storage reservoirs (3 reservoirs of 500,000 gallons each);
- Two water intakes from the Attran River, which shall be reunited into one intake under a Thai company project.

Table 4-13: Mawlamyine Surface Water Supply Sources

NAME	DAILY SUPPLY RECORDED (M3/D)	DAILY SUPPLY EXPECTED (M3/D)	DAILY SUPPLY CAPABLE (M3/D)
ShweNatTaung Dam	10,050	10,050	21,045
KhinPonChong Dam	12,500	8,000	8,000
Attran-1 River Intake	6,144	6,144	8,400
Attran-2 River Intake	7,444	7,444	8,340
Total	36,138	31,638	47,785

[3] The KhinPonChong dam can be considered part of the unique cultural heritage of Mawlamyine. The design of the rehabilitation measure for the dam should preserve and enhance the existing features.

ShweNatTaung Reservoir

ShweNatTaung outlet channel

KhinPonChong Dam

KhinPonChong water intake

Water is transferred through gravity from the KhinPonChong Dam to the three tanks reservoir. Water from ShweNatTaung Dam is transferred to Three Tanks Reservoirs by pumping and via RTC reservoir. The northern zone of Mawlamyine is currently partially served by the Attran River intakes (Wards 1 to 12). The southern zone and the major expansion area are currently partially served by the two reservoirs. This covers today urban wards 13 to 23. Wards 24 to 28 are currently not served by the current system as well as the rural villages.

In addition to the JICA financed project, another project is under consideration: The Thai Tap Water Project (TTWP), developed by a private Thai water supply company, which intends to supply the northern zone from an intake in the Attran River. This Project is totally independent from the present ADB project.

4.10.6 SANITATION

Wastewater treatment consists entirely of septic tanks and discharges to the natural or storm drains crossing the city and discharging directly to the estuarine front/esplanade area. The present Project doesn't cover sanitation.

4.10.7 SOLID WASTE MANAGEMENT

Mawlamyine Town Development Committee (MTDC) provides solid waste collection services to 23 of the 28 wards (which represent about 90% of the total population). MTDC relies on only 7 waste vehicles for 23 Wards and they have no possibility to include the other 5 wards to incorporate in the SWMS (Solid Waste Management System). Normally waste is collected twice/week.

SOLID WASTE COLLECTION CART

SOLID WASTE COLLECTION TRUCK

EXISTING LANDFILL SITE

LEACHATE FLOWING TO SURFACE WATER DURING WET SEASON

LANDFILL BURNING DURING DRY SEASON

RECYCLING BY WASTE PICKERS

Assuming a population of 258,809 in 2015 with a waste generation of 0.55/kg/capita/day results in about 142 ton/day. Initial observations estimate that around 50% of waste is collected and dumped at the designated dump site. Inadequate and uncontrolled waste disposal causes groundwater pollution, unpleasant odour and air pollution by unauthorised burning of the waste, drain clogging and spreading of mosquitoes. This has a negative impact on the city's health and environment. While the majority of the city is generally kept well clean, there are often accumulations of solid waste in drains which are washed down to the sea front and accumulate near to the promenade area. Most of the activities are operated by MTDC, but there is one ward (MyaingThaYar) which is actively undertaking a community based collection system.

At the moment the hazardous waste is not separately collected but mixed with household waste. Regarding the medical waste, none of the 5 hospitals and 6 clinics of Mawlamyine have any special provision as incinerator for the disposal of medical waste. These are directly disposed on the municipality landfill, with major contamination risks for the waste pickers.

At present, part of recyclable waste (steel, paper, aluminium, plastic) is collected by the informal sector at landfill level. This aspect is detailed in the RAP prepared in parallel with the present IEE.

Solid waste is dumped at a site to the South-East of the main city, along the Kyaikmayaw road, upstream of the Attran river water supply intakes; even if leachate follows few km of natural drainage before its junction with the Attran, there is a potential risk of contamination of these water resources by the leachate from the dump site.

4.10.8 CULTURAL HERITAGE

Mawlamyine currently has a rich built history which many other urban centres in the region have lost in their rapid desire to move to a "modern" city. There is a short window of opportunity (perhaps 5 years) during which there is time to conserve much of this heritage and then use or convert this resource to attract tourists and create related sustainable employment directly as guides/historians and indirectly through extra generated income in hotels, restaurants and travel related businesses. Several buildings currently in government use have the potential to be converted into more efficient and more appropriate working spaces better suited to modern needs.

Mawlamyine has a number of major historical attractions such as KyaikThalan pagoda (erected in 875 A.D), U Zina pagoda (3rd century B.C according to legend) and the Mahamuni pagoda (1904).

There are hundreds of potential heritage (100+ years old) buildings/structures spread over a vast area within Mawlamyine, with a wide range of current government, religious, commercial and private uses, and colonial secular and religious buildings, many of which are associated with Mawlamyine position as capital of British Burma from 1826 to 1852.

Figure 4-20: Heritage Buildings of Mawlamyine

The South

တောင်ဘက်ပိုင်း။

18

Map Ref	Chapter Ref:	Current Name	Old Name	Location	When Built	Notable History
1	2, 4, 5	Kyaik Than Lan Pagoda		Taung Yoe Tan		Built following a competition with the Siamese. Several repairs over the years, notably in 1538 by Wareru, King of Martaban and later by the Setkya Wungyi. Present pagoda erected by Siamese pongyi, Thila Withoddi (with a hair of Buddha). Repaired in 1831 for Rs. 1000. Measures 152 feet high and 377 feet circumference at the base.
2	3, 4	Mahamuni Pagoda	Bahaman Pagoda	Taung Yoe Tan		The Buddha image inside is based on one in a pagoda of the same name in Mandalay.
3	3	Yadanar Boone Myint Monastery, Seindon Mibaya Kyaung		Taung Yoe Tan	1886	King Mindon's Queen Sein Done, sought refuge here. A large Buddha was kept here before being installed in the Mahamuni.
4	3, 4	Tomb of the fourth daughter		Mahamuni Pagoda Road		
5	3	Basic Education Middle School B.E.M.S (8)		Pet Tan Quarter		The fourth daughter of King Thibaw previously lived here
6	3, 5	Basic Education High School B.E.H.S (5)	St. Patrick's School (1847). Old Jail (1840-1850)	Shwe Taung Quarter		The De La Salle Brothers opened St. Patrick's School. Part of the Institute of the Brothers of the Christian Schools, who are exclusively dedicated to education. They were invited to Myanmar by Bishop Bigandet. In 1893, they built the boy's hostel (now the Cooperative Department). In 1903, the school was divided into two; to the west is St. Patrick's Boys School and to the east St. Joseph's Convent for girls. Prince Sukkasem from Thailand attended St. Patrick's around 1905.
7	3, 5	University of Distance Education	St Joseph's Convent Girl School	Shwe Taung Quarter		The compound includes a derelict building which used to be part of the old Prison. Entry to the school is not allowed.
8	3, 6	B.E.H.S (9)	Shin Maha Buddhaghosa National School	Pan Pae Tan Quarter	1905 (the main building)	Founded by the Sāsanādhāra Society, the school produced notable writers and politicians who played a role in the Burmese independence movement. Still one of the most prestigious high schools in the city. Sein Tin (Theippan Maung Wa), writer, matriculated in 1919. In 1929, Mahatma Gandhi addressed a conference at the school. Note the two-storey teak building named U Thar Nyin Dhammayon.
9	3, 6	U Zina Pagoda	Kyaikpatan (white hill)	Taung Yoe Tan		Named after former monk who dreamt of finding gems in this spot and did, then used the proceeds to build a temple. Repaired in 1830 at cost of Rs 600 by U Lugalay and wife Daw Mi
10	3, 6	Pa Yan Pyan		Taung Yoe Tan	1904	Related to U Thar Nyin's dream. He dreamt of the building but could find no-one to construct the detailed interior designs in real life. On the left before arriving at U Zina.
11	3	Rookmanund Timber Mill				Note the several remaining brick chimneys along the waterfront. His original house was in the Military Camp area 204.
12	4	Kyaikpanae Pagoda		Kyaikpanae Quarter		
13	4	Yadanar San Kyaung Monastery		Taung Yoe Tan	1948	The temporary resting place of the statue of Buddha when it arrived by water
14	4	Magazine				Solid brick building used to store armaments from the earliest days of the Cantonment
15	4	Cantonment Pillars				
16	5	B.E.H.S (6)	Nilar Building	Corner of Tawae Ta Dar Street and Upper Main Rd		First Burmese Girl's School. Previously known as Morton Lane Judson School
17	5	State Government Office		Baho Street	1928	The Municipal Clock Tower was erected in 1912 by the citizens to commemorate the reign of Edward VII.
18	5	Ebenezer Baptist Church		Baho Street	1829	
19	5	First Baptist Church		No. 60, Upper Main Road, Ma Yan Gone Quarter		Founded by American Adoniram Judson, who had a long relationship with the country. In 1827, he founded the First Baptist Church order. In 1830, he printed the Bible in Myanmar language. An inscription to this is in the B.E.M.S (5) compound.
20	5	St. Patrick's Church		Shwe Taung Quarter	1903	
21	5	Cooperative Department	St. Patrick's Boy Hostel	Shwe Taung Quarter	1896	
22	5	Prison			1908	

Map Ref	Chapter Ref:	Current Name	Old Name	Location	When Built	Notable History
23	5	Maw Ya Wadi Garden	Victoria Gardens	Baho Street		
24	5	Port Authority				
25	5	Department of Education		Baho Street		
26	5	Forest Office				
27	5	Department of Construction		Baho Street		
28	5	Ellen Mitchell Memorial Hospital	American Hospital		1917	Mount Hope lies abandoned in the grounds
29	6	General Administration Office				
30	6	Court House				
31	6	St. Matthew's Church		Mayangone Quarter	1887	Consecrated in 1890. Tower is a memorial to members of Bombay Burmah Corporation members killed in 1WW. The church was originally in the Cantonment Area (built in 1843)
32	6	St. Mary's Church		Near B.E.H.S (6)	before 1876	In the grounds of the Holy Family Cathedral Catholic Mission which dates from 1958
33	6	B.E.H.S (1)		Upper Main Road, Pae Bae Tan Qt, Mawlamyine		The first Government School. Government High School (Company Kyaung)
34		B.E.H.S (4)	Baptist Karen Normal School		1854	
35		B.E.H.S (8)		Pet Tan Quarter		Before the Second World War, it was St. Joseph's Convent (for Girls). It was a Japanese Office during the war. It then became the Pway Sitt Chinese School.
36		B.E.M.S (7)	SPG		1880	
37		Daing Won Kwin Market				
38		Kyaikpanai Mosque		Kyaikpanae Quarter	1896	
39		Lyndhurst				Private house. See http://www.greatmirror.com/index.cfm?navid=265&picturesize=medium
40		Ma Gyi Daw Shwe Kyaung		Taung Yoe Tan	1240 (Myanmar Year)	The first Brick Monastery In Mawlamyine
41		Market (Ka Lar Zae)				
42		Police Training School				Abandoned and gutted building on the top of the ridge.
43		Rakhaing Mosque		Shwe Taung Quarter		Built in 1820's or 30's. Burnt down in 1860's fire. Brick replacement. Damaged in the 2nd World War.
44		Sikh Temple		A Shae Tet Myay Street, Pet Tan Quarter		
45		B.E.M.S (1)	St Matthews Boy's School			
46		St. Augustine's Church			1883	
47		Surtee Sunni Jamae Masjid		No. 139/14, Lower Main Road, Pet Tan Quarter	1848	
48		Telecommunication Department				This was the site of the Bank of Bengal
49		Thanlwin Hotel	House of Rookmanund			Was also a Regional Party Office
50		Tower House	Andaman Club			
51		U Khanti Pagoda		Taung Yoe Tan		Built to commemorate the architect, U Khanti. Can buy coins to throw into revolving bowls and make wishes.
		Kay Mar Thi Won Monastery	Japanese Jail	Tha-yet-kong Quarter, Thiri Myaing Quarter		South of Mawlamyine

There are very few groupings of heritage buildings including:

- the North end of the ridge which has a number of pagodas and associated buildings with interesting histories;
- the area south and east of the Myawaddy Park which has several functioning government buildings; and
- the area around St. Patrick's Church and BEHS 5 which has a varied history.

And there are a number of mature trees have been retained in conjunction with several of the heritage attractions. They would also need to be protected in future as an integral part of each heritage building and its curtilage/habitat.

After detailed consultation between the Project, the Municipality of Mawlamyine and the Mon State Government, decision to include as a project component the rehabilitation of the Administration Complex U building, a reasonably well preserved building from the British colonial period. An architecture company from Yangon, with building restoration experience in Myanmar, was appointed to prepare, within the PPTA framework, the rehabilitation study.

5 IMPACT ANALYSIS

5.1 Methodology

The impacts were identified by confronting the environmental and social baseline situation of the area with the activities related to each component and stage of the project. For every interrelation between Project activities and each pertinent environmental component, all probable impacts have been identified.

This identification was mainly based on:

- The technical information related to project components design and operation as presented in Chapter 3 of this report;
- Field visits conducted in August-September and November 2014 by the Consultant in the Project area;
- The Consultant experience of environmental impacts of a variety of projects including urban development, water supply, sanitation and waste management;
- The checklists of potential impacts from various types of projects drawn up by international financial organizations (WB, ADB, AFD).

The result of this analysis is presented in the following sections covering 1) impacts connected with the location of the projected facilities, 2) impacts connected with construction activities and 3) impacts connected with the actual operation of the facilities.

The potential impacts for each of these sections are presented in a summary table, followed by descriptions and analyses of the most probable significant impacts. These tables present, successively, the cause of the impact, the potential impact along with its risk level, the corrective measure along with the ease/difficulty of implementing it and the residual risk level after implementing the measure.

Each summary table shows, for each identified impact, an assessment of the overall risk level, taking three criteria into a consideration: the probability of occurrence of the impact as part of the project, the expected gravity of such an impact given no special corrective measures, and the difficulty of implementing the proposed corrective measures.

- The probability of occurrence reflects how often the impacts are observed during construction and operation of similar projects: some impacts are inevitable (noise, dust, suspended sediment in surface water) whereas others occur only exceptionally (accident, explosion).
- The gravity of an impact incorporates various considerations of intensity of effects on the natural or human environment, its extent and its duration. All necessary efforts must be made to implement corrective and monitoring measures on impacts that are judged to be potentially serious.
- The overall risk relating to an impact, rated from 1 (low) to 3 (high) takes into account the abovementioned criteria.

Table 5-1: Impact Assessment Criteria

CRITERION	LEVEL 1	LEVEL 2	LEVEL 3
Difficulty for implementing corrective measures	Easy, inexpensive and generally effective	Demands special attention (monitoring or training, for example)	Difficult due to complexity or cost
Probability of occurrence of the impact	Low: can be seen in cases of negligence or accident	Medium: generally seen a few times during construction or during the operation of the concerned facility	High: consistently seen if effective corrective measures are not put in place
Gravity of the impact	Generally limited impact in terms of intensity, duration or extent	Significant environmental impact but not endangering human or animal populations	Major environmental impacts with risks to people or special-status animals
Overall Risk	Low: subject of routine monitoring but impacts are minor and easily manageable	Significant: merits special attention	Major: merits close monitoring and the implementation of effective measures

5.2 Anticipated Benefits from the Project

The components of the Project are anticipated to significantly improve the environmental conditions and quality of life of the population in Mawlamyine through the following results:

- Better quality of life and public health by the improvement of the water supply services and security through (i) increasing the water supply service in terms of satisfaction of the demand, providing 24/7 supply and good water pressure, increasing storage capacity of the system by the construction of a new storage next to KhinPonChong dam, (ii) reduction of non-revenue water and extension of serviced area, (iii) construction of a water treatment plant and (iv) improving and extending the distribution network;
- Better quality of life and public health by the improvement of solid waste management through better collection and safe disposal of waste: increased number of collection vehicles and collection points, a new transfer station and upgrading and extension of sanitary landfill, construction of an incinerator for medical waste, rehabilitation of former landfill site;
- Better quality of life and public health by improving indirectly rainfall drainage: improvement of solid waste collection shall reduce the volume of waste presently dumped in the drains and clogging the system. This shall also reduce the temporary and localised flooding which occurs during heavy rainfall.
- Contribution towards Green City Principles through the implementation of a composting plant for solid waste. When compared to the "No Project" option, the Project solid waste component shall reduce the GHG emissions in Mawlamyine by as much as 42,600 tons of $CO2$-eq per year in 2020 and 132,000 tons of $CO2$-eq per year in 2040. The Project shall reduce the cumulated GHG emissions by as much as 2,3 million tons of $CO2$-eq over the period 2016-2040;

- In addition to the improvement of Mawlamyine cleanliness, the Project, through its cultural heritage preservation component, shall favour the general beautification of the city in the long term and consequently boost its tourism attractiveness.
- Secondary benefits related to increased attractiveness of Mawlamyine regarding investment, economic development, tourism, employment, income and increased value of land and buildings.

5.3 Impacts related to Project Location

5.3.1 IMPACTS ON LAND ACQUISITION AND RESETTLEMENT

Water Supply Components

Water Treatment Plant

Water treatment plant to be constructed just next to the KhinPonChong dam will require about 3,000 m² or 0.75 acres. Land area is currently unused land owned by the State Development Committee. As there is no asset on the land, no land acquisition nor compensation or resettlement is required. The site is already accessible from KhinPonChong dam and will not require access road. As the area is surrounded by a military compound, agreements for access from the main road will be needed. However no difficulty is expected here as the access was easily provided to PPTA consultants during their mission. Nearest residential receptor is a Monastery but which buildings are more than 500 m from the proposed facility.

New Water Storage at KhinPonChong

The new 4,000 m^3 storage to be constructed shall require about 1,400 m² (0.35 acres). The land is located next to the proposed water treatment plant, on a land owned by MTDC.

Rehabilitation of the 3 existing storages

The 3 reservoirs of 500,000 gallons (2,200 m3) each, located Kan Thone Kan inside Mawlamyine urban area, shall be rehabilitated including limited rehabilitation of piping system, and rehabilitation of the building sheltering control valves. Construction of a concrete roof cover of the 3 reservoir initially proposed was in fact completed in 2016 under a Jica Project (See Due Diligence report attached). As rehabilitation doesn't include any extension, no additional land is required, no tree cutting necessary and no impact on any external built-up property located near the reservoirs.

Rehabilitation and extension of main and network supply system

The existing main pipe system to be replaced is located along roads, as well as the distribution system considered under this project. As the system relies on gravity distribution, no pumping station shall be required. This component will not require any land acquisition nor resettlement. In densely urbanised area, the component shall mainly result in temporary nuisances during construction, including sometimes difficult access to certain places (shops, government buildings, hospitals etc.). These impacts shall be mitigated during the construction phase on a case by case basis in order to avoid or minimise nuisances.

WS: PROPOSED LAND FOR WATER TREATMENT PLANT

WS: SAME, SHOWING ELECTRIC LINE AVAILABLE ON SITE

SOLID WASTE COMPONENTS

Sanitary Landfill and Composting Plant

The site is located near the existing landfill site. The nearest surrounding houses are located at least 300 meters far from the proposed new site. The future land would measures 19.4 ha (48 acres) and mostly belongs to the Mon State Government except 1.5 ha (3.7 acres) to be purchased from a private owner. The land is presently unused, vegetation is low scrub with scattered trees of small size. No significant forest clearing is anticipated.

The 4.8 ha (12 acres) old site would be closed. The waste pickers currently living in the area will receive compensation according to the preconisation of the Resettlement Plan implemented under PPTA 8758.

A temporary stream is located in the middle of the proposed future land. This stream is dry except during the rainy season according to the villagers. A hydraulic analysis is included in the landfill detailed design cost estimate. The path of the stream must be diverted and well designed in order to avoid leachates collection but also flooding. The stream is displayed in blue on the picture below.

MSW: VIEW OF NEW LANDFILL

AREA ANTICIPATED FOR NEW LANDFILL

CULTURAL HERITAGE COMPONENT

The building under consideration for rehabilitation is the administrative complex (GAD) building in PaBaeTan Ward. No land acquisition nor compensation is required as the works shall not encroach outside the premises. As already mentioned, the project assessment has been carried out by a competent architecture company from Yangon, in compliance with requirements SPS SR1, Section 11.

5.3.2 IMPACTS FROM CLIMATE CHANGE AND NATURAL HAZARDS

Climate Change (CC) or natural hazards are not anticipated to represent a risk in relation to project components location:

- Project components are not located in floodable areas or areas anticipated as floodable in the future.
- The general topography is rather smooth, not prone to landslide.
- Seismic risk in Mawlamyine is considered as low (refer to 0).
- No fault or fractured geological structure is observed at the landfill site, as the area is developed on deep sedimentary deposit.

None of the Mawlamyine Third GMS Corridor Project component is anticipated to be particularly exposed to CC or natural hazards because of its proposed location.

5.3.3 IMPACTS ON CULTURAL HERITAGE

The Project has a dedicated component for the conservation and rehabilitation of Mawlamyine historical buildings, consequently with strong positive impacts on the city cultural heritage. Action program has been prepared by a recognized architecture company currently working on cultural heritage sites restoration in Myanmar.

The historical (heritage) buildings identified during the assignment showed evidence of no heritage features in the vicinity of the Kin Pon Chong reservoir (except for the reservoir features notably the intake itself[4]). In the vicinity of the two reservoirs there are a number of Pagodas as illustrated below. None are affected by the project during construction

[4] It will be necessary to ensure protection of these features as part of the rehabilitation of the reservoir to be financed under the project

Location of Pagodas around reservoir sites

5.3.4 IMPACTS ON NATURAL RESOURCES

Being mainly developed inside or nearby urbanized areas, none of the components of the Project has significant impacts on natural resources. Few old trees (3 to 5) may be cut in the urban area to accommodate the transfer station for the solid waste, but detailed design will take the constraint into consideration to avoid or minimize such impact.

The vegetation of the proposed landfill and the water treatment plant consists mainly of scrub land with few scattered trees of small size.

No wetland or protected area is affected by the project location.

5.3.5 SUMMARY OF IMPACTS AND MITIGATION MEASURES

Table 5-2 summarizes the impacts relating to the location of the 3rd GMS Project Components in Mawlamyine.

TA 8758 – Preparing Third GMS Corridor Towns Development

Table 5-2: Summary of Impacts related to Project Components Location in Mawlamyine

Component or activity	Potential risks	Potential impact – Description of impact	Impact assessment – Probability	Impact assessment – Gravity	Impact assessment – Overall risk	Corrective or support measure – Description of measure	Easiness of implementation	Overall risk after correction
Improved Water Supply System								
Upgrading KPC reservoir water intake	None related to the location	No land acquisition required. Temporary land needed is part of the dam area. No resettlement required.	-	-	-	No particular measure required	-	-
New storage next to KhinPonChong reservoir	Permanent and temporary land occupation	Next to WTP on MTDC land. No land acquisition is required, no built-up property is affected. Area large enough to satisfy needs for temporary land use during construction.	3	1	2	No particular measure required Monitor during construction temporary land occupation in compliance with previsions.	1	1
Construction of a Water Treatment Plant	Permanent and temporary land occupation	Only 3 000 m² required of land belonging to MTDC; no land acquisition required and no built-up or crop production to compensate. Access road existing, just rehabilitation required. Land available large enough to satisfy temporary needs during construction. No adjacent residents.	1	1	1	No specific measure except monitoring during construction to ensure no encroachment happens outside dedicated area.	-	-
	Vegetation clearing	No forest or large trees concerned. Only open scrub over unused land	-	-	-	No specific measure required.	-	-
Rehabilitation of 3 existing reservoirs	Permanent and temporary land occupation	Rehabilitation concerns only civil works improvement and roofing without extension. No land required, no impacts on vegetation and built-up properties	-	-	-	No specific measure required.	-	-
New water distribution pipe system	Permanent and temporary land occupation	Short term land occupation required during works which may locally impact road traffic and access to house or business in urban area. Possible need for tree cutting	3	2	1	Minimize as much as feasible tree cutting; Compensate by 2 trees planted for 1 tree cut;	1	1
Improved Solid Waste Management								
Creation of Sanitary Landfill	Permanent occupation of land	Land mostly belongs to Mon State Government. 1.5 hectares to be acquired from private owner. Possibility for few trees to be cut. Access to site already existing (existing landfill)	3	2	2	No particular measure required. Ensure the 250 meters buffer zone around any cell with no housing is respected at detailed design stage.	1	1

Component or activity	Potential risks	Potential impact: Description of impact	Impact assessment: Probability	Impact assessment: Gravity	Impact assessment: Overall Risk	Corrective or support measure: Description of measure	Easiness of implementation	Overall risk after correction
		No built up property on the land.						
	Stream diversion	Deviation of a temporary drain usually dry except during rainy season.				Undertake diversion and reduce future flood risk. The future stream must not catch leachates from the new dump site.		
Closing the old dump site	Permanent land occupation	Disturbances regarding wastepickers available work.				Measures already included in resettlement plan.		
Creation of a Composting Plant	Permanent land occupation	Plant located on the premises of the landfill site. No further land required and more than 250 m from closest residents.	-	-	-	No particular measure required	-	-
Construction of Collection Points		56 collection points (2 per each of the 28 wards) consisting of a concrete slab with 3 containers of 240 l in each point. Installed on public space, land acquisition or building demolition not required. Most located on existing collection points.	-	-	-	New collection points to avoid proximity with sensitive locations (monasteries and pagodas, hospitals, schools etc.)	1	1
Improved Waste Collection equipment	Need for garage & parking area	No land required as parking & maintenance area installed in Municipality compound	-	-	-	-	-	-
Improved Cultural Heritage								
Rehabilitation of a Government building	Permanent and temporary land occupation	No additional land requirement; Risk of nuisances and safety issues during rehabilitation works	2	2	1	Tendering for companies to include detailed EHS specifications for the construction period; Training of MTDC for supervision of EHS compliance during works	2	1
Implementation of procedures for financial support to owners of CH buildings		Main risk is to have rehabilitation works not performed in compliance with best practices with impacts on nearby buildings, street trees cutting etc.	3	2	2	Preparation of strict technical and EHS specifications for the works as an obligation to benefit financial support. MTDC to ensure compliance is achieved during rehabilitation	2	1

5.4 Impacts and Mitigation during Construction Stage

5.4.1 DISRUPTION TO COMMUNITY UTILITIES

Construction works in urban areas, particularly those involving ground excavation works, may involve a temporary disruption of utilities for individuals or groups of residents. The following components of the project may involve such impacts:

- Water supply network rehabilitation poses only a short term concern to residents affected by construction activities. Interruptions to power and communication, disruption of water supply, discoloration of water from re-located pipes can be anticipated but should not exceed periods of few consecutive days; Contamination of water during replacement of pipes along the network may happen, but with limited risks for public health as water distributed presently is not potable and not used directly by the population as drinking water.
- Water supply network extensions shall not create any significant disruption in existing water supply as population in concerned areas relies either on tube wells, shallow wells or small independent distribution systems.
- Some disruption related to electricity supply, to accesses to households and shops or to road traffic may be temporarily and locally observed when lying down the main pipes along the streets.

To minimize impacts, the contractor shall implement the following measures:

- Water supply pipelines, power supply, communication lines and other utilities shall be re-provisioned before construction works commence;
- Provisions shall be made to preserve the operation of current facilities in sufficient quantity and in agreement with the local community;
- Re-provisioning shall be undertaken in coordination with MTDA and other concerned utility companies;
- Affected households and establishments shall be notified at least 3 days in advance of such disruption if its duration is less than 24 hrs. Notification shall be given at least 1 week in advance if disruption is anticipated to last more than 24 hrs.

5.4.2 IMPACTS ON AIR QUALITY

MAIN SOURCES OF IMPACTS

The main sources of air pollution are machines burning fuel for digging, transportation and loading. Dust and waste gas from these machines affect air quality in the surroundings of construction work places. Areas most affected are located in a range of around 50 m all around project sites, but also along the main access roads to sites which will be supporting heavy traffic of trucks. Carbon dioxide and other harmful pollutants may also be released through the burning of waste on construction sites, including plastics.

The production of dust is generally the most widely perceived nuisance generated by earthworks and transport on non-surfaced roads during dry season. Works carried out for water supply network rehabilitation may significantly generate dust if no preventive measure is applied during excavations.

MITIGATION MEASURES

Best management practices will be adopted during construction to minimize dust and combustion exhaust emissions. Mitigation measures to be implemented by the Contractors to minimize impacts on air quality shall comply with IFC guidelines on construction, which shall be at a later stage detailed in the bidding specifications. Main mitigation measures include:

- Reduce pollutant emission at source: Wherever possible, use electrically-powered equipment rather than gas or diesel-powered equipment; Use only vehicles and equipment in good condition for works in densely urbanised areas; Construction equipment and vehicles shall be well-maintained and meet with applicable national emission standards (MONREC, 2015); Undertake immediate repairs of any malfunctioning construction vehicles and equipment, particularly regarding smoke emission and noise. Maintenance and control of equipment shall be done by the Contractor under the supervision of the PMO..
- Burning of wastes generated at the construction sites, work camps and other project-related activities shall be strictly prohibited.
- Position any stationary emission sources (e.g., portable diesel generator, compressor, etc.) as far as is practical from sensitive receptors and residents.
- Control the risk of dust release: Keep excavated soil moist and cover vehicles and stockpiles with tarpaulin sheets or other suitable materials to minimize dust emission and prevent spillage of materials (e.g. soil, cement, stone, sand, aggregates, etc.). In dense residential area, spoils shall be loaded and transported immediately; provide wheel cleaning for any truck/car leaving muddy construction site (as the future new landfill or the water treatment plant) and accessing to public road; clean daily road surfaces of debris/spills from construction equipment and vehicles in the vicinity of activities.
- Ensure availability of water spraying facility on site if the works area is not surfaced, or dry and dusty, near sensitive receptors (i.e. residential areas, roadside tea and food stalls, monasteries, schools, hospitals and other sensitive receptors).Spray water on the exposed surfaces to reduce dust emission.
- Impose compliance with speed limits of construction vehicles (generally 30 km/h) to minimize dust emission as well as the risk of traffic accident.
- Provide prior notification to the community on schedule of construction activities which may generate some dust and implement 24 hour community grievance hotline.

5.4.3 IMPACTS FROM NOISE AND VIBRATION

SOURCES OF IMPACTS

Works for the rehabilitation of the water supply network could be the most impacting activity in terms of noise nuisances due to the operation of equipment like backhoes or jackhammers in the immediate vicinity with residences. Along the hauling roads for material and equipment, the average noise level will probably rise because of increased truck traffic.

Table 5-3 provides some typical noise levels measured at various distances from the emission point related to various construction machineries. These values are indicative and already used since several years. More efficient system of noise abatement are available on recent equipment.

Table 5-3: Noise Level of Various Construction Equipment in dBA

Equipment Type	15 m	30 m	50 m	100 m	200 m
Excavator / Backhoe	78	72	67	61	53
Bulldozer	78	72	67	61	53
Jackhammer	89(1)	83	78	72	66
Air compressor	75	69	64	58	52
Vibrator	76	70	65	59	53
Mixer	75	69	64	58	52
Truck	76	70	65	59	53

(1): According to IFC-EHS Guidelines, PPE (ear plugs) must be provided to staff working in noisy environment starting from 80dBA.

At night, construction noise would impose a severe nuisance on the residents in the vicinity, especially those located at less than 50 m from activities. Night working and especially the use of the noisiest equipment during the night should then be strictly prohibited.

The present draft of the National Environmental Quality (Emission) Standards of Myanmar imposes restrictions regarding noise levels which should not exceed the values presented in **Table 5-4**, or result in a maximum increase in background levels of 3 dBA at the nearest receptor location off-site.

Table 5-4: Draft National Standards for Noise Levels

Receptor	One Hour LAeq (dBA)	
	Day time 07:00 – 22:00 (10:00 – 22:00 for Public holidays)	Night time 22:00 – 07:00 (22:00 – 10:00 for Public holidays)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Source: MOECAF, 2014 and IFC EHS, 2007

Mitigation Measures

- Before site works commence, a Noise Control Plan shall be prepared by the Contractor and shall be non-objected by the PMO. The plan shall provide details of mitigation measures, specific location and schedule where such measures shall be implemented to minimize impacts to sensitive receptors (residential areas, schools, hospitals, etc.) due to construction works, sourcing and transport of construction materials, and other project-related activities.
- Restriction of noisy construction activities as well as the transport of materials to day time from7:00 AM (10:00 AM on public holidays) to 10:00 PM, and enforce in residential areas the suspension of the works during night time.
- Reduction of noise level for surrounding population through a set of measures: Selecting equipment with lower sound power levels, installing silencers for fans, installing suitable mufflers on engine exhausts and compressor components, installing acoustic enclosures for equipment casing radiating noise, installing acoustic barriers without gaps and with a continuous minimum surface density

of 10 kg/m2 in order to minimize the transmission of sound through the barrier position any stationary equipment that produce high noise levels (e.g., portable diesel generators, compressors, etc.) as far as is practical from sensitive receptors; whenever possible, completely enclose noisy equipment which can reduce noise level by 15-25 dB(A) and restrict duration of use of noisy equipment (e.g.15 min for every consecutive 30 min period); erect temporary walls around the construction sites, as necessary, especially near sensitive areas such as schools, hospitals, administration buildings, monasteries, etc. All construction equipment and vehicles shall be well maintained, regularly inspected for noise emissions, and shall be fitted with appropriate noise suppression equipment consistent with applicable national regulations;

- Training of truck drivers: minimization of the use of horn, compliance with speed limitation particularly in residential zones.
- Provide prior notification to the community on schedule of noisy construction activities and implement 24 hour community complaint hotline.

5.4.4 OFF SITE PUBLIC SAFETY AND NUISANCES

Source of Impacts

All activities involving work along public roads (as construction of solid waste collection and transfer stations, water supply network rehabilitation or extension) will definitely reduce the accessibility to certain streets, reduce the number of usable lanes and create traffic congestion. The presence of population including children next to construction activities where heavy machinery is operating and with the presence of excavations and construction equipment will create additional risks for public safety.

Also, the working area may temporary alienate access to work sites, schools and community facilities. In addition, retail merchants may suffer economic losses if access is denied to their establishments. The project will be required to take all the necessary measures in order to minimize the detrimental side effects of construction activities particularly regarding traffic and public safety.

Mitigation Measures

The following measures shall be implemented by the contractor to address impacts to traffic flow and access to properties:

- Before site works commence, a Traffic Management Plan for the construction phase shall be prepared by the concerned contractors and shall be approved by the PIC. The plan shall be designed to ensure that traffic congestion due to construction activities and movement of construction vehicles, haulage trucks, and equipment is minimized. The plan shall be prepared in consultation with local traffic police. The plan shall identify traffic diversion and management, define routes for construction traffic from materials storage/parking areas to construction site and from construction site to waste disposal locations, traffic schedules, traffic arrangements showing all detours/lane diversions, modifications to signals at intersections, necessary barricades, warning/advisory signs, road signs, lighting, and other provisions to ensure that adequate and safe access is provided to cars, motorists and pedestrians in the affected areas.
- Provide signs advising road users that construction is in progress and that the road narrows to one lane using cones.

- Employ flag persons to control traffic at sites for safety reasons when construction equipment is entering or leaving the work area.
- Lanes through the work site created by rope or flagging, shall be developed to minimize risks of injuries.
- Post traffic advisory signs (to minimize traffic build-up) in coordination with local authorities
- Provide road signs indicating the lane is closed 200 m before the worksite and signs to indicate the proposed detour road.
- Provide sufficient lighting at night within and in the vicinity of construction sites.
- Regularly monitor traffic conditions along access roads to ensure that project vehicles are not causing congestion.
- As much as possible, schedule delivery of construction materials and equipment as well as transport of spoils during non-peak hours.
- Implement suitable safety measures to minimize risk of adverse interactions between construction works and traffic flows through provision of temporary signals or flag controls, adequate lighting, fencing, signage and road diversions.
- Comply with traffic regulations and avoid, where possible, roads with the highest traffic volumes, high density of sensitive receivers or capacity constraints are not used as access to and from the construction areas and spoils disposal sites.
- Provide induction training on road safety to drivers and ensure they comply with regulations regarding speed and the ban of alcohol when on duty.
- Install temporary accesses to properties affected by disruption to their permanent accesses.
- Reinstate good quality permanent accesses following completion of construction.

5.4.5 IMPACTS FROM WASTE PRODUCTION

Source of Impacts

Quantities of solid waste will be generated by construction activities or by worker camps and canteens. A plan for managing all these types of waste needs to be put in place. There are three categories of waste to consider: domestic waste, inert construction waste and hazardous waste.

The quantity of domestic waste, mainly produced by temporary or permanent camps set up for the needs of the project, can be estimated at 0.5 to 0.7 kg/person/day. This waste mainly includes waste from canteens, packaging, plastic bottles, glass bottles, paper and cardboard. As the project is located in an urban area which may supply most of the manpower required, it is not anticipated large worker camps, but small camps on the sites to ensure a presence 24h and the protection of the equipment. Production of waste should be rather limited nevertheless it is worth being properly managed.

Inert construction waste is generated on the construction sites in variable quantities. It consists mainly of wood, packing boxes, scrap, plastics and concrete debris (the later coming from the few demolition required). This waste is generally disposed of, and landfilled in appropriated sites or in permanent inert materials sites. They represent no direct danger to health. Scrap metal is generally collected for recycling. Wood and cardboard waste if burnt on site will produce fumes and nuisance for the neighbourhood.

Hazardous waste such as vehicle batteries, oil filters, various containers that had held hazardous products (mainly paints, solvents, glue) and other alkaline/lithium ion batteries is generated by construction activities, but in specific places and in limited quantities. This waste is harmful to the environment and public health and must receive appropriate treatment so as to ensure it is eliminated safely. The main risk comes from used engine and hydraulic oil resulting from the maintenance on site of heavy equipment (backhoe, bulldozer, levellers, etc.) and which may be produced in significant quantities. If released on the ground, these hydrocarbons will involve surface and underground water pollution. The present project does not anticipate the maintenance of trucks on site, as the project is developed in an urban area where garage facilities are available for trucks. Hazardous waste also includes sludge from temporary toilets to be installed on construction sites within urbanized areas.

Mitigation Measures

EHS specifications for bidding documents will follow and detail EHS guidelines from IFC (2007). Main measures include the following:

Prior to the start of the works, the contractor shall be requested to prepare a Waste Management Plan addressing the management issues related to all types of waste and providing anticipated production and schedule, collection system proposed, disposal methods and location. The Plan shall reflect the following obligations:

For Non-hazardous Waste

- Provide garbage bins and facilities within the project sites for temporary storage of construction waste and domestic solid waste and ensure that wastes are regularly removed by the concerned department of Mawlamyine Township Development Committee and transferred to the existing landfill until new landfill is operational.
- Promote recycling on site and store material in appropriate storage areas before removal by recycling companies.
- Implement an employee awareness program in waste management and site cleanliness.

For Hazardous Waste

- Any waste engine oil and hydraulic lubricants from heavy machinery and the floating oily residue from oil separators will be collected and stored in tightly sealed containers to avoid contamination of soil and water resources. Transport and off-site storage of such wastes for recycling shall be presented in the Plan.
- Any container of such waste will be stored in a dedicated area with waterproof floor surrounded by a bund the height of which will ensure retention of a volume equal to at least 110% of that of the largest container stored in the area.
- Batteries, vehicle batteries, oil filters from the site will be sorted and deposited in separate containers. The contractor will identify a circuit for elimination/recycling of these products and will submit his choice to the PMO for non-objection.

- Any medical waste (in probably very small quantities) from the First Aid station on site shall be safely stored in a container before being delivered to the landfill area where the content will be burnt as none of the hospital or clinics is equipped with an incineration system.
- Metal or plastic containers that have contained hazardous or toxic chemical substances (mainly hydrocarbons, paints and glue) shall be collected with other hazardous waste for treatment and safe storage prior to recycling in a metal smelter facility).

As no facility does exist in Mawlamyine or even in Myanmar for the treatment and safe disposal of hazardous waste, it is proposed to implement, within the premises of the landfill area a temporary disposal area for hazardous waste, where the contractors will deliver all hazardous waste produced on the construction sites. This disposal area shall be implemented in priority at the start of the landfill construction works in order to service all contractors involved in the project.

5.4.6 HAZARDOUS MATERIAL MANAGEMENT & ACCIDENTAL SPILL

According to the type of construction activities anticipated for the present project components, it is not anticipated any significant storage of fuel on sites, as works are mainly implemented in urbanized areas with gasoline stations available. However, small quantities will probably be stored on site in jerry cans or 200 l drums to refill small equipment (compressor, generator) or heavy machinery (backhoe, bulldozer etc.) with related risks of accidental spillage. To avoid any leakage when refuelling on site, the contractor will be required:

- To store fuel or engine oil (as well as any other hazardous product as paint or solvent) in dedicated storage areas compliant with applicable good practice: storage bottom waterproof surrounded by a bund providing a safe retention capacity in case of accidental spillage or leakage of at least 110% of the largest container stored. The storage area shall be covered to be protected from the rain.
- To set-up a refuelling procedure for mobile equipment involving (1) the use of leakage-collection equipment, (2) a training program for the workers in charge of refuelling, (3) the availability of spill clean-up materials (e.g., absorbent pads, fine sand, etc.) specifically designed for petroleum products, and (4) the availability of an extinguisher.
- To train relevant construction personnel in handling of fuels and spill control procedures.

5.4.7 IMPACTS ON WATER RESOURCES QUALITY AND USE

Source of Impacts

There is no project component anticipated along the Thanlwin or the Attran rivers so no particular impact is expected on river water quality. The project anticipates developing a water treatment plant (WTP) next to the existing KhinPonChong reservoir from which the water will be pumped. A water intake shall be developed on the reservoir to supply the WTP and to replace the existing intake. The intake shall be a floating structure, so excluding heavy earthworks within the reservoir boundary. However it may involve some activities on the reservoir shoreline, with potential water pollution risks. The risk of accidental spill of chemical (diesel, oil, paint) as well as the increased turbidity of the water during works in the water or just nearby could happen if no preventive measure is implemented by the contractor.

- Release of suspended sediments during limited excavation works required for the lying of the pipes between intake and WTP on the shoreline of the reservoir;
- Chemical contamination by leakages of engine oil, hydraulic fluids or fuel from the machinery during works;
- Biological contamination from the workers;
- Release of solid waste from the workers.

Works for rehabilitation of the existing water supply network, particularly the change of the main pipes, may alter the quality of the water distributed by increasing temporarily sediment load or by creating contamination sources.

Mitigation Measures

The contractor shall be required the following prevention measures for works carried out adjacent to river body:

- Ensure equipment used for works is free of leaks and excess oil or grease
- Storage of fuel and chemicals and equipment refuelling operations shall be organized at least 50 m away from the water body on an efficient retention storage facility;
- The contractor shall submit an emergency plan in case of accidental spillage of hazardous product into the reservoir, describing the measures it intends to take in case of such event.
- Carry out the earthworks during dry season to avoid sediment run-off to the KhinPonChong water body;
- Minimize disturbance of vegetation on surrounding areas. Cut brush off to ground height where needed but without disturbing the roots, to allow vegetation regrowth from root stocks and reduce risk of erosion and sediment transfer to the reservoir.
- When muddy water is pumped from excavation works related to the construction of the WTP foundations, it shall be transferred into a sediment trap or pond to collect as much as possible sediment before discharging returning water in natural drains or in the reservoir. Even better, discharge water into vegetated area for eventual infiltration into the ground;
- Equipment shall be washed in a dedicated area located at least 30 m from the water body and the resulting wastewater (including grease, oil or cement) collected in a sediment pond.

For rehabilitation works on the main water supply network system, methods shall be selected to avoid risks of contamination of water supplied. Prevention of earth and wastewater or any contaminated water or chemicals from entering the distribution system shall be implemented. Training of workers shall be required to ensure the respect of the specific measures to be developed.

5.4.8 IMPACTS ON CULTURAL HERITAGE RESOURCES

Source of Impacts

Several monasteries and pagodas are distributed all over the city. Also, several buildings dating from the British period provide Mawlamyine with a distinct character from other cities. Setting up a financing system to promote their rehabilitation by their respective owners and the rehabilitation of the Township Administrative Office Building are proposed as a component of the present project. None of the religious or cultural heritage buildings identified shall be affected by the construction works related to water supply or solid waste management components.

However, even if no valuable physical cultural resource has been identified from the project sites, impacts on archaeological relicts may still happen, particularly during earthwork excavation in the streets for the rehabilitation of the water supply network.

Mitigation Measures

The following measures shall be implemented by the Contractor:

- For any works carried in streets following religious and cultural heritage buildings, a protection of the surrounding walls shall be put in place in the areas the closest to the works. The protection shall consist of a mobile fence to ensure at least 1m safety distance between works and the preserved structure. This safety distance shall also be used for the passage of pedestrians.
- No activity generating vibrations shall be authorised next to a cultural heritage building to avoid any risk of degradation. Appropriate equipment and methods shall be implemented in such places.
- Any time, to dispose earth, materials, pipes, equipment etc. directly against a heritage structure (or its surrounding wall) shall be strictly forbidden.
- The owner of the building or the monk community and the government heritage staff concerned shall be informed of the measures imposed to the contractor and will ensure these are enforced 24/7 during the works. In case of breach with these obligations, the PMO shall be contacted for immediate corrective measure.

The contractor shall implement a "chance to find" procedure throughout the construction works to account for any undiscovered items identified during construction/excavation works. The procedure shall include the followings:

- Workers will be trained in the location of heritage zones within the construction area and in the identification of potential items of heritage significance. This training shall be provided by an experienced professional in cultural heritage;
- Should any potential item be located, the site supervisor will be immediately contacted and work will be temporarily stopped in that site.
- If the site supervisor determines that the item is of potential significance, a representative from the Department of Archaeology and National Museum (DANM, Ministry of Culture) or from the Mawlamyine University shall be invited to inspect the site and work will be stopped until he has responded to this invitation.
- Work will not resume in this location until agreement has been reached between Mon State Government and DANM of Mawlamyine as to any required mitigation measures, which may include excavation and recovery of the item.

- A precautionary approach shall be adopted in the application of this procedure.

5.4.9 HEALTH AND SAFETY OF WORKERS

Source of Impacts

The project will concentrate a number of workers, mostly recruited from Mawlamyine. Inappropriate accommodation or food quality may result in communicable diseases and outbreak of water, hygiene and mosquito related infections. Inappropriate safety conditions on construction sites may lead to accidents, muscular diseases and eventually fatalities. Issue of occupational health and safety (OHS) is a major one in Myanmar, where these aspects are hardly considered on most construction sites observed. It may also represent a risk for the surrounding community if construction sites are not sufficiently fenced.

Mitigation Measures

To ensure appropriate health and safety conditions for the workers, and in compliance with the requirements of the ADB or any other international lending Agency, a Health and Safety Management Plan shall be prepared by the concerned contractors and shall be non objected by the PMO. The Plan shall be designed to ensure that Burmese labour regulations and international good practices (ILO, IFC ESHS Guidelines) related to health and safety are complied with and measures efficiently implemented on site. This Plan shall also be considered as a pilot experience for the Mawlamyine municipality to be systematically replicated for further construction projects.

The OHS Plan will address the following obligations:

- To identify health and safety hazards associated with construction activities (e.g., working at heights, work in confined space, permits to work, excavations and trenching, etc.), establishment and operation of construction/worker's camps, use of heavy equipment, transport and handling of materials and hazardous products (fuel);
- To propose for each potential risk appropriate and realistic prevention measures;
- To appoint an Environment, Health and Safety (EHS) Coordinator to look after implementation of required EHS measures, and to ensure the safety of the public in the vicinity of construction areas;
- To conduct awareness training for construction workers regarding occupational health and safety measures, hygiene, emergency response in case of accidents, fire, etc., and prevention of water related diseases;
- To provide first aid facilities in all working sites, particularly in those located outside the urban area: first aid kits in sufficient numbers with content complying with OSHA standard No. 1910.266 App.A, first aid officer present any time on site during working hours (at least 1 first aid officer per shift of 10-50 workers), first aid officer and stations clearly identifiable on sites;
- To provide fire-fighting equipment (extinguishers) on the work sites;
- To provide adequate accommodation for all workers living in a worker camp including building of acceptable quality, room size, sleeping equipment (bed, mattress, sets of bed sheets and blanket, mosquito net, storage area, light etc. ESHS specifications for bidding documents will elaborate in detail on all these

requirements. It is anticipated that the worker camps will accommodate only a limited number of workers as most of them should be resident in Mawlamyine and should not require accommodation in camps;

- To provide reliable supply of potable water on work sites and in camps controlled at least on a weekly basis for residual chlorine and coliforms;
- To provide separate hygienic sanitation facilities/toilets and bathing areas with sufficient water supply for male and female workers.
- To establish clean canteen/rest area.
- To ensure proper collection and disposal of solid wastes produced within the construction and camp sites.
- To provide solid fencing on all areas of excavation greater than 1 m deep. For all worksite areas without excavation, provides movable barriers to prevent accident with surrounding residents.
- To provide personnel protection equipment (PPE) appropriate to the job: at least helmets and safety boots to all workers, and depending on job safety risk, to provide also gloves, protective clothes, goggles and ear protection and ensure the equipment is effectively and adequately used.
- To ensure reversing signals are installed on all construction vehicles.
- To implement fall prevention and protection measures whenever a worker is exposed to the hazard of falling more than two meters, of falling into operating machinery or of falling through an opening in a work surface. Based on a case-specific basis, fall prevention/protection measures may include installation of guardrails with mid-rails and toe boards at the edge of any fall hazard area, proper use of ladders and scaffolds by trained employees, use of fall prevention devices, including safety belt and lanyard travel limiting devices to prevent access to fall hazard, fall protection devices such as full body harnesses, etc.
- To secure all construction sites inside urban areas from entering for the surrounding population and particularly children.

5.4.10 SUMMARY OF IMPACTS AND MITIGATION MEASURES

The table below summarizes the impacts identified and the corrective measures proposed for the Third GMS Project Components during the construction period. For the meaning given to the evaluation of the impact, see Section 5.1: Methodology for Impact Assessment.

Table 5-5: Potential Impacts and Mitigation Measures related to Project Construction

Component or activity	Potential risks	Description of Potential Impact	Impact assessment: Probability	Gravity	Overall Risk	Corrective or support measure: Description of Measure	Easiness of Implementation	Overall Risk after Correction
Land preparation	Excessive destruction of trees	Limited impact for the whole project. Construction of the WTP and the linked storage involves only 4.4 ha (1.1 acres) of open scrubland type vegetation. Water supply network component may only impose occasionally tree cutting in the streets for pipe laying. About 19.4 ha of open scrubland located around the existing landfill shall be used for the new landfill facility. Secondary vegetation only with mainly small trees.	3	1	1	Monitoring of tree cutting by PIC, and maximization of conservation	1	1
			3	1	1	Mitigation greening program considering at least 2 trees planted for 1 mature tree cut. Consider plantation of a greenbelt around the landfill, at least 10 m width using fast growing trees as Eucalyptus or any other native fast growing species, to create a buffer zone with surrounding development areas.	1	1
	Destruction of protected tree species	Based on literature and direct observation, none of the species identified in Mawlamyine has a status of protected species (national or international)	1	2	1	Vigilance of the PIC during land preparation activities	1	1
	Interference with compensation & resettlement	Construction works start while land acquisition is not completed, raising conflicts with concerned owners.	1	3	2	Procedure with issuance of a land access certificate by PMO as a prerequisite for authorizing contractor to access the land.	2	1
						Monitoring by PIC of compensation progress and of issuance certificate	1	1
Workers' camps	Pollution of surface water and groundwater	Wastewater discharged into the environment	3	2	2	Wastewater receives treatment before being released outside premises in compliance with MONREC domestic effluent standards	2	1
						Contractor to monitor the quality of effluents released outside the bounds of the camps	2	1

Component or activity	Potential risks	Description of Potential Impact	Impact assessment: Probability	Impact assessment: Gravity	Impact assessment: Overall Risk	Corrective or support measure: Description of Measure	Easiness of Implementation	Overall Risk after Correction
	Zones of stagnant water	Proliferation of water-borne disease vectors (mainly dengue fever and malaria, highly prevalent in Mawlamyine)	2	3	2	Create and maintain ditches to ensure efficient drainage and drain all stagnant water zones in camp	2	1
						Regular treatment of living areas with pesticide in compliance with authorised pesticides in Myanmar and EHS IFC guidelines	2	1
	Health risks	Development of diseases among workers because insufficient hygiene in camps and construction sites	2	2	2	Systematic awareness sessions for all new arrivals at the camp: meetings, posters in circulation areas, monitored by the camp chief	1	1
		Risk of epidemics in the camps	2	2	2	Prevention by automatic medical check-up at hiring	1	1
						Monitoring of hygiene conditions at the camps	2	1
						Anti-malarial prophylaxis, including mosquito netting	1	1
	Workers' living conditions	The most serious impact would be the contractor not providing acceptable housing and subsistence for workers.	2	3	3	Include detailed specifications on camp equipment and management in the tender documents. Enforce contractor obligations on site by regular site inspections (PIC)	1	1
	Non-potable water supplied to workers.	Impact on public health, risk of epidemic. Main risk at the WTP site and landfill site where worker camps may be installed. Other project components located within urban areas, where camp facilities may not be required. However, water supplied on construction sites may also be of bad quality with impacts on worker's health	1	3	2	Tender documents to define obligations of contractors regarding supply of potable water in camps and on construction sites.	1	1
						Contractor and PMO to regularly monitor coliforms or residual chlorine (if not industrial drinking water bottles supplied) by reference to MONREC/WHO standards	2	1
Workshops and garages	Water and soil pollution	Such facilities should not be required in the urban area. One workshop may be installed near the landfill component considering extent of civil works. Storm water drainage contaminated by pollutants (mainly oil & grease)	3	2	2	Drains of workshops and garages equipped with oil separators	2	1
						Properly store hazardous products (including hydrocarbons). See activity "Use and storage of hazardous products"	1	1
						PMO to monitor and control used oil: Monitoring registers/logs and dedicated storage areas.	1	1

Component or activity	Potential risks	Description of Potential Impact	Impact assessment: Probability	Impact assessment: Gravity	Impact assessment: Overall Risk	Corrective or support measure: Description of Measure	Easiness of Implementation	Overall Risk after Correction
Excavations in urban area	Loss of cultural resources	Possible archaeological physical resource discovery during excavation work with the total loss of the relic if special measures are not taken.	1	2	2	Put in place a "Chance to Find" procedure aimed at halting work and warning the supervisors and the national authorities concerned for conservation measures to be taken to preserve the discovery and restart work as quickly as possible. Ensure personnel are aware of the procedure.	1	1
Hazardous waste management	Water and soil pollution	Located in urban area, most truck maintenance will be done in private garages. Only heavy machinery will receive basic maintenance and refuelling on site. Limited volumes of used engine oil and used hydraulic oil will be produced on site and will need appropriate storage to avoid soil and water pollution	3	2	2	Require the contractor to prepare a hazardous waste management plan explaining where and how he will manage used oils	1	1
						Use storage sites that meet safety standards (with retention)	2	1
						Identify the existing used oil recycling facilities in Mawlamyine (none identified so far except re-use as paint for wood houses)	1	1
						Contractor to maintain a log of production/recycling of used oil	1	1
Production of non-hazardous solid waste	Water and soil pollution	By domestic waste: Possible impact if the waste is not managed in line with best practices in the worker camps and construction sites.	3	2	2	Contractor to submit a Solid Waste Management Plan including methods and procedures for (i) Awareness training of workers, (ii) collection and storage of waste on project sites, (iii) selective collection and recycling of waste (iv) eventual collection and disposal of waste, (v) coordination with MTDC/Mawlamyine Township Development Affairs Committee/ Mawlamyine Cleansing Department	1	1
		By construction waste: Limited risk for inert products which may be associated to the fill for other project components	2	1	2	Ensure recycling of metals, plastics and glass	2	1
Concrete production	Water pollution	Typical impact is water pollution by the alkaline wastewater from equipment and concrete trucks cleaning. This may concern the WTP and the intake at KhinPonChong reservoir	2	2	2	Install a sedimentation pond with pH buffering before release of water in the natural drainage system	2	1
						Contractor (and PIC) to monitor the quality (SS, pH) of effluent released	1	1

Component or activity	Potential risks	Description of Potential Impact	Impact assessment: Probability	Impact assessment: Gravity	Impact assessment: Overall Risk	Corrective or support measure: Description of Measure	Easiness of Implementation	Overall Risk after Correction
Spoil Disposal	Excessive use of productive land to dispose the spoil	Sediment dredging is anticipated from KhinPonChong reservoir.	3	1	1	Contractor shall identify surrounding development projects involving land reclamation in low lying areas which could benefit the availability of spoil.	-	-
		Spoil from landfill construction to be disposed over productive land	2	2	2	Spoil could be stored on the landfill area for use as cover soil for waste during landfill operation	1	1
Road Traffic	Public safety	Risk of road accidents related to truck traffic increase in urban zones for the transport of equipment and materials. Limited increase is anticipated as works will require limited quantities of materials/equipment (	2	3	2	Selected hauling routes and preventive/monitoring measures to be presented by the contractor in the Road Traffic and Access Plan	1	1
						Monitoring of driver behaviours in relation with Police Department	1	1
	Risk of traffic disruption in urban zones	Most sensitive areas in small streets concerned by rehabilitation of water supply network.	3	2	3	Road Traffic and Access Management Plan to be prepared by contractor shall detail procedures for traffic management: coordination with police, public information, signs and safety etc.	2	1
	Air pollution	Excessive exhaust gas emissions	3	2	2	Keep engines serviced	2	1
		Production of dust	3	2	2	Speed control, regular sprinkling of sensitive urban areas and on construction sites, cleaning of truck wheels when exiting muddy sites	2	1
Handling of hazardous products	Fire risk	Related to the storage of flammable products: hydrocarbons, paints, solvents. Potential risk on most sites involving heavy machinery	1	3	2	Provide fire equipment (extinguishers, fine sand) and safety posters displayed at each site.	1	1
						Set up a safety procedure and awareness/training for personnel concerned.	1	1
	Risk of accidents to personnel	Skin burning during handling operations, but risks quite limited for such type of project (few hazardous products required)	1	3	2	Provide training for personnel plus personal protective equipment and onsite safety data sheets for the products concerned	1	1

Component or activity	Potential risks	Description of Potential Impact	Impact assessment: Probability	Impact assessment: Gravity	Impact assessment: Overall Risk	Corrective or support measure: Description of Measure	Easiness of Implementation	Overall Risk after Correction
	Water pollution	Potential risk of accidental spillage: Leak in a storage tank, accidental spillage when handling or refuelling engines, road accident when transporting hydrocarbons.	2	3	2	Contractor to prepare hazardous products management plan, in particular: Store using containment trays, measures for preventing and detecting leaks and accidental spills, register/log of hazardous products and their use, antipollution equipment.	2	1
						Emergency response procedure in the case of accidental spillage	2	1
						Special safety procedures for refuelling engines	1	1
All Components and Activities	Occupational Accident of workers	As observed on on-going construction sites in Mawlamyine, occupational safety of workers is almost inexistent, with high risks of injuries and accidents during construction activities	3	3	3	Contractor to prepare and enforce a Health and Safety Plan to describe organisation, prevention and measures in case of accident. Particular attention dedicated to measures in urban areas (rehabilitation/extension of water supply network)	2	1
						Obligation of Personal Protective Equipment (PPE) for all workers on project sites, minimum being helmet and safety shoes	2	1
						Main contractors to designate a HSE Coordinator to ensure safety measures are enforced on sites	2	1
						Regular construction site inspections of PIC	1	1

5.5 Impacts during Operation stage

5.5.1 IMPACTS ON/FROM FLOODING

None of the components of the Project in Mawlamyine is implemented in a floodable area (even considering the long term situation with sea level rise because of climate change) or may generate flooding because of its location or its operation. The improvement of solid waste collection will have direct beneficial impacts on urban drainage which is presently severely clogged by dumped waste, resulting in localised flooding during heavy rainfall events.

DRAINAGE CLOGGED BY DOMESTIC WASTE…

…AND BY UNCONTROLLED WATER SUPPLY PIPES

5.5.2 IMPACTS ON UNDERGROUND WATER RESOURCES

The water supply component of the project relies on surface water sources and does not exploit underground resources. As such, no impact related to overexploitation of underground resources is anticipated from the Project. In the long term, the Project may have indirect beneficial impacts on the underground water resources:

- The water supply component will significantly increase the water supply of the population both in terms of duration of service, volumes and quality of water. Considering that presently people rely partly on low quality underground water (from shallow wells) and on septic tanks for their sanitation, the project will increase the volume of water released to the soil by septic tanks and eventually reduce the dependency on shallow wells, thus improving aquifer recharge;
- The solid waste component will drastically increase the quantity of waste collected (from 24 500 t/year in 2015 to 65 900 t/year in 2040) and safely disposed in a controlled landfill. At landfill site, leachates will be collected and treated. This component will definitely reduce the pollution load from solid waste which presently percolate into the soil and affects the underground water quality.

However, if leachates from waste piles is not appropriately collected and treated before being released in the environment it may have significant impacts on underground water quality with health threats for the surrounding population relying on shallow wells.

The project design as presented in the Project description Section of this report fully considers this risk and provide for a full collect, treatment and disposal process for the leachate:

- The landfill cell bottom and side slopes will be fully covered by an impervious liner made of high density polyethylene (HDPE) minimum 1.5 mm thick with sheets welted together by a specialized company;
- A drainage system will cover the bottom of the cell including layers of gravels of various grain size with a network of drainage pipes to collect the leachate;
- The leachate will be transferred into an on-site treatment process including physical treatment (sedimentation, settling pond) and biological treatment (oxidation pond);
- Environmental monitoring includes 6 groundwater monitoring wells, 1 well up-gradient of the groundwater flow and 5 wells along the sides in down gradient direction, all wells 30 m away from landfill;

The organic load of the leachate shall be reduced as a part of the biodegradable waste will be diverted to the composting plant to be developed on the landfill site. The composting plant will have a design capacity of 65 t/day, for the treatment of 25% of the generated waste till 2025. In a second stage, the target is to compost 40% of the generated waste with a capacity of 120 t/day. Composting pad, maturing pad and storage pad will be covered, reducing the volume of leachate produced. Leachate produced by the composting plant will be drained and transferred to the leachate treatment facility.

Compost production is intended to be used for agriculture or green urban areas. To maximize the usability of end products (compost), waste should not be accepted that contains organics that are contaminated by potentially hazardous chemicals (e.g., PCBs, chlordane and other pesticides, heavy metals and metalloids) and/or pathogenic substances and micro-organisms (e.g., prions, viruses, bacteria, and parasites) that will not be rendered harmless by the process or may constitute a health or environmental risk. This may include certain clinical waste and other related wastes of clinical origin, and diseased carcasses, or contaminants classified as hazardous or industrial wastes.

5.5.3 IMPACTS ON SURFACE WATER QUALITY

The solid waste component of the Project will have major impact on surface water which is, presently the main receiving body for most of the solid waste generated by Mawlamyine. At the existing dumping site, leachates are presently released into surface water without any treatment. The drastic improvement of solid waste collection and disposal will definitely reduce the pollution load to the drains and eventually to the Thanlwin River.

Waste will be weighted at entrance on the landfill site, then discharged on a platform for sorting and segregating the waste: organic waste to be directed to the compost plant, recyclable waste, hazardous waste (including infectious waste from hospital and clinics) and other dangerous items (gas containers, explosive products, etc.).

Water treatment plant will generate sludge from the treatment process, with potential but very limited risk of pollution of water resources. The volume produced will be limited as the KhinPonChong reservoir presents a low TSS during rainy season of about 60 mg/l, probably not exceeding 30 mg/l during dry season. For a production of 8 000 m^3/day, the maximum sludge production represents only about 500 kg dry matter per day or less than 0.4 m^3/day, a volume which can be easily stored temporary on site before regular delivery to the landfill, where it can be used as daily soil cover. This value shall probably be divided by at least 2 during dry season. This sludge will consist mainly of mineral material, and shall not represent any risk of toxicity as no industry or urbanised area discharge into the catchment of the KhinPonChong reservoir and also because the low SS load shall not require any flocculation stage in the process.

Treatment of water at WTP level will rely on liquid chlorine. Liquid chlorine may involve a risk of accidental spill. This risk shall be mitigated by a dedicated storage area with an active retention capacity of at least 110% of the largest container capacity stored on site. Dedicated safety training shall be organised for the workers in charge. No residents in the immediate vicinity of the plant.

Measures for the protection of the resource shall also be implemented. The catchment of KhinPonChong reservoir is of small size and not populated. Only few tree plantations are observed. No industry is located in the catchment. It is required to ensure this situation will be preserved in the future.

- Ensure that treatment capacity is adequate to meet anticipated demand;
- Construct, operate and maintain the water treatment facility in accordance with national requirements and internationally accepted standards26 to meet national water quality standards or, in their absence, WHO Guidelines for Drinking Water Quality ;27
- Evaluate the vulnerability of the treatment system and implement appropriate security measures, such as:
- Background checks of employees
- Perimeter fencing and video surveillance
- Improve the electrical power feeds to the facilities
- Redundant electrical power systems significantly reduce the vulnerability risk to essential operations.

5.5.4 IMPACTS ON URBAN ENVIRONMENT AND QUALITY OF LIFE

The Project components will eventually contribute to a healthier and cleaner urban environment. Improvement of water supply capacity, rehabilitation/extension of networks and supply of treated water will reduce the population dependency to private or public shallow wells, most being significantly contaminated, and reduce population expenses related to the purchase of drinking water bottles. Improved collection of waste will contribute to reduce the risk for waterborne diseases among the population and will contribute to improve public health conditions of diseases transmitted through insects or rodents. Improvement of waste collection shall drastically improve the cleanliness of the city.

5.5.5 IMPACTS ON GHG EMISSIONS

METHODOLOGY

Green House Gas (GHG) will be produced during construction and operation of the project components, water supply and solid waste management improvement. GHG production shall be limited during construction for both components, mainly related to exhaust fumes from trucks and other thermal machinery relying on diesel. During operation, the water supply component shall also release some quantities of GHG, mainly related to the use of electricity for pumps and treatment plant operation and to the transport of residual treatment sludge to the landfill. The amount released by such activities will be very limited.

However, GHG emissions from conventional solid waste management in Asian countries are considered to contribute significantly to global climate change: methane (CH_4) emission from open dumping and landfilling is considered the third highest anthropogenic methane emission source (IPCC, 2006). These two processes are currently the most common waste treatment methods in Asian countries. In addition, GHG emissions (e.g. CO_2, N_2O) from waste handling, transportation and operation of machinery contribute also in GHG emission, but at a much modest level. Depending the treatment processes considered, there is a possibility for important indirect GHG savings through materials and energy recovery from waste management which may even result in global GHG emission avoidance.

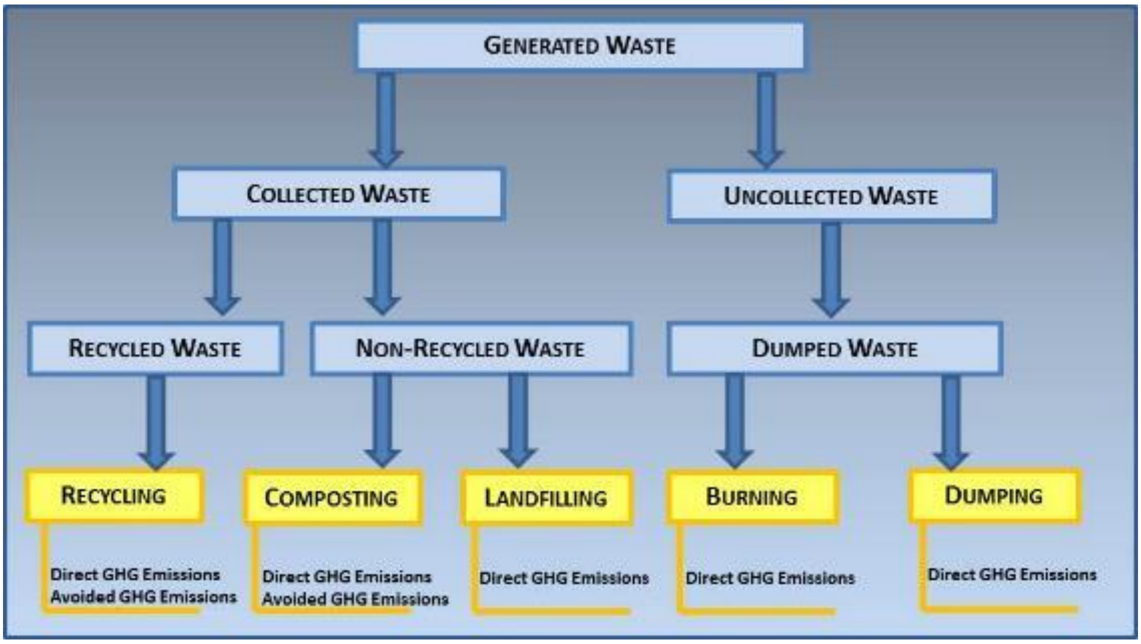
Thus, this section focusses mainly on GHG emissions from waste management components, as they shall provide most of the future emissions from Project components.

Simulations carried out by the PPTA Consultant to quantify GHG emissions from various waste management technologies rely on the IPCC 2006 guidelines from which the Institute for Global Environmental Strategies (IGES) simulation model was developed. The simulation calculates both the total GHG emissions and total GHG avoidance potentials of individual technologies. Based on the total GHG emissions and avoidance values, net GHG emissions are calculated from all the individual technologies considered in the Project.

The net GHG emission value reflects the overall climate impact/benefit of a particular technology taking into account the impact of all the possible resource and material recovery from the waste.

The simulation performed relies on the type of waste distribution in the municipal solid waste (MSW) and on the eventual treatment or disposal of the waste. The general waste processing organisation considered for simulations is presented in **Figure 5-1**.

Figure 5-1: Organization of GHG Simulations for MSW



Source: PPTA Consultant, 2015

In addition to these various processes for which GHG emissions and/or savings are estimated, an additional estimate is performed for waste collection and transport, mainly represented by the combustion of fossil fuel (diesel).

The main assumptions used for the estimate of waste types and quantities are those established by the PPTA Consultant in charge the waste management component and presented in the related Feasibility Study report. Assumptions regarding GHG production per unit of fossil fuel consumption and per unit of specific waste are those recommended by IPCC (2006) for the estimate of national GHG emissions. Decay equations are those recommended by IPCC (2006) and presented by the Institute for Global Environmental Strategies (IGES) from Japan in their Estimation Tool for Greenhouse Gas Emissions from Municipal Solid Waste Management in a Life Cycle perspective[5].

Table 5-6: Main Sources and Values of References

Topic	Source or Values of Reference
Waste Collection and Transportation	Diesel consumption estimated in FSR Diesel Energy content: 36,42 MJ/l diesel Diesel GHG emission factor: 0,074 kg CO_2/MJ Uncollected waste is 53,17% of generated waste in 2015, 10% in 2020, 2% in 2040

[5]Tool developed by Nirmala Menikpura and Janya Sang-Arun under project « Measurement, Reporting and Verification for Low Carbon development in Asia » (2013)

Recycling	GHG emission based on recycling emissions from fossil fuel and electricity consumption from Thailand; Avoided emissions also based on energy required from related material production in Thailand (paper, aluminium, plastic, glass, metal) Recycling is 16% of generated waste in 2015 and 20% from 2020
Managed Landfill	Landfill gas: 60% methane and 40% CO_2 Equations regarding decay according to IPCC 2006 Waste Model Model considers emission without/with gas collection & flaring Waste disposed to landfill is equal to collected waste minus recycled and minus composted fractions
Composting	IPCC default emission factors: 4kg $CH_4$and 0,3 kg N_2O/ton organic waste (wet basis) Electricity: basis is Thailand grid emissions of 566 kg CO_2eq/MWh Composted waste is 25% of generated waste in 2020 and 40% from 2025. 90% of the compost produced is re-used for agriculture or urban gardening as fertilizer substitute
Dumping	Similar to managed landfill but it considers more shallow deposits (<5m) and no collection of landfill gas. Fraction dumped in various locations of the city equivalent to uncollected waste, with 70% decaying as in shallow landfill (<5m)
Burning	Model considers only emission of CO2 Quantity burnt is estimated as 30% of uncollected waste.

RESULTS

Results from the assessment are provided for Mawlamyine for years 2015, 2020 and 2040 in **Table 5-7**.

Table 5-7: GHG Emissions from MSW for Mawlamyine

GHG Emissions (in tons CO_2-eq/year)		2015	2020	2040
Emissions from Collection & Transportation of waste				
	Direct Emissions from fossil fuel consumption	48	98	157
	Net GHG Impact/Benefit	48	98	157
Emissions from Recycling of waste				
	Direct Emissions from recycling	11501	23904	51641
	Avoided emissions from material production	-21290	-44251	-95598
	Net GHG Impact/Benefit	-9790	-20347	-43957
Emissions from Composting of waste				
	Direct Emissions from Plant Operation	N.A.	78	155
	Direct Emissions from waste degradation	N.A.	3424	11836
	Avoided emissions from fertilizer production	N.A.	-12323	-63781
	Avoided emissions from organic waste landfilling	N.A.	-8997	-66085
	Net GHG Impact/Benefit	N.A.	-17818	-117876
Emissions from Landfilling of waste				
	Emissions of Methane Gas	763	1126	1761
	Emissions of Methane with gas flaring	N.A.	225	352
	Direct GHG emissions without gas flaring	16024	23693	37060
	Direct GHG emissions with gas flaring	N.A.	4731	7473
	Net GHG Impact or Benefit (with flaring)	N.A.	4731	7473
	Net Total GHG Emissions from Collected waste	6283	-33336	-154202
Emissions from Uncollected Waste				
	Emissions from uncontrolled dumping	8672	2613	1230

GHG EMISSIONS (IN TONS CO_2-EQ/YEAR)		2015	2020	2040
	Emissions from waste burning	1895	148	13
	Net GHG Impact or Benefit	10567	2762	1242
	Net GHG Emissions from Generated Waste	16 850	-30 574	-152 960

Source: PPTA Consultant

At present, the highest contribution to GHG is coming from collected waste dumped in Mawlamyine landfill (16 000 t CO_2eq/year). Fortunately, this figure is buffered by the avoided emissions from the recycled waste, almost 10 000 t CO_2eq/year. Uncollected waste GHG emission is in a similar range with about 10 000 t CO_2eq/year. The annual balance is a net emission of 16 850 t CO_2eq/year.

With the project components, which intend to strongly reinforce waste collection, promote recycling and composting and develop a sanitary landfill with gas collection and flaring, the yearly balance shall be strongly beneficial, **with a GHG net benefit of about 30 000 t CO_2eq/year in 2020 and 153 000 t CO_2eq/year in 2040**. This beneficial situation results from major emissions avoidance related to recycling and mainly to composting. **Flaring of landfill gas (60% methane) provides also a major reduction of GHG emissions from the managed landfill with 80% abatement.**

In a project duration perspective, the benefits of the proposed Project regarding GHG emission/avoidance are considerable. Cumulated emissions and avoidances from MSW in Mawlamyine are presented inSection 6.

5.5.6 IMPACTS ON AIR QUALITY AND NOISE

The project shall have beneficial impacts on Mawlamyine air quality. Indeed, the large volume of rotting organic solid waste dumped in any possible place around the urban area contributes to release unpleasant gas. The several collection points with only degraded containers (or without container) are also places generating smell nuisances to the surrounding population. The several points in the city, where such dumped waste is burnt, release smoke and unpleasant smells. The solid waste component will improve this situation: improving the waste collection will reduce the volume of waste dumped into the drains and open spaces of the city where it either rot or is burnt. The new transfer points proposed will be equipped and managed to reduce gas emission: shorter transit time for the waste, closed containers, closed trucks.

However, handling of solid waste during the collection and disposal process may generate nuisance dust but also bioaerosols (i.e., particles in the air consisting wholly or partially of microorganisms). Bioaerosols are of particular concern to the health of waste workers and have been shown to be the source of reduced pulmonary function and increased respiratory disease for those in immediate proximity to waste sweeping and collection activities. Recommended management strategies to minimize dust, bio-aerosols, and odours include:

- Establishing frequent waste collection schedules;
- Instituting a washing program for waste collection vehicles and for company-owned waste collection and transfer containers;

- Promoting the use of bags to reduce the odours from soiling of waste collection and transport equipment.
- Cover collection and transfer vehicles along the entire route of transport to avoid windblown litter;
- Clean vehicles used for waste hauling before transportation of any goods, including compost;
- Encourage residents to put waste out at designated times and locations;
- Where possible, blocking off access to dumping sites and fining illegal dumpers.

Specific measures to prevent, minimize and control vehicle air emissions during waste collection and transport include the following:

Optimize waste collection routes to minimize distance travelled and overall fuel use and emissions

Waste collection and transport vehicle owners and operators should implement the equipment manufacturers' recommended engine maintenance, along with the mechanical maintenance for the safe operation of the vehicle, including proper tire pressure.;

Drivers should also be instructed on the benefits of driving practices which reduce both the risk of accidents and fuel consumption, including measured acceleration and driving within safe speed limits (working with garbage truck drivers can save as much as 25% on fuel use and reduce maintenance by 15%).

Additional fleet management recommendations are presented in the General EHS Guidelines.

The following measures are recommended to prevent, minimize, and control vehicle emissions and emissions of dust, odours, and bioaerosols during waste receipt, unloading, processing, and storage:

- Select vehicles and containers that minimize air emissions during waste loading and unloading;
- Design drop-off points to minimize queuing of vehicles;
- Sweep waste management areas and roads frequently and use water spray for dust control where needed;
- Pre-treat wastes as needed (e.g., solidification, encapsulation, or wetting sufficient to reduce dust but without forming leachate);
- Use enclosed waste handling and storage areas for malodorous wastes or wastes that generate hazardous dust (e.g., asbestos). Enclosed waste storage and handling areas are preferred for all wastes;
- Use extraction system to remove dust from working areas, buildings, and storage vessels, and treat as needed to control particulate emissions (e.g., bag filter);
- Remove, treat, or dispose of all biological/malodorous wastes in an expeditious manner;
- Use odour-neutralizing sprays where necessary;

- Use negative pressure in processing buildings and appropriate air filtration (e.g., bio filter) to remove odour

In addition, annual medical check-up shall be organized for all waste workers involved in waste collection and in activities on the landfill.Principal sources of noise and vibration include truck traffic, loading equipment (e.g., cranes, wheeled loaders), stationary compactors, balers, grinders, and other treatment and conveyance systems.

Recommended noise management strategies include:

- Construct a buffer zone between the facility and the external environment or locate facilities away from sensitive receptors;
- Include noise and vibration considerations during design, including use of models to predict noise levels at specified noise-sensitive locations, using standardized sound power levels for construction plant;
- Maintain site roads in good condition to reduce noise and vibration from vehicle movements;
- Use acoustic screens around fixed/mobile plant and equipment;
- Select equipment that has low noise emission levels;
- Fit silencing equipment to plant, e.g. baffles/mufflers;
- Use buildings to contain inherently noisy fixed plant equipment (e.g., locate waste shredder in the tipping hall, and enclose tipping hall on all sides) and consider use of sound-insulating materials in construction.

Noise shall not be an issue when compared to the present situation. For waste, only the noise related to the carts and trucks transporting waste is expected. For the water supply component, no noise nuisance is expected as the distribution of water is by gravity and does not include the construction of any pumping station within the urbanized area. Both facilities (WTP and landfill) are located reasonably far from residential area (300 to 500m) and shall not create any noise disturbance at night.

5.5.7 SUMMARY OF IMPACTS AND MITIGATION MEASURES

Table 5-8 summarizes the potential operation impacts of the project components in Mawlamyine with proposed corrective measures.

Table 5-8: Summary of Impacts and Mitigation measures during Operation Phase

Component or activity	Potential Effect	Potential impact: Description of impact	Impact assessment: Probability	Gravity	Overall Risk	Corrective or support measure: Description of measure	Easiness of implementation	Overall risk after correction
Improved Water Supply Systems								
Construction of a WTP with disinfection stage	Quality of life and public health	Improved water supply security in Mawlamyine and improved public health	-	-	-	-	-	-
		Benefits from disinfection may be erased if disinfection not permanent or not strong enough to reach far points of network	2	3	3	Regular monitoring of residual chlorine and coliforms in the network, to confirm residual chlorine >0.5 mg/l Operation ensures permanent and appropriate level of disinfection Monthly monitoring of general drinking water parameters	2	2
	Surface water pollution	Risk of pollution by accidental spill of chlorine if chlorine solution is used	1	2	2	Storage area of liquid chlorine to ensure retention capacity of 110% of the capacity of the largest container on site; Regular monitoring of storage and container conditions Training of workers in charge of handling chlorine	1	1
		Pollution of surface water by inappropriate management of grid residues and sludge: Limited impacts anticipated according to limited volume of sludge produced (less than 0.5 m3/day as a maximum; sludge shall not be contaminated	2	1	2	Ensure drying up of sludge and regular delivery with grid removals to the solid waste landfill	1	1
		Degradation of reservoir watershed and of KhinPonChong reservoir water	2	2	2	Ensure protection of this small catchment against residential and industrial development		
Rehabilitation of urban storages		The 3 storages of 2,200 m3 each shall be better protected against pollution: peripheral drainage and roofing; no particular impact or risk anticipated except the fast reduction of residual	2	3	2	Due to high temperature in Mawlamyine, and 1 day capacity of storage, control of residual chlorine recommended at storage level with possibility of additional chlorination if required	2	1

Component or Activity	Potential Effect	Potential Impact	Impact Assessment			Corrective or Support Measure		Overall Risk after Correction
		Description of Impact	Probability	Gravity	Overall Risk	Description of Measure	Easiness of Implementation	
		chlorine in water because of the high temperature in the region						
Rehabilitation of KhinPonChong water intake	None	No impact anticipated	-	-	-	No particular measure required	-	-
Creation of WS storage near KhinPonChong dam	Quality of life	Improved water supply security for Mawlamyine	-	-	-	No measure required	-	-
	Landscape	Storage shall be semi-underground with no impact on landscape	2	1	1	Ensure full revegetation of the site after works and particularly with trees) to dissimulate the storage. Rubber trees are recommended as surroundings are mainly occupied by rubber tree plantations.	1	1
Network Rehabilitation and Extension	Quality of life and public health	Increase of population serviced may decrease number relying on polluted shallow wells for drinking purpose	-	-	-	-	-	-
Climate Change	Affect water resources mobilised by the project	Risk of insufficient surface water resources is not anticipated because located in the wettest area of Myanmar and rainfall trend is increasing; As water source is not related to Thanlwin or Attran river, the risk of increased salinity because of CC is not of concern.	-	-	-	No particular measure required	-	-
	Increase of flooding risk	None of the facilities (WTP, storages) are located within floodable zones or zones which could be flooded in the long term.	-	-	-	-	-	-
Improved Solid Waste Management								
Improving waste collection	Impact on Water Quality and Drainage	Reduced quantity of waste discharged into the local drainage system and in the surface water bodies	2	2	2	The achievement of all these positive impacts depends on a major awareness campaign and capacity building on waste management among population of Mawlamyine	3	1

Component or activity	Potential Effect	Potential impact: Description of impact	Impact assessment: Probability	Gravity	Overall Risk	Corrective or support measure: Description of measure	Easiness of implementation	Overall risk after correction
		Improvement of drainage discharge capacities and reduction of localised flood risk, but risk of solid waste dumping continues by surrounding population, wasting efforts						
	Impacts on Quality of life and Public Health	General improvement of city image and quality of life of residents as a result of better waste collection rate	-	-	-			
		Risk of air nuisance if collection and transfer points not regularly cleaned	2	1	2	Cleaning procedure for collection and transfers points	2	1
	Impacts on Air quality	Reduction of waste presently dumped in the city shall reduce air pollution from gas, unpleasant smells and smoke from burnt waste	-	-	-	The achievement of all these positive impacts depends on a major awareness campaign and capacity building on waste management among population of Mawlamyine	-	-
	Reduction of pollution load	Collection point will improve waste segregation and management of hazardous waste from domestic origin	-	-	-	Organise and facilitate segregation on sites	2	1
Creation of a Sanitary landfill with composting plant	Impacts from smells and insects on surrounding population	The closest inhabited area is located about 300 m from the most SW boundary of the landfill. Risk of nuisance is limited as dominant wind direction is from SW.	2	1	2	Avoid locating a cell close to the extreme SW boundary of the landfill. Develop a green belt of trees around the landfill to preserve smells to be transferred outside at ground level Daily coverage of fresh waste by soil to limit insects/rodents	2	1
	Release of GHG by the landfill and composting plant	Landfill and composting process release methane gas. However, when compared with the present situation, the project will create an abatement of GHG release estimated at 30 000 t CO2eq/year in 2020	-	-	-	No specific measure required	-	-

COMPONENT OR ACTIVITY	POTENTIAL EFFECT	POTENTIAL IMPACT	IMPACT ASSESSMENT			CORRECTIVE OR SUPPORT MEASURE		OVERALL RISK AFTER CORRECTION
		DESCRIPTION OF IMPACT	PROBABILITY	GRAVITY	OVERALL RISK	DESCRIPTION OF MEASURE	EASINESS OF IMPLEMENTATION	
		and 153 000 t CO2eq/year in 2040. A major cause of abatement is related to the flaring of landfill gas. From 2016 to 2040, the project will avoid the emission of almost 2.13 million t CO2eq when compared to the situation without project.						
Cultural Heritage Conservation and Rehabilitation								
Rehabilitation of the Administrative Complex building	Improvement of Quality of Life	Improvement in the working environment for the employees and of the general image of Mawlamyine administration for the population	-	-	-	Maximize advertisement of the rehabilitation program and result at local and national level to promote similar initiative in other cities	-	-
		Creates a model for the promotion of cultural heritage conservation and rehabilitation by their owners	-	-	-	Ensure financial incentive procedure is officialised rapidly and advertise around it in Mawlamyine through promotion campaign and supporting material (leaflets, posters and dedicated desk for detailed information in the Administrative building)	-	-
			-	-	-	Include rehabilitated buildings into visits of tours operators	-	-

6 PROJECT ALTERNATIVES

For water supply, the "No Project" alternative shall maintain the urban population in a situation of the delivery of insufficient and unsafe domestic water. A significant number of wards shall continue to rely on underground water resources, more and more polluted and contaminated by the septic tanks servicing an increasing population, and oblige the population to rely on expensive water bottles for drinking purposes.

For the solid waste component, should no action being implemented and the present 2016 situation for MSW management being maintained on the long term, the cleanliness of the city shall continue to decrease with more solid waste dumped in the urban area creating unhealthy conditions and increasing the clogging of the drainage network, resulting in more frequent conditions of localised flooding during the wet season, with secondary impacts on the city activities and economy.

Furthermore, the "No Project" alternative should have much more detrimental impacts on GHG emissions as presented in **Table 6-1**.

Table 6-1: Comparison of GHG Emissions with and without Project

Situation	Year	Collected Waste				Uncollected	Total
		Collection	Recycling	Composting	Landfilling		
Mawlamyine							
No Project	2020	48	-12 208	0	19 983	13 178	21 001
	2040	131	-26 374	0	43 172	28 469	45 397
With Project	2020	98	-20 347	-8 821	4 731	2 762	-21 577
	2040	157	-43 957	-51 791	7 473	1 242	-86 875
Difference	2020	50	-8 139	-8 821	-15 252	-10 416	-42 578
	2040	27	-17 583	-51 791	-35 698	-27 226	-132 272

Source: PPTA Consultant, 2015

The results of the comparison shows that GHG emissions from solid waste in Mawlamyine could be **reduced by more than 42,000 t CO2-eq/year in 2020 and even reach 132,000 t CO2-eq/year in 2040**.

The MSW management measures proposed under the Project should result, from 2016 to 2040, in the cumulated emission avoidance of almost 2,13 Million t CO_2-eq. Composting is by far the most beneficial activity in terms of GHG avoidance, should the target of 90% of the compost produced to be used as fertilizer substitute for agriculture of urban greening, be effective. This objective is considered achievable as the plant operation may involve private sector (DBO type) and considering the extensive areas of industrial plantations (fruit trees, rubber) and rice fields in the Mon State which rely on fertilizer for their production.

For the cultural heritage component, no action will simply let the Mawlamyine cultural heritage to continue degradation and progressively reduce the city attraction for tourists, with consequent decrease of income from tourism sector.

7 INFORMATION DISCLOSURE AND PUBLIC CONSULTATION

7.1 Consultation and Public Participation Process

Information disclosure and stakeholder consultations were conducted as part of the environmental assessment process. The consultations involved in-depth key informant interviews with relevant Government agencies and focus grouped discussions.

The consultations aimed on environmental issues and concerns affecting the community. Specifically, the objectives of the consultation meetings are the following:

- To present the proposed projects to the stakeholders;
- To solicit views of the stakeholders relative to the proposed project;
- To identify the most important project components for the locals;
- To identify possible environmental issues inherent on the proposed project and to identify mitigation measures to address these issues in the project design.

Preliminary consultations with relevant Government agencies were conducted as part of the IEE of the proposed project. The focus grouped consultations primarily focused on presenting the project components, identifying the most important issue for the locals, receiving inputs and suggestions from the participants regarding environmental concerns arising out of the project, obtain baseline environmental and cultural information for project sites as well as Government clearance requirements and discuss their opinions on the perceived environmental impacts of the project. Suggestions were sought on measures to consider to properly implementing the project and in avoiding any potential adverse impact.

The principles of information dissemination, information solicitation, integration, coordination, and engagement into dialogue were incorporated during the preliminary consultations.

7.2 Consultation Meetings

7.2.1 SCHEDULE AND PARTICIPATION

Main consultation activities held during the PPTA are summarized in **Table 7-1**.

Table 7-1: Consultation Activities for Environment Component

DATE	ACTIVITY	PERSONS MET	LOCATION	PURPOSE
Throughout the project since 27 April 2015	Meetings and interviews	Department heads of township and state Development Affairs	MTDC office	To get better understanding of the project and the existing situations, and the requirements for the projects; to obtain perspectives and suggestions from the MCDC officers and representatives on the project
30 April 2015	In-depth key informant interviews	Deputy Director, Staff Officer	Environmental Conservation Department, Mon State, Ministry of Environmental Conservation and Forestry.	To discuss about the Environmental Impact Assessment Procedures (Draft) and implication of the draft EIA procedures on the proposed project, to obtain views and concerns on the current environmental issues and to discuss initial scoping of the project and scope of the IEE/EIA assignment, to reveal the roles of the residence office of Environmental Conservation Department, Mon State.
30 April 2015	In-depth key informant interviews	Deputy Director	Forest Department, Mawlamyine District, Ministry of Environmental Conservation and Forestry.	To gather the common plant and tree species found in the region, and to discuss the concerns and suggestions regarding the existing environmental situation
20 July 2015	In-depth key informant interviews	Director and Staff officers	Meteorological Department, Mon State	To inquiry to buy the meteorological data, the availability, and discuss on the current issues of environmental and climate change,
22 July 2015	In-depth key informant	Professor	Marine Science Department,	To inquiry the local fish species, environmental status, concerns and

DATE	ACTIVITY	PERSONS MET	LOCATION	PURPOSE
	interviews		University of Mawlamyine	suggestions, the existing water quality data of Thanlwin and Attran river, and to discuss on the mangroves in the region
23 July 2015	Observation of the State level workshop	Representatives of General Administrative Offices, Members of TDC	Mon State Hluttaw	To observe the discussions on the main issues raised and requirements regarding each township developments in Mon State.
28-29 September 2015	Public consultation with the locals, stakeholders and civil society	Project Manager (National Enlightenment Institute); Ward Administrators (Auk Kyin, Thar Yar Aye Ward), Director (Mon Women's Organization); Regional Manager (Local Resource Manager)		To disclose the proposed project and gather information on the critical environmental problem in the society, and the concerns and suggestions on the proposed project.

7.2.2 SUMMARY OF FEEDBACKS FROM PARTICIPANTS

From discussing with the public and the stakeholders, it was summarized that the necessity of good quality water supply, and the good solid waste management are important for Mawlamyine. Some main feedbacks from the discussions are as follow:

- In order to implement the good management on the municipality such as solid waste and water supply, there should also be strict rules and regulations.
- The civil society thinks having own tube wells at every household may effect on the destruction of the underground water table in the future.
- Public awareness and individual awareness are very crucial to keep the environment clean. More training programs on raising public awareness should be encouraged.
- To bring up the successful project and to avoid unwanted negative impacts on natural and social Environment, proper management along the whole project cycle is very crucial.

7.3 Future Consultations

Information dissemination to, consultation with and participation of affected people and involved agencies reduce the potential for conflicts and minimize the risk of project delays. Further information and consultations will be carried out before construction starts (during the first year of the project) and during the construction period.

Prior to the start of the construction, consultation will be carried out in all the areas where the proposed project activities area anticipated. The objective will be to provide the local population with accurate information on activities to be undertaken, on the schedule of these activities and on the potential nuisances for them during construction. This information stage, which concerns all the project sites, will be carried out jointly with the team in charge of RP preparation in those areas concerned by compensation and/or resettlement.

During construction stage, consultation will be carried out with local population in specific area where construction activities are expected to start within 1 month. This will be carried out through focus group discussion with residents and key stakeholders (police station, ward heads) on possible nuisances (noise, dust, traffic/access constraint, temporary suspension of public utility, etc.), on safety measures they will have to respect (regarding engines under activity, risks of fall in excavations, risks specific to children etc.) and on the detailed schedule of activities.

At the end of the construction activities in a dedicated site, inspection of site to ensure cleaning and rehabilitation has been done by the Contractor will include interview of residents to possibly identify non-compliance in the rehabilitation of the site.

7.4 Disclosure

The Draft Final IEE will be submitted to the ADB for review and approval. It will then be transferred to the Mon State Development Affairs for endorsement. Upon finalization, the final IEE will be disclosed on the ADB's website before the Board Approval, in compliance with ADB Public Communication Policy (2011).

The IEE will be used by the Mon State Development Affairs to produce the EIA report in Myanmar language. The report will be submitted to MONREC for environmental clearance[6]. The EIA report will be made available for consultation by the public in the Mon State Development Affairs-PMO premises. The summary of the EIA in Myanmar language will be made available at dedicated locations in the concerned areas as police station, ward heads.

[6] First stage in the process has been achieved in April 2017 with the submission by the Mon State Government to MONREC-ECD of the Project Proposal. EIA report are already under preparation and expected to be ready for submission not later than mid 2017.

8 GRIEVANCE AND REDRESS MECHANISM

A grievance redress mechanism (GRM) will be established in compliance with ADB's SPS (2009) requirement to prevent and address community concerns and assist the project to maximize environmental and social benefits. The grievance mechanism proposed for the environmental issues follows the same process than the one proposed for the compensation and resettlement issues.

The GRM will be accessible to diverse members of the community, including more vulnerable groups such as women and youth. Multiple points of entry, including face-to-face meetings, written complaints, telephone conversations, or e-mail, will be available. Opportunities for confidentiality and privacy for complainants will be honoured where this is seen as important.

8.1 Types of Grievance Expected and Eligibility Assessment

Public grievances addressed by the GRM will most likely relate to environmental issues during the construction phase, as consultations with potentially affected people conducted during project preparation confirmed their basic support to the project. Grievances will most likely include damage to public roads due to heavy vehicle operation and transportation of heavy equipment and materials; disturbance of traffic and increased traffic congestion; dust emissions; construction noise; inappropriate disposal of waste materials; damage to private houses; safety measures for the protection of the general public and construction workers; water quality deterioration, disruption of services (water supply, electricity), loss of access, etc.

During operation, grievances will most likely include nuisances related to unpleasant odours around waste collection points or around the landfill site. Possible grievances may also concern quality of distributed water during maintenance works on the network or pressure problems in some areas.

8.2 Proposed Mechanism

The overall purpose of the grievance redress mechanism (GRM) will be to reduce risk for the project, offer communities an effective platform for expressing concerns, and achieving solutions that will promote a constructive relationship between the government, project staff, and communities.

Specifically, the project GRM will be established to allow all persons affected by the urban infrastructure and services project to appeal any disagreeable decision, practice, or activity arising from the implementation of the Third Greater Mekong Subregion Corridor Town Development Project.

The design of the GRM should enable the mechanism to provide:

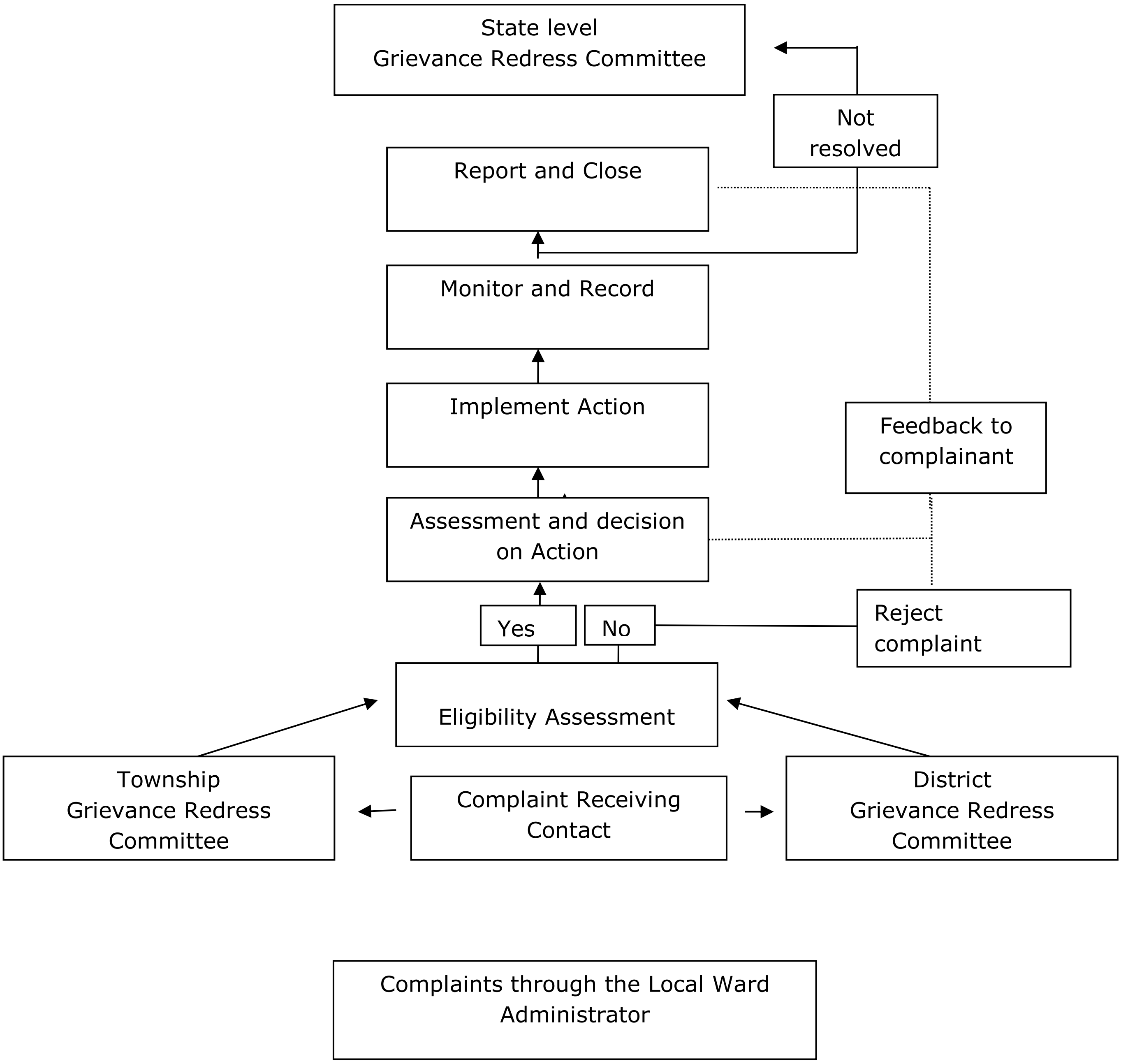
- a predictable, transparent, and credible process to all parties, resulting in outcomes that are seen as fair, effective, and lasting;
- builds trust as an integral component of broader community relations activities; and
- enables more systematic identification of issues or problems, facilitating corrective action, and pre-emptive engagement.

The GRM will include the following elements:

- a transparent grievance receipt and registration system to provide ways for community members to register complaints and confirm they have been received;
- grievance eligibility assessment to determine if the issues raised in the complaint fall within the mandate of the grievance mechanism and if the complainants are legitimate;
- grievance assessment and investigation to clarify concerns raised in the complaint, to gather information on the situation, and to identify how the issues might be resolved;
- several choices for solving problems are as follows:
    1. Internal decision-making processes, whereby issues are handled by designated members of the GRM, using set criteria to develop a response to the grievance and to allow for tracking complaints, monitoring and evaluation of the resolution and an appeals process.
    2. Joint problem-solving, in which the project and the complainant engage in a dialogue and action planning to resolve the problem.
    3. Third-party mediation to facilitate a solution when a voluntary agreement is not possible.
- grievance tracking, including maintenance of written records of grievances, monitoring, public information disclosure and reporting to the community; and
- grievance closure, including community feedback and confirmation of resolution of the problem.

All project stakeholders (Ministry of Construction [MOC], Project Management Office [PMO] and Project Implementation Unit [PIU] staff of the Kayin and Mon State Governments [M/KSG], district/township/ward officials, communities, civil society organizations (CSOs), and ADB staff) were involved in the design of the GRM—to outline the purpose, structure, and specifics about how the grievance mechanism will function.

Below is the structure of the GRM and its operational arrangements.



The GRM will be established in three townships, namely Mawlamyine, Hpa-An and Myawaddy. It involves the following process:

- Stage 1: Access to the GRM. If a concern arises, the complainant will make his/her complaint known to the Local Ward Administrator (LWA) of the concerned ward through verbal, phone, email, or written submission. CSOs may file complaints on behalf of affected persons through the LWA or directly to the Complaint Receiving Contact (CRC) with a copy to the LWA.
- Stage 2: Submission and Registration. The LWA or CSO will submit a written complaint to the Complaint Receiving Contact (CRC). The CRC will register the

complaint and forward it to the township grievance redress committee (GRC) or district GRC depending on the nature of the complaint. The CRC will issue an acknowledgement of receipt of the complaint with information of which GRC will handle the complaint to the LWA. The LWA will inform the complainant and CSO if appropriate, and deliver the acknowledgement of receipt. The township level GRC will handle complaints or queries pertaining to construction activities (including road safety, and environmental issues), information about project activities, give general feedback. The district level GRC will handle complaints regarding environment and construction-related impacts, resettlement, compensation and livelihood improvement issues.

- Stage 3: Determine Eligibility. The township or district GRC will determine whether the complaint requires further action to address. A screening procedure based on simple eligibility criteria will be established for the GRCs. If the complaint is deemed ineligible, the complainant is informed of the decision and the reasons for ineligibility. Where appropriate, the GRC may refer the complainant to alternative options for resolution of the complaint.
- Stage 4: Assessment and Decision on Action. If the complaint is eligible, the appropriate GRC will conduct an assessment and gather information about the complaint and key issues and concerns to determine how the complaint might be resolved. The LWA and community members will participate in the assessment as necessary. If outside experts or technical information is needed, the GRC may seek such guidance and may request all parties concerned to participate in the GRM process. The GRM may offer a variety of grievance resolution approaches. The decision on the solution will be by the GRC. The GRC will develop an action plan and identifies responsibilities for the plan. This action plan will be reported to the complainant through the LWA.
- Stage 5: Implementation of Actions. Implementation of the action plan commences with close collaboration of relevant project stakeholders depending on the type of complaint.
- Stage 6: Monitoring and Reporting on Implementation. The GRC will monitor the implementation of actions and record findings which will be filed through the CRC. As part of the monitoring process, the GRC will consult the relevant project stakeholders, as needed. The monitoring time frame will be project-specific depending on the implementation of the actions.
- Stage 7: Closure of the Complaint. When the monitoring has been completed, the GRC will prepare a final report which is shared with the LWA and complainant, and filed with the CRC. The complainant will confirm completion of the actions and agree to the closure of the complaint. The grievance dossier is closed and filed in the project archive.
- Stage 8: Appeal to the State GRC. If the complainant is not satisfied with the solution suggested by the GRC during the assessment stage or after the implementation of actions, an appeal can be lodged at the state GRC through the LWA in writing, with a copy sent to the PMO/PIU of the M/KSG. The state GRC will serve as the second level authority for addressing grievances that were not resolved satisfactorily. It will also look into grievances regarding inconsistencies of grievance handling by the township and district GRCs. It may assign a second investigation of the grievance case to another expert or group of experts, depending on the required expertise for analysis and reporting, with final decision-making remaining with the State GRC.

If efforts to resolve complaints or disputes are still unresolved and unsatisfactory, the complainants have the right to send their concerns or problems directly to ADB's Southeast Asia Department (SERD) through ADB Myanmar Resident Mission. If the households are still not satisfied with the responses of SERD, they can directly contact the ADB's Office of the Special Project Facilitator as outlined in the Information Guide to the Consultation Phase of the ADB Accountability Mechanism.

GRM proceedings will entail one or more meetings for each complaint and may require field investigations by specific technical or valuation experts. Grievance cases shared by more than one complainant will be treated as a single case.

The GRC and the procedures for resolving complaints and grievances will be made public through an effective public information campaign. During the RP updating process when the detailed engineering design is available, the grievance redress procedure shall also be explained in the project's Public Information Booklet.

The mechanism proposed relies on the creation of a Grievance Redress Committee (GRC) integrated into the Department of Public Relations and Information (DPRI) of MSG and basically dealing with grievances related to resettlement and compensation. The GRC will additionally address those complaints related to construction activities when the grievance cannot be closed at the level of the contractor. The GRC, as defined in the RAP, will be headed by the Senior Officer of DPRI and would include representatives from townships, from civil society (Woman Association, Elder groups, Social Welfare groups) and Community representatives from the complainant's ward.

When construction starts, a sign will be erected at each construction site providing the public with updated project information and summarizing the grievance redress mechanism process including details of the GRM entry points. The contact persons for different GRM entry points, such as PMO, community leaders, contractors, and operators of project facilities, will be identified prior to construction. The contact details for the entry points (e.g. phone numbers, addresses, e-mail addresses, etc.) will be publicly disseminated on information boards at construction sites and on the website of the local government.

The GRC will establish a GRM tracking and documentation system. The system will include the following elements: (i) tracking forms and procedures for gathering information from project personnel and complainant(s); (ii) dedicated staff to update the database routinely; (iii) systems with the capacity to analyse information so as to recognize grievance patterns, identify any systemic causes of grievances, promote transparency, publicize how complaints are being handled, and periodically evaluate the overall functioning of the mechanism; (iv) processes for informing stakeholders about the status of a case; and (v) procedures to retrieve data for reporting purposes, including the periodic reports to the ADB.

.

9 ENVIRONMENTAL MANAGEMENT PLAN

9.1 Purpose and Objectives

The role of the Environmental Assessment process is to identify the impacts which may be caused by the project and to develop a series of attenuating or mitigating measures which will be technically appropriate, financially acceptable and easily applicable in the context of the project. These measures are identified in Chapter 6 of the present IEE.

The role of the EMP is to complement this analysis by defining the operational context in which these measures will be implemented. The present chapter therefore sets out the principles, the approach, the procedures and methods which will be applied to monitor and reduce the environmental and social impacts resulting from the construction works and subsequent operation of the components projected in Mawlamyine.

To this effect, the EMP includes 3 complementary Action Programs that are adapted to the phases of pre-construction, construction and operation of the Project components:

- The Preliminary Program of Action (PPA), which includes all the measures recommended during the early stage of the Project, particularly before the construction works start. These measures essentially concern the organization and training of the teams which will be responsible for environmental and social management during construction and operation of the project, as well as all the complementary studies and investigations identified during preparation of the EIA and deemed to be necessary before starting the construction works.
- The Program of Actions adapted to the Construction period (PAC), which defines the principles of organization and the environmental inspection procedures for the construction sites. This PAC also defines the contractors' obligations in relation to environmental and social management of the construction sites and camps.
- The Program of Actions adapted to the Operation period (PAO), which defines the environmental quality controls (water, air and noise) applicable during the period of operation of the structures and necessary to evaluate the environmental efficiency and performance of the corrective measures put in place.

The present EMP accordingly establishes and describes the context in which all the proposed corrective measures shall be implemented, under the following headings:

- organization to be established to ensure effective implementation of the corrective measures and the associated environmental monitoring;
- role and responsibilities of the various parties to be involved in the Project;
- principal tasks to be undertaken during the phases of preparation, construction and operation of the project;
- complementary studies deemed to be necessary;
- financial resources to be mobilized and their origin.

All the measures proposed in this EMP are based on the results of the analysis of impacts and corrective measures outlined in previous Section 5 of the present EIA. These aspects will not therefore be repeated here.

9.2 Summary of Key Impacts

As detailed in Chapter 6 of the report, anticipated key detrimental impacts from the project components are summarized in **Table 9-1**.

Table 9-1: Summary of Project Key Impacts

GMS 3 COMPONENTS	ANTICIPATED KEY IMPACT
Improved Water Supply Systems	
Creation of WTP	No land acquisition; No detrimental impact anticipated Occupational health and safety risks during construction and operation stages; Water contamination risk during operation is limited;
Creation of 4,000 m3 storage	No land acquisition; No detrimental impact anticipated
Rehabilitation of existing 3 storages	No land acquisition; No detrimental impact anticipated Work completed in 2016 under JICA WS Project, only minor improvements on the piping remain under GMS.
WS Network Rehabilitation and extension	No land acquisition; Mainly risk of nuisances during construction activities; occupational and public safety mainly related to road traffic next to worksites in public streets, risk of water contamination during network rehabilitation.
Improved Solid Waste Management	
Creation of 56 collection points	Mainly risk of temporary nuisances from construction activities; few trees to be cut in some sites; odours nuisance during operation if not regularly cleaned
Construction of a sanitary landfill	1.5 hectare of land acquisition; deviation of the stream shall be well designed and implemented Risk of contamination of water bodies by leachate but leachate collection and treatment is already included in the landfill design.
Construction of a composting plant	No land acquisition; No detrimental impact anticipated
Conservation of Cultural Heritage	
Rehabilitation Administrative Complex Building	No land acquisition; Limited nuisances from construction activities;

As observed from this table, only limited environmental impacts are anticipated from the Project components. All new components are developed on land own by TDC or MSG (except 1.5 ha acquired for the landfill), so avoiding delicate process for land acquisition and compensation. Only limited nuisances are anticipated from the construction activities, particularly those which are located within urbanized areas. No forest clearing is required. As a Resettlement Plan (RP) is prepared in parallel with this IEE, where social issues are addressed, this EMP principally focuses on construction activities, supervision and monitoring activities during construction period and operation.

9.3 EMP Organisation and Responsibilities

9.3.1 OVERALL ORGANIZATION

Three levels of organization for environmental management, fully complementary, will be set-up:

- The Government Implementing Agency (IA) through its PMO and the PIU, will have to provide for all aspects related to environment and social including (i) general supervision of activities carried out prior, during and after construction of the project and (ii) coordination with other stakeholders including other Government Agencies and IFIs involved (ADB any other lending institution);
- The Project Implementation Support Consultant (PISC) will assist PMO and the PIU for all aspects dealing with environmental management preparation, provide environmental training to PMO and PIU staff, provide coordination and supervision for all environment-related activities during construction and report regularly to the IA;
- The Construction Contractor Environment, Health and Safety Unit (CC-EHSU), will provide resources for, and effective implementation of, all measures which are defined in the EMP and in the contract documentation in addition to health and safety aspects on site.

Environmental staff in the PMO, PISC and CC is intended to be independent of construction staff. Environmental staff will work alongside construction staff, however they will report through separate channels up to the Project Director for the PIC and to the executive management level for each CC concerned.

9.3.2 STAKEHOLDER ORGANISATION

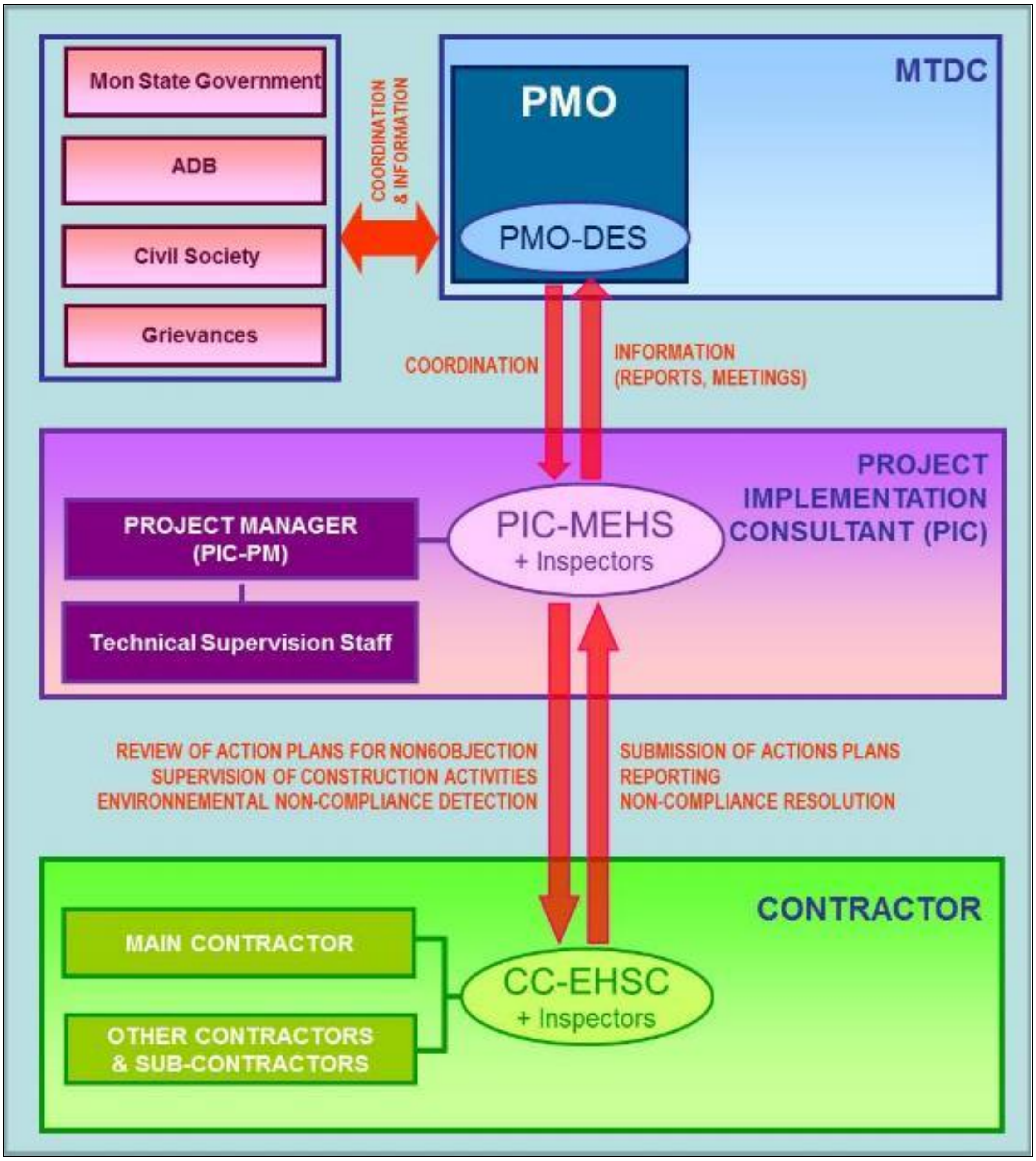
The IA-PMO will have an integrating role at the top of the organisation. It will be responsible for (i) informing the political and financial agencies of the correct implementation of the EMP and (ii) ensuring effective compliance in terms of E&S obligations and procedures in the implementation of the Project. To do this, it will appoint a Director Environmental and Social (DES), whose role shall be (i) to supervise the Project's environmental and social activities in the name of the IA and (ii) to ensure coordination with the international agencies (funding agencies, investors, panel of experts) and national agencies (other Government Ministries, NGOs). The PMO-DES will in particular follow up and ensure operations relating to compensation and resettlement of APs resulting from the implementation of the project components are progressing satisfactorily. The DES will be assisted in this supervisory role by the PIC.

The PIC will set up within its Engineering Team an Environmental Management Unit (EMU) which will ensure effective implementation of the environmental measures. This team will be under the responsibility of a Manager Environment, Health and Safety (PIC-MEHS) assisted by staff responsible for supervising EHS aspects on the construction sites, grievances expressed by the population, any disturbances or harmful impacts they are subjected to, claims for compensation for temporary disorders related to the construction activities and liaison with the traditional local authorities or representatives of the State. The EMU will include a team of Site Inspectors.

Each CC having responsibility for one of the main components will set up its own EHS Unit (EHSU) responsible for providing the interface with its construction team. Depending on how the contracts are distributed, certain contractors may group together to set up a common environmental team. Each EHSU will have an EHS Coordinator (EHSC) and Environment, Health & Safety (EHS) Inspectors.

Proposed organization is depicted on **Figure 9-1**.

Figure 9-1: Proposed Organization for EMP Implementation



9.3.3 STAKEHOLDERS ROLES AND RESPONSIBILITIES

ROLE OF PMO-DES

Project Preparation Phase

- Coordinate, with those concerned, the definition of the environmental measures at the level of detailed design and prepare the corresponding environmental obligations of the contractors as General and Particular Specifications in the Tender Documents;

- participate in the evaluation of the tenders and negotiation with the contractors for all the environmental and social aspects;
- ensure coordination with the financial institutions involved (ADB), in order to guarantee compliance with their specific environmental and social requirements;
- ensure, with those concerned, the monitoring and coordination of all consultations carried out with the local population prior to starting the construction works; this aspect is particularly important for urban development components;
- coordinate with Government Authorities concerned, the issues of land acquisition and compensation operations required to be completed before the start of construction works;
- prepare timeline for compliance with various national applicable laws and requirements including environmental emission standards.

Construction Phase

- Ensure coordination of activities with the PIC-EMU;
- participate in environmental coordination meetings with the representatives concerned from PIC and Contractors;
- directly refer results and problems encountered to the PMO-Project Director;
- contribute for E&S aspects to the monthly and/or quarterly Works Progress Reports prepared to the attention of the IA, of the EA and of the lenders (ADB);
- provide liaison with MONREC;
- provide liaison with other authorities as .required.

Operating Phase

At the end of the Project construction, the various components will come under the responsibility of various MTDC Departments. Each department will need to be clearly informed about the environmental monitoring requirements and to have organized in accordance. The PMO-DES will:

- Ensure coordination between MTDC Departments on environmental issues and monitoring needs;
- ensure environmental monitoring required on the sites are efficiently implemented;
- ensure effective completion of the measures to rehabilitate the sites temporarily used during construction;

Role of Project Implementation Consultant (PIC)

- At the start of the Project Contract, the PIC Manager EHS (PIC-MEHS) will provide training to PMO-DES and other staff of PMO and PIU regarding results of EIA reports, EMP obligations, organization of PMO for environmental management;
- Preparation of baseline template documentation required for PMO-DES activities: weekly, monthly report structure, template checklists for site inspection, etc.
- Assistance for ToR and contract preparation for effect monitoring (air, water) to be carried out by any registered laboratory appointed by PMO;

- Organize and control the work performed by the Environmental Management Unit (PIC-EMU);
- ensure coordination with the PMO-DES;
- ensure that all environmental plans and programs requested from the CCs (this generic term covering all the main Construction Contractors) have been submitted and have been non-objected prior to the start of works;
- with PIC-EMU inspector collaboration, check whether the Contractor's environmental obligations have effectively been complied with on the sites, and refer to his manager (the PIC-Project Manager, PIC-PM) any detected case of non-conformity for formal action;
- report any observed case of non-conformity and ensure that it is remedied by the concerned CC within the imposed time limit;
- participate in the site monitoring meetings and prepare a monthly environmental monitoring report covering all project components;
- prepare the monthly evaluation report, recording the Contractor's environmental performance, which may, if necessary, be used to justify a deduction on the monthly claim for payment presented to the PMO;
- ensure the regular implementation of compliance monitoring programs (water and air quality) and present the interpretation of results in the context of the monthly report;
- provide liaison with the local communities concerned for any social aspect including health, respect of recruitment procedures, land use agreements, handling of complaints and compensation for unexpected damages to private property during construction activities;
- organize a database for storing all environmental documentation generated during construction of the project (letters, memos and technical notes, registers, site photos, non-compliances and resolution forms, etc.);
- prepare the documentation required prior to the project's environmental and social audits performed by the Lenders.

Role of PIC-EMU Site Inspectors

- Perform regular visits to the construction sites and the worker camps; frequency shall be adjusted according to the environmental risks, the sensitivity of the environment and the contractors' performance;
- establish reports on all detected cases of non-compliance and follow up their resolution by the concerned CC;
- regularly provide input to the environmental database, in particular the reports on non-compliance, the records of non-compliance correction and the supporting photographic documents.

Role of the Construction Contractor EHS Coordinator

The EHSC, with the support of his team, will have the following responsibilities:

- adapting construction activities to ensure they comply with the EHS obligations defined in the Tender Documents and the Terms of the Contract;
- ensuring that all sub-contractors under his responsibility comply with the same EHS obligations;

- preparing the environmental plans and programs specified by the Tender Documents, in particular the monitoring programs;
- supervising the environmental good practices for construction activities on all construction sites used by the Contractor or his sub-contractors, by calling on his inspectors to make regular inspection visits;
- treating cases of non-compliance notified by these inspectors and instructing the construction teams to apply the necessary remedial measures immediately;
- preparing the weekly and monthly activity reports for presentation to the PIC-MEHS;
- organizing and performing E&S training of CC staff (management & workers).

9.4 Key Environmental Management procedures

9.4.1 INTERNAL COMMUNICATION PROCEDURES

The efficiency of environmental and social management is dependent upon the clear organisation of communication among the stakeholders as shown in **Table 9-2**. In particular, there has to be a clearly defined channel for handling rapidly all possible environmental disorders and implementing efficiently the necessary remedial actions, especially in emergency situations.

The following table presents the key links with regard to internal communication among the stakeholders during the construction period. This procedure must be laid down in greater detail before the start of the project in accordance with the Contractor EHS policy and the final Project organisation.

Table 9-2: Main Steps of Internal Communication

ORIGIN	RECIPIENT	FREQUENCY	SUBJECT
PIC-PM	PIC-MEHS	Weekly	Updating the construction programme; specific construction activities in the coming period and their location
PIC-PM	PMO-DES, PIC-MEHS	Ad hoc	Additional needs for land, or notification of a change in construction techniques
PIC-MEHS	PIC-PM	Weekly	Weekly report on environmental events (EE) detected and their treatment; programme of activity of the PIC-EMU for the coming week
PIC-MEHS	PIC-PM	Ad hoc	Communication of EE of levels II or III
PIC-MEHS	PIC-PM	Monthly	Monthly report on activity and results of monitoring for review and approval before forwarding to the PMO-DES
PIC-MEHS	PIC-Inspectors	Weekly	Updating the construction programme; specific construction activities in the coming period and their location, particular directives
PIC-Inspectors	PIC-MEHS	Weekly	Weekly activity report, list of observed EE of level I
PIC-Inspectors	PIC-MES	Immediate (same day)	Observed EE of levels II & III; particular problem requiring technical assistance; observation of construction activities outside specified areas
CC-EHSC	PIC-MEHS	Monthly	List of training modules followed in the past month and the personnel concerned (list of attendance)
CC-EHSC	PIC-MEHS	Fortnightly	Updating of new activity zones for the coming 2 weeks and operations presenting a particular risk for the environment; results of monitoring of the previous 2 weeks

ORIGIN	RECIPIENT	FREQUENCY	SUBJECT
PIC-PM	PMO-DES	Immediate (same day)	Memo to inform on any observed non-compliance of level III; proposal to suspend the works on the incriminated site if justified
PIC-PM	PMO-DES	Monthly	Transmission of the monthly activity report including environment as prepared by the PIC-MES
PIC-MEHS	PIC-PM	Quarterly	Summary report on significant environmental events (Levels II and III) observed, on the decisions taken, and on the measures implemented; proposal, if necessary, to modify certain mandatory thresholds or obligations of the Contractor
PIC-PM	PMU-DES	Quarterly	Summary report on significant environmental events (Levels II & III) observed, on the decisions taken, and on the measures implemented; request for approval of the proposed modifications
PIC-MEHS	PMU-DES	Yearly	Annual audit of construction sites and submission of an annual environmental audit report
Note: PMO-DES (Director Environment & Social from MSG PMO) – PIC-MEHS (Manager Environment, Health& Safety from Project Implementation Consultant) – CC-EHSC (Contractor's EHS Coordinator) - EE (Environmental Event = detected non-compliance)			

9.4.2 EXTERNAL COMMUNICATION PROCEDURES

External communication for environmental and social subjects will be the prerogative of his PMO-DES, assisted by MTDC's Director of Communication. This communication will essentially concern exchanges of information with the media, with NGOs and with Government representatives at Central and Regional levels. The PIC-MEHS and the CC-EHSC will only intervene in these exchanges when expressly invited to do so by PMO.

The PMO-DES will regularly contribute for all E&S aspects to the activity report provided to ADB, to various government organisations and NGOs in Myanmar.

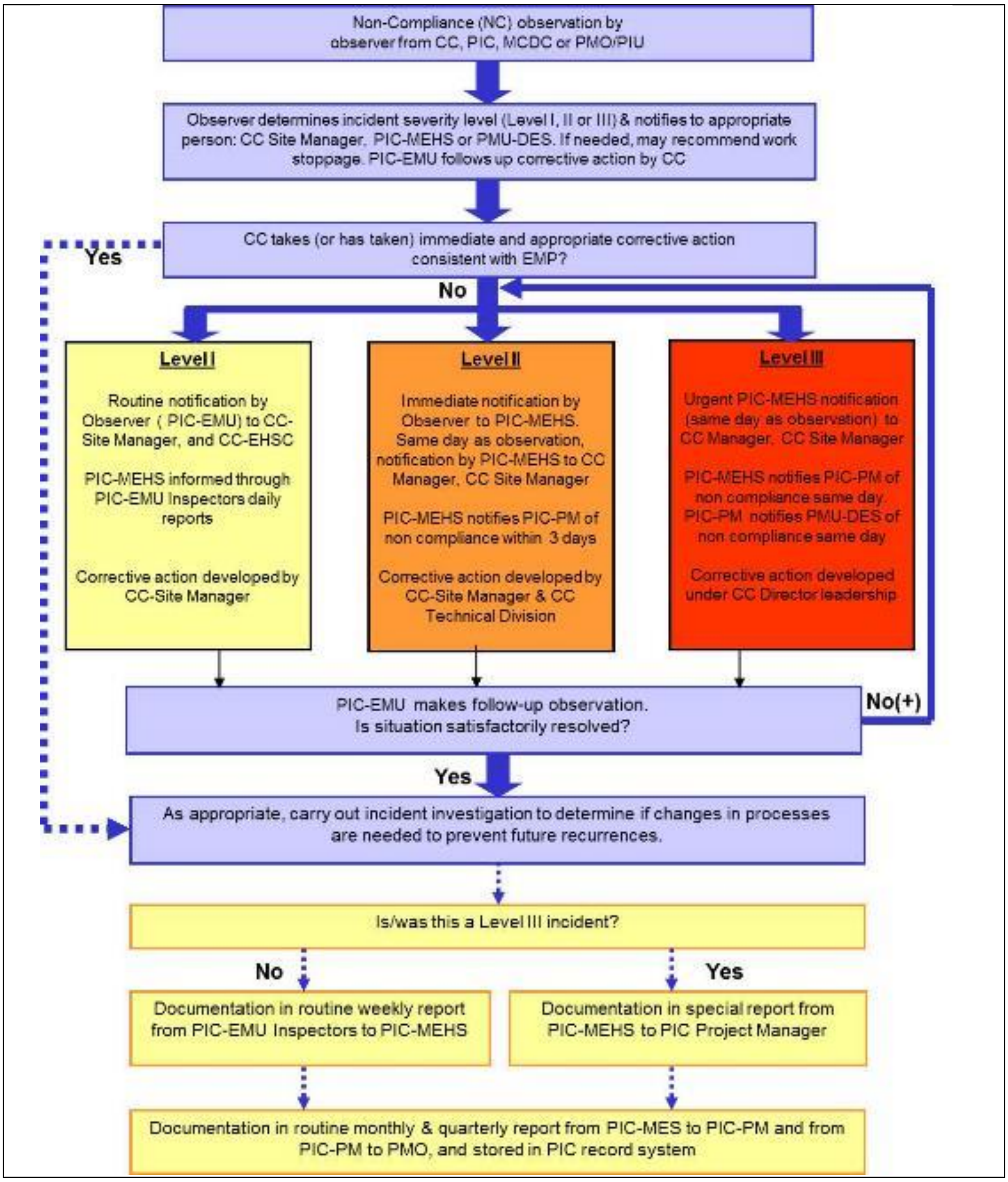
9.4.3 ENVIRONMENTAL EVENTS MANAGEMENT PROCEDURE

An important element of the process of communication among the parties is the ranking of events which do not meet the obligations and environmental objectives assigned to the project. These situations detected on site by the PIC-EMU must then be notified to a higher level but following procedures that are graduated according to the extent of the risk and the urgency of remedial action. These environmental events could be ranked according to the system of quality assurance applied to the construction works, in which case their subdivision would be variable according to the subdivisions taken into account for non-conformity of a technical nature. In the present EMP, considering the absence of information on the project's future quality assurance plan, preference is given to an evaluation system specific to environmental aspects, better adapted to the problems encountered and which represents a proven and reliable system, which can work satisfactorily even in the absence of an efficient quality assurance system.

Environmental events correspond to non-conformities (Non-Compliances, NC) and are subdivided into three levels. The communication and handling procedures depend on the level of non-conformity. Level III represents the most serious incidents, while level I represents the incidents of least gravity.

Level I (Minor Incident): Situations on Level I are addressed on a day-to-day basis at the time of site visits and routine meetings; the recommended measures are generally discussed on the spot with the construction teams concerned. Formal communication takes place through the Environmental Event (EE) report prepared by the PIC-EMU Inspectors and handed to the PIC-MEHS for official notification to the concerned CC-EHSC.

Figure 9-2: Diagram of Procedure for Non-Compliance Resolution



Source: PPTA Consultant, 2015.
Note: PMO-DES: PMO Director E&S; PIC-MEHS: Project Implementation Consultant Manager EHS; CC-EHSC: Construction Contractor EHS Coordinator; PM: Project Manager (from PMO, PIC or CC); MTDC: Mawlamyine Township Development Committee

Level II (Moderate Incident): The EE of Level II is notified by the PIC-MEHS to the PIC-Project Manager and the CC Site Supervisor the same day as the situation is observed, and within three days to the PMO-DES. The PMO-DES informs the PMO

Project Director of the situation and details the proposed corrective measures, which must be implemented as rapidly as possible.

Level III (Major Incident): The PIC-Project Manager and the PMO-Project Director must be informed on the day an event is observed. The corrective measures must be applied within three days. Should more time be required to implement a corrective measure, or if the risk is imminent, the PIC-PM may order suspension of the works concerned until the observed situation returns to normal.

Figure 9-2 illustrates the principles of this non-compliance procedure and shows how the approach favours direct resolution on site of the less serious EE (Level I) by direct communication with the construction workers, and how the senior levels of responsibility are progressively involved in the processes to solve the more serious EE (Levels II and III). The full arrows denote the decision processes, while the dotted arrows denote the reporting and information processes.

This procedure is often implemented on complex work sites, and generally gives satisfactory results. It also offers three advantages:

- A mechanism allowing the works to be stopped if the situation is deemed to be hazardous;
- provision for feedback so that the site inspectors monitoring implementation of the requested measures can ensure that the remedial action has been taken;
- the possibility of initiating an incident enquiry in order to determine the deep-seated causes of the incident and to assess whether they justify changes in the specifications, the requirements or the methods, to prevent reoccurrence of such a situation in the future.

9.5 Action Plan Prior to Construction Works (PPA)

All the elements described above reflect the main details of the organisation to be set up for supervision and monitoring in the construction and operation phases. However, it is essential to ensure that the necessary means and references are available and totally operational from the time the works start. To this effect, a certain number of activities are to be undertaken before the start of construction works. These actions cover the aspects of recruitment, organisation and training for PMO. The main recommended actions for this pre-construction period, resulting from the impact analysis, are detailed in the following paragraphs in the form of a Preliminary Action Programme (PPA). Revision of measures proposed during this pre-construction and construction periods will be considered as soon as the PISC will be recruited. Indeed detailed design will start at this stage (for components not developed under DBO) and it is required (i) that design fully integrate mitigation measures identified in this IEE and (ii) that monitoring activities are adjusted in accordance with the selected design (particularly sampling points and parameters).

Following PPA-01 to 03 are proposed to strengthen the capacity of PMO to handle full control of environmental, health and safety issues related to project implementation.

9.5.1 PPA-01: APPOINTMENT OF THE PMO-DES

The PMO will appoint its Director Environment and Social (DES) before construction works start. The DES will be assisted at the beginning of his mandate by the Project Implementation Support Consultant (PISC) who will deliver training to the DES and assist him (i) for the preparation of tenders regarding monitoring surveys, (ii) for the selection of the Consultants, (iii) for the follow-up of the studies.

9.5.2 PPA-02: ENVIRONMENTAL CAPACITY BUILDING OF PMO

The PISC-MES will carry out training of the PMO-DES and other PMO staff at the early stage of its recruitment. Purpose is to have the PMO-DES and his staff fully operational at the start of the project construction activities. Training will focus on:

- Detailed review of impact analysis and mitigation from the Third GMSIEE and national EIA for Mon State
- Detailed review of EMP Program of Action
- Organization of MSG PMO for EMP implementation
- Basics for site inspection practices: organization of visits, frequency, control checklist;
- Basics for non-compliance procedures: reporting procedure and form, organization of follow-up, procedure for resolution approval;
- Data management for PMO-DES: key information to be stored, data base organization, registers;
- Structure and content of weekly, monthly reports.

9.5.3 PPA-03: CAPACITY BUILDING ON HEALTH AND SAFETY

When observing construction sites in Mawlamyine the conclusion comes easily that health and safety considerations are still strongly ignored. Project construction sites must be compliant with international good practices regarding health and safety of workers on sites. This project may even be considered as a pilot project for introducing good EHS practices in MTDC and for the concerned contractors.

The PIC shall organise safety training courses not only for the staff of PMO but also for all technical departments of MTDC. The aim is to provide the basics of safety rules and organization of constructions sites and for the PMO staff, to clearly understand what must be required from the contractors on the sites.

Similarly and as described under the following Action Plan during construction, the Contractors will be contractually requested to organise awareness training on health and safety for all their staff.

9.5.4 PPA-04: PREPARATION OF COMMUNICATION INSTRUMENTS

In support and follow up to the public consultations carried out within this PPTA, it is important to prepare the appropriate communication material rapidly, allowing MTDC to present, before starting the works, clear information on the design of the project, on the phasing of construction work, on the recruitment procedures and on the environmental and social measures which will be implemented.

Preparation of proactive communication is essential to ensure the widest possible circulation of information at the most critical time, since it is during this period prior to the start of works, when important decisions and negotiations are in progress, that information on the Project must be available in a completely transparent manner. The communication tools to be developed include:

- Colour flyers and posters to be posted all along the various sub-components sites;
- Articles in the press and radio or TV messages;
- The technical EIA documentation available for consultation by any person, at MTDC.

These documents will be prepared under the PMO-DES authority with the assistance of MTDC Communication Department and of the PIC.

9.5.5 PPA-05: PREPARATION OF CONTRACTOR EHS SPECIFICATIONS

Effective consideration of the EHS during construction activities pre-supposes the production of a clear, complete and detailed contractual document at the time the contract is awarded. This means including the specifications which will lay down all the EHS obligations to be imposed on contractors by PMO in the Tender Documents. These requirements dictated by the Project Owner will be presented in a document entitled "Environmental and Social Obligations of the Contractors", which will be prepared together with the Technical Specifications (General and Particular) of the Project. The PIC-MEHS will assist PMO for the preparation of the Tenders.

The document will set out all the EHS obligations imposed to the contractors and the principles and measures required for complying with. These obligations will be articulated around the key fields of environmental and social management for all construction activities related to the Third GMS project components, including:

- general specifications for good environmental management which will be applicable to the contractor at any point within the work site and at all times, covering areas such as: training/awareness of employees on protection of the environment and safety, management of hazardous substances and waste, protection of biodiversity, prevention of water and air pollution, preservation of soils, rehabilitation of sites;
- minimum conditions to be established in the contractors' camps and installations, covering aspects related to housing, catering, waste management, drinking water, sewerage and conditions of public hygiene;
- minimum conditions to be observed by the contractor in the field of employees' health and safety;
- minimum conditions to be observed by the contractor with a view to protecting the environment of the sites as well as that of the areas contiguous, most densely urbanized;
- minimum conditions to be observed by the contractor in managing the social aspects of construction activity including applicable procedures for temporary land occupation or in case of damage to any private property.

A specific monitoring program will be set up to ensure that the contractors fulfil their EHS obligations, detailed in the following section relating to the Construction Phase. In practice, the selected contractors will be asked to draw up a number of specific environmental plans, within a specified period of time after the contract is notified, describing how these contractors (and their sub-contractors) will be organised and how they will work together to meet their environmental and social obligations. In principle, the list should cover the following key fields:

- Solid waste management plan,
- Dredging and Sediment management plan,
- Hazardous substances management plan,
- Accidental spill response plan,
- Erosion control and sedimentation management plan,
- Camps management plan,
- Workers health and safety plan,
- Air pollution, dust and noise management plan,
- Road traffic and access management plan,
- Water quality monitoring plan
- Cultural resources protection plan,
- Environmental training plan

9.6 Action Plan during Construction (PAC)

This action plan provided below is sufficiently detailed to provide the baseline information for further preparation of Contractor Environmental and Social Specifications to be included later into the Project Tender documentation. The following Program of Action will be implemented during the construction phase:

9.6.1 PAC-01: WASTE MANAGEMENT

A waste management programme will be established and will be mandatory for contractors and their sub-contractors. The programme will include two waste management plans which will be prepared and implemented by the contractors. The first relates to domestic waste (mainly generated in worker camps) and other non-hazardous waste generated on the construction sites, while the second is related to hazardous wastes. The objectives of the programme are:

- to minimize the generation of wastes by carefully considered use of raw materials;
- to sort and treat the wastes in order to limit their environmental impact;
- to raise awareness and train personnel in good waste management practices.

These plans will include procedures, in accordance with local regulations or with international best practice, concerning the handling, transport, storage, treatment and elimination of wastes depending on their category:

- Non-hazardous wastes (Group A): putrescible wastes from the camps and canteens, paper, cardboard, plastics, wood and vegetation, inert wastes from construction or demolition (concrete, scrap iron, bricks, etc.);
- Hazardous wastes (Group B): wastes that are corrosive, explosive, toxic, representing a degree of danger for humans or for the ecosystem. In the context of the present project components considered, this will mainly include engine oils and used hydraulic fluids, the residues of paints, solvents and resins,

first aid medical wastes, sludge from septic tanks and mobile toilets, various concrete additives (but with a lesser degree of danger for the latter).

Non-hazardous Waste Management

A system of waste segregation at source, ensuring separation of metal products (including drink cans or food cans), plastic products (bottles, cartons, wrapping, etc.), glass bottles, paper and cardboard, will be set up on the construction sites and in the camps. All these products will, as far as possible, be made available for collection by outside contractors responsible for recycling.

The workers' camp will be provided with two types of covered bins for selective collection of the various products listed above: putrescible in one, for recycling in the other. The contractor will carry out systematic awareness campaigns among residents of the camps to promote efficient use of these refuse bins.

On the construction sites, metal wastes that have not been polluted by hazardous substances (oils, acids, paints, etc.) will be collected in containers for recycling. The same applies to wood and cardboard and plastic packaging. It will be absolutely forbidden to burn plastic or lubricants.

Concrete and plaster debris that is not reused will be collected and dumped with other materials which may be usable for land filling or reclamation.

The Contractor will prepare a detailed Action Plan indicating the anticipated volumes of non-hazardous waste to be produced, the procedures for management, collection and disposal, the technical means implemented, the location and dimensions of the controlled landfill, the contact details of the companies involved in waste recycling, as well as the training programs to raise awareness among workers on this subject.

Hazardous Waste Management

Should maintenance of heavy equipment happens on site, used engine lubricants from maintenance activities or floating oily residue from oil separators will be collected in 200 litre drums with a view to recycling. The drums will be stored in a dry and covered area, surrounded by a bund the height of which will ensure retention of a volume equal to at least 110% of that of the largest container stored in the area, and equipped with an oil separation system at its outlet. The contractor will identify an acceptable solution where the waste can be burned or recycled. A register will be maintained to record all handling of used lubricants, for the purpose of monitoring wastes. Machine and plant maintenance operations will be centralised in appropriate area allowing collection of the used oils and hydraulic liquids.

Should the use of chemical substances happens on sites, the following rules shall be followed: (i) give preference to substances with low toxicity values and minimize quantities to use, (ii) used chemical substances will be stored in containers or drums in the same storage areas as used oils, as long as these substances are compatible; (iii) otherwise, they will be stored in a safe area protected from inclement weather. The possibility of reuse in situ will be evaluated; failing this, the materials will be returned to the supplier or to appropriate waste treatment installations.

9.6.2 PAC-02: HAZARDOUS SUBSTANCES MANAGEMENT

A plan for the management of chemical substances will be prepared by the Contractor, detailing the measures planned for minimising pollution risks. The program will be applicable to all project activities involving the handling, storage and use of substances catalogued as hazardous. The information set out in this programme will cover the following aspects:

- procedure for registering and monitoring any substance of a hazardous nature including in particular the drafting of a safety data sheet per substance;
- procedure for identification of alternative and less hazardous substances;
- handling and storage conditions, including details on compatibility of the substances;
- emergency procedures in case of a spill;
- condition for final treatment of residues or recycling.

Chemical substances will be stored in a locked container located on a watertight floor surrounded by a bund, capable of storing at least 110% of the volume of the largest receptacle placed there. Each storage site will be provided with a substance collection pit, absorbent products and extinguishers. Standard signs will warn of the presence of toxic substances.

The substances' safety data sheets will be available on the site and from the CC-EHSC of the contractor concerned. All chemical substances stores will be regularly inspected in order to detect any possible leakage or damage to the containers.

The largest volume of chemical substances anticipated under a project of this type may concern hydrocarbons (diesel, oil and grease). The programme will lay down the conditions to be respected for storage and refuelling of machinery.

The programme will specify the pollution control equipment to be installed by contractors at the storage sites: anti-pollution kits, extinguishers, substance description sheets, etc.

At each site, the employees in charge of handling chemical substances will be given special training relative to best practice and emergency measures in case of an incident (see PAC-03 below).

9.6.3 PAC-03: ACCIDENTAL SPILL PREPAREDNESS AND RESPONSE PLAN

An anti-pollution program will be established to define the intervention procedures in case of leaks or accidental spills of liquid hazardous substances. This programme will include a description of the organisation planned for such situations and the work stations of key people. Specific training will be given for the activities to be performed in case of emergency intervention, for all staff and workers involved in any stage of the procedure. This plan will be required even if the Project doesn't imply the necessity for handling and storage of large quantities of hazardous material.

9.6.4 PAC-04: EROSION AND SEDIMENT CONTROL

Erosion control measures will be applied to all land that is stripped or excavated, all embankments and temporary or permanent deposits of materials in order to minimise and control the resulting sediment loads before they reach surface water bodies. This protection will involve, on one hand, the implementation of methods for stabilising slopes where justified and, on the other, collection of surface water runoff. This Plan mainly concerns the new water storage and the water treatment plant to be constructed next to KhinPonChong reservoir, as significant earthworks will happen very close to the existing reservoir.

Erosion control will include methods that are incorporated into construction practices, as the provision of temporary protection of a mechanical nature (geotextile covering sheets, sediment barriers).

Drainage of the entire area of any construction operations will be provided prior to the start of any other activity. Drained water will be channelled towards one or several sedimentation basins designed following accepted best practice and sized to contain the rainwater falling in 24 hours with a return period of two years.

The contractor will present a Drainage and Erosion and Sedimentation Control Plan setting out the applicable principles and practices adopted for the Project sites concerned. For each site to be opened for construction activities, a detailed plan of the drainage system and the proposed anti-erosion measures will be prepared by the contractor and submitted to the PIC-MEHS for non-objection at least three weeks before starting works on the site. The drainage channel and sedimentation basins will be built as a priority before any other activity is carried out.

9.6.5 PAC-05: MANAGEMENT OF CAMPS

The following obligation will apply for any site sheltering workers on a 24 hrs. basis, including both permanent camps only dedicated for the residence of the workers and the temporary camps implemented on the construction sites where few workers may stay permanently (also to guard equipment and material at night).

A permanent and temporary camp management program will be prepared by each concerned contractor. The various aspects covered by such a program will include:

- choice of location for the camp, proposed organization, controlled entry;
- installations proposed for water supply and sewerage, waste management and drainage of storm water;
- equipment chosen for the sanitary facilities, collective equipment, bedrooms and dormitories;
- anticipated catering and food supply services, particularly canteens; means for monitoring the quality of foodstuffs stored and distributed in the camp;
- the policies implemented with regard to prevention of drug and alcohol abuse.

The specifications of the Tender Documents will lay down the requirements regarding water supply and sewerage. In order to eliminate the risks of development of disease vectors, rainwater drainage will be provided. The ratios to be respected in terms of sanitation (number of toilets, showers and wash-basins) will also be defined. The standards applicable to bedrooms and their furnishing and fittings will also be detailed in the Tender Documents. In particular, the minimum floor space per person, the supply of impregnated mosquito nets and mattresses, will be stipulated.

The procedures to ensure hygiene in all common facilities and in particular food hygiene procedures for storing and monitoring fresh products used by the canteens will be detailed by the contractor responsible.

In order to prevent possible abuse of drugs and alcohol, measures to raise the awareness of employees and specific control measures will be set up by the contractor responsible.

9.6.6 PAC-06: PUBLIC HEALTH MANAGEMENT PLAN

The program requirements will be described in detail in the Tender Documents and will cover the following main areas of action:

- First aid facilities established on the construction or camp site; hospital facilities available in Mawlamyine;
- emergency intervention procedures in case of an accident;
- employee surveillance measures: medical check-up on recruitment, annual medical check-up;
- regular cleaning of the sanitary facilities provided, in particular toilets and septic tanks;
- waste management and regular cleaning of refuse bins;
- systematic program to keep employees aware of good hygienic practices;
- monitoring hygiene in canteens;

9.6.7 PAC-07: MANAGEMENT OF AIR QUALITY, DUST AND NOISE

A program to limit atmospheric and noise emissions will be put in place in all areas likely to be affected by construction of the Project. Emissions of exhaust gases and fumes will be limited by appropriate maintenance of equipment and trucks, and by banning the burning of waste on the sites.

Dust caused by road traffic on unpaved surfaces will be subject to reduction measures in residential areas, by requiring the contractor to water spray the ground at regular intervals, i.e. at least two to four times per day during periods without daily rainfall. All loads of fine materials potentially causing dust to be spread during transport will be covered by a tarpaulin. In storage areas, watering will be recommended for all materials likely to generate dust. Wheels of trucks will be washed every time before leaving sites for dredging, to avoid deposition of sludge on public road and later production of dust.

Noise will be the subject of regular monitoring by the PIC-MEHS to ensure that the limits imposed for the site are respected or that the employees exposed to higher noise levels are appropriately equipped with PPE. Measures will be taken to reduce noise levels and the corresponding disturbance on the site and along the access roads: maintenance of plant and vehicles, use of soundproofed equipment, reduction of the hours of use of certain noisy activities.

The Tender Documents will define the thresholds to be respected by the contractor in terms of gas emissions, dust and noise.

9.6.8 PAC-08: MANAGEMENT OF ROAD TRAFFIC AND ACCESS

Road traffic is a prime cause of accidents during the construction phase of infrastructure projects. It is therefore essential to regulate traffic both on site and outside. This is particularly important for the present project as (i) components are located in (or close to) dense urban area and (ii) the project shall involve the transport of significant quantities of materials and equipment which may generate heavy truck traffic. Various measures will be considered and adopted by the contractors:

- Awareness raising and training of drivers of trucks on elementary traffic safety rules and on the legal risks : driving under the influence of alcohol or drugs, excess speed, monitoring of tyre condition, load stability, etc.;
- visual acuity of all recruited drivers and their ability to drive;
- provision for parking trucks not encroaching on the roadway;
- respect of speed limitations;

Access to the construction sites will be indicated by appropriate road signals.

The Tender Documents will set out all these obligations as well as the penalties that will be applied to contractors and their sub-contractors in case of infringement.

9.6.9 PAC-09: WATER QUALITY MONITORING (BY CONTRACTOR)

The contractor shall prepare a water quality monitoring plan to appreciate the performance of the environmental management implemented on the sites. This monitoring will control the quality of liquid effluents (waste water, drainage water) leaving the limits of the work site concerned and their compliance with applicable norms or standards provided in the tender Documents.

The contractor will be responsible for monitoring the quality of all discharges leaving its sites or subcontracting a competent consultant or local agency to do so. The parameters to monitor will be defined according to the type of discharge (grey water, storm water) and detailed in the Tender Documents:

Sampling sites and parameters may change in the course of construction in order to adapt to the areas of activity and the types of activity observed, some components being linear. The monitoring will be carried out on a monthly frequency.

This monitoring will be supervised by the PIC-MEHS, who will carry out control measurements at similar location points into his own water quality monitoring process (see the following section related to environmental monitoring of the sites).

Compliance monitoring will concern at least the following water quality indicators:

- organic pollution: BOD5, COD, nitrates, phosphates, coliforms, (particularly related to the camps areas);
- oils and grease, relating to drainage water from the areas used for mechanical activities, storage of hazardous substances (hydrocarbons) and wastewater from canteens;

- suspended solids in drainage water and used also as performance criteria for the dredging activities and for sedimentation basins;

9.6.10 PAC-10: PROTECTION OF CULTURAL RESOURCES

The IEE confirms that the project components are not affecting any cultural site or building. However, as some components involve significant excavation (particularly for the rehabilitation of the water supply network, the chance to find any physical cultural resource does exist.

The Tender Documents will define an emergency intervention procedure (chance to find procedure) in case a discovery is made or an interaction is observed during the works. This procedure will include aspects such as:

- immediate measures to stop work at the site concerned and mark out the area to be protected;
- information procedure involving the CC-EHSC, the PIC-MES and PMO-DES;
- approval of the measures decided by the DES;
- organization of removal of the resource (if physical);
- closure of the incident and resumption of work.

9.6.11 PAC-11: EHS TRAINING PLAN

The objective of this plan is to ensure effective implementation of the measures proposed under the EMP on the construction sites. This Plan will define the general training programs (awareness training) for the attention of all personnel and the specialized training programs intended for the employees involved in particularly sensitive activities from the environmental standpoint (management and distribution of hydrocarbons, hazardous waste management, etc.). Each new recruit must participate in the awareness-raising program within 15 days following his recruitment. Each employee in charge of sensitive activities will follow a catch-up session every 6 months.

This training will be delivered by the CC-EHSC of the main Contractors or by a specialized consultant appointed by the contractors. All personnel shall be trained. The sessions shall be recorded in a register where the names and attendance signatures of all participants will be noted.

The environmental management awareness program on the sites will cover at least the following priority subjects:

- rules for waste management within the sites;
- rules for management of hazardous substances and wastes, particularly their storage authorized exclusively in specially adapted areas;
- pollution control, in particular the response required in case of an accidental pollutant spill;
- protection of sites against fire;
- protection of sites against erosion and sedimentation;
- procedure to follow in case of discovery of a physical cultural resource;
- rules for traffic safety on public roads and within the sites;

- principles for saving energy and other resources;
- applicable penalties in case of infringement against the established rules.

Complementary training sessions will be made relating to hygiene, health and safety including:

- Hygiene and basic public health issues;
- Safety rules on-site and off-site;
- Emergency response in case of accident;
- Personal and collective protective equipment and measures;
- Safety measures in public areas;
- Electricity hazards;
- Fire control and fire protection;
- Works in elevation and scaffolding safety.

9.7 E&S Supervision during Construction

The Project Implementation Consultant (PIC), through its Manager Environment Health and Safety (MEHS) and his team, is responsible for ensuring the Contractor complies with its E&S obligations. The PIC is the one that certifies payments to the contractor and as such, he can therefore 'negotiate' the deployment by the contractor of equipment or labour initially allocated to the works in favour of specific environmental measures.

9.7.1 PAC-12: MONITORING OF CONSTRUCTION ACTIVITIES (PIC)

Contractors' compliance with their environmental and social obligations will be the subject of a specific monitoring process, coordinated by the PIC-MES. In order to ensure compliance with E&S requirements and efficient implementation of corrective measures an environmental monitoring program will be set up, including:

- E&S supervision of the contractors: Through regular site inspections the objective is to ensure that all EHS measures set out in the obligations for Contractors and in the Action Plans prepared by the Contractors are effectively and efficiently implemented;
- Environmental quality monitoring: monitoring of changes in the quality of the environment in order to evaluate the efficiency of the mitigation measures applied and, if necessary, to modify acceptability thresholds or methods;
- Environmental compliance control monitoring: ensuring that all discharges from all project sites are compliant with environmental legislation or with related specifications in the Tender Documents (under the responsibility of the Contractor, see PAC-09 above). This monitoring will also confirm or not the validity of information supplied by the CCs on a monthly basis. Analysis will be performed on a limited number of parameters indicators of pollution from construction activities.

Weekly Inspections

Weekly inspection of the different work sites will be organised by the PIC-MEHS and will be the subject of a report using a standard inspection sheet. This information sheet will cover all the environmental specifications imposed to the contractor, item by item, giving an immediate overview during each inspection, of potential situations of non-conformity.

Each environmental event (EE) will be the subject of a standard record sheet to be filled in by the observer (Inspector) and submitted to the PIC-MEHS for action. The record sheet signed by the PIC-MEHS is handed over to the CC-EHSC who then completes the document by explaining the proposed corrective measure. If the solution is acceptable, the EE is closed after checking that the corrective measure has been effectively and successfully implemented.

Coordination Meeting

Regular (weekly or semi-monthly) coordination meetings will be held between the CC-EHSCs (and their inspectors) and the PIC-MEHS (and his inspectors), during which they discuss the EE in progress, the remedial measures taken and any other subject of current concern such as the Action Plans presented by the CC-EHSCs.

9.7.2 PAC-13: AIR QUALITY AND NOISE MONITORING (PIC)

The main anticipated impact will be caused by dust near the construction sites. No significant problem is seriously anticipated with exhaust emissions, except very locally along hauling routes.

Two types of sampling monitoring are under the responsibility of the PMO:

- ad-hoc controls for dust at the boundaries of construction sites near residential areas and along hauling routes used between the dredging sites and WWTP site to be filled. Action will be taken as soon as few complaints from residents have been collected for a particular location, or where visual inspection confirms that excessive dust is being generated. The PIC-MEHS will make spot checks of noise levels on the various work sites and in certain residential areas during daytime and night, in order to check that applicable references at the boundaries of the work sites or in the surrounding residential areas are complied with.
- regular monitoring for air quality and noise carried out by an external registered laboratory on a semi-annual basis. Locations may vary according to progressive transfer of activities, particularly for the road works.

Proposed Monitoring Plan is detailed in **Table 9-3**.

Table 9-3: Environmental Monitoring for Air and Noise

REFERENCE	PARAMETERS	LOCATIONS	FREQUENCY
Ambient air quality standards: Ministry of Health	CO, SO_2, NO_x, TSP, O_3, lead dust (Pb), (PM10), (PM2.5),	3 sites WTP and storage 1 site 3 storages (rehabilitation) 2 sites (mobiles) WS network	Quarterly
Noise level standards: Ministry of Health	Day time and night time noise levels dB(A)		

For the quarterly monitoring of air quality, the PIC-MEHS will appoint a registered professional laboratory to perform the task.

All results will be checked against MONREC Environmental Quality (Emissions) Standards, 2015. Any non-compliance detected will require immediate correction from the Contractor.

9.7.3 PAC-14: SITE CLEANING AND REHABILITATION PROGRAM

By the end of the construction activities, each contractor has to decommission the sites where its activities for Project needs have been performed, which includes:

- The demolishing of all temporary structures/buildings developed for the purpose of Project construction.
- The removal from the sites of all equipment and remaining material and waste, the safe disposal or recycling of construction and demolition waste and of construction material;
- The restoration of the land in order to return it as close as possible from its initial state
- The official handover of the site to its owner, signed by parties.

In order to ensure that this Site Cleaning and Rehabilitation (SCR) operation is successfully implemented, the Contractor will be required to prepare a Site Cleaning and Rehabilitation Plan (SCRP) which provides operational methods for (i) site assessment and (ii) cleaning and rehabilitation in compliance with Contractual obligation and international good practices. The Plan will respect the following:

Cleaning Stage

- All construction materials, equipment, buildings, facilities and residual waste will be removed from all sites, except if a site specific decision modifies this principle. This decision shall be commonly agreed on by the CC and the PMO.
- All waste collected on site will be treated in compliance with the requirements of the Tender Documents Environmental Obligations and the Waste Management Plan prepared by the CC at the start of the construction, depending on the classification of the waste product considered.
- Recycling of waste will be maximized.

The Plan will be submitted to the PIC-MES not later than 1 month before the start of decommissioning and include the methods for carrying out the following activities:

- Evaluation of quantities regarding each group of materials/waste identified;
- Identification of registered companies for the recycling of materials and waste;
- Procedures for treatment and disposal of non-recycled material and waste;
- Schedule for cleaning operations;

Rehabilitation Stage

Rehabilitation will be carried out in immediate continuation or even in parallel with the cleaning stage, taking advantage of the presence of the manpower and the equipment. Consultation with concerned stakeholders will be carried out where necessary. The following principles will apply:

- Sites shall be rehabilitated in a way to restore, as much as feasible and reasonably possible, the original use of the land;
- All sites must be returned free of any buildings or infrastructures developed for the purpose of Project construction, except if specific request is made;
- All sites where structures were temporary removed (market stalls, shops, other) will be reinstalled at the end of the works, excepts if special request from the owner.
- All spoil disposal areas shall be rehabilitated according to the obligations of the Tender Documentation and the obligations of the Plan on Sediment and Spoil Management.
- Rehabilitation option will eventually be selected through consultation between CC, PIC, PMO and any private party if the land is privately owned.

After completion of SCR works, the CC will inform the PIC-MEHS regarding the final site status. After acceptance by PIC-MEHS of the site conditions MTDC/PMO will be notified. To finalize the SCR process a joint site visit with all concerned parties will be organized by the PIC-MEHS to sign SCR Completion Certificates as follows:

- For public land, the SCR Completion Certificate will be signed by PIC, PMO and by MTDC Land Services as witness;
- For private land, the SCR Completion Certificate will be signed by the land owner, CC, PIC and PMO.

9.8 Action Plan for Operation stage

The implementation of environmental monitoring is necessary from the time the works are completed and commissioned, in order to ensure impacts and mitigation measures proposed have been efficiently implemented during the construction stage and show positive results as expected.

The start of the operation stage will vary depending on the project components considered. The total project construction is anticipated to last 5 years. Due to the type of sub-components concerned, only a water quality monitoring of the resources used to supply Mawlamyine is anticipated.

9.8.1 PAE-01: WATER QUALITY MONITORING OF KHINPONCHONG RESERVOIR

Monitoring of KhinPonChong reservoir in order to ensure water quality remains stable on the long term and fully compatible for domestic water supply purpose.

Sampling will be carried out on a semi-annual basis (one sampling in wet and in dry seasons) close to water intake in KhinPonChong.

- On site measurement: Temperature, EC, dissolved oxygen, pH, turbidity;
- Physical and chemical analysis: BOD, COD, Total Suspended Solids, Total Phosphorus, Phosphate, Total Nitrogen, Nitrates, Ammonia Nitrogen, Ammonium, Sulphates, Chloride, Calcium, Magnesium, Sodium, Potassium, Alkalinity (Bicarbonate HCO_3^- and Carbonate CO_3^{2-});
- Total and faecal coliforms;

- Heavy metals (during dry season sampling only): Iron, Lead, Cadmium, Chromium, Zinc, Copper.

PMO shall appoint a certified laboratory in Myanmar to carry out the KhinPonChong monitoring program.

Exact location of sampling sites shall be determined after the completion of the detailed design. Sampling of water resource will be complemented by the daily/monthly monitoring of distributed water carried out by the operator of the WTP.

9.8.2 PAE-02: MONITORING OF TREATED WATER SUPPLY QUALITY

The Operator of the WTP shall be requested to monitor on a daily basis the safety of the water supplied to the system. Sampling shall be done at the 4,000 m^3 reservoir before water enters the network and at tap level (4 random sites every day). Parameters controlled daily include residual chlorine for all sites and coliforms for any sample measured with residual chlorine lower than 0,5 mg/l.

9.8.3 PAE-03: MONITORING OF WTP SLUDGE

The operator of the WTP shall be requested to monitor twice a year the quality of the sludge delivered to the landfill. Parameters to control include: pH, EC, N, NH_4, P_2O_5, K_2O, Ca, Mg, Al, Cu, Fe, Mn, Zn, Cd, Cu, NI, Hg, Pb, Helminth eggs, salmonella, odour.

9.8.4 PAE-04: MONITORING OF TUBEWELLS AROUND THE LANDFILL

5 monitoring tubewells to control any contamination of underground water around the landfill have been implemented at the start of the construction. These tubewells will continue to be monitored by the operator of the landfill during the operation of the landfill and even during at least 5 years after its eventual closing.

Sampling shall be organized on a semi-annual basis including the control of the following parameters: pH, EC, BOD5, COD, TDS, Chlorides, Sulphates, Phosphates, Total N, Ammonia-N, Nitrate-N, Mn, Fe, Cu, Cd, Ni.

Should the results prove that no contamination is observed, sampling on an annual basis shall be sufficient.

9.8.5 PAE-05: MONITORING OF GAS EMISSION AT LANDFILL

The owner/operator of the landfill will also be required, for health and safety concerns, to regularly monitor landfill gas (LFG). Monitoring is intended to detect unacceptable gas emissions resulting from landfill operations. Methane (CH_4) and carbon dioxide (CO_2) are the major constituents of landfill decomposition gas; other gases present in trace quantities include non-methane organic compounds (NMOCs), hydrogen sulfide (H_2S), nitrogen (N_2), hydrogen (H_2) and oxygen (O_2).

Gas will be controlled on a monthly basis the first year of operation, then reduced to quarterly control if results are below applicable limits. Any control detecting above standard value will re-activate monthly controls for at least 3 months.

the concentration and migration of methane, CO_2, H_2S, O_2 and percent lower explosive limit (%LEL, a concentration of 5% methane in the air). Hazardous conditions are not considered to be present on a landfill when methane concentrations are less than 25% of LEL in facility structures, and when the concentration of methane gas does not exceed the LEL (5% by volume) at the property boundary. Air sampling and analysis shall be carried out by a registered laboratory in Myanmar. Cost of monitoring will be supported by the owner/operator.

9.8.6 PAE-06: MONITORING DISCHARGE FROM LEACHATE TREATMENT PLANT

Monitoring of Leachate Treatment Plant discharge water quality in order to ensure water quality remains in compliance with the national emissions standards of MONREC

Sampling will be carried out on a daily basis tracking the parameters included in the standard and including the following general parameters on at least a monthly basis. In addition specific parameters related to new standards for municipal solid waste emissions will be monitored as agreed with MONREC prior to construction.

- On site measurement: Temperature, EC, dissolved oxygen, pH, turbidity;
- Physical and chemical analysis: BOD, COD, Total Suspended Solids, Total Phosphorus, Phosphate, Total Nitrogen, Nitrates, Ammonia Nitrogen, Ammonium, Sulphates, Chloride, Calcium, Magnesium, Sodium, Potassium,;
- Total and faecal coliforms;
- Heavy metals (during dry season sampling only): Iron, Lead, Cadmium, Chromium, Zinc, Copper, Mercury.

This monitoring is only reminded in this EMP as it is part of the conventional follow-up and maintenance to be carried out for this type of plant. The cost is not a part of the EMP budget.

9.9 Cost of Environmental Impact Prevention, Mitigation and Monitoring

Table 9-4 sets out the estimated budgets required for implementation of the corrective measures and monitoring activities during the 3 phases of implementation of the Third GMS Project in Mon State. The budget presented is exclusive of salaries and supporting facilities (transport, office equipment, secretarial services) for staff from PMO and PIC dedicated to environmental supervision of construction sites.

Table 9-4: Tentative Budget for EMP Implementation in Mon state

No	Corrective Measure / Action	Responsibility		Budget per Year (US$)	Duration (years)	Total
		Funding	Implement			
Program of Action Preliminary to Construction Start (PAP)						50,000
PPA-01	Appointment of PMO-DES	PMO	PMO	(1)	7	-
PPA-02	Environmental Training of PMO-DES & PMO	PMO	PISC/Consult.	15,000	-	15,000
PPA-03	Health & Safety Training of PMO-DES & PMO	PMO	PISC/Consult.	15,000	-	15,000
PPA-04	Preparation of Communication instruments	PMO	PISC	10,000	-	10,000
PPA-05	Preparation of Contractor E&S specifications	PMO	PISC	10,000	-	10,000
Program of Actions in Construction Phase (PAC)						100,000
PAC-01	Waste Management	Contractor	Contractor	(3)	5	-
PAC-02	Hazardous Substances Management	Contractor	Contractor	(3)	5	-
PAC-03	Accidental Spill Preparedness and Response	Contractor	Contractor	(3)	5	-
PAC-04	Erosion and Sediment Control	Contractor	Contractor	(3)	5	-
PAC-05	Management of Camps	Contractor	Contractor	(3)	5	-
PAC-06	Public Health Management	Contractor	Contractor	(3)	5	-
PAC-07	Management of Air Quality, Dust and Noise	Contractor	Contractor	(3)	5	-
PAC-08	Management of Road Traffic and Access	Contractor	Contractor	(3)	5	-
PAC-09	Monitoring of Water Quality (by CC)	Contractor	Contractor	(3)	5	-
PAC-10	Protection of Cultural Resources	Contractor	Contractor	(3)	5	-
PAC-11	EHS Training Plan	Contractor	Contractor	(3)	5	-
PAC-12	Monitoring of Construction Activities	PMO	PISC	(2)	5	-
PAC-13	Air Quality & Noise Monitoring (PMO)	PMO	Laboratory	10,000	5	50,000
PAC-14	Monitoring of Water Quality (by PMO)	PMO	Laboratory	10,000	5	50,000
PAC-15	Site Cleaning & Rehabilitation Program	Contractor	Contractor	(3)	5	-
PAC-16						
Operational Phase Action Programme (PAE)						75,000
PAE-01	WQ Monitoring of KhinPonChong	MTDC	Laboratory	15,000	5	75,000
PAE-02	WQ monitoring of treated water supply	MTDC	WTP Operator	(4)		-
PAE-03	Monitoring of WTP sludge	MTDC	WTP Operator	(4)		-
PAE-04	Monitoring landfill tubewells	MTDC	WTP Operator	(4)		-
PAE-05	Monitoring landfill Gas emission	MTDC	WTP Operator	(4)		-
PAE-06	Monitoring leachate treatment plant	MTDC	Landfill Operator	(4)		-
	TOTAL	-	-			225,000
	Contingencies 20%	-	-			25,000
	TOTAL	-	-			250,000

Notes: (1) Budget internal to PMO operation costs
(2) Budget is part of PIC Contract
(3) Related E&S expenses are included into construction costs of the CCs
(4) Control and Opex under routine maintenance of facility

SAFEGE Ingénieurs Conseils

10 CONCLUSIONS

The Third GMS Corridor Town Development Project focuses on the town of Mawlamyine in Mon State. The Project intends to significantly improve the environmental conditions in Mawlamyine and the quality of life of its population through the improvement of water supply and solid waste facilities.

Water supply is presently insufficient in terms of serviced areas, service duration, quantities supplied and water quality. The Project beneficial impacts are the followings:

- Improvement of the water supply efficiency by the improvement of KhinPonChong reservoir water resource mobilisation;
- Improvement of water supply security by increasing the water supply storage capacity through (i) the construction of a new 4,000 m^3 new water storage, located next to the proposed water treatment plant and (ii) the rehabilitation of the 3 existing storages of Kan Thone Kan;
- Improvement of public safety through the construction of a water treatment plant based on rapid sand filtration process with disinfection by chlorine;
- Improvement of distribution networks and extension over the whole town of Mawlamyine;
- Improvement of quality of life and reduction of public health risks related to water.

Solid waste management is a major environmental issue in Mawlamyine where only 50% of the solid wastes are collected at present. The remaining 50% are dumped all over the city where the waste either decay with unpleasant smells and proliferation of insects or is burnt by the residents with emission of unpleasant and dangerous smokes as materials like plastics are also burnt. The collected waste is disposed in a large dumping site where it is regularly burnt in dry season and from where untreated leachates are discharged into the surface water bodies. Large quantities of waste are dumped into the storm drainage networks, clogging the drains and creating localised flooding during the rainy season.

The solid waste component beneficial impacts include:

- Improvement of quality of life and public health by (i) increasing the collection rate of solid waste in the city and (ii) improving collection points facilities;
- Improvement of storm drainage efficiency by reducing the amount of waste dumped in the drains and clogging the system;
- Reduction of water pollution load by improved collection rate and construction of a sanitary landfill with leachate collection and treatment;
- Reduction of air emissions and particularly GHG through (i) construction of a composting plant on the landfill site and (ii) collection of landfill gas and flaring;
- Improvement of waste recycling efficiency resulting in secondary beneficial environmental impacts through significant avoidance of GHG emission;
- Reduction of public health risk particularly among the population of waste pickers through the construction of an incinerator facility for the treatment of medical waste from the several hospitals and clinics and presently disposed in the dumping site without any precautionary measure.

Cultural heritage in Mawlamyine is mainly represented by buildings dated from the British era, and for most of them, in very poor conditions. The project intends to stimulate the rehabilitation of such buildings with the objectives to

- improve the general urban landscape and city beautification;
- stimulate the returns from the development of tourism;

The proposed acquisition of private land (3.7 acres or 1.5 ha) to build the future sanitary landfill near MuYong Village in Kyaikmayaw is only involving agricultural land. Then it will affect no household.

The only affected households are the waste pickers living in the existing dump site area that will be closed. Details regarding their affectation are available in resettlement plan report.

Except these 1.5 ha, the Project components do not require land acquisition as all new components are developed on MTDC or Mon Government land and others rehabilitated are in public areas (water supply networks).

None of the Project components involves significant forest clearing or encroachment into wetland or other conservation area.

The project will support innovation with the construction of the first composting plant in Myanmar, attached to the landfill and will equip the proposed new landfill with a system of gas collection and flaring. When compared with the situation without project, the solid waste component of the Third GMS in Mon State shall reduce the annual emissions of GHG from generated waste by more than 42,000 t CO_2-eq/year in 2020 and even by 132,000 t CO_2-eq/year in 2040 when compared to a situation without Project. From 2016 to 2040, the reduction of cumulated GHG emissions shall be reduced by more than 2 million tons CO_2-eq.

The IEE also considered climatic trends at the national, regional and local scale in Myanmar and more specifically in Mawlamyine for which long term climatological data is available. Both temperature and rainfall show increasing trends in Mawlamyine along the last 50 years of observations, in line with MONREC trend analysis for Mon State. Annual rainfall increased by 500 mm over a 50 years period, or a raise of about 100 mm/decade. The month of July shows the highest raise during the 50 years period, about 300 mm, followed by May with 120 mm. Other months are almost stable or show only slight increase.

Temperature also increased over the same period. The average annual maximum temperature rose by 1.1°C over the last 48 years, or an increase of about 0.23°C per decade, a value significantly higher than what is considered in the Mon State (0.14°C increase per decade). July and November are the months showing the highest raise over the period, about 2°C. According to IPCC, sea level rise could reach 0.82 m by the end of the century. The present project considers a safety over-elevation of 1 meter as a design criteria for concerned project components, to avoid long term flooding risk.

The results of AWARE were considered in the preparation of the IEE Report. In this connection, climate change and natural hazards considerations had been incorporated in the IEE. AWARE was used by ADB to undertake an initial climate risk screening exercise. The results had rated the project as MEDIUM RISK and have identified flooding and landslide as a high level risk factor as the project is located in a region which has experienced recurring flood events in the recent past. However, the effective risk level is dependent on local geographical factors. On this basis, due to the location of Mawlamyine in a flat or smoothly undulating area, the risk for landslide may be considered as low. Mawlamyine experiences infrequent flooding mainly localized next to the Thanlwin River which may affect the strand road, but hardly more of the urban area as the elevation raises quickly by several meters. None of the Project sub-component is localized in flood prone area. The WTP, located next to the KhinPonChong reservoir is designed to be higher than the maximum elevation of water in the reservoir. The Project components shall not be affected or put at risk by climate change.

A screening carried out during the Interim phase of the Project confirmed that environmental impacts raised by the project were either very beneficial or mainly related (i) to the risks of nuisances during the construction phase but easily controllable by appropriate construction site supervision and conventional mitigation measures and (ii) during operation to typical risks in relation to WTP and landfill management but also easily avoidable considering the simple technology applied and the small size of the projects. Consequently, the proposed categorisation of the Project was B, involving the preparation of the present IEE. The conclusions of the present report confirm this initial categorization as category B Project.

Aside from the several and undisputable beneficial impacts of the Project in Mawlamyine, some potential risks of limited importance are still to be considered should the management program anticipated be deficient:

- Most of the anticipated environmental and social impacts are related to nuisances which may happen during the construction activities. Because of the project located in an urban environment, risk of nuisances is higher: traffic congestion, temporary alienation of access, temporary disruption of community facilities, noise and engine gas and dust release may temporarily disturb the nearby communities. However, recommendations formulated in the present EMP combined with a solid environmental contractual framework and an effective inspection and supervision of construction sites will definitely reduce these risks to acceptable levels.
- Impacts related to water treatment plant operation (pollution from sludge, contamination of water resource) can be easily avoided by appropriate management measures already discussed in the IEE. Monitoring of KinPonChong and of treated water is considered to ensure compliance.
- Impacts related to landfill operation (gas emission and pollution by leachate) are unlikely to occur as design already consider gas collection and flaring and leachate collection and treatment. Monitoring of gas emission, leachate and adjacent underground water table is considered to ensure compliance.

The EMP also emphasizes the low level of consideration for occupational health and safety (OHS) in Myanmar but also in Mawlamyine nowadays. Construction sites generally ignore safety signals, personal or collective protections for workers, safety belts, EHS awareness training, public safety measures for activities in populated areas etc. This situation is not compliant with the EHS requirements of international lending organisations as the ADB. For that reason, the EMP emphasises (i) the need for EHS capacity building for MSG, MTDC, the PMO and the PIU staff, (ii) the need for very strict and detailed EHS specifications for the tender documents and (iii) the need for strict EHS enforcement through monitoring of construction activities.

11 APPENDICES

Appendix 1 Bibliography

Chingmai University. (n.d.). *Overview of Mawlamyine's General Condition and Sample Selection.*

Hadden, R. L. (2008). *The Geology of Burma (Myanmar): An Annotated Bibliography of Burma's Geology, Geography and Earth Science.* Virginia: Topographic Engineering Center.

Istituo Oikos and BANCA. (2011). *Myanmar Protected Areas: Context, Current Status and Challenges.* Milano, Italy.

Ministry of Border Affairs , & Japan International Cooperation Agency. (2013). *Preparatory survey for the integrated regional development for ethnic minorities in the South-East Myanmar.*

Ministry of Environmental Conseration and Forestry. (2012). *Myanmar's Initial National Communication under the United Nations Framework Convention on Climate Change.* Naypyitaw.

Ministry of Immigration and Population. (2015). *The 2014 Myanmar Population and Housing Census, Mon State Report.* Naypyitaw.

Myanmar Information Management Unit. (2014). *Mon State Profile.* UNHCR South-East Myanmar Information Management Unit.

Than, M. M., Tun, T., & Htay, T. T. (2014). *Species composition of some fish from downshtream area of Thanlwin river.* Department of Zoology. University of Mawlamyine.

Fund, W. (2014). Myanmar Coast mangroves. Retrieved from http://www.eoearth.org/view/article/154737

Appendix 2 PC Participant List

DATE	NAME	DESIGNATION	ORGANIZATION
30 April 2015	i. Daw Mai Aster ii. U TunTunOo iii. U Win TUn	i. Deputy Director, ii. Staff Officer iii. Deputy Staff Officer	Environmental Conservation Department, Mon State, Ministry of Environmental Conservation and Forestry.
30 April 2015	i. U TheinHtwe	i. Deputy Director	Forest Department, Mawlamyine District, Ministry of Environmental Conservation and Forestry.
20 July 2015	i. U AungKo ii. Daw SoeSoeLwin	i. Deputy Director ii. Staff Officer	Meteorological Department, Mon State
22 July 2015	i. Dr. San TharTun	i. Professor	Marine Science Department, University of Mawlamyine
23 July 2015	Not Known	Representatives of General Administrative Offices, Members of Townships Development Committee	Mon State Hluttaw
	iv. Daw Mai Aster v. U TunTunOo vi. Daw ThidaNyein vii. Daw Tin New Ye	iv. Deputy Director, v. Staff Officer vi. Deputy Staff Officer vii. Deputy Staff Officer	Environmental Conservation Department, Mon State, Ministry of Environmental Conservation and Forestry.
28 Sept 2015	Yee Yee Mon	Project Manager	National Enlightenment Institute Auk Kyin Ward
28 Sept 2015	U ThaungHteik	Ward Administrator	Auk Kyin Ward
28 Sept 2015	U MyoNaing	Ward Administrator	TharYar Aye Ward
29 Sept 2015	MiKon Chan Non	Director	Mon Women's Organization
29 Sept 2015	U Min Win Bo	Regional Manager	Local Resource Center

Photos of the public consultations

MEETING AT THE ENVIRONMENTAL CONSERVATION DEPARTMENT, MON STATE.

GROUP DISCUSSION AT THE MON STATE HLUTAW ON 23 JULY 2015

DISCUSSION AT THE NATIONAL ENLIGHTENMENT INSTITEUTE ON 28 SEPTEMBER 2015

GROUP DISCUSSION AT THE MON STATE HLUTAW ON 23 JULY 2015

Appendix 3 REA Checklists

Urban Development

Screening Questions	Yes	No	Remarks
A. Project Siting Is the project area…			-
▪ Densely populated?		X	The proposed facilities (WS storage, pumping station, WTP and landfill) are located in non-populated areas.
▪ Heavy with development activities?		X	-
▪ Adjacent to or within any environmentally sensitive areas?		X	-
• Cultural heritage site	X		One proposed site for WTP for Kinponchone Dam is located close to the house of Rookamanund (Donor of KinponchoneDamBothKinponchone Dam and Three Tank Reservoirs were built in 1904. Appropriate measures have been included in the project design and in the EMP to avoid any negative impact on this heritage site.
• Protected Area		X	-
• Wetland		X	-
• Mangrove		X	-
• Estuarine		X	-
• Buffer zone of protected area		X	-
• Special area for protecting biodiversity		X	-
• Bay		X	-
B. Potential Environmental Impacts Will the Project cause…			-
▪ impacts on the sustainability of associated sanitation and solid waste disposal systems and their interactions with other urban services.		X	-
▪ deterioration of surrounding environmental conditions due to rapid urban population growth, commercial and industrial activity, and increased waste generation to the point that both manmade and natural systems are overloaded and the capacities to manage these systems are overwhelmed?		X	-
▪ degradation of land and ecosystems (e.g. loss of wetlands and wild lands, coastal zones, watersheds and forests)?		X	-

Screening Questions	Yes	No	Remarks
▪ dislocation or involuntary resettlement of people?		X	Not anticipated (no building destruction) but agricultural land or vacant land acquisition possible (but limited in size) for WWTP and composting plant
▪ disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable group?		X	-
▪ degradation of cultural property, and loss of cultural heritage and tourism revenues?		X	Presence of cultural physical resources (building, pagodas, temples) considered in project design and not affected
▪ occupation of low-lying lands, floodplains and steep hillsides by squatters and low-income groups, and their exposure to increased health hazards and risks due to pollutive industries?		X	-
▪ water resource problems (e.g. depletion/degradation of available water supply, deterioration for surface and ground water quality , and pollution of receiving waters?		X	Objective of project is improvement of water supply.
▪ air pollution due to urban emissions?		X	-
▪ risks and vulnerabilities related to occupational health and safety due to physical, chemical and biological hazards during project construction and operation?		X	OHS Plan to regulate safety procedures for workers and the use of PPE as a typical practice worldwide in similar construction activities
▪ road blocking and temporary flooding due to land excavation during rainy season?		X	Not anticipated. The EMP which hasbeen provided in the report will address obligations for contractors during construction
▪ noise and dust from construction activities?	X		Some noise and possibly dust nuisance anticipated but kept compliant with acceptable standards and mitigable through contractor specifications and construction monitoring. Appropriate measures have been included in the EMP to address the issues.
▪ traffic disturbances due to construction material transport and wastes?		X	Not anticipated from construction material transport because the requirements will be limited and spread over the city
▪ temporary silt runoff due to construction?	X		For new facilities (pumping station, WTP, new water supply networks, solid waste composting plant), the construction sites will be well mitigated with sediment control facilities and procedures, particularly for the activities located next or even in the river (new pumping station)
▪ hazards to public health due to ambient, household and occupational pollution, thermal inversion, and smog formation?		X	Appropriate measures have been included in the EMP to avoid any negative impact on the ambient air quality and health of workers and residents.
▪ water depletion and/or degradation?		X	Project objective is to reduce water leakages along network, (thus increasing supply without increasing pressure on resource) and to reduce pollution of surface and underground water
▪ overpumping of ground water, leading to land subsidence, lowered ground water table, and salinization?		X	Appropriate measures have been included in the EMP to avoid any negative impact on the underground water when it is implemented

SAFEGE
Ingénieurs Conseils

Screening Questions	Yes	No	Remarks
▪ contamination of surface and ground waters due to improper waste disposal?		X	Objective of project is to improve waste collection and disposal and to reduce contamination of water bodies
▪ pollution of receiving waters resulting in amenity losses, fisheries and marine resource depletion, and health problems?		X	-
▪ large population influx during project construction and operation that causes increased burden on social infrastructure and services (such as water supply and sanitation systems)?		X	Local workforce to be used for construction. Construction sites will be of small size. No in-migration anticipated
▪ social conflicts if workers from other regions or countries are hired?		X	See above
▪ risks to community health and safety due to the transport, storage, and use and/or disposal of materials such as explosives, fuel and other chemicals during operation and construction?		X	No storage of hazardous materials is anticipated during construction or operation of the facilities, particularly fuel available in several petrol stations. Water disinfection will rely on electrolysis of salt (no chlorine gas)
▪ community safety risks due to both accidental and natural hazards, especially where the structural elements or components of the project are accessible to members of the affected community or where their failure could result in injury to the community throughout project construction, operation and decommissioning?		X	Appropriate measures have been included in the EMP to avoid any negative impact

A Checklist for Preliminary Climate Risk Screening

Screening Questions		Score	Remarks[7]
Location and Design of project	Is siting and/or routing of the project (or its components) likely to be affected by climate conditions including extreme weather related events such as floods, droughts, storms, landslides?	0	Not anticipated.
	Would the project design (e.g. the clearance for bridges) need to consider any hydro-meteorological parameters (e.g., sea-level, peak river flow, reliable water level, peak wind speed etc)?	1	Obviously, the design of components dealing with river water level or drainage will integrate trends and forecasts for rainfall and river level related to climate change
Materials and Maintenance	Would weather, current and likely future climate conditions (e.g. prevailing humidity level, temperature contrast between hot summer days and cold winter days, exposure to wind and humidity hydro-meteorological parameters likely affect the selection of project inputs over the life of project outputs (e.g. construction material)?	0	Anticipated changes in rainfall and temperature are unlikely to affect project inputs or outputs.
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s) ?	0	Anticipated changes in rainfall and temperature are unlikely to affect negatively project maintenance and output
Performance of project outputs	Would weather/climate conditions and related extreme events likely affect the performance (e.g. annual power production) of project output(s) (e.g. hydro-power generation facilities) throughout their design life time?	0	No impact

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1

[7] If possible, provide details on the sensitivity of project components to climate conditions, such as how climate parameters are considered in design standards for infrastructure components, how changes in key climate parameters and sea level might affect the siting/routing of project, the selection of construction material and/or scheduling, performances and/or the maintenance cost/scheduling of project outputs.

Very Likely	2

Responses when added that provide a score of 0 will be considered low risk project. If adding all responses will result to a score of 1-4 and that no score of 2 was given to any single response, the project will be assigned a medium risk category. A total score of 5 or more (which include providing a score of 1 in all responses) or a 2 in any single response, will be categorized as high risk project.

Result of Initial Screening (Low, Medium, High): Low (1)

Other Comments:____
_

Water Supply

Screening Questions	Yes	No	Remarks
A. Project Siting Is the project area…			-
▪ Densely populated?	X		Except water storage extension which is in a non-populated area other WS components are in urban area
▪ Heavy with development activities?		X	-
▪ Adjacent to or within any environmentally sensitive areas?			-
• Cultural heritage site	X		The KinPonChong and the Three Tanks reservoirs in Mawlamyine were built in 1904.Strict construction specifications for the contractor to preserve the original structures of the reservoirs and cultural heritage buildings when improving them.
• Protected Area		X	-
• Wetland		X	-
• Mangrove		X	-
• Estuarine		X	-
• Buffer zone of protected area		X	-
• Special area for protecting biodiversity		X	-
• Bay		X	-
B. Potential Environmental Impacts Will the Project cause…			-
▪ pollution of raw water supply from upstream wastewater discharge from communities, industries, agriculture, and soil erosion runoff? 1.		X	-
▪ impairment of historical/cultural monuments/areas and loss/damage to these sites?		X	-

Screening Questions	Yes	No	Remarks
▪ hazard of land subsidence caused by excessive ground water pumping?		X	-
▪ social conflicts arising from displacement of communities ?		X	-
▪ conflicts in abstraction of raw water for water supply with other beneficial water uses for surface and ground waters?		X	-
▪ unsatisfactory raw water supply (e.g. excessive pathogens or mineral constituents)?		X	-
▪ delivery of unsafe water to distribution system?		X	-
▪ inadequate protection of intake works or wells, leading to pollution of water supply?		X	-
▪ over pumping of ground water, leading to salinization and ground subsidence?		X	-
▪ excessive algal growth in storage reservoir?		X	-
▪ increase in production of sewage beyond capabilities of community facilities?		X	-
▪ inadequate disposal of sludge from water treatment plants?		X	Issue of sludge management has been clearly addressed in the design.
▪ inadequate buffer zone around pumping and treatment plants to alleviate noise and other possible nuisances and protect facilities?		X	-
▪ impairments associated with transmission lines and access roads?		X	Except very temporary and localized during extension of network
▪ health hazards arising from inadequate design of facilities for receiving, storing, and handling of chlorine and other hazardous chemicals.		X	Treatment relies on salt hydrolysis, no chlorine
▪ health and safety hazards to workers from handling and management of chlorine used for disinfection, other contaminants, and biological and physical hazards during project construction and operation?		X	Treatment relies on salt hydrolysis, no chlorine
▪ dislocation or involuntary resettlement of people?		X	
▪ disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable groups?		X	-
▪ noise and dust from construction activities?	X		Typical nuisances from construction activities, controllable through detailed specifications for contractors. Appropriate measures have been included in the EMP to address the issues.
▪ increased road traffic due to interference of construction activities?		X	Localized temporary increase of traffic during network extension works, but preventive measures considered

Screening Questions	Yes	No	Remarks
▪ continuing soil erosion/silt runoff from construction operations?		X	-
▪ delivery of unsafe water due to poor O&M treatment processes (especially mud accumulations in filters) and inadequate chlorination due to lack of adequate monitoring of chlorine residuals in distribution systems?		X	O&M shall be addressed in the design preparation
▪ delivery of water to distribution system, which is corrosive due to inadequate attention to feeding of corrective chemicals?		X	-
▪ accidental leakage of chlorine gas?		X	-
▪ excessive abstraction of water affecting downstream water users?		X	-
▪ competing uses of water?		X	The project will increase potable water availability and network and will not compete with other water uses. Water is abundant in the area
▪ increased sewage flow due to increased water supply		X	-
▪ increased volume of sullage (wastewater from cooking and washing) and sludge from wastewater treatment plant		X	-
▪ large population influx during project construction and operation that causes increased burden on social infrastructure and services (such as water supply and sanitation systems)?		X	Local workers to be recruited and construction sites of moderate size
▪ social conflicts if workers from other regions or countries are hired?		X	Same as above
▪ risks to community health and safety due to the transport, storage, and use and/or disposal of materials such as explosives, fuel and other chemicals during operation and construction?		X	No storage of hazardous materials is anticipated during construction or operation
▪ community safety risks due to both accidental and natural hazards, especially where the structural elements or components of the project are accessible to members of the affected community or where their failure could result in injury to the community throughout project construction, operation and decommissioning?		X	

A Checklist for Preliminary Climate Risk Screening

Screening Questions		Score	Remarks[8]
Location and Design of project	Is siting and/or routing of the project (or its components) likely to be affected by climate conditions including extreme weather related events such as floods, droughts, storms, landslides?	0	No effect on project components siting and routing
	Would the project design (e.g. the clearance for bridges) need to consider any hydro-meteorological parameters (e.g., sea-level, peak river flow, reliable water level, peak wind speed etc)?	0	The design will obviously consider potential climate change issues but this aspect is not critical for the present project
Materials and Maintenance	Would weather, current and likely future climate conditions (e.g. prevailing humidity level, temperature contrast between hot summer days and cold winter days, exposure to wind and humidity hydro-meteorological parameters likely affect the selection of project inputs over the life of project outputs (e.g. construction material)?	0	Unlikely to affect the project inputs and outputs
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s) ?	0	Unlikely to affect the project maintenance
Performance of project outputs	Would weather/climate conditions, and related extreme events likely affect the performance (e.g. annual power production) of project output(s) (e.g. hydro-power generation facilities) throughout their design life time?	1	Changing climateconditions and thelikelihood of futuredams along theThanlwin (andperhaps Attran)Rivers may increase salinity intrusion intotube wells and affectwater intake points inMawlamyine,especially duringdry seasons.

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

Responses when added that provide a score of 0 will be considered low risk project. If adding all responses will result to a score of 1-4 and that no score of 2 was given to any single response, the project will be assigned a medium risk category. A total score of 5 or more (which include providing a score of 1 in all responses) or a 2 in any single response, will be categorized as high risk project.

Result of Initial Screening (Low, Medium, High):_ Low (1)__________

[8] If possible, provide details on the sensitivity of project components to climate conditions, such as how climate parameters are considered in design standards for infrastructure components, how changes in key climate parameters and sea level might affect the siting/routing of project, the selection of construction material and/or scheduling, performances and/or the maintenance cost/scheduling of project outputs.

: **Solid waste**

Screening Questions	Yes	No	Remarks
A. Project Siting Is the project area…			
▪ Densely populated?		X	-
▪ Heavy with development activities?		X	-
▪ Adjacent to or within any environmentally sensitive areas?		X	-
• Cultural heritage site		X	Appropriate measures have been included in the EMP to avoid any negative impact on the heritage sites.
• Protected Area		X	Appropriate measures have been included in the EMP to avoid any negative impacts.
• Wetland		X	Not anticipated
• Mangrove		X	Not anticipated
• Estuarine		X	Not anticipated
• Buffer zone of protected area		X	Not anticipated
• Special area for protecting biodiversity		X	Not anticipated
• Bay		X	Not anticipated
B. Potential Environmental Impacts Will the Project cause…			
▪ impacts associated with transport of wastes to the disposal site or treatment facility 2.		X	Not anticipated
▪ impairment of historical/cultural monuments/areas and loss/damage to these sites?		X	No historical/cultural impact anticipated. Appropriate measures have been included in the EMP
▪ degradation of aesthetic and property value loss?		X	Not anticipated
▪ nuisance to neighboring areas due to foul odor and influx of insects, rodents, etc.?		X	Unlikely under regular operation and maintenance of composting plants.
▪ dislocation or involuntary resettlement of people?		X	Not anticipated
▪ disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable groups?		X	Not anticipated
▪ risks and vulnerabilities related occupational health and safety due to physical, chemical, biological, and radiological hazards during project construction and operation?		X	Not anticipated
▪ public health hazards from odor, smoke from fire, and diseases transmitted by flies, insects, birds and rats?		X	Not anticipated
▪ deterioration of water quality as a result of contamination of receiving waters by leachate from land disposal system?		X	Not anticipated

Screening Questions	Yes	No	Remarks
▪ contamination of ground and/or surface water by leachate from land disposal system?		X	Appropriate measures have been included in the EMP to avoid any negative impact due to the leachate
▪ land use conflicts?		X	Not anticipated
▪ pollution of surface and ground water from leach ate coming form sanitary landfill sites or methane gas produced from decomposition of solid wastes in the absence of air, which could enter the aquifer or escape through soil fissures at places far from the landfill site?		X	Appropriate measures have been included in the EMP to avoid any negative impact due to the leachate and gas
▪ inadequate buffer zone around landfill site to alleviate nuisances?		X	No residence in immediate vicinity of landfill
▪ road blocking and/or increased traffic during construction of facilities?		X	Not anticipated as area is remote from dense urban areas
▪ noise and dust from construction activities?		X	Possible construction noise, but not in populated areas.
▪ temporary silt runoff due to construction?	X		Possible during excavation works of extension of landfill site. Obligations for contractors of peripheral drainage of construction zones and sediments capture facilities (sediment traps, ponds) . Appropriate measures have been included in the EMP to address the issues.
▪ hazards to public health due to inadequate management of landfill site caused by inadequate institutional and financial capabilities for the management of the landfill operation?		X	No hazards as no residential zones next to the landfill
▪ emission of potentially toxic volatile organics from land disposal site?		X	Composting plants will have appropriate air filtration facilities
▪ surface and ground water pollution from leachate and methane gas migration?		X	Design will prevent this risk
▪ loss of deep-rooted vegetation (e.g. trees) from landfill gas?		X	Probably marginal (non-forested area)
▪ explosion of toxic response from accumulated landfill gas in buildings?		X	Not anticipated
▪ contamination of air quality from incineration?		X	The incineration plant will have appropriate filtration and will be well designed to prevent incomplete combustion
▪ public health hazards from odor, smoke from fire, and diseases transmitted by flies, rodents, insects and birds, etc.?		X	No hazards as no residential zones next to the landfill sites
▪ health and safety hazards to workers from toxic gases and hazardous materials in the site?		X	Typical OHS Plan to be developed and implemented with capacity building and regular health checks
▪ large population influx during project construction and operation that causes increased burden on social infrastructure and services (such as water supply and sanitation systems)?		X	Local workforce for construction

Screening Questions	Yes	No	Remarks
▪ social conflicts if workers from other regions or countries are hired?		X	Local workforce for construction
▪ risks to community health and safety due to the transport, storage, and use and/or disposal of materials such as explosives, fuel and other chemicals during construction and operation?		X	No significant storage of Hazardous Materials required for this type of construction During operation, site not anticipated to accommodate hazardous waste
▪ community safety risks due to both accidental and natural hazards, especially where the structural elements or components (e.g., landfill or incinerator) of the project are accessible to members of the affected community or where their failure could result in injury to the community throughout project construction, operation and decommissioning?		X	Not anticipated

A Checklist for Preliminary Climate Risk Screening

Screening Questions		Score	Remarks[9]
Location and Design of project	Is siting and/or routing of the project (or its components) likely to be affected by climate conditions including extreme weather related events such as floods, droughts, storms, landslides?	0	Appropriate drainage and protection against rainfall is part of the design
	Would the project design (e.g. the clearance for bridges) need to consider any hydro-meteorological parameters (e.g., sea-level, peak river flow, reliable water level, peak wind speed etc)?	0	Site is not in a floodable zone or next to river course
Materials and Maintenance	Would weather, current and likely future climate conditions (e.g. prevailing humidity level, temperature contrast between hot summer days and cold winter days, exposure to wind and humidity hydro-meteorological parameters likely affect the selection of project inputs over the life of project outputs (e.g. construction material)?	0	Design takes consideration of projected temperature due to CC and define treatment process accordingly
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s) ?	0	No
Performance of project outputs	Would weather/climate conditions, and related extreme events likely affect the performance (e.g. annual power production) of project output(s) (e.g. hydro-power generation facilities) throughout their design life time?	0	No in a significant manner for a landfill and composting facility.

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

Responses when added that provide a score of 0 will be considered low risk project. If adding all responses will result to a score of 1-4 and that no score of 2 was given to any single response, the project will be assigned a medium risk category. A total score of 5 or more (which include providing a score of 1 in all responses) or a 2 in any single response, will be categorized as high risk project.

Result of Initial Screening (Low, Medium, High):_Low (0)__________

Other Comments: Methane gas collection significantly reduces GHG emissions from waste

[9] If possible, provide details on the sensitivity of project components to climate conditions, such as how climate parameters are considered in design standards for infrastructure components, how changes in key climate parameters and sea level might affect the siting/routing of project, the selection of construction material and/or scheduling, performances and/or the maintenance cost/scheduling of project outputs.

Appendix 4 ADB Monitoring Template

TEMPLATE/FORMAT

Safeguard Monitoring Report

Summary:

(to be included as part of the *main* Report)

- **Summary of EMP/RP Implementation**
- **Description of monitoring activities** carried out (e.g. field visits, survey questionnaire, public consultation meetings, focus group discussions, etc)
- **Key issues**, any **corrective actions** already taken, and any **grievances**
- Recommendations

Safeguards Monitoring Report

(to be included in the annex/appendix of the *main* Report)

1. Introduction and Project Overview

Project Number and Title:	
Safeguards Category	Environment Indigenous Peoples Involuntary Resettlement
Reporting period:	
Last report date:	
Key sub-project activities since last report:	This section can include, among others, the following: • Activities of Proponent • Progress of Work (% physical completion) • Changes of Surrounding Environment • Status of Permits / Consents
Report prepared by:	

2. Environmental Performance Monitoring

a. Summary of Compliance with EMAP Requirements (Environmental Performance)

EMAP Requirements	Compliance Status (Yes, No, Partial)	Comment or Reasons for Non-Compliance	Issues for Further Action
Use environmental impact as main heading and EMAP as listing (see example below)	Use EMoP list as basis for rating/evaluating compliance (see example below)		
Rise of employment opportunities: • Job openings of the project should give priority to local communities. • Recruitment of local laborers should be stipulated in the contract for construction	• Field inspections and interviews with communities - DONE • Note each complaint case in the field – 3 COMPLAINTS RECEIVED • Set up grievance centre and report as part of monitoring action plan – NOT DONE		

b. Issues for Further Action

Issue	Required Action	Responsibility and Timing	Resolution
Old Issues from Previous Reports			
List of EMoP measures or activities not completed (last column of previous table)			

New Issues from This Report

c. Other activities

- Other issues not covered by EMAP/EMoP
- Environmental monitoring as required by GOI (e.g., air quality, water sampling)

3. Involuntary Resettlement Performance Monitoring

a. Summary of Compliance with RP Requirements

RP Requirements	Compliance status Yes/No/Partial	Comment or Reasons for Compliance, Partial Compliance/Non-Compliance	Issues for Further Action[10]
Establishment of personnel in PMU/PIU			
Public consultation and socialization process		Provide information on: • Public consultation, participation activities carried out • Inclusive dates of these activities To be elaborated on in Item 5	

[10] To be elaborated further in table 3.b (Issues for Further Action)

Land area to be acquired is identified and finalised	
Land acquisition completed	
Establishment of Resettlement Site(s)	Please state: • Number of AHs to be relocated as per agreed RP • Number of AHs already relocated • Number of houses built • Status of installation of community facilities to be provided as per agreed RP
Compensation payments for affected assets is completed	Please state: • Total Number of Eligible AHs and APs (as per agreed RP) • Number of AHs and APs compensated as of this monitoring period • Total Budget allocation as per agreed RP • Total budget disbursed to AHs as of this monitoring period
Transport assistance for relocating affected households	As above
Additional assistance to vulnerable affected household	Please state: • Total Number of vulnerable AHs and APs (as per agreed RP) • Agreed forms of assistance as per RP • Number of AHs and APs assisted as of this monitoring period

Income Restoration Program	Please state progress per income restoration feature/activity and actual period of implementation
Temporary impacts have been addressed (affected properties restored to at least pre-project conditions)	Please state: • Total Number of AHs affected by temporary impacts as per agreed RP • Actual Number of AHs and total area affected by temporary impacts (if this differs from the projected number, such as in cases of unforeseen project impacts) • Status of restoring affected property
Capacity building activities	

b. Issues for Further Action

Issue	Required Action	Responsibility and Timing	Resolution
Old Issues from Previous Reports			
List of RP activities not completed (last column of previous table)			
New Issues from This Report			

4. Occupational, Health and Safety (OHS) Performance Monitoring

a. OHS for worker

Issue	Required Action	Responsibility and Timing	Resolution
Old Issues from Previous Reports			
New Issues from This Report			

b. Public Safety

Issue	Required Action	Responsibility and Timing	Resolution
Old Issues from Previous Reports			
New Issues from This Report			

5. Information Disclosure and Socialization including Capability Building

- Field Visits (sites visited, dates, persons met)
- Public Consultations and meetings (Date; time; location; agenda; number of participants disaggregated by sex and ethnic group, not including project staff; Issues raised by participants and how these were addressed by the project team)
- Training (Nature of training, number of participants disaggregated by gender and ethnicity, date, location, etc.)
- Press/Media Releases
- Material development/production (e.g., brochure, leaflet, posters)

6. Grievance Redress Mechanism

Summary:

- Number of new grievances, if any, since last monitoring period: ____
- Number of grievances resolved: _____
- Number of outstanding grievances: _____

Type of Grievance	Details (Date, person, address, contact details, etc.)	Required Action, Responsibility and Timing	Resolution
Old Issues from Previous Reports			
New Issues from This Report			

7. Conclusion

- Important results from the implementation of EMAP/EMoP and RP monitoring
- Recommendations to improve EMAP/EMoP and RP management, implementation, and monitoring

8. Attachments

- Consents / permits
- Monitoring data (water quality, air quality, etc.)

- Photographs
- Maps

Appendix 5 Myanmar EQEG (2nd draft)

The Ministry of Natural Resources and Environmental Conservation (MONREC), in exercise of the power conferred by sub-section (b) of section 42 of the 2012 Environmental Conservation Law (ECL), hereby issues the following Guidelines.

CHAPTER I
General Provisions

Objective

1. These national Environmental Quality (Emission) Guidelines (hereafter referred to as Guidelines) provide the basis for regulation and control of noise and vibration, air emissions, and effluent discharges—as provided for in sub-sections (e–g) of section 10 of the Environmental Conservation Law —from various sources in order to prevent pollution for purposes of protection of human and ecosystem health.

Definitions

2. The expressions contained in these Guidelines shall have the same meanings as are assigned to them under the ECL and Environmental Impact Assessment (EIA) Procedure. In addition thereto, the following expressions shall have the meanings given hereunder:

   (a) **Adverse impact** means any adverse environmental, social, socioeconomic, health, occupational safety or human health effect suffered or borne by any entity, natural person, or natural resource, including, but not limited to, the environment, flora and fauna, where such effect is attributable in any degree or extent to, or arises in any manner from, any action or omission on the part of the project proponent, or from the design, exploration, testing, development, construction, implementation, maintenance, operation, or decommissioning of a project or any activities related thereto.

   (b) **Concentration** means the quantity of a harmful substance in air or water with the dimension of mass per volume (or sometimes mass per mass) calculated according to a common measurement unit (e.g. milligram per liter).

   (c) **EIA Report** means a report comprising a systematic assessment of a proposed activity or project that is prepared to aid in determining whether such activity or project has the potential to significantly affect the environment, humans or other living things, and in deciding whether such activity or project should be allowed or not. The form, content and structure of the report shall be in accordance with the Ministry's requirements and guidelines, and include an Environmental Management Plan (EMP).

   (d) **Emission** means the direct or indirect release of any substance, radiation, vibration, heat or noise from individual or diffuse sources into the air, water, land or any subterranean area. Emissions include emissions of solid waste, effluent, gas, noise, odor, light, radiation, vibration or heat.

(e) **Environmental compliance certificate (ECC)** is a legal document through which the Ministry approves an Initial Environmental Examination (IEE) report or an EIA report, or an EMP.

(f) **EMP** means a document contemplated with form, content and structure in accordance with the Ministry's requirements and guidelines, which describes the measures to be taken for avoiding, preventing, mitigating, monitoring and compensating for all adverse impacts resulting from the design, exploration, testing, construction, implementation, operation, maintenance, decommissioning, closure and post-closure or other aspects of the proposed project or activity.

(g) **Good practice** means that practice which is recognized by a consensus of relevant stakeholders (including without limitation government, industry, labor, financiers, and academia) as having been adopted by leading, reputable companies of international standard, which is capable of being adhered to within the Republic of the Union of Myanmar, and which, when carried out by or in respect of an activity or project, can be expected to further reduce adverse impacts arising from an activity or project related thereto.

(h) **Guideline Values** maximum level of concentration of pollutants allowed in the emitted waste.

(i) **IEE Report** means a report comprising a systematic assessment of a proposed project or activity that is prepared to aid in determining whether or not potential impacts of a project or activity is significant, whether or not it is necessary to carry out EIA, and in deciding whether such project or activity should be allowed or not. The form, content and structure of the report shall be in accordance with the Ministry's requirements and guidelines, and include an EMP.

(j) **Ministry** means the Union Ministry assigned by the Union Government to perform the matters of environment.

(k) **Parameter** means indicators used to measure the level or concentration (population density in case of biological pollutants) against guidelines or standards. The result of measurement could be shown in either numeric or textual form.

(l) **Point of compliance** means the location on land or in water at which a given substance concentration must meet the applicable Guideline value.

(m) **Pollution** means any direct or indirect alteration, effect of the physical, thermal, chemical or biological properties of any part of the environment including land, water and atmosphere by discharging, emitting, dispersion, migration or depositing hazardous substances or wastes so as to effect beneficial use of the environment, or to affect public health, safety or welfare, or animals or plans or to contravene any condition, limitation or prohibition contained in the prior permission issued under the ECL.

(n) **Pollution prevention** refers to the use of processes, practices, materials, products, substances or energy that avoids or minimizes the creation of pollutants and waste, and reduces the overall risk to the environment or human health.

(o) **Project** means any commercial, economic, agricultural, social, academic, scientific, political or other project, activity, program, business, service or undertaking, whether regarded individually or in the aggregate, the performance of which (requires any approval or is licensed, restricted, or otherwise regulated to any extent by any part of the Union government and which) may have an adverse impact.

Scope of Application

3. These Guidelines have been excerpted from the International Finance Corporation (IFC) Environmental Health and Safety (EHS) Guidelines, which provide technical guidance on good international industry pollution prevention practice for application in developing countries. The Guidelines are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of these Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

4. Unless otherwise indicated, these Guidelines refer to emission sources, and are intended to prevent or minimize adverse impacts to ambient environmental quality by ensuring that pollutant concentrations do not reach or exceed ambient guidelines and standards. The Guidelines apply to projects or activities that generate noise or air emissions during any stage of the project life cycle, and / or that have either direct or indirect discharge of process waste wastewater, wastewater from utility operations or storm water to the environment

5. General and industry-specific Guidelines as specified in Annex 1 – Emissions Guidelines shall apply to any project subject to EIA Procedure, as adopted by the Ministry, in order to protect the environment and to control pollution in the Republic of the Union of Myanmar. These Guidelines specifically apply to all project types listed in the EIA Procedure under 'Categorization of Economic Activities for Assessment Purposes' which sets out projects that are subject to EIA, IEE, or EMP.

6. Provisions of the general and applicable industry-specific Guidelines shall be reflected in project EMP and ECC and together constitute a project's commitment to take necessary measures to avoid, minimize and control adverse impacts to human health, safety, and the environment through reducing the total amount of emissions generation; adopting process modifications, including waste minimization to lower the load of pollutants requiring treatment; and as necessary, application of treatment techniques to further reduce the load of contaminants prior to release or discharge.

7. Original IFC document cited in the Guidelines shall be consulted if the case EMP developers need further advices on ways to achieve the limit vales set in the annex.

8. These Guidelines supersede any existing national guideline or standard provision relating to regulation and control of noise, air, and water emissions from activities and projects subject to the EIA Procedure.

CHAPTER II

Implementation Procedures

9. As specified in Article 56 of the EIA Procedure, all projects are obliged to use, comply with and refer to applicable national guidelines or standards or international standards adopted by the Ministry. These Guidelines will henceforth be applied by the Ministry in satisfying this requirement until otherwise modified or succeeded by other guidelines or standards.

10. As specified in Article 77 of the EIA Procedure, following project approval, a project shall commence implementation strictly in accordance with the project EMP and any additional requirements set out in the project ECC, which according to Article 82 of the EIA Procedure, will encompass conditions relating to emissions. In this regard, the Ministry will require that projects shall adhere to general and applicable industry-specific guidelines as specified in Annex 1.

11. While these Guidelines are generally applicable to all projects subject to the EIA Procedure, it is the prerogative of the Ministry to decide how Guidelines should be applied to existing projects, as distinguished from new projects. If the Ministry considers that less stringent levels or measures that those provided for in these Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed on an interim basis.

12. As specified in Article 95 of the EIA Procedure, projects shall engage in continuous, proactive and comprehensive self monitoring of the project and comply with applicable guidelines and standards. For purposes of these Guidelines, projects shall be responsible for the monitoring of their compliance with general and applicable industry-specific Guidelines. Projects shall be responsible for ensuring compliance at the point of compliance specified in the applicable Guidelines.

13. To demonstrate compliance with these monitoring requirements as specified in articles 97 and 98 of the EIA Procedure, projects shall submit monitoring reports to the Ministry at least every six months or more frequently as provided in the EMP and ECC. Monitoring reports shall *inter alia* document compliance, difficulties encountered in complying with EMP and ECC conditions, number and type of non-compliance with EMP and ECC, and monitoring data of prescribed environmental parameters as detailed in the EMP and ECC.

14. In instances of self-reported noncompliance or, as provided for in articles 100 and 101 of the EIA Procedure, identification of noncompliance with the EMP and ECC conditions during monitoring and inspection by the Ministry, the project is required to undertake remedial measures to bring the project into compliance within a specified time period.

15. In instances of continued noncompliance or insufficient response by the project to control emissions as specified in these Guidelines, the Ministry, as provided for in Article 112 of the EIA Procedure, shall have the right to impose penalties on a project for such breach of environmental obligations.

Annex 1
Emission Guidelines

1.0 General Environmental, Health, and Safety

1.1 Air Emissions

Projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that: (i) emissions do not result in pollutant concentrations that reach or exceed ambient quality guidelines and standards, or in their absence the current World Health Organization (WHO) Air Quality Guidelines; and emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards (i.e. not exceeding 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed.

1.2 Wastewater

This guideline applies to projects that have either direct or indirect discharge of process wastewater, wastewater from utility operations or storm water to the environment. It is also applicable to industrial discharges to sanitary sewers that discharge to the environment without any treatment. Process wastewater may include contaminated wastewater from utility operations, storm water, and sanitary sewage. Projects with the potential to generate process wastewater, sanitary (domestic) sewage, or storm water should incorporate the necessary precautions to avoid, minimize, and control adverse impacts to human health, safety or the environment.

Indicative Guideline for Treated Sanitary Sewage Discharges[11]

Parameter	Unit	Maximum Concentration
Biological oxygen demand	mg/L	30
Chemical oxygen demand	mg/L	125
Oil and grease	mg/L	10
pH	S.U.	6-9
Total coliform bacteria	MPN[a]/100 ml	400[b]
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a] MPN = Most Probable Number

[b] Not applicable to centralized, municipal wastewater treatment systems

1.3 Noise Levels

Noise prevention and mitigation measures should be applied where predicted or measured noise impacts from a project facility or operations exceed the applicable noise level guideline at the most sensitive point of reception. Noise impacts should not exceed the levels presented below, or result in a maximum increase in background levels of 3 dBA at the nearest receptor location off-site.

Receptor	One Hour LAeq (dBA)	
	Daytime 07:00 – 22:00 (10:00 – 22:00 for Public holidays)	Nighttime 22:00 – 07:00 (22:00 – 10:00 for Public holidays)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

2.0 Sector-specific Environmental, Health and Safety

2.1 Forestry

2.1.1 Board and Particle-based Products[12]

Effluent Levels

[11] Environmental, health, and safety general guidelines. 2007. International Finance Corporation, World Bank Group.

[12] Environmental, health, and safety guidelines for board and particle-based products. 2007. International Finance Corporation, World Bank Group.

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Chemical oxygen demand	mg/L	150
Formaldehyde	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

Parameter	Unit	Guideline Value
Condensable volatile organic compounds	mg/Nm^3 (as carbon)	130
Formaldehyde	mg/Nm^3	20 (Wood dryers) 5 (Other sources)
Particulate matter	mg/Nm^3	20 (Medium density fiberboard) 20 (Wood dryers) 50 (Other sources)

2.1.2 Wood Treatment and Preservation[a][13]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Arsenic	mg/L	0.1
Chemical oxygen demand	mg/L	150
Chromium (total)	mg/L	0.5
Chromium (hexavalent)	mg/L	0.1
Copper	mg/L	0.5
Fluorides	mg/L	5
Oil and grease	mg/L	10
Pesticides (each)	mg/L	0.05
pH	S.U.	6-9
Phenols (mono- and dihydric)	mg/L	0.5
Polychlorinated dibenzo-p-dioxins / dibenzo furans	mg/L	0.1
Polycyclic aromatic hydrocarbons (each)	mg/L	0.05

[13] Environmental, health, and safety guidelines for sawmilling and wood-based products. 2007. International Finance Corporation, World Bank Group.

Temperature increase	°C	<3[b]
Total suspended solids	mg/L	50
Toxicity	To be determined on a case specific basis	

[a] Process wastewater containing chemical preservatives should be contained as part of closed loop application system

[b] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

2.1.3 Sawmill Facilities[10]

Air Emissions

Parameter	Unit	Guideline Value
Volatile organic compounds	mg/Nm^3	20
Wood dust	mg/Nm^3	50

2.1.4 Forest Harvesting Operations[14]

The forestry sector does not typically give rise to significant effluent discharges or point source air emissions. Where potentially contaminated water runoff or dust exists, site operations should comply with specified general ambient surface water and air quality standards.

2.1.5 Pulp and Paper Mills[15]

Effluent Levels

Parameter	Unit	Guideline Value
Bleached kraft pulp, integrated		
5-day Biochemical oxygen demand	kg/ADt[a]	1
Adsorbable organic halogen	kg/ADt	0.25
Chemical oxygen demand	kg/ADt	20
Flow	m^3/ADt	50
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.2
Total phosphorus	kg/ADt	0.03

[14] Environmental, health, and safety guidelines for forest harvesting operations. 2007. International Finance Corporation, World Bank Group.

[15] Environmental, health, and safety guidelines for pulp and paper mills. 2007. International Finance Corporation, World Bank Group.

Total suspended solids	kg/ADt	1.5
Unbleached kraft pulp, integrated		
5-day Biochemical oxygen demand	kg/ADt	0.7
Chemical oxygen demand	kg/ADt	10
Flow	m^3/ADt	25
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.2
Total phosphorus	kg/ADt	0.02
Total suspended solids	kg/ADt	1.0
Sulfite pulp, integrated and non-integrated		
5-day Biochemical oxygen demand	kg/ADt	2.0
Adsorbable organic halogen	kg/ADt	0.005
Chemical oxygen demand	kg/ADt	30
Flow	m^3/ADt	55
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.5
Total phosphorus	kg/ADt	0.05
Total suspended solids	kg/ADt	2.0
Chemi-thermo-mechanical		
5-day Biochemical oxygen demand	kg/ADt	1.0
Chemical oxygen demand	kg/ADt	5
Flow	m^3/ADt	20
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.2
Total phosphorus	kg/ADt	0.01
Total suspended solids	kg/ADt	1.0
Mechanical pulping, integrated		
5-day Biochemical oxygen demand	kg/ADt	0.5
Adsorbable organic halogen	kg/ADt	0.01
Chemical oxygen demand	kg/ADt	5.0
Flow	m^3/ADt	20
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.1
Total phosphorus	kg/ADt	0.01
Total suspended solids	kg/ADt	0.5
Recycled fiber, without de-inking, integrated		
5-day Biochemical oxygen demand	kg/ADt	0.15
Adsorbable organic halogen	kg/ADt	0.005
Chemical oxygen demand	kg/ADt	1.5
Flow	m^3/ADt	10
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.05
Total phosphorus	kg/ADt	0.005
Total suspended solids	kg/ADt	0.15
Recycled fiber, with de-inking, integrated		

5-day Biochemical oxygen demand	kg/ADt	0.2
Adsorbable organic halogen	kg/ADt	0.005
Chemical oxygen demand	kg/ADt	4.0
Flow	m^3/ADt	15
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.1
Total phosphorus	kg/ADt	0.01
Total suspended solids	kg/ADt	0.3
Recycled fibre tissue mills		
5-day Biochemical oxygen demand	kg/ADt	0.5
Adsorbable organic halogen	kg/ADt	0.005
Chemical oxygen demand	kg/ADt	4.0
Flow	m^3/ADt	25
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.25
Total phosphorus	kg/ADt	0.015
Total suspended solids	kg/ADt	0.4
Uncoated fine paper mills		
5-day Biochemical oxygen demand	kg/ADt	0.25
Adsorbable organic halogen	kg/ADt	0.005
Chemical oxygen demand	kg/ADt	2.0
Flow	m^3/ADt	15
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.2
Total phosphorus	kg/ADt	0.01
Total suspended solids	kg/ADt	0.4
Coated fine paper mills		
5-day Biochemical oxygen demand	kg/ADt	0.25
Adsorbable organic halogen	kg/ADt	0.005
Chemical oxygen demand	kg/ADt	1.5
Flow	m^3/ADt	15
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.2
Total phosphorus	kg/ADt	0.01
Total suspended solids	kg/ADt	0.4
Tissue mills		
5-day Biochemical oxygen demand	kg/ADt	0.4
Adsorbable organic halogen	kg/ADt	0.01
Chemical oxygen demand	kg/ADt	1.5
Flow	m^3/ADt	25
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.25
Total phosphorus	kg/ADt	0.015
Total suspended solids	kg/ADt	0.4
Fiber preparation, non-wood		

5-day Biochemical oxygen demand	kg/ADt	2.0
Chemical oxygen demand	kg/ADt	30
Flow	m^3/ADt	50
pH	S.U.	6-9
Total nitrogen	kg/ADt	0.5
Total phosphorus	kg/ADt	0.05
Total suspended solids	kg/ADt	2.0

[a] kg/ADt = kilograms of pollutant per 1,000 of air dry pulp

Air Emissions

Parameter	Type of Mill	Unit	Guideline Value
Nitrogen oxide (as Nitrogen dioxide)	Kraft, bleached	kg/ADt	1.5 for hardwood pulp
			2.0 for softwood pulp
	Kraft, unbleached, integrated	kg/ADt	1.5 for hardwood pulp
			2.0 for softwood pulp
	Sulfite, integrated and non-integrated	kg/ADt	2.0
Sulfur dioxide (as Sulfur)	Kraft, unbleached, integrated	kg/ADt	0.4
	Sulfite, integrated and non-integrated	kg/ADt	1.0
	Kraft, bleached	kg/ADt	0.4
Total reduced sulfur compounds (as Sulfur)	Kraft, bleached	kg/ADt	0.2
	Kraft, unbleached, integrated		0.2
Total suspended particulates	Kraft, bleached	kg/ADt	0.5
	Kraft, unbleached, integrated		0.5
	Sulfite, integrated and non-integrated		0.15

2.2 Agribusiness / Food Production

2.2.1 Mammalian Livestock Production[16]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Active ingredients / Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/L	250

[16] Environmental, health, and safety guidelines for mammalian livestock production. 2007. International Finance Corporation, World Bank Group.

Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

2.2.2 Poultry Production[17]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Active ingredients / Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/L	250
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

2.2.3 Plantation and Annual Crop Production[18,19]

[17] Environmental, health, and safety guidelines for poultry production. 2007. International Finance Corporation, World Bank Group.

[18] Environmental, health, and safety guidelines for plantation crop production. 2007. International Finance Corporation, World Bank Group.

[19] Environmental, health, and safety guidelines for annual crop production. 2007. International Finance Corporation, World Bank Group.

Water, Soil and Produce Quality

Parameter	Media	Guideline Value
Nutrient balance	On-site soil	Nutrient surpluses should remain stable; nitrogen surplus should be preferably below 25 kg/ha/year
Pesticides	On-site soil and produce	Below applicable tolerance levels
Pesticides, nitrates, coliform or other potential agricultural contaminants	Irrigation water	Concentrations should not exceed internationally recognized guidelines (e.g. WHO Water Guidelines applicable to irrigation water quality)
Pesticides, nitrates, coliform or other potential agricultural contaminants	On-site water supplies	Concentrations should not exceed internationally recognized guidelines (e.g. WHO irrigation or drinking water guidelines for compounds potentially present in on-site groundwater wells or surface waters)

2.2.4 Aquaculture[20]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Active ingredients / Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/L	250
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[20] Environmental, health, and safety guidelines for aquaculture. 2007. International Finance Corporation, World Bank Group.

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

2.2.5 Sugar Manufacturing[21]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Active ingredients / Antibiotics	To be determined on a case specific basis	
Biocides	mg/L	0.05
Chemical oxygen demand	mg/L	250
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

2.2.6 Vegetable Oil Processing[22]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Active ingredients / Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/L	250
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400

[21] Environmental, health, and safety guidelines for sugar manufacturing. 2007. International Finance Corporation, World Bank Group.

[22] Environmental, health, and safety guidelines for vegetable oil processing. 2007. International Finance Corporation, World Bank Group.

Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

Air Emissions

Parameter	Unit	Guideline Value
Dust	mg/Nm^3	10 (dry dust) 40 (wet dust)
Hexane / Volatile organic compounds	mg/Nm^3	100

2.2.7 Dairy Processing[23]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Active ingredients / Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/L	250
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

[23] Environmental, health, and safety guidelines for diary processing. 2007. International Finance Corporation, World Bank Group.

2.2.8 Fish Processing[24]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Active ingredients / Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/L	250
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

Air Emissions

Parameter	Unit	Guideline Value
Ammonia	mg/m^3	1
Amines and amides	mg/m^3	5
Hydrogen sulfide, Sulfides, and Mercaptans	mg/m^3	2

2.2.9 Meat Processing[25]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Active ingredients / Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/L	250
Oil and grease	mg/L	10

[24] Environmental, health, and safety guidelines for fish processing. 2007. International Finance Corporation, World Bank Group.

[25] Environmental, health, and safety guidelines for meat processing. 2007. International Finance Corporation, World Bank Group.

pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

2.2.10 Poultry Processing[26]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Active ingredients / Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/L	250
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

2.2.11 Breweries[27]

Effluent Levels

Parameter	Unit	Guideline Value

[26] Environmental, health, and safety guidelines for poultry processing. 2007. International Finance Corporation, World Bank Group.

[27] Environmental, health, and safety guidelines for breweries. 2007. International Finance Corporation, World Bank Group.

5-day Biochemical oxygen demand	mg/L	25
Active ingredients / Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/L	125
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

2.2.12 Food and Beverage Processing[28]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Active ingredients / Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/L	250
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[28] Environmental, health, and safety guidelines for food and beverage processing. 2007. International Finance Corporation, World Bank Group.

[b] MPN = Most Probable Number

Air Emissions

Emissions from food processing activities are principally associated with particulate matter and odor. Particulate matter and odor emissions from point sources such as ventilation exhaust systems and smoking units should be released through good engineering practice-designed stacks. Smoking unit emissions of particulate matter should typically not exceed 50 mg/Nm^3.

2.3 Chemicals

2.3.1 Pharmaceuticals and Biotechnology Manufacturing[29]

Effluent Levels

Parameter		Unit	Guideline Value
1,2-Dichloroethane		mg/L	0.1
5-day Biochemical oxygen demand		mg/L	30
Acetates (each)[a]		mg/L	0.5
Acetonitrile		mg/L	10.2
Active ingredient (each)		mg/L	0.05
Adsorbable organic halogen		mg/L	1
Amines (each)[b]		mg/L	102
Ammonia		mg/L	30
Arsenic		mg/L	0.1
Benzene		mg/L	0.02
Bioassays	Toxicity to fish Toxicity to Daphnia Toxicity to algae Toxicity to bacteria	T.U.[c]	2 8 16 8
Cadmium		mg/L	0.1
Chemical oxygen demand		mg/L	150
Chlorobenzene		mg/L	0.06
Chloroform		mg/L	0.013
Chromium (hexavalent)		mg/L	0.1
Dimethyl sulfoxide		mg/L	37.5
Isobutyraldehyde		mg/L	0.5

[29] Environmental, health, and safety guidelines for pharmaceuticals and biotechnology manufacturing. 2007. International Finance Corporation, World Bank Group.

Isopropanol	mg/L	1.6
Isopropyl ether	mg/L	2.6
Ketones (each)[d]	mg/L	0.2
Mercury	mg/L	0.01
Methanol / Ethanol (each)	mg/L	4.1
Methyl cellosolve	mg/L	40.6
Methylene chloride	mg/L	0.3
n-Heptane	mg/L	0.02
n-Hexane	mg/L	0.02
o-Dichlorobenzene	mg/L	0.06
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenol	mg/L	0.5
Tetrahydrofuran	mg/L	2.6
Toluene	mg/L	0.02
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	10
Xylenes	mg/L	0.01

[a] n-Amyl acetate, n-Butyl acetate, Ethyl acetate, Isopropyl acetate, Methyl formate

[b] Including Diethylamine and Triethylamine

[c] Toxicity unit (T.U.) = 100 / no effects dilution rate (%) of wastewater

[d] Including Acetone, Methyl isobutyl Ketone

Air Emissions

Parameter	Unit	Guideline Value
Active ingredient (each)	mg/Nm^3	0.15
Ammonia	mg/Sm^3	30
Arsenic	mg/Sm^3	0.05
Benzene, Vinyl chloride, Dichloroethane (each)	mg/Nm^3	1
Bromides (as Hydrogen bromide)	mg/Sm^3	3
Chlorides (as Hydrogen chloride)	mg/Sm^3	30
Ethylene oxide	mg/Sm^3	0.5
Hazardous air pollutants	kg/year	900-1,800[a]
Mutagenic substance	mg/Sm^3	0.05
Particulate matter	mg/Nm^3	20
Total Class A[b]	mg/Nm^3	20[c]
Total Class B[d]	mg/Nm^3	80[e]
Total organic carbon	mg/Nm^3	50
Volatile organic compounds	mg/Nm^3	20-150[f] 50[g]

[a] Process-based annual mass limit

[b] Class A compounds are those that may cause significant harm to human health and the environment

[c] Applicable when total Class A compounds exceed 100 g/year

[d] Class B compounds are organic compounds of less environmental impact than Class A compounds

[e] Applicable when total Class B compounds, expressed as Toluene, exceed the lower of 5 tones/year or 2 kg/hour

[f] Facilities with solvent consumption >50 tones/year

[g] Waste gases from oxidation plants

2.3.2 Coal Processing[30]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	30
Cadmium	mg/L	0.1
Chemical oxygen demand	mg/L	150 (40 cooling water)
Chromium (hexavalent)	mg/L	0.1
Chromium (total)	mg/L	0.5
Cobalt	mg/L	0.5
Copper	mg/L	0.5
Cyanides	mg/L	0.5
Heavy metals (total)	mg/L	3
Iron	mg/L	3
Lead	mg/L	0.5
Manganese	mg/L	2
Mercury	mg/L	0.02
Nickel	mg/L	1
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenol	mg/L	0.5
Sulphide	mg/L	1
Ammoniacal nitrogen (as Nitrogen)	mg/L	5
Total nitrogen	mg/L	10

[30] Environmental, health, and safety guidelines for coal processing. 2007. International Finance Corporation, World Bank Group.

Total phosphorus	mg/L	2
Total suspended solids	mg/L	35
Vanadium	mg/L	1
Zinc	mg/L	1

Air Emissions

Parameter	Unit	Guideline Value
Coal Preparation Plant		
Conveying, storage and preparation gas opacity	%	10
Pneumatic coal cleaning equipment opacity	%	10
Pneumatic coal cleaning equipment particulate	mg/Nm^3	40
Thermal dryer gas opacity	%	20
Thermal dryer particulate	mg/Nm^3	70
Overall		
Ammonia	mg/Nm^3	30
Carbonyl sulfide + Carbon disulfide	mg/Nm^3	3
Heavy metals (total)	mg/Nm^3	1.5
Hydrogen sulfide	mg/Nm^3	10
Mercury	mg/Nm^3	1.0
Nitrogen oxide	mg/Nm^3	200-400[a]
Particulate matter[b]	mg/Nm^3	30-50[a]
Sulfur dioxide	mg/Nm^3	150-200
Volatile organic compounds	mg/Nm^3	150

[a] Lower value for plants of >100 MW equivalent, higher value for plants of <100 MWth equivalent

[b] PM_{10} = particulate matter 10 micrometers or less in diameter

2.3.3 Natural Gas Processing[31]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Cadmium	mg/L	0.1
Chemical oxygen demand	mg/L	150
Chromium (total)	mg/L	0.5

[31] Environmental, health, and safety guidelines for natural gas processing. 2007. International Finance Corporation, World Bank Group.

Copper	mg/L	0.5
Cyanide (free)	mg/L	0.1
Cyanide (total)	mg/L	1
Heavy metals (total)	mg/L	5
Iron	mg/L	3
Lead	mg/L	0.1
Nickel	mg/L	1.5
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenol	mg/L	0.5
Total Nitrogen	mg/L	40
Total Phosphorus	mg/L	3
Total residual chlorine	mg/L	0.2
Total suspended solids	mg/L	50
Zinc	mg/L	1

Air Emissions

Parameter	Unit	Guideline Value
Carbon monoxide	mg/Nm^3	100
Nitrogen oxide	mg/Nm^3	150[a] 50[b]
Particulate matter[c]	mg/Nm^3	10
Sulfur dioxide	mg/Nm^3	75
Volatile organic compounds	mg/Nm^3	150

[a]Applicable to facilities with a total heat input capacity of up to 300 MW

[b] Applicable to facilities with a total heat input capacity greater than 300 MW

[c] PM_{10} = particulate matter 10 micrometers or less in diameter

2.3.4 Oleochemicals Manufacturing[32]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	40
Chemical oxygen demand	mg/L	150
Oil and grease	mg/L	10
pH	S.U.	6-9

[32] Environmental, health, and safety guidelines for oleochemicals manufacturing. 2007. International Finance Corporation, World Bank Group.

Total nitrogen	mg/L	30
Total phosphorus	mg/L	5
Total suspended solids	mg/L	50

Air Emissions

Parameter	Unit	Guideline Value
Volatile organic compounds	mg/Nm^3	100

2.3.5 Nitrogenous Fertilizer Production[33]

Effluent Levels

Parameter	Unit	Guideline Value
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Ammonia and Nitric Acid Plants		
Ammonia	mg/L	5
Total nitrogen	mg/L	15
Total suspended solids	mg/L	30
Urea Plants		
Ammonia (prill / granulation)	mg/L	5
Urea (prill / granulation)	mg urea/L	1
Ammonium Nitrate / Calcium Ammonium Nitrate Plants		
Ammonium nitrate	mg/L	100
Ammonia	mg/L	5
Total nitrogen	mg/L	15
Total suspended solids	mg/L	30

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

Parameter	Unit	Guideline Value
Ammonia Plants		
Ammonia	mg/Nm^3	50
Total nitrogen	mg/Nm^3	300

33 Environmental, health, and safety guidelines for nitrogenous fertilizer manufacturing. 2007. International Finance Corporation, World Bank Group.

Total suspended solids	mg/Nm³	50
Nitric Acid Plants		
Ammonia	mg/Nm³	10
Nitrogen oxide	mg/Nm³	200
Nitrous oxide	mg/Nm³	800
Particulate matter[a]	mg/Nm³	50
Urea / Urea Ammonium Nitrate Plants		
Ammonia (prill / granulation)	mg/Nm³	50
Particulate matter[a]	mg/Nm³	50
Urea (prill / granulation)	mg/Nm³	50
Ammonium Nitrate / Calcium Ammonium Nitrate Plants		
Ammonia	mg/Nm³	50
Particulate matter[a]	mg/Nm³	50

[a] PM_{10} = particulate matter 10 micrometers or less in diameter

2.3.6 Phosphate Fertilizer Manufacturing[34]

Effluent Levels

Parameter	Unit	Guideline Value
Ammonia	mg/L	10
Cadmium	mg/L	0.1
Fluorides	mg/L	20
	kg/ton NPK	0.03
	Kg/ton Phosphorus oxide	2
Heavy metals (total)	mg/L	10
pH	S.U.	6-9
Total nitrogen	mg/L	15
Total phosphorus	mg/L	5
Total suspended solids	mg/L	50

[34] Environmental, health, and safety guidelines for phosphate fertilizer manufacturing. 2007. International Finance Corporation, World Bank Group.

Air Emissions

Parameter	Unit	Guideline Value
Phosphoric Acid Plants		
Fluorides (gaseous as Hydrogen fluoride)	mg/Nm^3	5
Particulate matter[a]	mg/Nm^3	50
Phosphate Fertilizer Plants		
Ammonia	mg/Nm^3	50
Fluorides (gaseous as Hydrogen fluoride)	mg/Nm^3	5
Hydrogen chloride	mg/Nm^3	30
Nitrogen oxide	mg/Nm^3	500 (nitro-phosphate unit) 70 (mix acid unit)
Particulate matter[a]	mg/Nm^3	50

[a] PM_{10} = particulate matter 10 micrometers or less in diameter

2.3.7 Pesticides Formulation, Manufacturing and Packaging[35]

Effluent Levels

Parameter		Unit	Guideline Value
5-day Biochemical oxygen demand		mg/L	30
Active ingredients (each)		mg/L	0.05
Adsorbable organic halogens		mg/L	1
Ammonia		mg/L	10
Arsenic		mg/L	0.1
Bioassays	Toxicity to fish	T.U.[a]	2
	Toxicity to Daphnia		8
	Toxicity to algae		16
	Toxicity to bacteria		8
Chemical oxygen demand		mg/L	150
Chlorinated organics		mg/L	0.05
Chromium (hexavalent)		mg/L	0.1
Chromium (total)		mg/L	0.5
Copper		mg/L	0.5
Mercury		mg/L	0.01
Nitrorganics		mg/L	0.05

[35] Environmental, health, and safety guidelines for pesticides formulation, manufacturing and packaging. 2007. International Finance Corporation, World Bank Group.

Oil and grease	mg/L	10
pH	S.U.	6-9
Phenol	mg/L	0.5
Total phosphorus	mg/L	2
Total suspended solids	mg/L	10-20[b]
Zinc	mg/L	2

[a] T.U. = 100 / no effects dilution rate (%) of wastewater

[b] Lower value for pesticide manufacturing, higher value for pesticide formulation

Air Emissions

Parameter	Unit	Guideline Value
Ammonia, gaseous inorganic chlorine compounds	mg/Nm^3	30
Bromines, Cyanides, Fluorines, Hydrogen sulfide	mg/Nm^3	3
Chloride	mg/Nm^3	5
Chlorine	mg/Nm^3	3
Particulate matter[b]	mg/Nm^3	20, 5[a]
Total organic carbon	mg/Nm^3	50
Volatile organic compounds	mg/Nm^3	20

[a]Applicable where very toxic compounds are present

[b] PM_{10} = particulate matter 10 micrometers or less in diameter

2.3.8 Petroleum-based Polymers Manufacturing[36]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	25
Adsorbable organic halogens	mg/L	0.3

[36] Environmental, health, and safety guidelines for petroleum-based polymers manufacturing. 2007. International Finance Corporation, World Bank Group.

Benzene	mg/L	0.05
Cadmium	mg/L	0.1
Chemical oxygen demand	mg/L	150
Chromium (hexavalent)	mg/L	0.1
Chromium (total)	mg/L	0.5
Copper	mg/L	0.5
Lead	mg/L	0.5
Mercury	mg/L	0.01
Nickel	mg/L	0.5
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenol	mg/L	0.5
Sulphide	mg/L	1
Temperature increase	°C	<3[a]
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	30
Toxicity	To be determined on a case specific basis	
Vinyl chloride	mg/L	0.05
Zinc	mg/L	2

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

Parameter	Unit	Guideline Value
Acrylonitrile	mg/Nm^3	5 (15 from dryers)
Ammonia	mg/Nm^3	15
Dioxin / Furans	ng TEQ/Nm^3	0.1
Formaldehyde	mg/m^3	0.15
Heavy metals (total)	mg/Nm^3	1.5
Hydrogen chloride	mg/Nm^3	10
Mercury	mg/Nm^3	0.2
Nitrogen oxides	mg/Nm^3	300
Particulate matter[a]	mg/Nm^3	20
Sulfur oxides	mg/Nm^3	500
Vinyl chloride (VCM)	g/t s-PVC g/t e-PVC	80 500
Volatile organic compounds	mg/Nm^3	20

[a] PM_{10} = particulate matter 10 micrometers or less in diameter

2.3.9 Petroleum Refining[a,37]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	30
Benzene	mg/L	0.05
Benzo(a)pyrene	mg/L	0.05
Chemical oxygen demand	mg/L	150
Chromium (hexavalent)	mg/L	0.05
Chromium (total)	mg/L	0.5
Copper	mg/L	0.5
Cyanide (free)	mg/L	0.1
Cyanide (total)	mg/L	1
Iron	mg/L	3
Lead	mg/L	0.1
Mercury	mg/L	0.02
Nickel	mg/L	0.5
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenol	mg/L	0.2
Sulphides	mg/L	1
Temperature increase	°C	<3[b]
Total nitrogen	mg/L	10[c]
Total phosphorus	mg/L	2
Total suspended solids	mg/L	30
Vanadium	mg/L	1

[a]Assumes an integrated petroleum refining facility

[b] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[c] The effluent concentration of total nitrogen may be up to 40 mg/L in processes that include hydrogenation

Air Emissions

Parameter	Unit	Guideline Value
Hydrogen sulfide	mg/Nm^3	10

[37] Environmental, health, and safety guidelines for petroleum refining. 2007. International Finance Corporation, World Bank Group.

Nickel	mg/Nm³	1
Nitrogen oxide	mg/Nm³	450
Particulate matter[a]	mg/Nm³	50
Sulfur oxide	mg/Nm³	150 (for sulfur recovery units) 500 (for other units)
Vanadium	mg/Nm³	5

[a] PM_{10} = particulate matter 10 micrometers or less in diameter

2.3.10 Large Volume Petroleum-based Organic Chemicals Manufacturing[38]

Effluent Levels

Parameter	Unit	Guideline Value
1,2-Dichloroethane	mg/L	1
5-day Biochemical oxygen demand	mg/L	25
Adsorbable organic halogens	mg/L	1
Benzene	mg/L	0.05
Cadmium	mg/L	0.1
Chemical oxygen demand	mg/L	150
Chromium (hexavalent)	mg/L	0.1
Chromium (total)	mg/L	0.5
Copper	mg/L	0.5
Lead	mg/L	0.5
Mercury	mg/L	0.01
Nickel	mg/L	0.5
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenol	mg/L	0.5
Sulphide	mg/L	1
Temperature increase	°C	<3[a]
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	30
Vinyl chloride (VCM)	mg/L	0.05
Zinc	mg/L	2

[38] Environmental, health, and safety guidelines for large volume petroleum-based organic chemicals manufacturing. 2007. International Finance Corporation, World Bank Group.

[a] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

Parameter	Unit	Guideline Value
1,2-Dichloroethane	mg/Nm^3	5
Acrylonitrile	mg/Nm^3	0.5 (incineration) 2 (scrubbing)
Ammonia	mg/Nm^3	15
Benzene	mg/Nm^3	5
Caprolactam	mg/m^3	0.1
Dioxin / Furans	ng TEQ/Nm^3	0.1
Ethylene	mg/Nm^3	150
Ethylene oxide	mg/m^3	2
Formaldehyde	mg/m^3	0.15
Heavy metals (total)	mg/Nm^3	1.5
Hydrogen chloride	mg/Nm^3	10
Hydrogen cyanide	mg/m^3	2
Hydrogen sulfide	mg/m^3	5
Mercury and compounds	mg/Nm^3	0.2
Nitrobenzene	mg/m^3	5
Nitrogen oxides	mg/Nm^3	300
Organic sulfide and Mercaptans	mg/m^3	2
Particulate matter[a]	mg/Nm^3	20
Phenols, Cresols and Xylols (as Phenol)	mg/Nm^3	10
Sulfur oxides	mg/m^3	100
Vinyl chloride (VCM)	mg/Nm^3	5
Volatile organic compounds	mg/Nm^3	20

[a] PM_{10} = particulate matter 10 micrometers or less in diameter

2.3.11 Large Volume Inorganic Compounds Manufacturing and Coal Tar Distillation[39]

Effluent Levels

Parameter	Unit	Guideline Value
pH	S.U.	6-9

[39] Environmental, health, and safety guidelines for large volume inorganic compounds manufacturing and coal tar distillation. 2007. International Finance Corporation, World Bank Group.

Temperature increase	°C	<3[a]
Ammonia Plants		
Ammonia	mg/L	10[b]
Total suspended solids	mg/L	30
Nitric Acid Plants		
Ammonia	mg/L	10
Nitrates	mg/L	25
Total suspended solids	mg/L	30
Sulfuric Acid Plants		
Phosphorus	mg/L	5
Fluoride	mg/L	20
Total suspended solids	mg/L	30
Phosphoric Acid Plants		
Phosphorus	mg/L	5
Fluoride	mg/L	20
Total suspended solids	mg/L	30
Hydrofluric Acid Plants		
Fluorides	kg/ton HF	1
Suspended solids	kg/ton HF	1
	mg/L	30
Chlor-alkali / Hydrochloric Acid Plants		
Adsorbable organic halogens	mg/L	0.5
Chemical oxygen demand	mg/L	150
Chlorine	mg/L	0.2
Mercury	mg/L	0.05
	g/ton chlorine	0.1
Sulphides	mg/L	1
Total suspended solids	mg/L	20
Toxicity to fish eggs	T_F	2
Soda Ash Plants		
Ammonia (as Nitrogen)	mg/L	10
Phosphorus	kg/ton	0.2
Suspended solids	kg/ton	270
Total suspended solids	mg/L	30
Carbon Black Plants		
Chemical oxygen demand	mg/L	100
Total suspended solids	mg/L	20
Coal Tar Distillation Plants		
5-day Biochemical oxygen demand	mg/L	35 (monthly average) 90 (daily maximum)
Anthracene, Naphthalene and Phenanthrene (each)	µg/L	20 (monthly average) 60 (daily maximum)
Total suspended solids	mg/L	50 (monthly average) 160 (daily maximum)

[a] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] Load based guideline: 0.1 kg/ton of product

Air Emissions

Parameter	Unit	Guideline Value
Ammonia Plants		
Ammonia	mg/Nm^3	50
Nitrogen oxide	mg/Nm^3	300
Particulate matter	mg/Nm^3	50
Nitric Acid Plants		
Ammonia	mg/Nm^3	10
Nitrogen oxide	mg/Nm^3	300
Nitrous oxide	mg/Nm^3	800
Sulfuric Acid Plants		
Hydrogen sulfide	mg/Nm^3	5
Nitrogen oxide	mg/Nm^3	200
Sulfur dioxide	mg/Nm^3	450 (2 kg/ton acid)
Sulfur trioxide	mg/Nm^3	60 (0.075 kg/ton acid)
Phosphoric / Hydrofluoric Acids Plants		
Fluorides (gaseous as Hydrogen fluoride)	mg/Nm^3	5
Particulate matter[a] / Calcium fluoride	mg/Nm^3	50 (0.10 kg/ton phosphate rock)
Chlor-alkali / Hydrochloric Acid Plants		
Chlorine gas	mg/Nm^3	1 (partial liquefaction) 3 (complete liquefaction)
Hydrogen chloride	ppmv	20
Mercury	mg/Nm^3	0.2 (annual average emission of 1 g/ton chlorine)
Soda Ash Plants		
Ammonia	mg/Nm^3	50
Hydrogen sulfide	mg/Nm^3	5
Nitrogen oxide	mg/Nm^3	200
Particulate matter[a]	mg/Nm^3	50
Carbon Black Plants		
Carbon monoxide	mg/Nm^3	500
Nitrogen oxide	mg/Nm^3	600
Particulate matter[a]	mg/Nm^3	30
Sulfur dioxide	mg/Nm^3	850
Volatile organic compounds	mg/Nm^3	50
Coal Tar Distillation Plants		
Particulate matter[a]	mg/Nm^3	50
Tar fume	mg/Nm^3	10
Volatile organic compounds	mg/Nm^3	50

[a] PM_{10} = particulate matter 10 micrometers or less in diameter

2.4 Oil and Gas

2.4.1 Offshore Oil and Gas Development[40]

The following table presents effluent performance standards for offshore oil and gas development. These guidelines are primarily applicable to discharges in offshore locations (e.g. greater than 12 nautical miles from shore). Additional guidance on applicable standards is provided in the General EHS Guidelines.

Effluent Levels

Parameter	Guideline
Drilling fluids and cuttings (Non-aqueous drilling fluid)	Non-aqueous drilling fluid – re-inject or ship-to-shore, no discharge to sea Drilled cuttings – re-inject or ship-to-shore, no discharge except: – Oil concentration lower than 1% by weight on dry cuttings – Mercury – maximum 1 mg/kg dry weight in stock barite – Cadmium – maximum 3 mg/kg dry weight in stock barite – Discharge via a caisson at least 15 m below sea surface
Drilling fluids and cuttings (Water-based drilling fluid)	Water-based drilling fluid – re-inject or ship-to-shore, no discharge to sea except: – In compliance with 96-hr LC-50 of SPP-3% volume toxicity test first for drilling fluids or alternatively testing based on standard toxicity assessment species[a] (preferably site-specific species) Water-based drilling fluids and cuttings – re-inject or ship-to-shore, no discharge to sea except: – Mercury – 1 mg/kg dry weight in stock barite – Cadmium – 3 mg/kg dry weight in stock barite – Maximum chloride concentration must be less that four time's ambient concentration of fresh or brackish receiving water – Discharge via a caisson at least 15 m below sea surface
Produced water	Re-inject – Discharge to sea maximum one day oil and grease discharge should not exceed 42 mg/L; 30 day average should not exceed 29 mg/L
Completion and well work-over fluids	Ship-to-shore or re-inject – No discharge to sea except: – Maximum one day oil and grease discharge should not exceed 42 mg/L; 30 day average should not exceed 29 mg/L – Neutralize to attain a pH of 5 or more
Produced sand	Ship-to-shore or re-inject – No discharge to sea except when oil concentration lower than 1% by weight on dry sand

[40] Environmental, health, and safety guidelines for offshore oil and gas development. 2007. International Finance Corporation, World Bank Group.

Hydrotest water	− Send to shore for treatment and disposal − Discharge offshore following environmental risk analysis, careful selection of chemicals − Reduce use of chemicals
Cooling water	The effluent should result in a temperature increase of no more than 3°C at edge of the zone where initial mixing and dilution take place; where the zone is not defined, use 100 m from point of discharge
Desalination brine	Mix with other discharge waste streams if feasible[b]
Sewage	Compliance with MARPOL 73/78[b]
Food waste	Compliance with MARPOL 73/78[b]
Storage displacement water	Compliance with MARPOL 73/78[b]
Bilgewater	Compliance with MARPOL 73/78[b]
Deck drainage (non-hazardous and hazardous drains)	Compliance with MARPOL 73/78[b]

[a] 96-hr LC-50: Concentration in parts per million or percent of the suspended particulate phase from sample that is lethal to 50 percent of the test organism exposed to that concentration for a continuous period of 96 hours.

[b] In nearshore waters, carefully select discharge location based on environmental sensitivities and assimilative capacity of receiving waters.

2.4.2 Onshore Oil and Gas Development[41]

Effluent Levels

Parameter	Guideline
Drilling fluids and cuttings	Treatment and disposal in accordance with applicable standards provided in the General EHS Guidelines
Produced sand	Treatment and disposal in accordance with applicable standards provided in the General EHS Guidelines
Produced water	Treatment and disposal in accordance with applicable standards provided in the General EHS Guidelines For discharge to surface waters or to land: − Total hydrocarbon content 10 mg/L − pH 6-9 − Biochemical oxygen demand 25 mg/L − Chemical oxygen demand 125 mg/L − Total suspended solids 35 mg/L − Phenols 0.5 mg/L − Sulfides 1 mg/L

[41] Environmental, health, and safety guidelines for onshore oil and gas development. 2007. International Finance Corporation, World Bank Group.

	− Heavy metals (total)[a] 5 mg/L − Chlorides 600 mg/L (average), 1,200 mg/L maximum
Hydrotest water	Treatment and disposal in accordance with applicable standards provided in the General EHS Guidelines For discharge to surface waters or to land, apply standards specified for Produced Water
Completion and well work-over fluids	Treatment and disposal in accordance with applicable standards provided in the General EHS Guidelines For discharge to surface waters or to land: − Total hydrocarbon content 10 mg/L − pH 6-9
Storm water drainage	Storm water runoff should be treated through an oil / water separation system able to achieve oil and grease concentration of 10 mg/L
Cooling water	The effluent should result in a temperature increase of no more than 3°C at edge of the zone where initial mixing and dilution take place; where the zone is not defined, use 100 m from point of discharge
Sewage	Treatment as per General EHS Guidelines, including discharge requirements
Air emissions	Treatment as per General EHS Guidelines Emission concentrations as per General EHS Guidelines, and: − Hydrogen sulfide 5 mg/Nm^3

[a] Heavy metals include: Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Silver, Vanadium and Zinc

2.4.3 Liquefied Natural Gas Facilities[42]

Effluent Levels

Parameter	Guideline
Hydrotest water	Treatment and disposal as per General EHS Guidelines For discharge to surface waters or to land: − Total hydrocarbon content 10 mg/L − pH 6-9 − 5-day Biochemical oxygen demand 25 mg/L − Chemical oxygen demand 125 mg/L − Total suspended solids 35 mg/L − Phenols 0.5 mg/L − Sulfides 1 mg/L − Heavy metals (total) 5 mg/L − Chlorides 600 mg/L (average), 1,200 mg/L maximum

[42] Environmental, health, and safety guidelines for liquefied natural gas facilities. 2007. International Finance Corporation, World Bank Group.

Hazardous storm water drainage	Storm water runoff should be treated through an oil / water separation system able to achieve oil and grease concentration of 10 mg/L
Cooling water	The effluent should result in a temperature increase of no more than 3°C at edge of the zone where initial mixing and dilution take place; where the zone is not defined, use 100 m from point of discharge Free chlorine (total residual oxidant in estuarine / marine water) concentration in cooling / cold water discharges (to be sampled at point of discharge) should be maintained at 0.2 parts per million
Sewage	Treatment as per General EHS Guidelines, including discharge requirements Provision of facilities to receive liquefied natural gas tanker effluents may be required (see Ports and Harbors guidelines)

Air Emissions

Air emissions from liquefied natural gas facilities should be controlled through the application of techniques describes in the General EHS Guidelines.

2.5 Infrastructure

2.5.1 Tourism and Hospitality Development[43]

Tourism and hospitality effluents levels and air emissions should be managed in a manner consistent with the conventional treatment and discharge of sanitary wastewater as specified in General EHS Guidelines.

2.5.2 Railways[44]

Emissions from new engines used in the propulsion of locomotives and rail cars should be consistent with internationally recognized emissions limit values for nitrogen oxides, particulate

[43] Environmental, health, and safety guidelines for tourism and hospitality development. 2007. International Finance Corporation, World Bank Group.

[44] Environmental, health, and safety guidelines for railways. 2007. International Finance Corporation, World Bank Group.

matter, carbon monoxide, and total hydrocarbons. Effluents from maintenance facilities should be treated to a level consistent with the requirements of a local sewer network operation or, if discharged to surface waters, according to the guideline values provided for Metals, Plastics and Rubber Products Manufacturing, which provide treated effluent guideline values applicable to metals machining, cleaning, and plating and finishing processes, including painting. Site-specific discharge levels may be established for sewer and process effluents from maintenance facilities and terminals based on the availability of publicly-operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in General EHS Guidelines.

2.5.3 Ports, Harbors and Terminals[45]

Given the nature of port operations where there are few stationary effluents (e.g. wastewater and storm water) it is difficult to continuously monitoring most emissions and effluents. Discrete point source sanitary wastewater and storm water should meet requirements described in General EHS Guidelines.

2.5.4 Airports[46]

Airport operations should establish site-specific discharge levels based on the requirements of publicly-operated sewage collection and treatment systems or, if discharged directly to surface waters, according to requirements described in General EHS Guidelines.

2.5.5 Airlines[47]

Aircraft air emissions and noise levels should meet the certification requirements established by the International Civil Aviation Organizations for their year of manufacture. Emission and effluents from heavy maintenance facilities should be treated to a level consistent with the requirements of a local sewer network operation or, if discharged to surface waters, according to the guideline

[45] Environmental, health, and safety guidelines for ports, harbors and terminals. 2007. International Finance Corporation, World Bank Group.

[46] Environmental, health, and safety guidelines for airports. 2007. International Finance Corporation, World Bank Group.

[47] Environmental, health, and safety guidelines for airlines. 2007. International Finance Corporation, World Bank Group.

values provided for Metals, Plastics and Rubber Products Manufacturing, which provide treated effluent guideline values applicable to metals machining, cleaning, and plating and finishing processes, including painting. Site-specific discharge levels may be established for sewer and process effluents from maintenance facilities and terminals based on the availability of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in General EHS Guidelines.

2.5.6 Shipping[48]

For vessels engaged in national traffic only, environmental performance requirements are usually dictated by the flag state's maritime administration. Vessels engaged in international routes should also comply with environmental requirements set out in international regulations, primarily effluent standards for oil and grease and sewage as described in Annex I and IV of MARPOL, emissions standards for ozone depleting substances, and maritime diesel engine emissions and shipboard incinerator emissions described in Annex VI of MARPOL.

2.5.7 Gas Distribution Systems[49]

Although there are no significant point source effluents or emissions for the gas distribution sector, fugitive emissions (from city gate and regulating stations, underground piping, and third party damage) from gas distribution systems constitute a significant portion of the overall atmospheric losses from the natural gas transmission and distribution industry. Gas distribution system should: i) conduct volume reconciliation programs as an indicator of leakages by comparing delivered amounts against sales to customers, and ii) implement inspection and maintenance programs to maintain and upgrade infrastructure and minimize fugitive gas emissions.

2.5.8 Toll Roads[50]

[48] Environmental, health, and safety guidelines for shipping. 2007. International Finance Corporation, World Bank Group.

[49] Environmental, health, and safety guidelines for gas distribution systems. 2007. International Finance Corporation, World Bank Group.

[50] Environmental, health, and safety guidelines for toll roads. 2007. International Finance Corporation, World Bank Group.

While roads do not typically give rise to significant point source effluents or air emissions, operators should comply with General EHS Guidelines, especially with regard to effluents or emissions from road maintenance facilities.

2.5.9 Telecommunications[51]

While telecommunications activities do not typically give rise to significant point source effluents or air emissions, site operations should comply with General EHS Guidelines, especially with regard to effluents or emissions during construction operations or from administrative and maintenance facilities. Additionally site operations should comply with guidance on exposure limits for general public exposure to electric and magnetic fields as set out by the International Commission on Non-ionizing Radiation Protection as summarized below.

Frequency	Electric Field (V/m)	Magnetic Field (µT)
3 – 150 kHz	87	6.25
10 – 400 MHz	28	0.092
2 – 300 GHz	61	0.20

2.5.10 Crude Oil and Petroleum Product Terminals[52]

Storm water runoff should be treated through an oil / water separation system to achieve oil and grease concentration of less than 10 mg/L. Process effluent discharge quality should be established on a site-specific basis, taking into account effluent characteristics and receiving water use. Volatile organic compounds emitted during crude oil and petroleum product terminal storage activities have the potential to be significant from an environmental perspective. Best industry practice should be followed to control emissions of volatile organic compounds resulting from: evaporative losses during storage; from operational activities such as filling, withdrawal,

[51] Environmental, health, and safety guidelines for telecommunications. 2007. International Finance Corporation, World Bank Group.

[52] Environmental, health, and safety guidelines for crude oil and petroleum product terminals. 2007. International Finance Corporation, World Bank Group.

additive blending, and loading / unloading of transport links; and due to leaks from seals, flanges, and other types of equipment connections.

2.5.11 Retail Petroleum Networks[53]

Storm water runoff should be treated through an oil / water separation system able to achieve an oil and grease concentration of less than 15 mg/L. The main sources of emissions to air include evaporative losses of volatile organic compounds of fuel product from storage, particularly during bulk deliveries, and during dispensing operations. Best industry practice should be followed to prevent and control the emission of volatile organic compounds from storage and working losses which apply to most bulk fuel storage tanks, piping and pump systems.

2.5.12 Health Care Facilities[54]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Cadmium	mg/L	0.05
Chemical oxygen demand	mg/L	250
Chlorine (total residual)	mg/L	0.2
Chromium (total)	mg/L	0.5
Lead	mg/L	0.1
Mercury	mg/L	0.01
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenols	mg/L	0.5
Polychlorinated dibenzodioxin and dibenzofuran	Ng/L	0.1
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

[53] Environmental, health, and safety guidelines for retail petroleum networks. 2007. International Finance Corporation, World Bank Group.

[54] Environmental, health, and safety guidelines for health care facilities. 2007. International Finance Corporation, World Bank Group.

Air Emissions (for hospital waste incineration facilities)

Parameter	Unit	Guideline Value
Antimony, Arsenic, Lead, Chromium, Cobalt, Copper, Manganese, Nickel, Vanadium	mg/Nm^3	0.5
Cadmium + Thalium	mg/Nm^3	0.05
Carbon monoxide	mg/Nm^3	50
Hydrogen chloride	mg/Nm^3	10
Hydrogen fluoride	mg/Nm^3	1
Mercury	mg/Nm^3	0.05
Nitrogen oxide	mg/Nm^3	200-400[a]
Polychlorinated dibenzodioxin and dibenzofuran	ng/Nm^3TEQ	0.1
Sulfur dioxide	mg/Nm^3	50
Total organic carbon	mg/Nm^3	10
Total particulate matter	mg/Nm^3	10

[a] 200 mg/m^3 for new plants or for existing plants with a nominal capacity exceeding 6 tons per hour, 400 mg/m^3 for existing incinerators with a nominal capacity of 6 tons per hour or less

2.5.13 Waste Management Facilities[55]

Effluent Levels

Parameter	Unit	Guideline Value			
		Hazardous Waste Landfills		Municipal Solid Waste Landfills	
		Daily Max.	Monthly Average	Daily Max	Monthly Average
5-day Biochemical oxygen demand	mg/L	220	56	140	37
Ammonia (as Nitrogen)	mg/L	10	4.9	10	4.9
Analine	mg/L	0.024	0.015	-	-
Arsenic	mg/L	1.1	0.54	-	-
a-Terpineol	mg/L	0.042	0.019	0.033	0.016
Banzoic acid	mg/L	0.119	0.073	0.12	0.071
Chromium (total)	mg/L	1.1	0.46	-	-
Naphthalene	mg/L	0.059	0.022	-	-
p-Cresol	mg/L	0.024	0.015	0.025	0,014

55 Environmental, health, and safety guidelines for waste management facilities. 2007. International Finance Corporation, World Bank Group.

pH	S.U.	6-9	6-9	6-9	6-9
Phenol	mg/L	0.048	0.029	0.026	0,015
Pyridine	mg/L	0.072	0.025	-	-
Total suspended solids	mg/L	88	27	88	27
Zinc	mg/L	0.535	0.296	0.2	0.11

Air Emissions

Parameter	Unit	Guideline Value[a]
Cadmium	mg/m^3	0.05-0.1 (0.5–8 hour average)
Carbon monoxide	mg/m^3	50-150
Hydrochloric acid	mg/m^3	10
Hydrogen fluoride	mg/m^3	1
Mercury	mg/m^3	0.05-0.1 (0.5–8 hour average)
Nitrogen oxide	mg/m^3	200-400 (24 hour average)
Polychlorinated dibenzodioxin and dibenzofuran	ng TEQ/m^3	0.1
Sulfur dioxide	mg/m^3	50 (24 hour average)
Total metals	mg/m^3	0.5-1 (0.5–8 hour average)
Total suspended particulates	mg/m^3	10 (24 hour average)

[a]Applicable to both municipal solid waste and hazardous waste incinerators

2.5.14 Water and Sanitation[56]

Water quality of potable water supply systems should meet national drinking water standards or, in their absence, the WHO Guidelines for Drinking Water Quality throughout the distribution network. Effluent water quality should meet internationally accepted standards such as summarized for the European Union below. Treated wastewater re-use and sludge quality for land application should be consistent with WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater.

Effluent Levels

Parameter	Unit	Guideline Value

[56] Environmental, health, and safety guidelines for water and sanitation. 2007. International Finance Corporation, World Bank Group.

5-day Biochemical oxygen demand	mg/L	25
Chemical oxygen demand	mg/L	125
Total nitrogen	mg/L	15
Total phosphorus	mg/L	2
Total suspended solids	mg/L	35

2.6 General Manufacturing

2.6.1 Cement and Lime Manufacturing[57]

Effluent Levels

Parameter	Unit	Guideline Value
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total suspended solids	mg/L	50

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions (for cement manufacturing)

Parameter	Unit	Guideline Value
Cadmium + Thallium	mg/Nm^3	0.05
Dioxins / Furans	$mg\ TEQ/Nm^3$	0.1
Dust (other point sources including clinker cooling, cement grinding)	mg/Nm^3	50
Hydrogen chloride	mg/Nm^3	10
Hydrogen fluoride	mg/Nm^3	1
Mercury	mg/Nm^3	0.05
Nitrogen oxide	mg/Nm^3	600
Particulate matter (existing kilns)	mg/Nm^3	100
Particulate matter (new kiln system)	mg/Nm^3	30
Sulfur dioxide	mg/Nm^3	400
Total metals[a]	mg/Nm^3	0.5
Total organic carbon	mg/Nm^3	10

[a] Total metals are Arsenic, Lead, Cobalt, Chromium, Copper, Manganese, Nickel, Vanadium and Antimony

[57] Environmental, health, and safety guidelines for cement and lime manufacturing. 2007. International Finance Corporation, World Bank Group.

Air Emissions (for lime manufacturing)

Parameter	Unit	Guideline Value
Dust	mg/Nm^3	50
Sulfur dioxide	mg/Nm^3	400
Nitrogen oxide	mg/Nm^3	500
Hydrogen chloride	mg/Nm^3	10

2.6.2 Ceramic Tile and Sanitary Ware Manufacturing[58]

Effluent Levels (for ceramic tile)

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Cadmium	mg/L	0.1
Chromium (total)	mg/L	0.1
Cobalt	mg/L	0.1
Copper	mg/L	0.1
Lead	mg/L	0.2
Nickel	mg/L	0.1
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total suspended solids	mg/L	50
Zinc	mg/L	2

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions (for ceramic tile)

Parameter	Unit	Guideline Value

[58] Environmental, health, and safety guidelines for ceramic tile and sanitary ware manufacturing. 2007. International Finance Corporation, World Bank Group.

Cadmium	mg/Nm^3	0.2
Hydrogen chloride	mg/Nm^3	30
Hydrogen fluoride	mg/Nm^3	5
Lead	mg/Nm^3	0.5
Nitrogen oxide	mg/Nm^3	600[a]
Particulate matter	mg/Nm^3	50[b]
Sulfur dioxide	mg/Nm^3	400[a]
Total organic carbon	mg/Nm^3	20

[a] Kiln operations

[b] Dryer and kiln stacks

2.6.3 Glass Manufacturing[59]

Effluent Levels

Parameter	Unit	Guideline Value
Antimony	mg/L	0.3
Arsenic	mg/L	0.1
Boric acid	mg/L	2
Chemical oxygen demand	mg/L	130
Fluorides	mg/L	5
Lead	mg/L	0.1
Oil and grease	mg/L	10
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total suspended solids	mg/L	30

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

Parameter	Unit	Guideline Value
Arsenic	mg/Nm^3	1
Cadmium	mg/Nm^3	0.2
Fluorides	mg/Nm^3	5
Hydrogen chloride	mg/Nm^3	30
Lead	mg/Nm^3	5
Nitrogen oxide	mg/Nm^3	1,000

[59] Environmental, health, and safety guidelines for glass manufacturing. 2007. International Finance Corporation, World Bank Group.

Other heavy metals (total)		mg/Nm^3	5[a]
Particulates	Natural gas Other fuels	mg/Nm^3	100[b] 50[b]
Sulfur dioxide		mg/Nm^3	700–1,500[c]

[a] 1 mg/Nm^3 for Selenium

[b] Where toxic metals are present, not to exceed 20 mg/Nm^3; to achieve dust emissions of 50 mg/Nm^3 installation of secondary treatments (bag fillers or electrostatic precipitators) is necessary

[c] 700 mg/Nm^3 for natural gas firing, 1,500 mg/Nm^3 for oil firing

2.6.4 Construction Materials Extraction[60]

Construction materials extraction operations do not typically generate point sources or effluents or emissions with the possible exception of dewatering effluents which may contain suspended solids. The implementation of total suspended solids prevention and control strategies should target concentrations of 50 mg/L at the point of discharge. Storm water flows should be managed so as to achieve the General EHS Guidelines for wastewater discharges. The principle sources of air emission are fugitive dust from earth works and materials handling and transport facilities. Prevention and control of air emissions should be sufficient to satisfy General EHS Guidelines for ambient air quality.

2.6.5 Textiles Manufacturing[61]

Effluent Levels[a]

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	30
Adsorbable organic halogens	mg/L	1
Ammonia	mg/L	10
Cadmium	mg/L	0.02
Chemical oxygen demand	mg/L	160
Chromium (haxavalent)	mg/L	0.1
Chromium (total)	mg/L	0.5
Cobalt	mg/L	0.5
Color	m^{-1}	7 (436 nm, yellow)

[60] Environmental, health, and safety guidelines for construction materials extraction. 2007. International Finance Corporation, World Bank Group.

[61] Environmental, health, and safety guidelines for textiles manufacturing. 2007. International Finance Corporation, World Bank Group.

		5 (525 nm, red) 3 (620 nm, blue)
Copper	mg/L	0.5
Nickel	mg/L	0.5
Oil and grease	mg/L	10
Pesticides	mg/L	0.05–0.10[a]
pH	S.U.	6–9
Phenol	mg/L	0.5
Sulfide	mg/L	1
Temperature increase	°C	<3[b]
Total coliform bacteria	MPN[a]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50
Toxicity to fish eggs	T.U. 96h	2
Zinc	mg/L	2

[a] 0.05 mg/L for total pesticides (organophosphorus pesticides excluded); 0.10 mg/L for organophosphorus pesticides

[b] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

Parameter	Unit	Guideline Value
Ammonia	mg/Nm^3	30
Carbon disulfide	mg/Nm^3	150
Chlorine	mg/Nm^3	5
Formaldehyde	mg/Nm^3	20
Hydrogen sulfide	mg/Nm^3	5
Particulates	mg/Nm^3	50[a]
Volatile organic compounds	mg/Nm^3	2/20/50/75/100/150[b,c]

[a] As the 30-minute mean for stack emissions

[b] Calculated as total carbon

[c] As the 30-minute mean for stack emissions: 2 mg/Nm^3 for volatile organic compounds classified as carcinogenic or mutagenic with mass flow greater than or equal to 10 g/hour; 20 mg/Nm^3 for discharges of halogenated volatile organic compounds with a mass flow equal or greater than 100 g/hour; 50 mg/Nm^3 for waste gases from drying of large installations (solvent consumption > 15 tons/year); 75 mg/Nm^3 for coating application processes for large installations (solvent consumption > 15 tons/year); 100 mg/Nm^3 for small installations (solvent consumption < 15 tons/year); if solvent is recovered from emissions and reused, the limit value is 150 mg/Nm^3

2.6.6 Tanning and Leather Finishing[62]

Effluent Levels (for tanning and leather finishing)

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Ammonia	mg/L	10
Chemical oxygen demand	mg/L	250
Chloride	mg/L	1,000
Chromium (hexavalent)	mg/L	0.1
Chromium (total)	mg/L	0.5
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenols	mg/L	0.5
Sulfate	mg/L	300
Sulfide	mg/L	1.0
Temperature increase	°C	<3[a]
Total coliform bacteria	MPN[b]/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

[a] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

[b] MPN = Most Probable Number

Air Emissions (for leather finishing)

Pollutant	Unit	Guideline Value
Upholstery leather (= 4 g add-on / square feet	Kg of hazardous air pollutant loss per 100 m^2 of leather processed	1.3 / 0.2
Upholstery leather (< 4 g add-on / square feet		3.3 / 1.2
Water resistant / specialty leather		2.7 / 2.4
Non-water resistant leather		1.8 / 1.1

2.6.7 Semiconductors and Electronics Manufacturing[63]

[62] Environmental, health, and safety guidelines for tanning and leather finishing. 2007. International Finance Corporation, World Bank Group.

[63] Environmental, health, and safety guidelines for semiconductors and electronics manufacturing. 2007. International Finance Corporation, World Bank Group.

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Adsorbable organic halogens	mg/L	0.5
Ammonia	mg/L	10
Arsenic	mg/L	0.1
Cadmium	mg/L	0.1
Chemical oxygen demand	mg/L	160
Chromium (hexavalent)	mg/L	0.1
Chromium (total)	mg/L	0.5
Copper	mg/L	0.5
Cyanide (free)	mg/L	0.1
Cyanide (total)	mg/L	1
Fluoride	mg/L	5
Lead	mg/L	0.1
Mercury	mg/L	0.01
Nickel	mg/L	0.5
Oil and grease	mg/L	10
pH	S.U.	6-9
Selenium	mg/L	1
Silver	mg/L	0.1
Temperature increase	°C	<3[a]
Tin	mg/L	2
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50
Zinc	mg/L	2

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

Parameter	Unit	Guideline Value
Acetone	mg/Nm^3	150
Ammonia	mg/Nm^3	30
Arsine and arsenic compounds	mg/Nm^3	0.5
Hydrogen chloride	mg/Nm^3	10
Hydrogen fluoride	mg/Nm^3	5
Inorganic hazardous air pollutants[a]	Ppmv	0.42
Organic hazardous air pollutants[a]	Ppmv	20
Phosphine	mg/Nm^3	0.5
Volatile organic compounds[b]	mg/Nm^3	20

[a]Industry-specific hazardous air pollutants include: Antimony compounds, Arsenic compounds, Arsine, Carbon tetrachloride, Catechol, Chlorine, Chromium compounds, Ethyl acrilate, Ethylbenzene, Elthylene glycol, Hydrochloric acid, Hydrofluoric acid, Lead compounds,

Methanol, Methyl isobutyl ketone, Methylene chloride, Nickel compounds, Perchloroethylene, Phosphine, phosphorus, Toluene, 1,1,1-trichloroethane, Trichloroethylene (phased-out), and Xylenes

[b] Applicable to surface cleaning processes

2.6.8 Printing[64]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	30
Adsorbable organic halogens	mg/L	1
Aluminum	mg/L	3
Cadmium	mg/L	0.1
Chemical oxygen demand	mg/L	150
Chromium (haxavalent)	mg/L	0.1
Chromium (total)	mg/L	0.5
Copper	mg/L	0.5
Cyanide	mg/L	0.2
Iron	mg/L	3
Lead	mg/L	1
Oil and grease	mg/L	10
pH	S.U.	6–9
Silver	mg/L	0.5
Temperature increase	°C	<3[a]
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50
Toxicity	To be determined on a case specific basis	
Zinc	mg/L	0.5

[a] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

[64] Environmental, health, and safety guidelines for printing. 2007. International Finance Corporation, World Bank Group.

Parameter	Unit	Guideline Value
Isocyanates	mg/Nm^3	0.1[a]
Nitrogen oxide	mg/Nm^3	100 – 500[b]
Particulates	mg/Nm^3	50[c]
Volatile organic halogens[d]	mg/Nm^3	100[d,e]
		20[d,f]
		75[d,g]
		100[d,h]

[a] As 30 minute mean for contained sources, excluding particulates; from all processes / activities using Isocyanates

[b] As 30 minute mean for contained sources; from turbines, reciprocating engines or boilers used as volatile organic compounds abatement equipment

[c] As 30 minute mean for contained sources; from all processes / activities

[d] Calculated as Total carbon

[e] Heatset web offset printing with 15–25 tons/year solvent consumption

[f] Heatset web offset printing with >25 tons/year solvent consumption

[g] Publication rotogravure with >25 tons/year solvent consumption

[h] Other rotogravure, flexography, rotary screen printing, laminating, or varnishing units (>15 tons/year solvent consumption); rotary screen on textile / card board (>30 tons/year solvent consumption

2.6.9 Foundries[65]

Effluent Levels

Parameter	Unit	Guideline Value
Aluminum	kg/t	0.02[a]
Ammonia	mg/L (as Nitrogen)	5
Cadmium	mg/L	0.01
Chemical oxygen demand	mg/L	125
Chromium (total)	mg/L	0.5
Copper	mg/L	0.5
Fluoride	mg/L (as Fluorine)	5
Iron	mg/L	5
Lead	mg/L	0.2

[65] Environmental, health, and safety guidelines for foundries. 2007. International Finance Corporation, World Bank Group.

Nickel	mg/L	0.5
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenol	mg/L	1
Temperature increase	°C	<3[b]
Tin	mg/L	2
Total suspended solids	mg/L	35
Zinc	mg/L	0.5

[a]Aluminum smelting and casting

[b] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

Parameter	Unit	Guideline Value
Amines	mg/Nm^3	5
Carbon monoxide	mg/Nm^3	200[a]
		150[b]
Chloride	mg/Nm^3	5[c]
Chlorine	mg/Nm^3	5
Copper and compounds	mg/Nm^3	5-20[d]
Fluoride	mg/Nm^3	5[e]
Hydrogen sulfide	ppm v/v	5
Lead, cadmium and their compounds	mg/Nm^3	1-2[f]
Nickel, Cobalt, Chromium, Tin and their compounds	mg/Nm^3	5
Nitrogen oxide	mg/Nm^3	400[g]
		120[h]
		150[i]
Oil Aerosol / mist	mg/Nm^3	5[j]
Particulate matter	mg/Nm^3	20[k]
		50[l]
Polychlorinated dibenzodioxin and dibenzofuran	ng TEQ/m^3	0.1
Sulfur dioxide	mg/Nm^3	400[g]
		50[m]
		120[g]
Volatile organic compounds	mg/Nm^3	20[n]
		30[g]
		15[0]

[a] Non-ferrous metal melting (aluminum)

[b] Thermal sand reclamation systems and solvent based investment foundry coating, shelling, and setting operation

[c] Furnace emissions where chloride flux is used

[d] Higher value applicable to copper and its alloy producing processes

[e] Furnace emissions where fluoride flux is used

[f] Higher value applicable to non-ferrous metal foundries from scrap

[g] Non-ferrous metal melting (shaft furnaces)

[h] From thermal sand reclamation systems / regeneration units

[i] Maximum emissions level considered on best available technology base and based on cold blast cupola furnaces

[j] Ferrous metal melting (maximum emissions level considered on best available technology base and based on cokeless cupola furnaces)

[k] Particulate matter emissions when toxic metals are present

[l] Particulate matter emissions when toxic metals are not present

[m] Ferrous metal melting (cupola furnaces)

[n] Ferrous metal melting (electric arc furnaces); cupola furnaces may have higher emissions levels (up to 1,000 mg/Nm^3)

[o] Cold box molding and core making shop

2.6.10 Integrated Steel Mills[66]

Effluent Levels

Parameter	Unit	Guideline Value
Ammonia	mg/L (as Nitrogen)	5
Cadmium	mg/L	0.01
Chemical oxygen demand	mg/L	250
Chromium (hexavalent)	mg/L	0.1
Chromium (total)	mg/L	0.5
Copper	mg/L	0.5
Cyanides (free)	mg/L	0.1
Cyanides (total)	mg/L	0.5
Fluoride	mg/L (as Fluorine)	5
Iron	mg/L	5
Lead	mg/L	0.2
Mercury	mg/L	0.01
Nickel	mg/L	0.5

[66] Environmental, health, and safety guidelines for integrated steel mills. 2007. International Finance Corporation, World Bank Group.

Oil and grease	mg/L	10
pH	S.U.	6-9
Phenol	mg/L	0.5
Polycyclic aromatic hydrocarbons	mg/L	0.05
Sulfides	mg/L	0.1
Temperature increase	°C	<3[a]
Tin	mg/L	2
Total nitrogen	mg/L	30
Total phosphorus	mg/L	2
Total suspended solids	mg/L	35
Toxicity	To be determined on a case specific basis	
Zinc	mg/L	2

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

Parameter	Unit	Guideline Value
Ammonia	mg/Nm^3	30
Benzo(a)pirene	mg/Nm^3	0.1
Cadmium	mg/Nm^3	0.2
Carbon monoxide	mg/Nm^3	100 (electric arc furnace)
		300 (coke oven)
Chromium	mg/Nm^3	4
Fluoride	mg/Nm^3	5
Hydrogen chloride	mg/Nm^3	10
Hydrogen fluoride	mg/Nm^3	10
Hydrogen sulfide	mg/Nm^3	5
Lead	mg/Nm^3	2
Nickel	mg/Nm^3	2
Nitrogen oxide	mg/Nm^3	500
		750 (coke oven)
Oil mist	mg/Nm^3	15
Particulate matter	mg/Nm^3	20-50[a]
Polychlorinated dibenzodioxin and dibenzofuran	ng TEQ/m^3	0.1
Sulfur dioxide	mg/Nm^3	500
Tar fume	mg/Nm^3	5
Volatile organic compounds	mg/Nm^3	20

[a] Lower value where toxic metals are present

2.6.11 Base Metal Smelting and Refining[67]

Effluent Levels (for nickel, copper, lead, zinc and aluminum smelting and refining)

Parameter	Unit	Guideline Value
Aluminum	mg/L	0.2
Arsenic	mg/L	0.05
Cadmium	mg/L	0.05
Chemical oxygen demand	mg/L	50
Copper	mg/L	0.1
Fluoride	mg/L	5
Hydrocarbons	mg/L	5
Lead	mg/L	0.1
Mercury	mg/L	0.01
Nickel	mg/L	0.1
pH	S.U.	6-9
Temperature increase	°C	<3[a]
Total suspended solids	mg/L	20
Toxicity	To be determined on a case specific basis	
Zinc	mg/L	0.2

Air Emissions (for nickel, copper, lead, zinc and aluminum smelting and refining – varying by metal type / smelting process)

Parameter	Unit	Guideline Value
Acid mists / gases	mg/Nm^3	50
Ammonia	mg/Nm^3	5
Arsine	mg/Nm^3	0.5
Carbon monoxide and carbonyls	mg/Nm^3	5
Chlorine	mg/Nm^3	0.5
Dioxins	$Ng\ TEQ/m^3$	0.1-0.5
Dust	mg/Nm^3	1-5
Hydrogen chloride	mg/Nm^3	5
Hydrogen fluoride	mg/Nm^3	0.5

[67] Environmental, health, and safety guidelines for base metal smelting and refining. 2007. International Finance Corporation, World Bank Group.

Mercury	mg/Nm^3	0.02
Nitrogen oxides	mg/Nm^3	100-300
Polyfluorinated hydrocarbons	Anode effects/ cell /day	0.1
Sulfur dioxide	mg/Nm^3	< 50-200
Total fluoride	mg/Nm^3	0.8
Total organic carbon	mg/Nm^3	5-50
Volatile organic compounds / solvents	mg/Nm^3	5-15

2.6.12 Metal, Plastic, Rubber Products Manufacturing[68]

Effluent Levels

Parameter	Unit	Guideline Value
Aluminum	mg/L	3
Ammonia	mg/L	10
		20 (electroplating)
Arsenic	mg/L	0.1
Cadmium	mg/L	0.1
Chemical oxygen demand	mg/L	250
Chromium (haxavalent)	mg/L	0.1
Chromium (total)	mg/L	0.5
Copper	mg/L	0.5
Cyanides (free)	mg/L	0.2
Cyanides (total)	mg/L	1
Fluorides	mg/L	20
Iron	mg/L	3
Lead	mg/L	0.2
Mercury	mg/L	0.01
Nickel	mg/L	0.5
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenols	mg/L	0.5
Silver	mg/L	0.2
Sulfide	mg/L	1
Temperature increase	°C	<3[a]
Tin	mg/L	2
Total nitrogen	T.U. 96h	15
Total phosphorus	mg/L	5

[68] Environmental, health, and safety guidelines for metal, plastic, rubber products manufacturing. 2007. International Finance Corporation, World Bank Group.

Total suspended solids	mg/L	50 25 (electroplating)
Toxicity	To be determined on a case specific basis	
Volatile organic halogens	mg/L	0.1
Zinc	mg/L	2

[a]At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Air Emissions

Parameter	Unit	Guideline Value
Ammonia	mg/Nm^3	50
Hydrogen chloride	mg/Nm^3	10
Nitrogen oxides	mg/Nm^3	350
Particulate matter (metal surface treatments)	mg/Nm^3	5
Particulate matter (plastic processing)	mg/Nm^3	3
Total organic carbon (rubber vulcanization)	mg/Nm^3	80
Volatile halogenated hydrocarbons (metal surface treatments)	mg/Nm^3	20
Volatile organic compounds (metal and plastic coating)	mg/Nm^3	100 (up to 15 ton/year solvent consumption) 75 (more than 15 ton/year solvent consumption) 50 (drying processes)
Volatile organic compounds (rubber conversion)	mg/Nm^3	20[a]
Volatile organic compounds(surface cleaning)	mg/Nm^3	20-75[b]

[a] Facilities with solvent consumption greater than 15 ton/year.

[b] 20 mg/Nm^3 for waste gases from surface cleaning using VOC classified as carcinogenic, mutagenic or toxic to reproduction; 75 mg/Nm^3 for waste gases from other surface cleaning.

2.7 Mining[69]

Effluent Levels

Parameter	Unit	Guideline Value
5-day Biochemical oxygen demand	mg/L	50
Arsenic	mg/L	0.1

[69] Environmental, health, and safety guidelines for mining. 2007. International Finance Corporation, World Bank Group.

Cadmium	mg/L	0.05
Chemical oxygen demand	mg/L	150
Chromium (hexavalent)	mg/L	0.1
Copper	mg/L	0.3
Cyanide	mg/L	1
Cyanide (free)	mg/L	0.1
Cyanide (weak acid dissociable)	mg/L	0.5
Iron (total)	mg/L	2
Lead	mg/L	0.2
Mercury	mg/L	0.002
Nickel	mg/L	0.5
Oil and grease	mg/L	10
pH	S.U.	6-9
Phenols	mg/L	0.5
Temperature	°C	<3 degree differential
Total suspended solids	mg/L	50
Zinc	mg/L	0.5

2.8 Power

2.8.1 Wind Energy[70]

Wind energy facilities do not typically generate process effluents and emissions during operations. Wastewater discharges, air emissions and solid wastes related to construction and decommissioning activities should comply with General Guidelines. Noise impacts during operations should not exceed the levels stipulated in the General Guidelines, nor result in a maximum increase in background levels of 3 dB at the nearest receptor location.

2.8.2 Geothermal Power Generation[71]

[70] Environmental, health, and safety guidelines for wind energy. 2007. International Finance Corporation, World Bank Group.

[71] Environmental, health, and safety guidelines for geothermal power generation. 2007. International Finance Corporation, World Bank Group.

Spent geothermal fluids are typically re-injected to the host rock formation, resulting in minor effluent volumes involving reject water. If spent geothermal fluids are not re-injected, effluents should meet site-specific discharge levels for surface water as stipulated in the General Guidelines. Minor air emissions of hydrogen sulfide, mercury vapor, and sulfur dioxide may arise as fugitive emissions from the cooling tower if the condensation process involves direct contact of steam with cooling water. Although geothermal energy projects do not normally generate significant point source emissions during construction and operations, hydrogen sulfide and other types of emissions should not result in ambient concentrations exceeding internationally recognized guidelines (e.g. WHO Air Quality Guidelines).

2.8.3 Electric Power Transmission and Distribution[72]

The power transmission and distribution sector does not typically give rise to significant effluents or air emissions. Where potentially contaminated water run-off or dust exists, site operations should comply with General Guidelines for surface water quality and air quality. Exposure limits for general public exposure to electric and magnetic fields should comply with International Commission on Non-ionized Radiation Protection guidelines for limiting general public exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz).

Frequency	Electric Field (V/m)	Magnetic Field (µT)
50 Hz	5000	100
60 Hz	4150	83

2.8.4 Thermal Power[73]

Effluent Levels

Parameter	Unit	Guideline Value
Arsenic	mg/L	0.5
Cadmium	mg/L	0.1
Chromium (total)	mg/L	0.5
Copper	mg/L	0.5
Iron	mg/L	1
Lead	mg/L	0.5
Mercury	mg/L	0.005
Oil and grease	mg/L	10
pH	S.U.	6-9

[72] Environmental, health, and safety guidelines for electric power transmission and distribution. 2007. International Finance Corporation, World Bank Group.

[73] Environmental, health, and safety guidelines for thermal power. 2007. International Finance Corporation, World Bank Group.

Temperature increase[a]	°C	<3
Total residual chlorine	mg/L	0.2
Total suspended solids	mg/L	50
Zinc		1

[a] Temperature increase due to discharge of once-through cooling water

Air Emissions (applicable to non-degraded airsheds)

Combustion Technology / Fuel	Parameter / Guideline Values		
	Particulate matter	Sulfur dioxide	Nitrogen oxides
Combustion turbine			
Fuels other than natural gas (unit > 50 MW)	50 mg/Nm^3	Use of ≤ 1% Sulfur fuel	152 ppm
Natural gas (all turbine types; unit > 50 MW)	N/A	N/A	51 ppm
Boiler			
Liquid fuels (plant > 600 MW)	50 mg/Nm^3	200 mg/Nm^3	400 mg/Nm^3
Liquid fuels (plant 50-600 MW)	50 mg/Nm^3	900 mg/Nm^3	400 mg/Nm^3
Natural gas	N/A	N/A	240 mg/Nm^3
Other gaseous fuels	50 mg/Nm^3	400 mg/Nm^3	240 mg/Nm^3
Solid fuels (plant > 600 MW)	50 mg/Nm^3	200 mg/Nm^3	510 mg/Nm^3
Solid fuels (plant 50-600 MW)	50 mg/Nm^3	900 mg/Nm^3	510 mg/Nm^3
Reciprocating engine			
Biofuels / gaseous fuels other than natural gas	50 mg/Nm^3	N/A	30% higher than for other fuels
Liquid fuels (plant > 300 MW)	50 mg/Nm^3	585 mg/Nm^3	740 mg/Nm^3
Liquid fuels (plant 50-300 MW)	50 mg/Nm^3	1170 mg/Nm^3	1460 mg/Nm^3
Natural gas	N/A	N/A	200 mg/Nm^3

Annex 1
Unit Table

No	Unit	Expression
1.	mg/L	milligram of pollutant per liter
2.	mg urea/L	milligram of urea per liter
3.	µg/L	Microgram of pollutant per liter
4.	ng/L	nanogram of pollutant per liter
5.	MPN	Most Probable Number
6.	S.U.	Standard Unit
7.	dBA	Decibel
8.	mg/m^3	milligram of pollutant per cubic meter
9.	mg/Sm^3	milligram per standard cubic meter
10.	mg/Nm^3	milligram of pollutant per normal cubic meter (273K, 1 atm)
11.	°C	Degree Celsius
12.	kg/ADt	kilograms of pollutant per 1,000 of air dry pulp
13.	m^3/ADt	volume in cubic meter per 1,000 of air dry pulp
14.	kg/ton NPK	kilogram per one ton of compound fertilizer
15.	kg/ton Phosphorus oxide	kilogram per one ton of Phosphorus oxide
16.	kg/ton HF	kilogram per one ton of HF
17.	mg/kg	milligram of pollutant per kilogram
18.	TEQ	Toxic Equivalent (for dioxins and related compounds)
19.	V/m	volts per meter
20.	µT	micro tesla
21.	m^{-1}	per meter
22.	T.U.	Toxicity Unit (100 / no effects dilution rate (%) of wastewater)
23.	T.U. 96h	Toxicity Unit for 96 hour
24.	ppm	parts per million
25.	ppmv	parts per million (volume)