

## 5.1 INTRODUCTION

This Chapter provides an overview of the environment-biophysical baseline conditions within the Project Study Area based on secondary data from published sources as well as primary data collected to fill data gaps. This section of the ESIA report is organized by different biophysical parameters and also includes a discussion of the baseline conditions and any additional methods used to fill in the gaps during primary data gathering at the Project Study Area.

### 5.1.1 Project Study Area

The Project Study Area refers to the area that needs to be studied in order to adequately understand and describe the baseline conditions likely to be affected by the Project. The Project Study Area (see **Figure 5.1**) comprises a 3km radius of the Project site and existing Steel Mill (shown as the Complex in **Figure 5.1**). The Project Study Area also comprises a 500m buffer of the water supply pipeline route presented in the Scoping Study undertaken by IFC in 2015<sup>(1)</sup>.

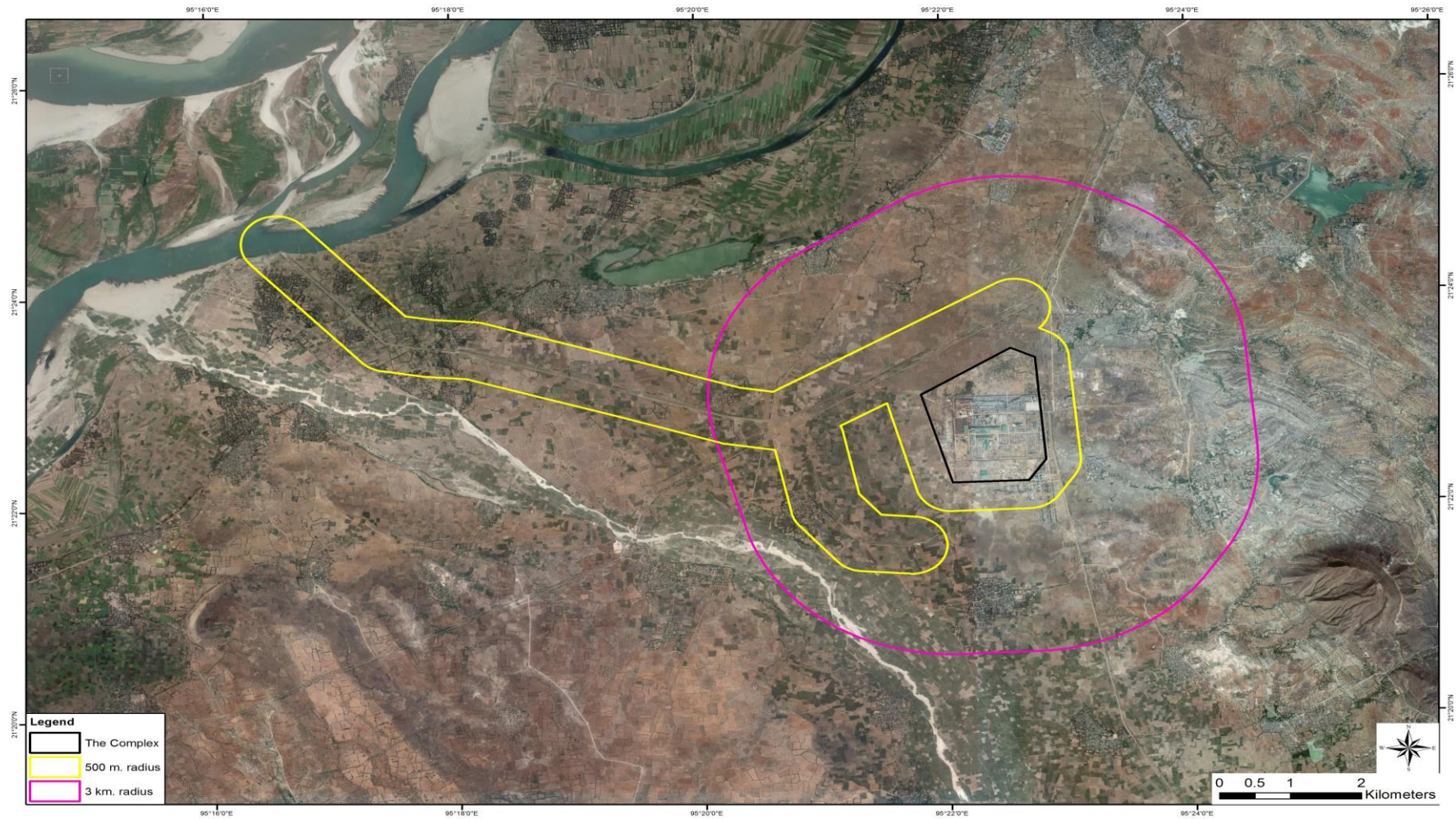
### 5.1.2 Project Area of Influence (Aoi)

The Project Area of Influence (Aoi) varies according to the potential impacts on a resource or receptor (influenced by spatial and temporal dimensions). The Aoi was determined from initial screening using the IFC Scoping Study undertaken in 2015 and professional judgement of similar types of power projects. The Aoi with respect to the biophysical baseline covers the Project Study Area. However, for air quality the Aoi was extended to 10km from the Complex to consider stack emissions.

The Government of Myanmar has not yet established numerical standards for environmental parameters, although there are some pending guidelines. In the absence of national standards, the Ministry of Environmental Conservation and Forestry (MOECAF) typically recommends that internationally accepted numerical environmental standards, such as the World Bank Group (WBG) / International Finance Corporation (IFC), Asian Development Bank (ADB) Safeguards Policy Statement and World Health Organisation (WHO) guidelines, should be adopted for environmental assessments.

<sup>(1)</sup> Myingyan IPP Project – Environmental & Social Consultancy Services in Support of Transaction Advisory Service’s for Private Sector Participation Scoping Report – Rev 4 – 18<sup>th</sup> May 2015.

Figure 5.1 Project Study Area



## 5.2

### CLIMATE AND METEOROLOGY

Information presented in this section has been collected through a combination of publically available data supplemented by meteorological monitoring that has been undertaken by ERM as part of the baseline monitoring programme. Meteorology data collected during the baseline survey included temperature, relative humidity wind speed and wind direction. The 24-hour monitoring has been carried out every month since July 2014 to June 2015 by using a Haz-Scanner EPAS Environmental Perimeter Air Station. Baseline meteorological sampling was undertaken in parallel with the ambient air quality Sensitive Receivers (SRs) described in **Section 5.3**.

#### 5.2.1

##### *Myanmar Climatic Conditions*

Most of Myanmar belongs to the tropical region. The climate of Myanmar is roughly divided into three (3) seasons: Summer, Rainy Season, and Winter Season. Summer months are from March to Mid-May; the rain falls from Mid-May to the end of October and the Winter Season starts in November up to the end of February. Due to widely differing topographical situations of the country, its climate conditions also differ widely from one place to another<sup>(1)</sup>. April and May are the hottest months with an average temperature of 32°C (79 – 83°F). The coldest month is January, with an average temperature of 21°C (°F).

The southwest monsoon starts in late March or early April with local turbulence that includes tornados and cyclones, with winds that can reach up to 200 – 300 kph. From October to mid-March the northeast monsoon arrives which is dry and cool. The monsoon rain in the Dry Zone of Myanmar is bimodal with a drought period during July when dry desiccating winds blow from the south of Myanmar.

Rainfall patterns during the dry season are highly variable. There has been an observed decrease of about 45 – 65 % of rainfall over the last five years (2007 – 2012) and further analysis has confirmed the increase in drought occurrence over the past few decades in the Dry Zone region<sup>(2)</sup>.

#### 5.2.2

##### *Mandalay Region Climatic Conditions*

The Project site is located in the central plain of Myanmar, and is primarily located in the Dry Zone of Myanmar, which includes the western and middle part of the Mandalay region; this region is the most susceptible to drought in Myanmar<sup>(3)</sup>. The region is characterised by low annual rainfall that ranges between 508 mm and 1,016 mm per annum with high variability and uneven distribution<sup>(4)</sup>. Mean temperature in the Dry Zone is about 27°C and the temperature often rises to about 43°C in the summer period<sup>(5)</sup>.

(1) <http://www.unccd.int/ActionProgrammes/myanmar-eng2005.pdf>

(2) United Nations Development Programme (2012), *Op cite*

(3) [http://lift-fund.net/downloads/Component%203%20Final\\_19Aug13.pdf](http://lift-fund.net/downloads/Component%203%20Final_19Aug13.pdf)

(4) United Nations Development Programme - Adaptation Fund Project/Proposal Information (2012)

(5) United Nations Development Programme (2012) *Op cite*

The central region of Myanmar lies within the following climatic zones:

- Tropical savannah climate (around the Dry Zone) with more pronounced dry seasons between the monsoon rains and thus lower precipitation, but similar mean temperatures to those in the tropical monsoon climate; and
- Tropical steppe climate (Dry Zone), semi-arid climate with less than 1,250 mm of precipitation per annum and mean annual temperatures in excess of 27° C.

### 5.2.3 *Project Site Climatic Conditions*

Climatic information for the study was obtained from a weather station located at Myingyan, Mandalay state, which is situated in latitudes 21° 28' 0" N and longitudes 95° 23' 0" E, approximately 14.5km to the north from the Project site <sup>(1)</sup> and meteorology data collected during the baseline survey.

A summary of data available publically for Myingyan is provided in **Table 5.1**, **Figure 5.2** and **Figure 5.3**.

#### **Temperature**

The data obtained from the Myingyan weather station shows that the hottest months in 2013 were April to July, with average temperatures between 31.8°C and 32.4°C. The lowest temperature experienced in 2013 was in January with 20.7 °C.

During July 2014 to June 2015, the five (5) SRs showed an average mean temperature was 27.7°C, with an average maximum temperature of 31.9°C and an average minimum of 22.9°C. The highest temperature was 34.7°C (in May 2015) while the lowest temperature was 21.7°C (in February 2015). This is consistent with the temperatures recorded at the Myingyan weather station for the corresponding months for 2013. On site monitoring data is presented in **Table 5.2**.

#### **Relative Humidity**

On site monitoring at the five (5) SRs showed that the averaged relative humidity fluctuates between 39.9% and 79.3%, with an annual average mean relative humidity of 64.2% (**Table 5.3**). The maximum and minimum monthly average relative humidity were 86% (in June 2015) and 35.2% (in March 2015), respectively.

#### **Rainfall**

According to **Table 5.1**, Myingyan Township in the year 2013 received an average of 632mm of rainfall per year. In 2013, the driest conditions were experienced over 5 months from December to April where 3 – 8mm of rainfall are received. The wettest months were August and September, with a maximum of 112mm and 150 mm of rainfall, respectively.

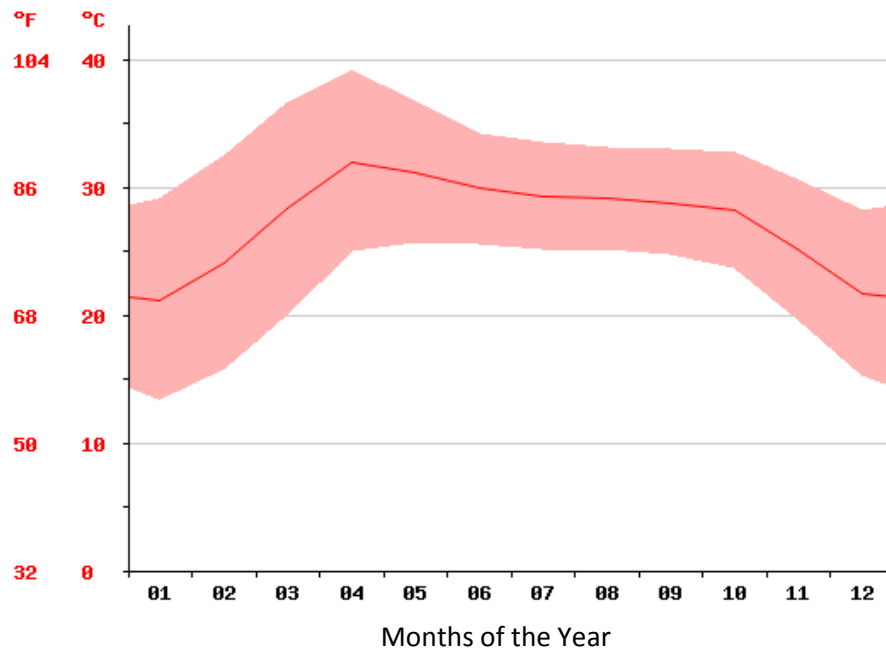
<sup>(1)</sup> <http://weather.gladstonefamily.net/site/48047>, accessed 18-06-2014

**Table 5.1 Climatic Data of Myingyan, Mandalay State, Myanmar 2013**

Climatic Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max Temperature °C ( °F)	28.5 (83.3)	33.5 (92.3)	37.6 (99.7)	39.7 (103.5)	38.6 (101.5)	36.5 (97.7)	36.6 (97.9)	34.6 (94.3)	34.2 (93.6)	32.5 (90.5)	31.1 (88.0)	27.8 (82.04)	34.3 (93.7)
Average Temperature °C ( °F)	20.7 (69.3)	23.9 (75.0)	28.5 (83.3)	32.1 (89.8)	32.4 (90.3)	31.8 (89.2)	32.4 (90.3)	30.1 (86.2)	29.8 (85.6)	28.2 (82.8)	25.3 (77.5)	21 (69.8)	28.02 (82.4)
Average Min Temperature °C ( °F)	12.9 (55.2)	14.4 (57.9)	19.5 (67.1)	24.5 (76.1)	26.3 (79.3)	26.7 (80.1)	28.3 (82.9)	25.7 (78.3)	25.5 (77.9)	24 (75.2)	19.4 (66.9)	14.4 (57.9)	21.80 (71.2)
Average Precipitation mm (in)	3.0 (0.1)	3.0 (0.1)	3.0 (0.1)	8.0 (0.3)	84.0 (3.3)	74.0 (2.9)	81.0 (3.2)	112.0 (4.4)	150.0 (5.9)	81.0 (3.2)	28.0 (1.1)	5.0 (0.2)	632.0 (24.9)

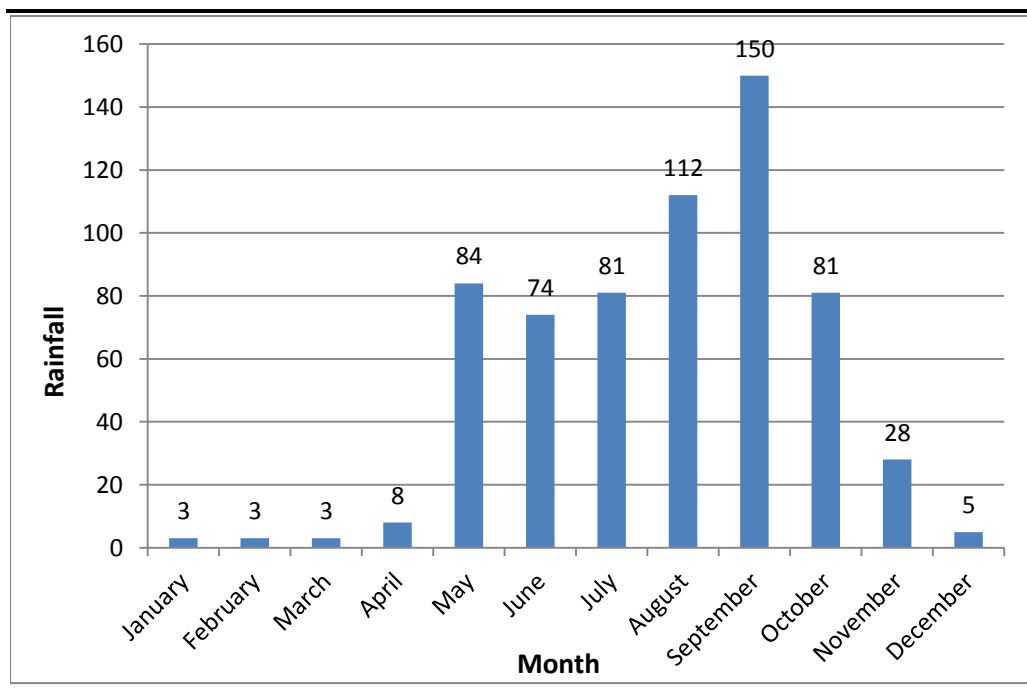
Source: Client data; 2011 – 2013, <http://www.levoyageur.net/weather-city-MYINGYAN.html>,

**Figure 5.2 Myingyan, Myanmar Climate Graph 2013**



Source: <http://en.climate-data.org/location/318/> (2013)

**Figure 5.3 Myingyan, Myanmar Precipitation (in mm) 2013**



Source: <http://www.levoyageur.net/weather-city-MYINGYAN.html>, (2013)

**Table 5.2 Average Ambient Temperature (°C) between July to December 2014 and January to June 2015..**

ASR Location	2014						2015						Annual
	July	August	September	October	November	December	January	February	March	April	May	June	
ASR-1	29.2	29.2	28.3	27.9	28.0	22.9	22.4	22.7	28.8	32.0	28.3	29.9	27.5
ASR-2	26.4	29.2	28.0	26.8	27.9	22.8	22.5	21.7	27.8	30.5	27.4	29.3	26.7
ASR-3	27.9	26.5	30.3	26.3	25.9	22.2	-	26.0	28.7	30.5	31.1	27.1	27.5
ASR-4	25.5	27.8	30.6	28.5	25.9	24.6	-	29.1	32.0	33.0	34.7	30.6	29.3
ASR-5	28.4	30.0	31.0	28.9	26.9	22.2	25.3	25.1	30.5	33.6	27.4	32.3	28.5
<b>Average</b>	<b>27.5</b>	<b>28.5</b>	<b>29.6</b>	<b>27.7</b>	<b>26.9</b>	<b>22.9</b>	<b>23.4</b>	<b>24.9</b>	<b>29.5</b>	<b>31.9</b>	<b>29.8</b>	<b>29.8</b>	<b>27.7</b>
<b>Maximum</b>	<b>29.2</b>	<b>30.0</b>	<b>31.0</b>	<b>28.9</b>	<b>28.0</b>	<b>24.6</b>	<b>25.3</b>	<b>29.1</b>	<b>32.0</b>	<b>33.6</b>	<b>34.7</b>	<b>32.3</b>	<b>34.7</b>
<b>Minimum</b>	<b>25.5</b>	<b>26.5</b>	<b>28.0</b>	<b>26.3</b>	<b>25.9</b>	<b>22.2</b>	<b>22.4</b>	<b>21.7</b>	<b>27.8</b>	<b>30.5</b>	<b>27.4</b>	<b>27.1</b>	<b>21.7</b>

Note: - No data collected in the Sensitive Receivers

**Table 5.3 Average Relative Humidity (%) between July to December 2014 and January to June 2015.**

ASR Location	2014						2015						Annual
	July	August	September	October	November	December	January	February	March	April	May	June	
ASR-1	63.3	65.6	78.7	76.2	80.6	76.6	56.9	50.5	35.2	44.8	36.0	67.8	61.0
ASR-2	46.0	66.8	76.7	77.4	79.0	65.9	62.4	59.6	42.3	47.7	78.8	65.9	64.0
ASR-3	62.7	72.2	76.9	85.5	74.0	70.0	-	41.6	42.2	50.1	59.6	75.0	64.5
ASR-4	- <sup>(a)</sup>	75.5	75.6	74.8	73.7	74.0	-	41.9	42.4	49.9	64.0	86.0	65.8
ASR-5	63.7	73.6	72.9	82.7	75.6	75.8	64.0	57.3	37.2	46.6	78.8	75.8	67.0
<b>Average</b>	<b>58.9</b>	<b>70.7</b>	<b>76.2</b>	<b>79.3</b>	<b>76.6</b>	<b>72.5</b>	<b>61.1</b>	<b>50.2</b>	<b>39.9</b>	<b>47.8</b>	<b>63.4</b>	<b>74.1</b>	<b>64.2</b>
<b>Maximum</b>	<b>63.7</b>	<b>75.5</b>	<b>78.7</b>	<b>85.5</b>	<b>80.6</b>	<b>76.6</b>	<b>64.0</b>	<b>59.6</b>	<b>42.4</b>	<b>50.1</b>	<b>78.8</b>	<b>86.0</b>	<b>86.0</b>
<b>Minimum</b>	<b>46.0</b>	<b>65.6</b>	<b>72.9</b>	<b>74.8</b>	<b>73.7</b>	<b>65.9</b>	<b>56.9</b>	<b>41.6</b>	<b>35.2</b>	<b>44.8</b>	<b>36.0</b>	<b>65.9</b>	<b>35.2</b>

Note:<sup>(a)</sup> Over 50% data recorded are invalid, therefore, the R.H. in July cannot be averaged.

### **Wind Conditions**

Dominant wind patterns in the Project Study Area are driven primarily by regular southwest (SW) monsoon wind in the rainy season and northeast (NE) monsoon wind in the winter or cold-dry season. These wind patterns are mediated by more mountainous terrain to the west and east. Localized meteorological conditions are also influenced by diurnal thermal cycles and cloud cover.

Wind data was collected for 24 hours continuously over a seven day period from July 2014 to June 2015. Wind roses for the data for the five SRs are presented in **Figure 5.4** to **Figure 5.8**. The results are presented in **Table 5.4**.

The dominant wind direction during the time of monitoring (June 2014 to July 2015) was south to southwest. The wind speed throughout the monitoring period is considered low.

**Table 5.4 Averaged Wind Speed and Direction at SRs**

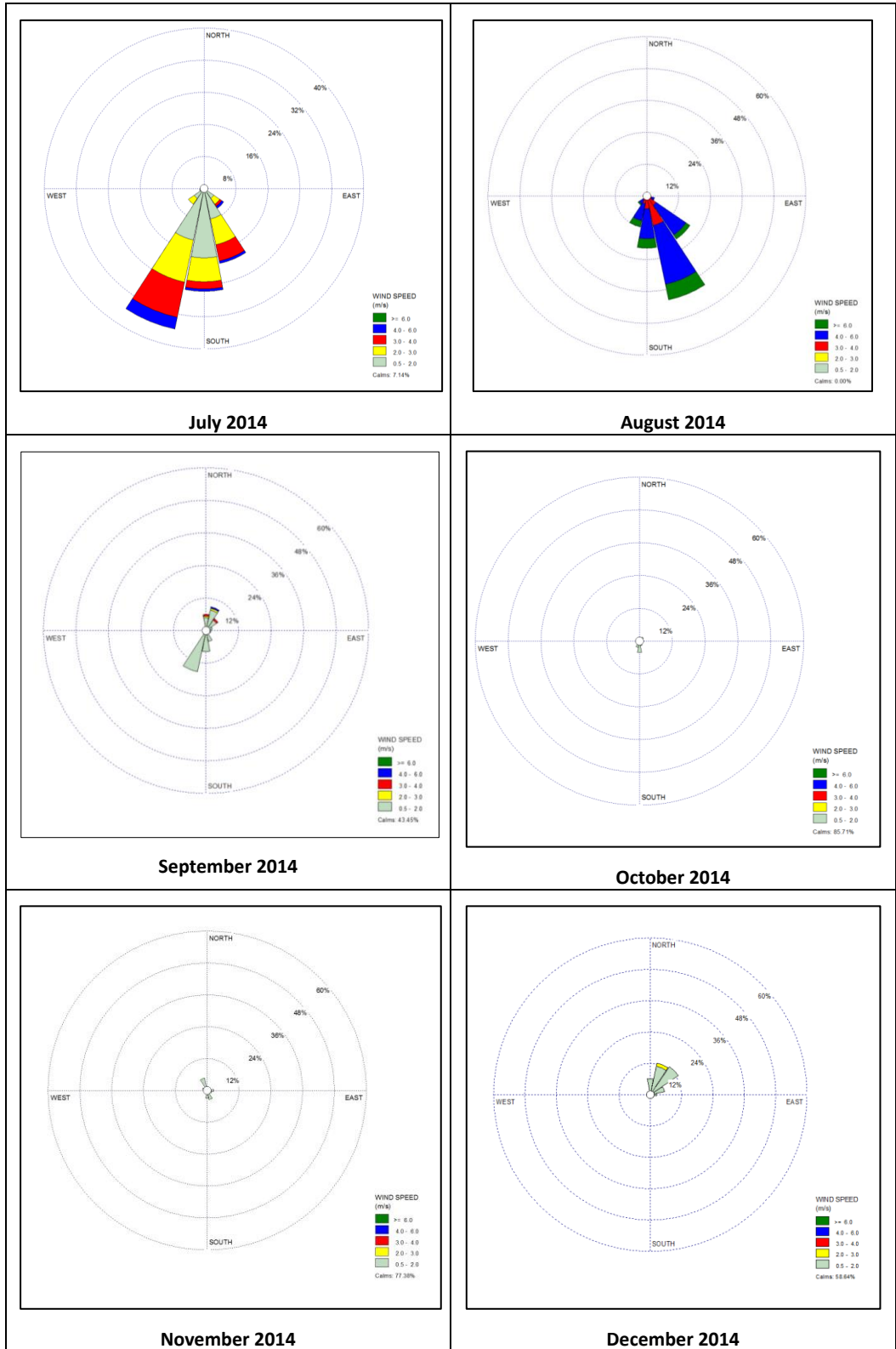
SR Location	July 2014		August 2014		September 2014		October 2014		November 2014		December 2014	
	Averaged Wind Speed (m/s)	Prevailing Wind Direction	Averaged Wind Speed (m/s)	Prevailing Wind Direction	Averaged Wind Speed (m/s)	Prevailing Wind Direction	Averaged Wind Speed (m/s)	Prevailing Wind Direction	Averaged Wind Speed (m/s)	Prevailing Wind Direction	Averaged Wind Speed (m/s)	Prevailing Wind Direction
ASR-1	1.93	South to southwest	4.80	South to southeast	0.60	Southwest and northeast	0.13	- <sup>a</sup>	0.19	- <sup>a</sup>	0.51	Northeast
ASR-2	1.97	South to southeast	4.12	South to southwest, North	2.20	South and north	0.39	- <sup>a</sup>	0.51	South to southwest	0.41	- <sup>a</sup>
ASR-3	1.64	South to southwest, North	0.84	Southeast	0.15	South	0.28	- <sup>a</sup>	0.03	- <sup>a</sup>	0.37	Southwest
ASR-4	1.65	South to southeast	2.74	Southwest and north	1.16	South to southwest	0.06	- <sup>a</sup>	0.07	- <sup>a</sup>	0.00	- <sup>a</sup>
ASR-5	1.68	West	2.68	Southwest	0.27	South	0.08	- <sup>a</sup>	0.24	- <sup>a</sup>	0.42	East to southeast

SR Location	January 2015		February 2015		March 2015		April 2015		May 2015		June 2015	
	Averaged Wind Speed (m/s)	Prevailing Wind Direction	Averaged Wind Speed (m/s)	Prevailing Wind Direction	Averaged Wind Speed (m/s)	Prevailing Wind Direction	Averaged Wind Speed (m/s)	Prevailing Wind Direction	Averaged Wind Speed (m/s)	Prevailing Wind Direction	Averaged Wind Speed (m/s)	Prevailing Wind Direction
ASR-1	0.31	West	0.45	Northeast	0.53	East	0.77	Northeast	1.17	South to southwest	2.09	Southwest
ASR-2	0.22	Northwest	0.36	Northwest	0.50	Northwest	0.74	Northwest	1.49	South	3.14	South
ASR-3	- <sup>b</sup>	- <sup>b</sup>	0.15	West	0.55	Southwest	0.78	West	0.89	South	2.34	South
ASR-4	- <sup>b</sup>	- <sup>b</sup>	0.01	West	0.18	South	0.15	Southwest	0.28	South	1.27	South
ASR-5	- <sup>b</sup>	- <sup>b</sup>	0.01	West	0.11	Southeast	0.27	Southwest	0.82	South	1.16	South

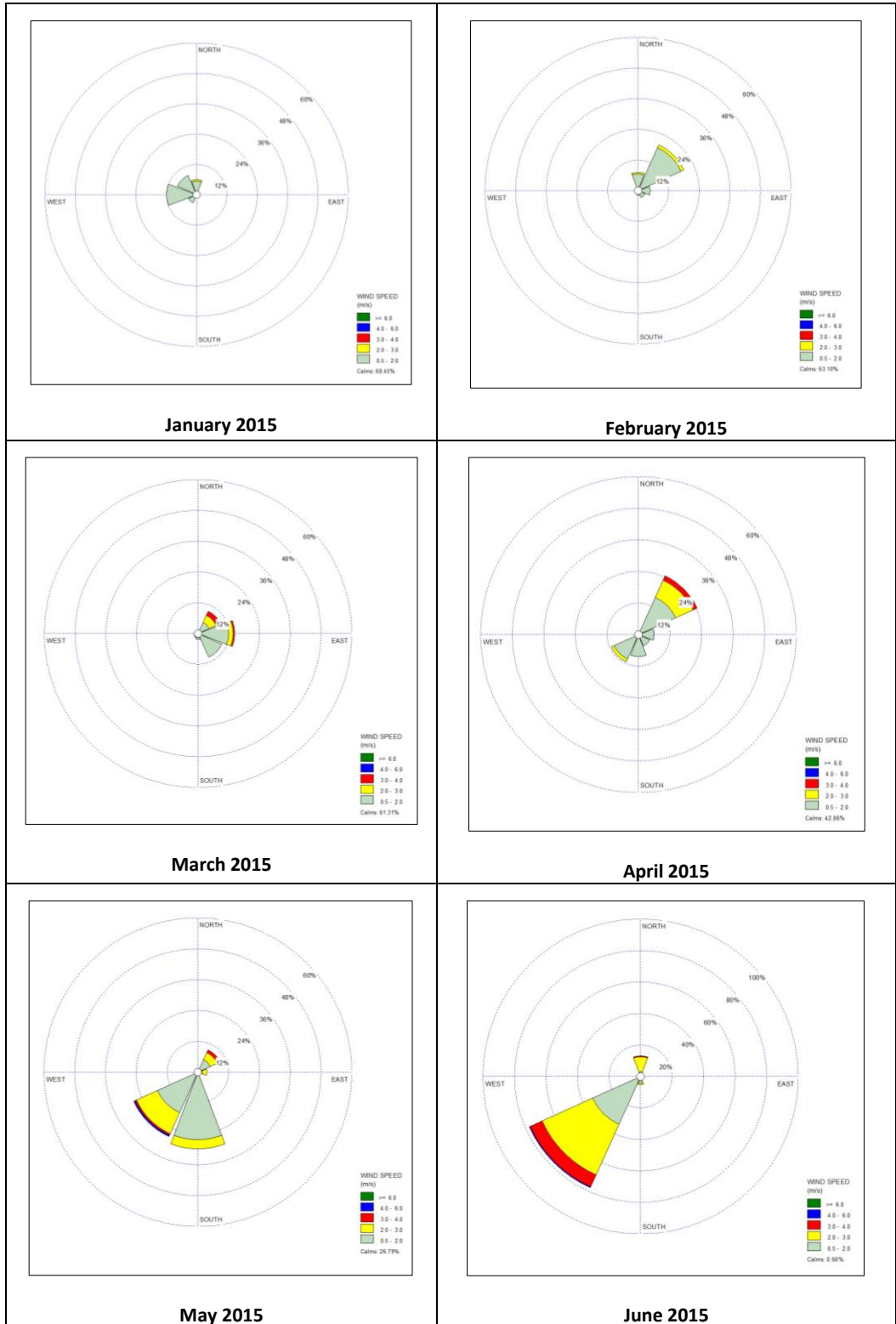
Note: -a. Since the averaged wind speed was very low, no prevailing wind was recorded at some ASRs

-b No data collected at the Sensitive Receivers

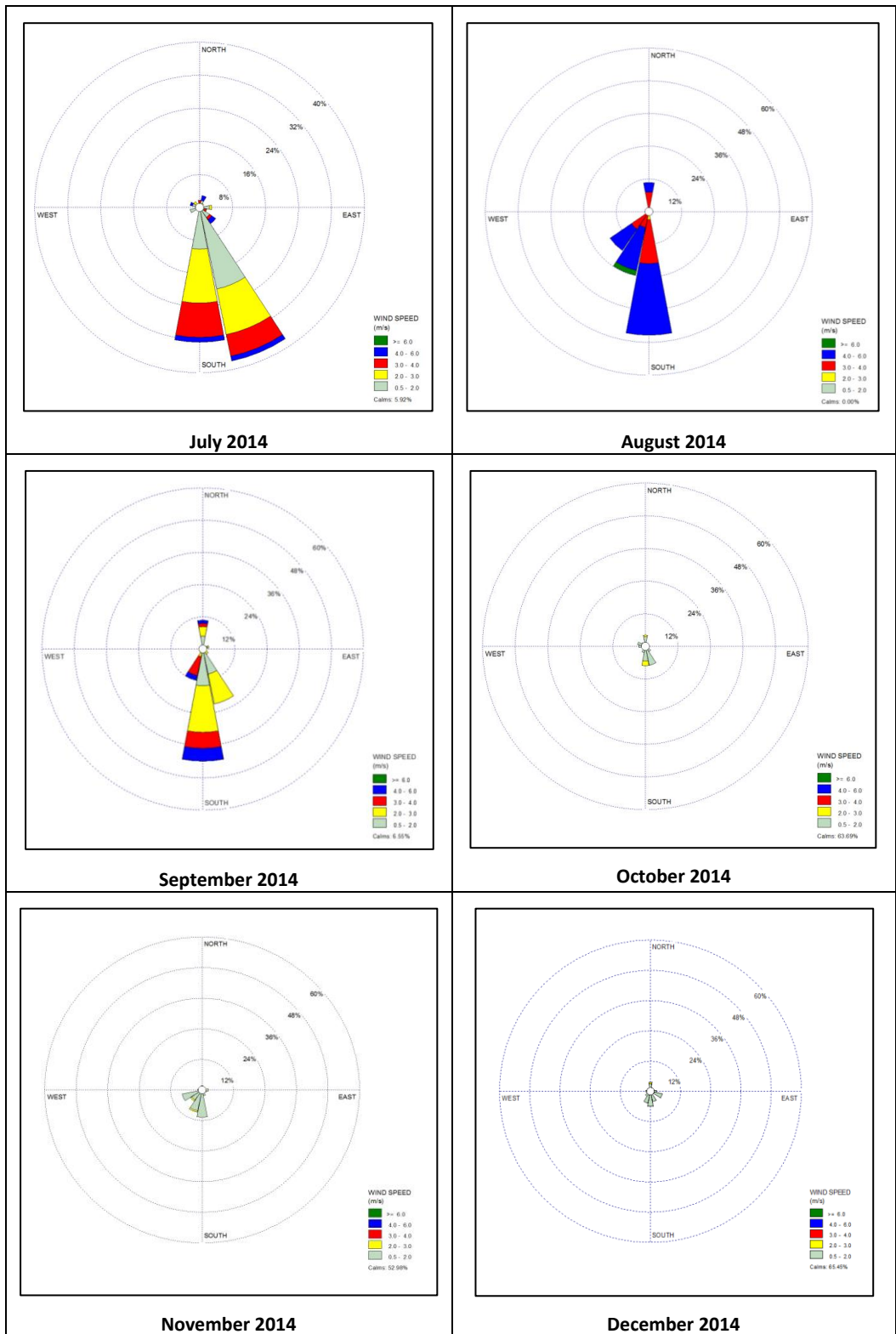
**Figure 5.4 Wind Rose for ASR 1**



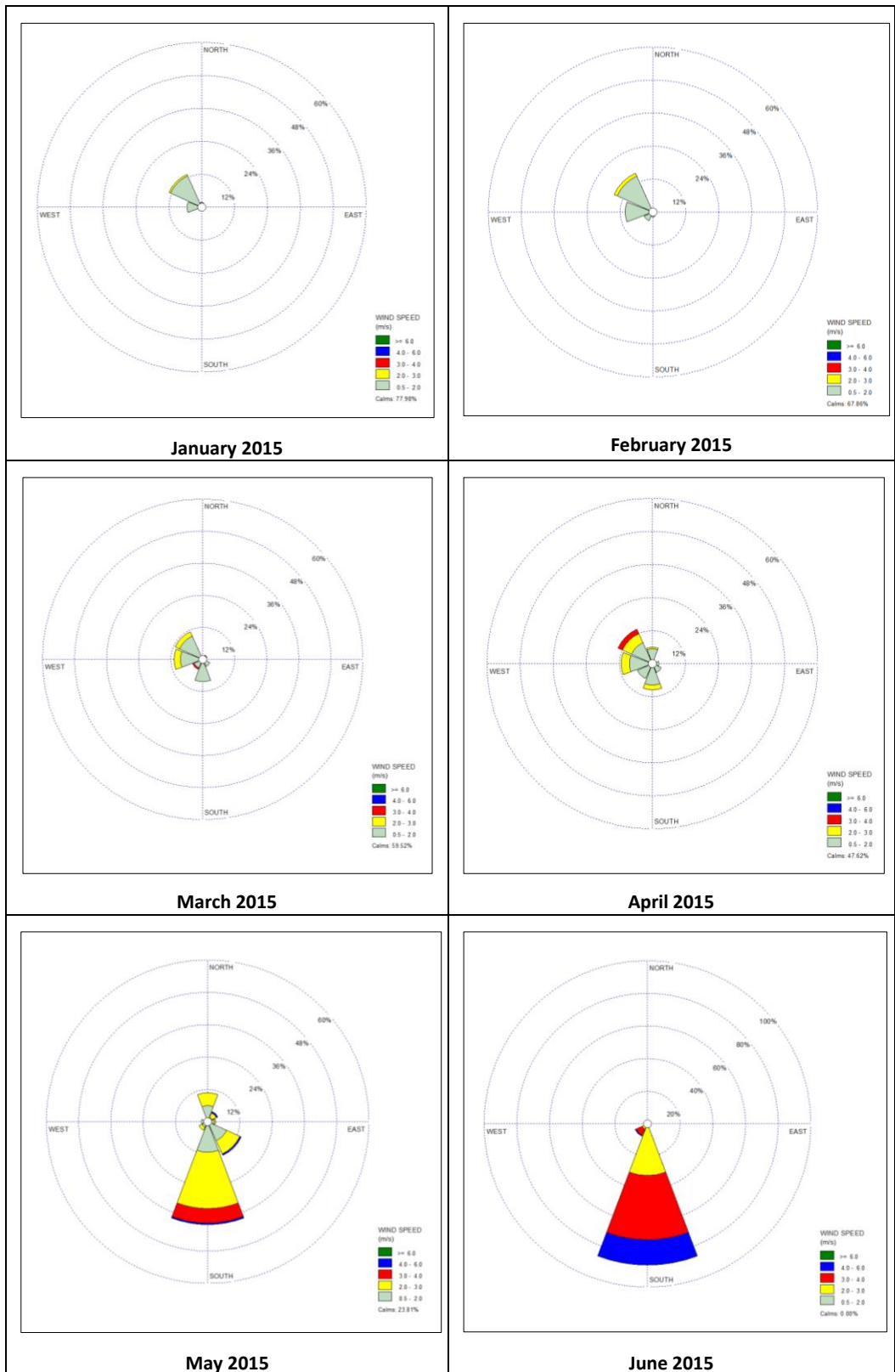
**Figure 5.4 Wind Rose for ASR 1 (Cont'd)**



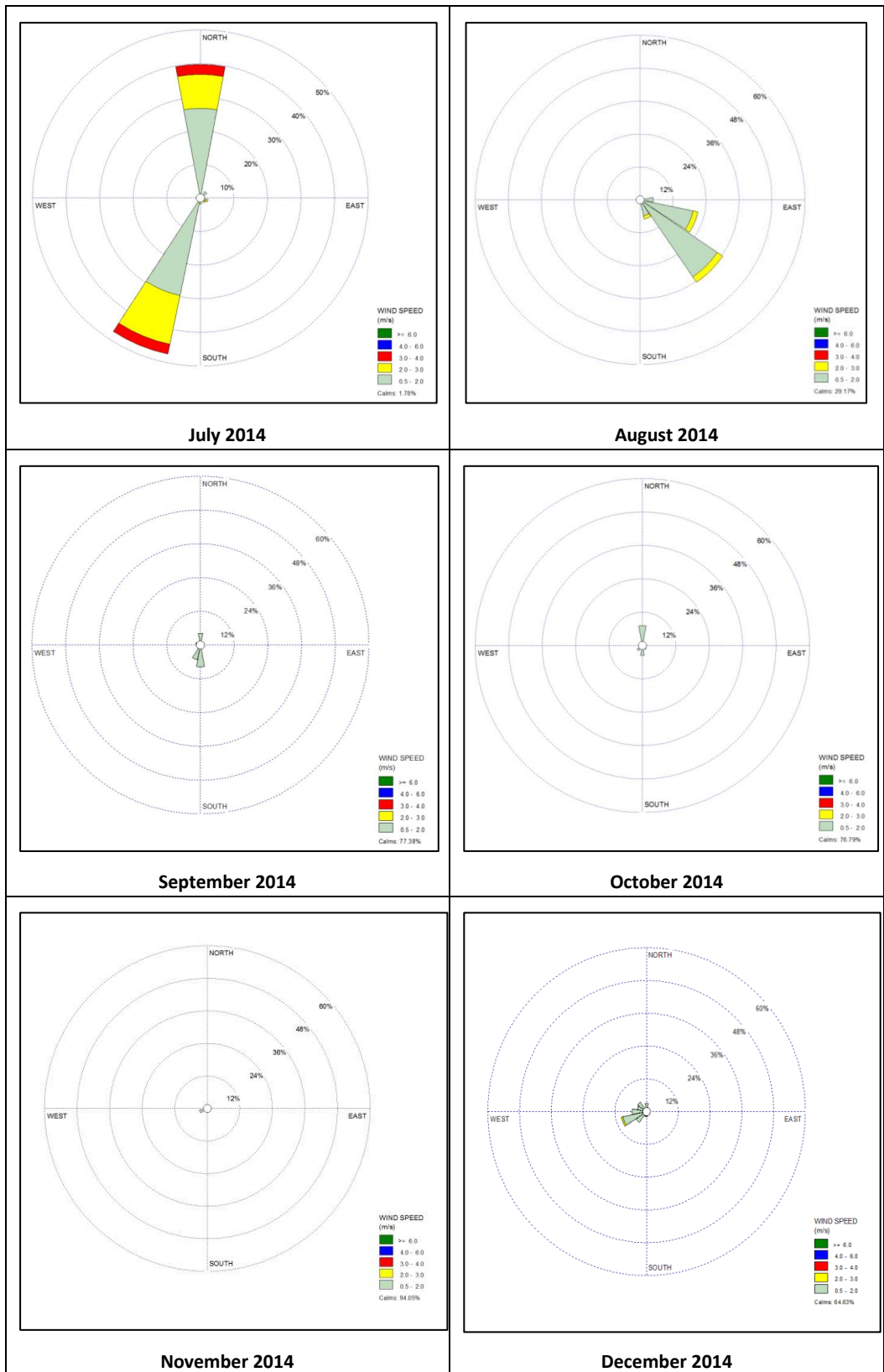
**Figure 5.5 Wind Rose for ASR 2**



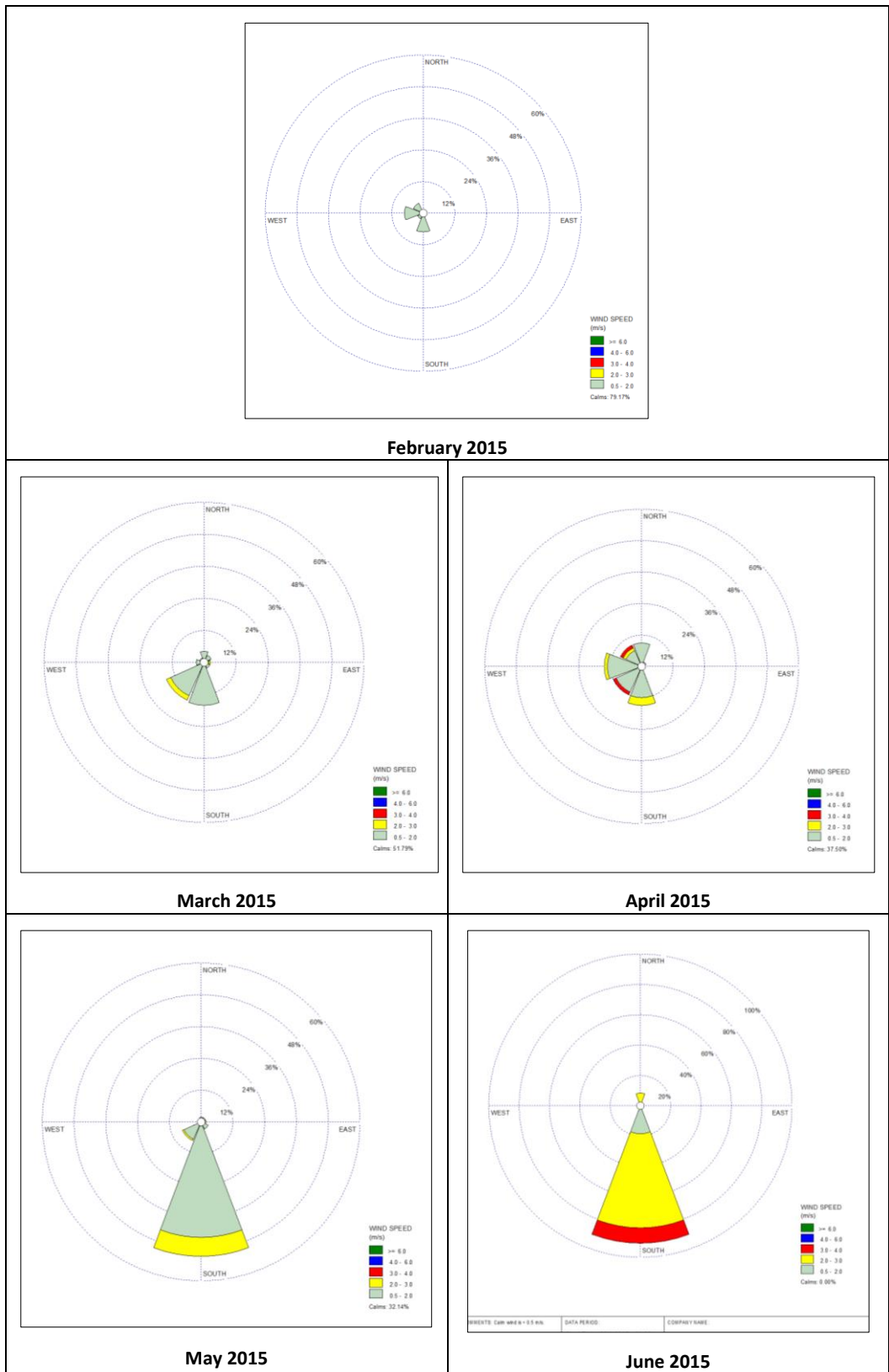
**Figure 5.5 Wind Rose for ASR 2 (Cont'd)**



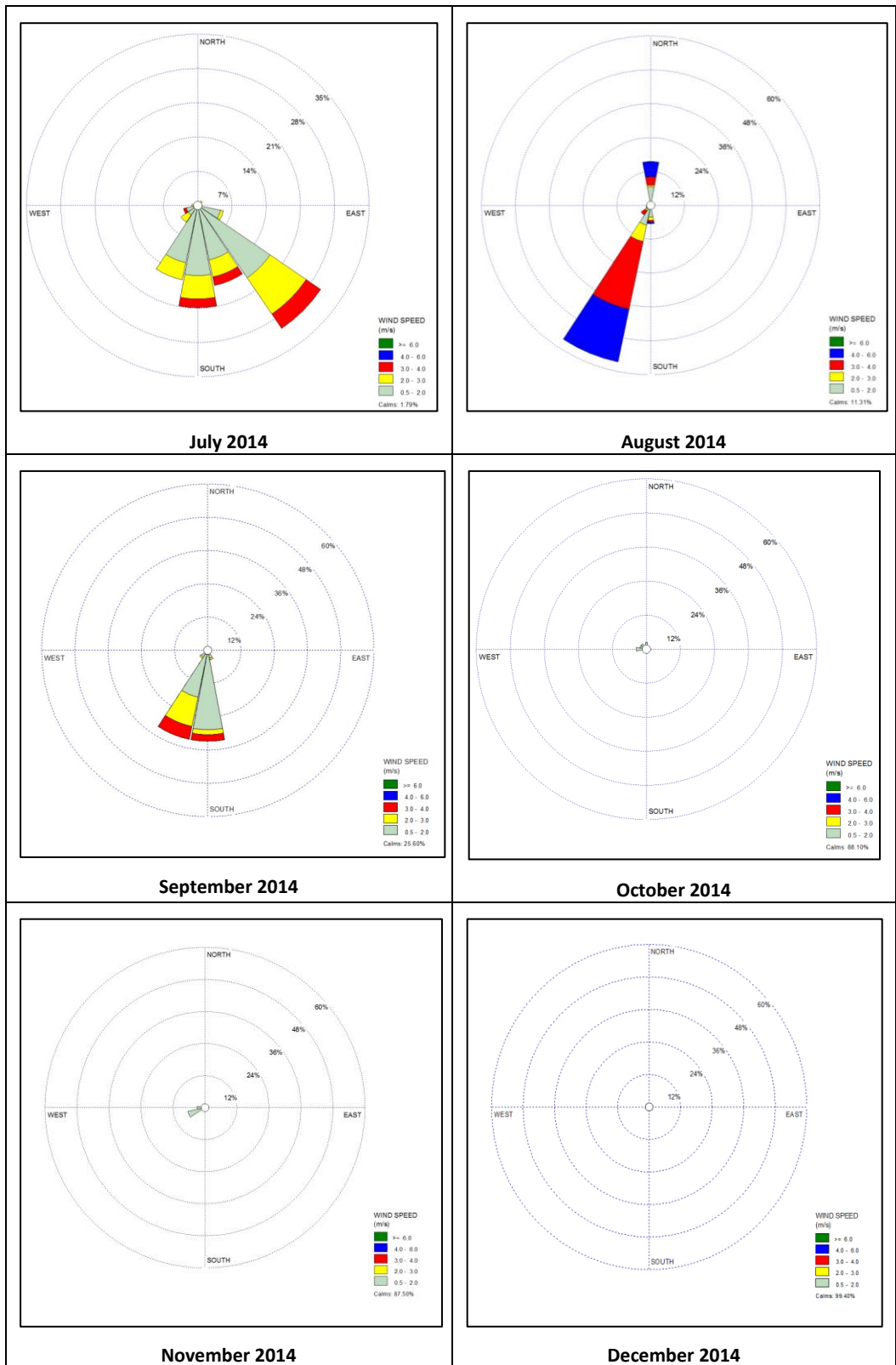
**Figure 5.6 Wind Rose for ASR 3**



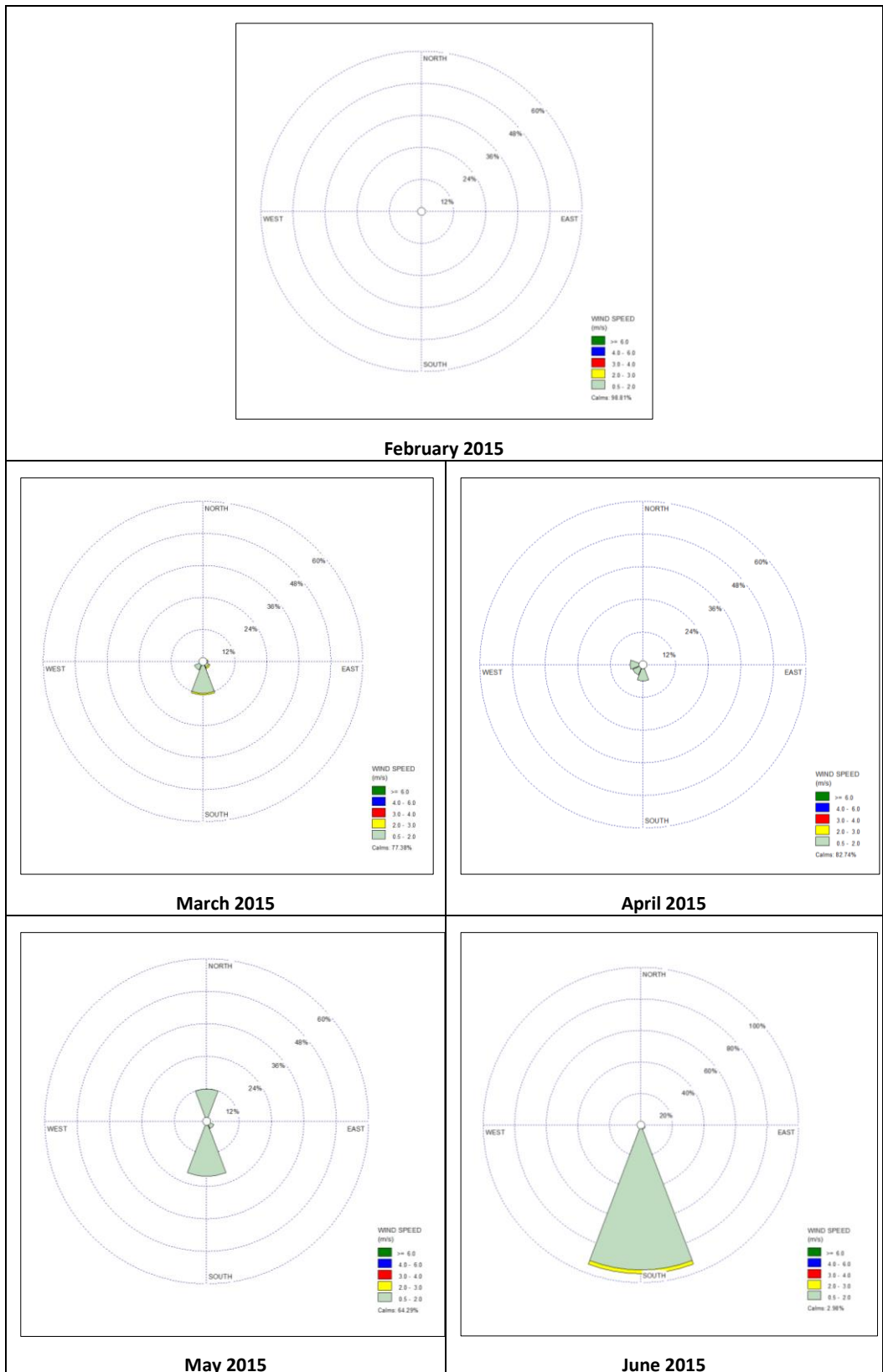
**Figure 5.6 Wind Rose for ASR 3 (Cont'd)**



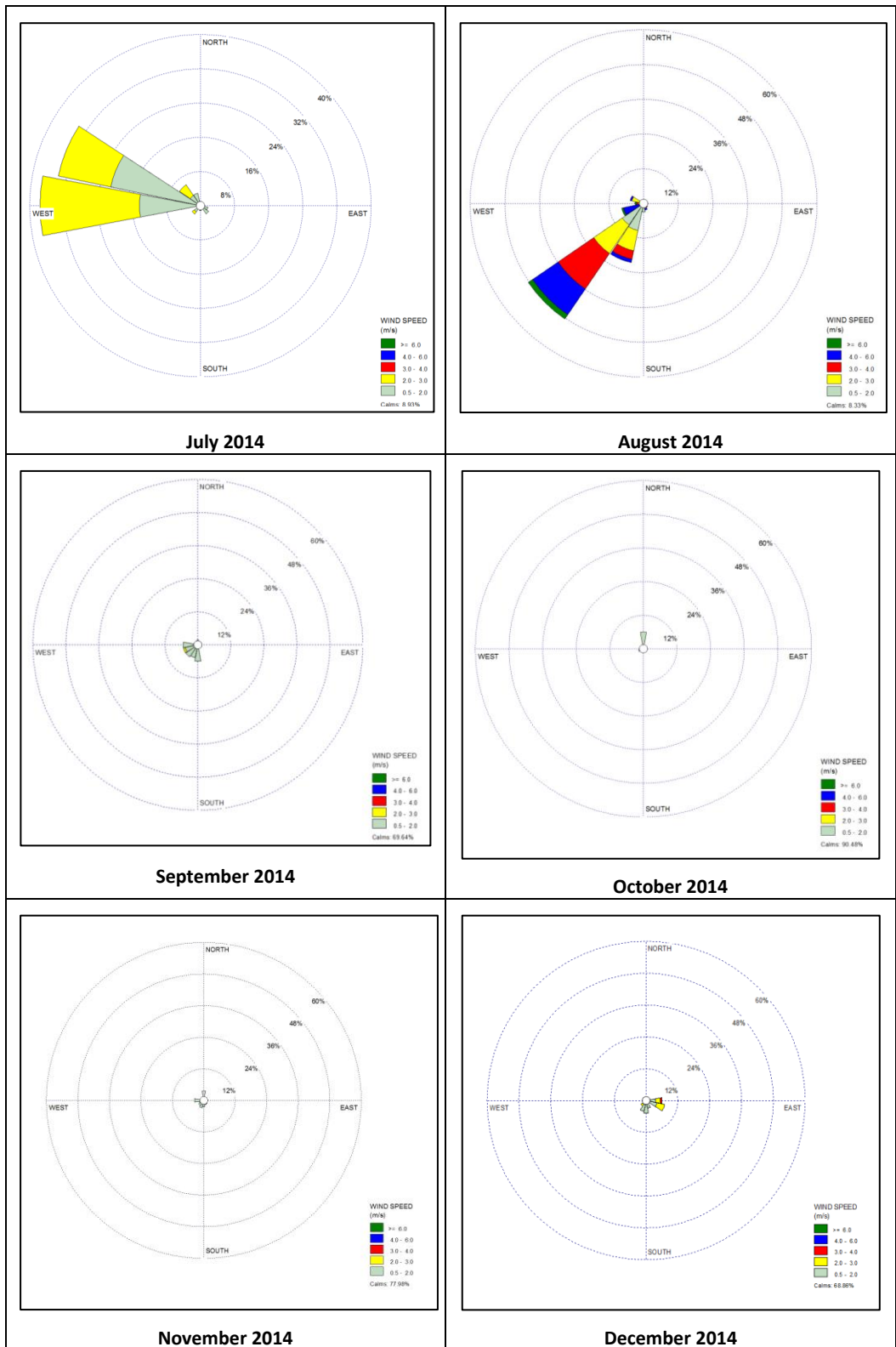
**Figure 5.7 Wind Rose for ASR 4**



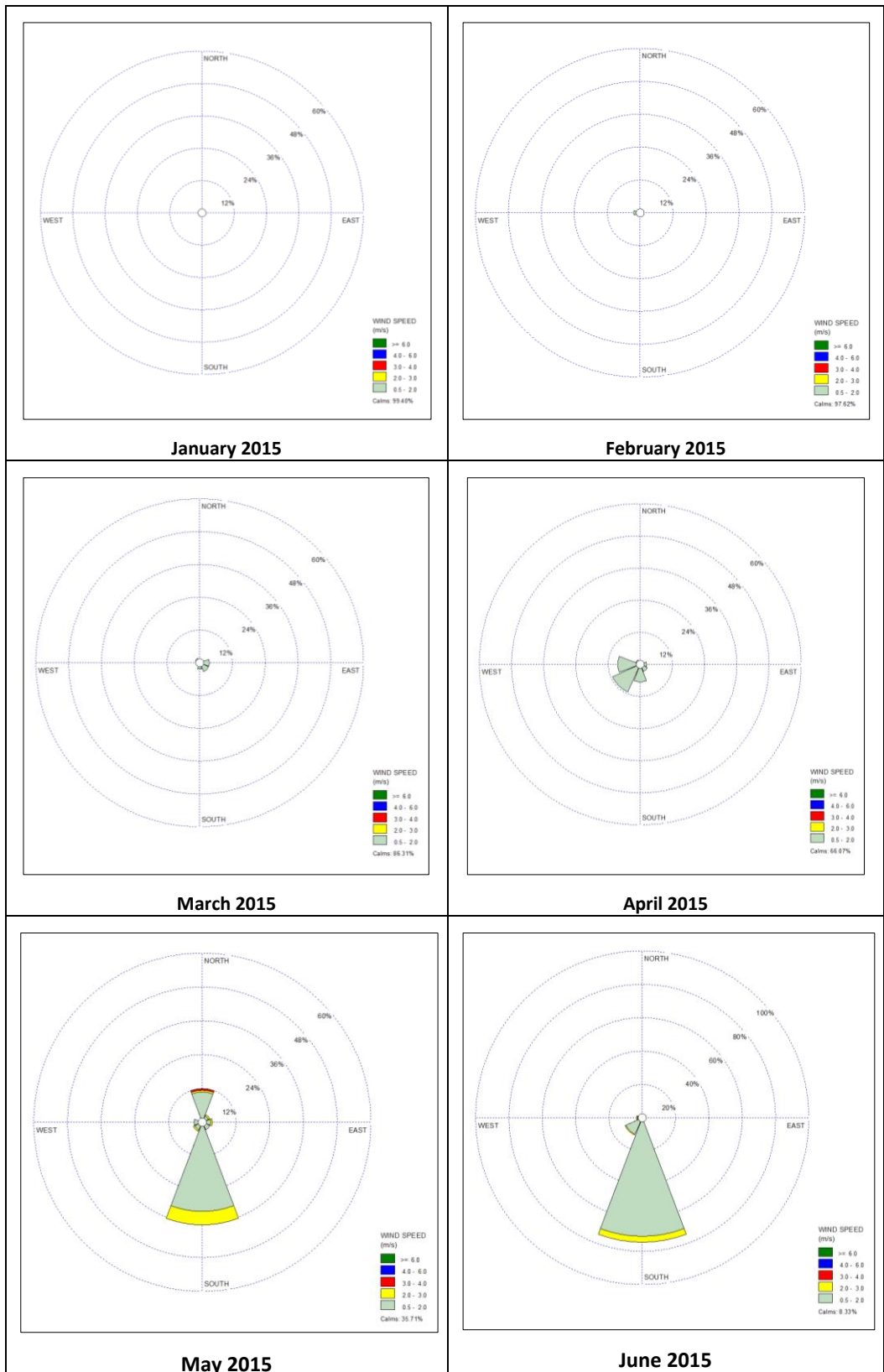
**Figure 5.7 Wind Rose for ASR 4 (Cont'd)**



**Figure 5.8 Wind Rose for ASR 5**



**Figure 5.8 Wind Rose for ASR 5 (Cont'd)**



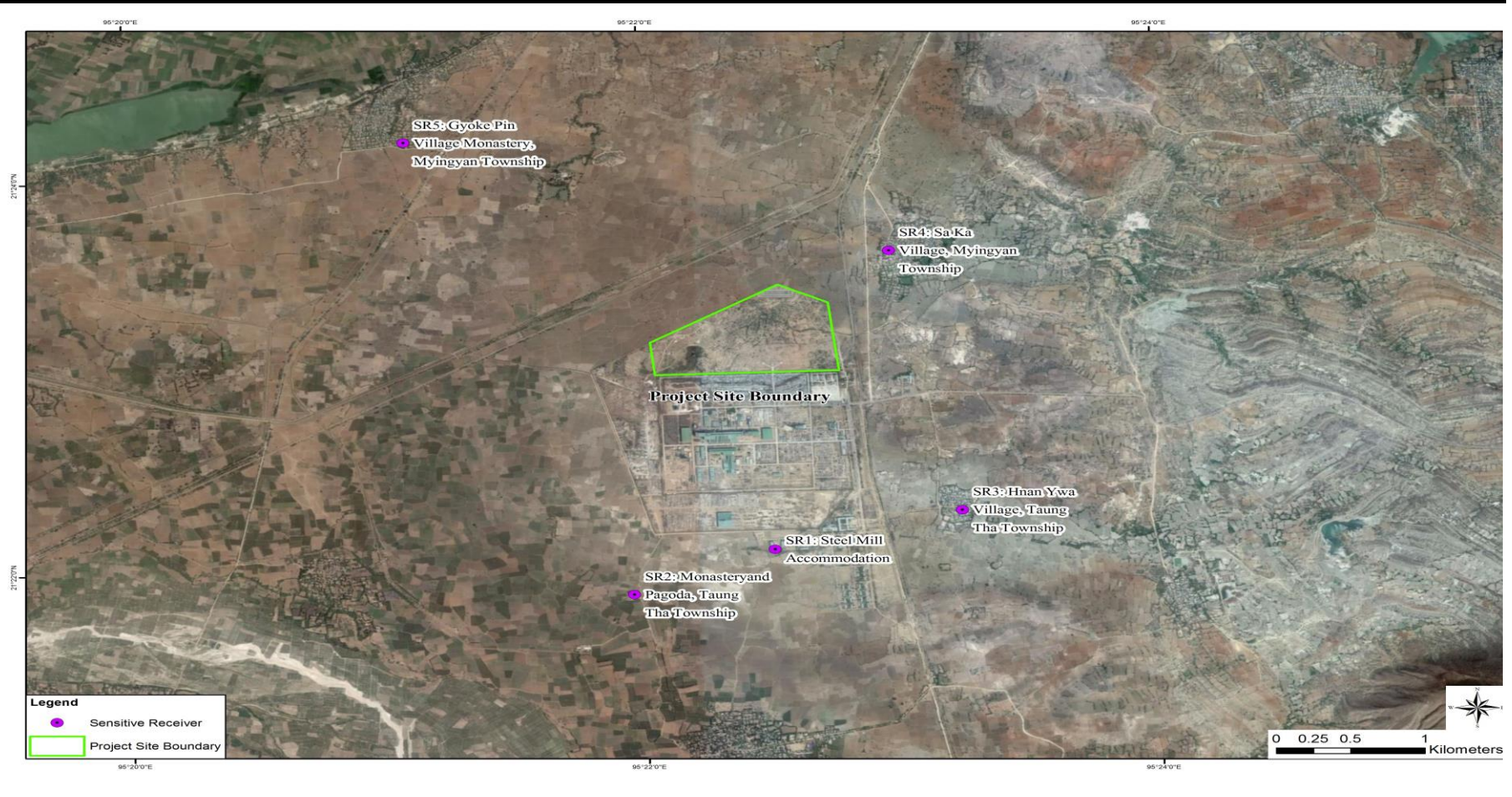
Ambient air quality monitoring was undertaken at each of the selected baseline air sampling locations surrounding the Project site for seven consecutive days per month from July 2014 to June 2015. The ambient air pollutants monitored included sulphur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), respirable suspended particulates (PM<sub>10</sub>) and fine suspended particulates (PM<sub>2.5</sub>), with measurements logged at 1-minute interval. The measurement data were then processed to obtain relevant averaging periods of each air pollutant for comparison with the respective WHO guidelines. Five baseline air sampling locations were selected namely MAQN-1, MAQN-2, MAQN-3, MAQN-4 and MAQN-5 (the locations are shown as sensitive receivers are shown in **Figure 5.9**). A description of the selected sampling locations is presented in **Table 5.5**.

**Table 5.5** Details of Baseline Air Sampling Locations

Air Sampling Location	Coordinates		Description of Monitoring Locations / Facilities or landmarks in the vicinity
	Easting	Northing	
MAQN-1: Steel Mill Accommodation	95°22'30.25"E	21°22'6.25"N	<ul style="list-style-type: none"> <li>Monitoring station set at open space between two compound buildings;</li> <li>Immediately south of the Myingyan steel plant boundary and approximately 1.8km south of the proposed Project site;</li> <li>Surrounded by bean and pea field, low land area but the station is located between the buildings of staffs;</li> <li>Steel mill workers and contractors housing compound and next to a government technical school for young children.</li> </ul>
MAQN-2: Monastery and Pagoda, Taung Tha Township	95°21'57.20"E	21°21'52.80"N	<ul style="list-style-type: none"> <li>Monitoring station set in front of a small monastery and pagoda, north of Phat Taw village facing the direction of the steel mill;</li> <li>Surrounded by low lying bean and pea fields; One monk and family lives in the monastery;</li> <li>Approximately 1km southwest of the Myingyan steel plant and 2.4km southwest of the proposed Project site.</li> </ul>
MAQN-3: Hnan Ywa Village, Taung Tha Township	95°23'14.15"E	21°22'17.75"N	<ul style="list-style-type: none"> <li>Monitoring station set in the compound of the monastery in the middle of this village;</li> <li>A village with 120 households, population about 700-800 people;</li> <li>Approximately 1.2km southeast of the Myingyan steel plant and 1.7km southeast of the Project site.</li> </ul>
MAQN-4: Sa Ka Village, Myingyan Township	95°22'58.15"E	21°23'37.50"N	<ul style="list-style-type: none"> <li>Monitoring station set at the west portion of Sa Ka village in the compound of one residential house located near the main access road to Project site;</li> <li>A village with about 285 households with population around 1500-1700 people;</li> <li>Approximately 1km northeast of the Project site, with the closest dwelling being located at about 500m of the Project site boundary.</li> </ul>

Air Sampling Location	Coordinates		Description of Monitoring Locations / Facilities or landmarks in the vicinity
	Easting	Northing	
MAQN-5: Gyoke Pin Village Monastery, Myingyan Township	95°21'5.40"E	21°24'11.90"N	<ul style="list-style-type: none"> <li>Monitoring station set at the southeast portion of the village towards the direction of the Project, at a monastery compound in front of a primary school, within 30m of the main Myingyan-Nyang Oo highway;</li> <li>A village with about 1500 households and a population of about 7000 people, similar size to Pet Taw Village in the south;</li> <li>Approximately 3km northwest of the Project site.</li> </ul>

Figure 5.9 Location of Sensitive Receivers



The sampling parameters, sampling equipment and method/standard are presented in **Table 5.6** and sampling date and number of samples taken of each sampling parameters are presented in **Table 5.7**.

**Table 5.6 Air Sampling Parameters, Equipment and Methodology / Standard for Baseline Monitoring**

Parameter	Equipment	Method / Standard
Sulphur dioxide (SO <sub>2</sub> )	<ul style="list-style-type: none"> <li>Haz-Scanner EPAS Wireless Environmental Perimeter Air Station</li> </ul>	<ul style="list-style-type: none"> <li>Recorded on site in real time</li> </ul>
Nitrogen dioxide (NO <sub>2</sub> )	<ul style="list-style-type: none"> <li>Haz-Scanner EPAS Wireless Environmental Perimeter Air Station</li> </ul>	<ul style="list-style-type: none"> <li>Recorded on site in real time</li> </ul>
PM <sub>10</sub> and PM <sub>2.5</sub>	<ul style="list-style-type: none"> <li>Haz-Scanner EPAS Wireless Environmental Perimeter Air Station</li> </ul>	<ul style="list-style-type: none"> <li>Recorded on site in real time</li> </ul>

Sampling and analysis of ambient air pollutants was conducted by referring to the recommendation of United States Environmental Protection Agency (U.S. EPA). The Haz-Scanner EPAS Environmental Perimeter Air Station was used to collect Ambient Air Monitoring data. The characteristics of the instrument are:

- Portable direct reading;
- Configure up to 14 simultaneous air measurements including U.S. EPA criteria air pollutants;
- Standard configuration measures PM<sub>2.5</sub>, PM<sub>10</sub> or TSP particulates, CO, NO, NO<sub>2</sub>, SO<sub>2</sub>, temperature, and relative humidity; and
- Wind parameters are also measured by Haz-sanner and the required data are analyzed by using the WRPLOT View of AERMOD View (ver. 7.0) where calm wind is defined below 0.5m/s.

**Table 5.7 Sampling Date and Number of Samples / Measurements**

Month	Air Sampling Location				
	MAQN-1	MAQN-2	MAQN-3	MAQN-4	MAQN-5
1	10th- 17th July, 2014	10th- 17th July, 2014	17th- 24th July, 2014	17th- 24th July, 2014	17th- 24th July, 2014
2	10th - 17th August, 2014	17th - 24th August, 2014	17th - 24th August, 2014	17th - 24th August, 2014	10th - 17th August, 2014
3	16th – 23rd September, 2014	9th - 16rd September, 2014	16th - 23rd September, 2014	23rd - 30th September, 2014	16th – 23rd September, 2014
4	10th – 16th & 28th – 30th October 2014	16th – 23rd October, 2014	23rd - 30th October, 2014	16th – 23rd October, 2014	10th – 16th & 28th – 30th October 2014
5	9th – 16th November 2014	16th – 23rd November 2014	23rd – 30 <sup>th</sup> November 2014	16th – 23rd November 2014	9th – 16th November 2014
6	9th – 16th December 2014	16th – 23rd December 2014	23rd – 30th December 2014	16th – 23rd December 2014	9th – 16th December 2014
7	29th January to February 5th, 2015	29th January to February 5th, 2015	-- (a)	-- (a)	29th January to February 5th, 2015

Month	Air Sampling Location				
	MAQN-1	MAQN-2	MAQN-3	MAQN-4	MAQN-5
8	14th to 21st February, 2015	14th to 21st February, 2015	21st to 28th February, 2015	21st to 28th February, 2015	14th to 21st February, 2015
9	14th to 21st March, 2015	14th to 21st March, 2015	21st to 28th March, 2015	21st to 28th March, 2015	14th to 21st March, 2015
10	11th April to 18th April, 2015	11th April to 18th April, 2015	18th April to 25th April, 2015	18th April to 25th April, 2015	11th April to 18th April, 2015
11	16th to 23rd May, 2015	16th to 23rd May, 2015	23rd to 30th May, 2015	23rd to 30th May, 2015	16th to 23rd May, 2015
12	13th to 20th June, 2015	13th to 20th June, 2015	20th to 27th June, 2015	20th to 27th June, 2015	13th to 20th June, 2015

Note:

(a) Monitoring was not undertaken at MAQN-3 and MAQN-4 in January 2015.

The measured results of NO<sub>2</sub>, SO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> at MAQN-1 to MAQN-5 are presented in **Table 5.8** to **Table 5.11**. **Table 5.8** shows the range of hourly NO<sub>2</sub> (maximum and minimum). **Table 5.9** shows 24-hour (daily) averaged SO<sub>2</sub>; **Table 5.10** shows 24-hour (daily) averaged PM<sub>10</sub> and **Table 5.11** shows 24-hour (daily) averaged PM<sub>2.5</sub> results.

All tables show results averaged from data measured for seven consecutive days per month from July 2014 to June 2015. Following the Asian Development Bank (ADB) guidelines and IFC's *Environmental, Health and Safety Guidelines: Air Emissions and Ambient Air Quality*, the current WHO Air Quality Guidelines should be used. Interim target levels for SO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> have been proposed by WHO to promote steady progress towards meeting the WHO guidance values. Given that air pollution levels in some countries may exceed the WHO guidance values, these proposed interim target levels can be adopted by countries taking into account their specific local circumstances. Countries can choose to adopt different interim targets considering the balance amongst factors such as risks to public health, technological feasibility, economic development and other political and social factors. Myanmar is a developing country and is yet to implement local national air quality standards to regulate local air quality. It is recommended that the monitored SO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> results are compared with their respective WHO Interim Target 1. Baseline NO<sub>2</sub> results are compared against the WHO guideline value since no interim target for NO<sub>2</sub> has been proposed. Raw hourly readings for NO<sub>2</sub> and SO<sub>2</sub> were in ppb and converted to µg/m<sup>3</sup> in line with the unit of the WHO AAQG.

### 5.3.1

#### *Nitrogen Dioxide (NO<sub>2</sub>)*

The baseline results show some hourly exceedance of WHO AAQG NO<sub>2</sub> guidance value (200µg/m<sup>3</sup>) at different monitoring locations over the 12 month period and these are highlighted (in red) in **Table 5.8**. Some of the hourly NO<sub>2</sub> concentrations were abnormally high. However, the NO<sub>2</sub> concentrations before and after the abnormally high NO<sub>2</sub> concentration were relatively low, therefore, the abnormally high NO<sub>2</sub> concentrations have been considered invalid and excluded when calculating the average background NO<sub>2</sub> concentration to be adopted in the subsequent cumulative impact assessment.

The potential sources of the NO<sub>2</sub> exceedances not under the above conditions have been attributed to tailpipe emissions and emissions from the Steel Mill.

### 5.3.2 *Sulphur Dioxide (SO<sub>2</sub>)*

The monitoring results in **Table 5.9** show that concentrations for SO<sub>2</sub> are within the applicable WHO AAQG interim target levels at the five monitoring locations for the duration of the monitoring period. SO<sub>2</sub> results measured at MAQN-5 in July 2014, MAQN-2 and MAQN-4 in August 2014, MAQN-1, 2, 3 and 5 on some days between October and December 2014 were discarded due to equipment failure. Overall, baseline SO<sub>2</sub> levels are considered to be low and typical of the rural setting of the Project site.

### 5.3.3 *Particulates Matters (PM<sub>10</sub> and PM<sub>2.5</sub>)*

The monitoring results in **Table 5.10** show that concentrations for PM<sub>10</sub> were within the applicable WHO AAQG interim target levels at the five monitoring locations for the duration of the monitoring period. PM<sub>10</sub> and PM<sub>2.5</sub> concentrations are generally low from July to September 2014, with an increasing trend of PM<sub>10</sub> and PM<sub>2.5</sub> concentrations from October 2014 through to March 2015. PM<sub>10</sub> and PM<sub>2.5</sub> were highest from February to March 2015 during which exceedances of the WHO AAQG PM<sub>2.5</sub> Interim Target 1 (75µg/m<sup>3</sup>) were observed. From March to June 2015, there was a decreasing trend in PM<sub>10</sub> and PM<sub>2.5</sub> concentrations. **Table 5.11** shows daily exceedances of the WHO AAQG PM<sub>2.5</sub> Interim Target 1 (75µg/m<sup>3</sup>) with exceedances highlighted (in red). The potential sources of the exceedance are burning of wood for cooking and unpaved road dust.

As PM<sub>2.5</sub> is a subcategory of PM<sub>10</sub>, an increase in PM<sub>2.5</sub> should correspond with an increase in PM<sub>10</sub> levels. Where the measured PM<sub>10</sub> was lower than PM<sub>2.5</sub> at the same hour, data was therefore considered invalid and excluded in the 24-hour averaging calculation.

**Table 5.8 Measurement Results of NO<sub>2</sub> in Ambient Air at All Monitoring Locations**

Monitoring Locations	Monitored Hourly NO <sub>2</sub> Concentration in µg/m <sup>3</sup>											
	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	June-15
<b>MAQN-1</b>												
MAX	72.03	70.55	450.34 <sup>(c) (d)</sup>	136.62	522.58 <sup>(c) (d)</sup>	284.97 <sup>(c) (d)</sup>	106.74	573.64 <sup>(c) (d)</sup>	71.71	122.92	212.93 <sup>(c) (d)</sup>	256.06 <sup>(c) (d)</sup>
MIN	0.00	64.72	4.14	5.68	0.22	5.80	4.01	3.95	3.76	3.76	3.76	42.74
<b>MAQN-2</b>												
MAX	240.35 <sup>(c)</sup>	533.33 <sup>(c) (d)</sup>	148.55	83.41	148.27	182.20	93.51	217.30 <sup>(c) (d)</sup>	206.92 <sup>(c)</sup>	185.60	141.45	55.53
MIN	0.00	3.90	3.76	8.75	0.25	6.80	4.14	36.34	6.90	17.15	4.92	105.19
<b>MAQN-3<sup>(a)</sup></b>												
MAX	70.61	71.57	591.44 <sup>(c) (d)</sup>	118.48	191.02	84.19	-	180.27	197.51	114.95	463.83 <sup>(c) (d)</sup>	100.50
MIN	0.00	0.00	6.37	3.76	1.60	1.03	-	3.76	3.76	3.76	21.79	23.42
<b>MAQN-4<sup>(b)</sup></b>												
MAX	339.43 <sup>(c)</sup>	364.81 <sup>(c) (d)</sup>	88.93	131.70	102.63	90.12	-	146.22	159.70	123.07	160.58	22.67
MIN	0.00	3.76	1.91	4.65	8.37	3.73	-	16.31	42.77	21.17	11.51	200.00
<b>MAQN-5</b>												
MAX	104.32	257.63 <sup>(c) (d)</sup>	192.51	619.25 <sup>(c) (d)</sup>	184.72	88.08	115.28	341.54 <sup>(c) (d)</sup>	124.17	173.09	141.45	0.00
MIN	0.00	17.21	3.76	0.00	6.46	3.73	23.71	27.19	40.95	32.91	4.92	0.00
<b>WHO Guideline 1-hour</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>

**Notes:**

- <sup>(a)</sup> Monitoring was not undertaken at MAQN-3 in January 2015.
- <sup>(b)</sup> Monitoring was not undertaken at MAQN-4 in January 2015.
- <sup>(c)</sup> WHO 1-hr guideline value is exceeded.
- <sup>(d)</sup> Exceedances considered to be abnormal and would be excluded from calculating the averaged background NO<sub>2</sub> concentration as the hourly NO<sub>2</sub> concentrations before and after the exceedances were relatively low.

**Table 5.9 Measurement Results of SO<sub>2</sub> in Ambient Air at All Monitoring Locations**

Monitoring Locations	Monitored 24-hour Averaged SO <sub>2</sub> Concentration in µg/m <sup>3</sup>											
	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	June-15
<b>MAQN-1</b>												
MAX	4.31	2.92	5.43	12.00	19.70 <sup>(f)</sup>	4.28 <sup>(f)</sup>	0	0	0	0	0	0
AVERAGE	1.99	1.00	3.66	4.58	17.22 <sup>(f)</sup>	2.75 <sup>(f)</sup>	0	0	0	0	0	0
<b>MAQN-2<sup>(a)</sup></b>												
MAX	91.44	-	4.64	5.51*	13.74 <sup>(f)</sup>	5.78 <sup>(f)</sup>	15.23	11.12	16.45	10.42	7.77	4.99
AVERAGE	19.48	-	2.79	3.47*	8.50 <sup>(f)</sup>	3.31 <sup>(f)</sup>	10.62	7.94	11.87	5.89	5.06	3.54
<b>MAQN-3<sup>(b)</sup></b>												
MAX	2.32	1.86	21.54	14.54*	14.28 <sup>(f)</sup>	16.92 <sup>(f)</sup>	-	0	0	0	7.87	3.41
AVERAGE	1.10	1.07	12.73	7.74 <sup>(f)</sup>	12.13 <sup>(f)</sup>	13.46 <sup>(f)</sup>	-	0	0	0	4.18	2.58
<b>MAQN-4<sup>(c) (d)</sup></b>												
MAX	24.05	-	20.04	22.45	18.54	28.92	-	14.09	10.97	15.04	4.72	2.37
AVERAGE	6.50	-	10.00	11.24	10.92	18.57	-	6.10	5.04	5.24	2.71	1.18
<b>MAQN-5<sup>(e)</sup></b>												
MAX	-	15.38	9.65	11.09 <sup>(f)</sup>	15.47 <sup>(f)</sup>	5.90 <sup>(f)</sup>	9.20	2.79	4.56	4.53	7.77	2.08
AVERAGE	-	6.39	6.80	5.92*	6.55*	4.96*	3.61	1.67	3.43	1.99	5.06	1.03
<b>WHO 24-hour (Interim Target 1)</b>	<b>125</b>	<b>125</b>	<b>125</b>	<b>125</b>	<b>125</b>	<b>125</b>	<b>125</b>	<b>125</b>	<b>125</b>	<b>125</b>	<b>125</b>	<b>125</b>

**Notes:**

- <sup>(a)</sup> No monitoring data at MAQN-2 was available in August 2014 due to equipment failure.
- <sup>(b)</sup> Monitoring was not undertaken at MAQN-3 in January 2015.
- <sup>(c)</sup> Monitoring was not undertaken at MAQN-4 in January 2015.
- <sup>(d)</sup> No monitoring data at MAQN-4 was available in August 2014 due to equipment failure.
- <sup>(e)</sup> No monitoring data at MAQN-5 was available in July 2014 due to equipment failure.
- <sup>(f)</sup> Average and maximum concentrations calculated from less than seven days of data due to equipment failure.

**Table 5.10 Measurement Results of PM<sub>10</sub> in Ambient Air at All Monitoring Locations**

Monitoring Locations	Monitored 24-Hour Averaged PM <sub>10</sub> Concentration in µg/m <sup>3</sup>											
	Jul-14	Aug-14	Sep-14	Oct-14 <sup>(a)</sup>	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	June-15
<b>MAQN-1</b>												
MAX	13.58	18.21	32.15	51.13	44.64	57.79	89.82	99.83	133.16	77.31	109.35	2.18
AVERAGE	9.68	12.46	25.12	26.66	32.24	50.79	76.77	90.19	109.57	58.65	43.94	2.06
<b>MAQN-2</b>												
MAX	13.03	20.88	26.02	48.55	47.38	70.71	83.37	105.36	136.78	76.73	41.30	96.96
AVERAGE	10.77	16.40	19.55	22.92	34.30	55.05	74.08	88.54	103.95	61.37	23.40	30.17
<b>MAQN-3<sup>(b)</sup></b>												
MAX	20.36	21.12	41.01	58.62	53.87	54.89	-	94.80	133.56	60.75	46.56	17.13
AVERAGE	10.76	14.07	24.43	45.21	46.47	46.78	-	83.89	95.11	44.96	31.69	14.29
<b>MAQN-4<sup>(c)</sup></b>												
MAX	21.11	27.80	21.67	47.39	71.78	102.59	-	133.18	99.18	58.42	26.31	21.31
AVERAGE	12.27	17.07	18.45	28.28	55.92	86.00	-	90.16	79.92	37.02	23.71	14.24
<b>MAQN-5</b>												
MAX	20.37	20.77	40.25	48.14	63.10	79.79	76.57	86.66	122.99	75.20	41.30	12.29
AVERAGE	15.99	12.32	24.25	41.57	45.82	58.23	69.65	76.88	94.30	51.27	23.40	10.74
<b>WHO 24-hour (Interim Target 1)</b>	<b>150</b>	<b>150</b>	<b>150</b>	<b>150</b>	<b>150</b>	<b>150</b>	<b>150</b>	<b>150</b>	<b>150</b>	<b>150</b>	<b>150</b>	<b>150</b>
<b>Notes:</b>												
(a)	8-day maximum/average level measured at MAQN-2 is presented for October 2014											
(b)	Monitoring was not undertaken at MAQN-3 in January 2015.											
(c)	Monitoring was not undertaken at MAQN-4 in January 2015.											

**Table 5.11 Measurement Results of PM<sub>2.5</sub> in Ambient Air at All Monitoring Locations**

Monitoring Locations	Monitored 24-Hour Averaged PM <sub>2.5</sub> Concentration in µg/m <sup>3</sup>											
	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	June-15
<b>MAQN-1</b>												
MAX	4.80	5.96	20.55	36.21	24.41	50.62	71.94	81.75 <sup>(c)</sup>	114.49 <sup>(c)</sup>	56.48	26.15	1.66
AVERAGE	2.54	4.49	15.71	17.34	18.16	33.01	61.58	74.18	86.27 <sup>(c)</sup>	45.23	15.36	1.39
<b>MAQN-2</b>												
MAX	4.90	13.49	19.73	28.69	33.16	57.82	59.46	77.34 <sup>(c)</sup>	93.11 <sup>(c)</sup>	52.73	22.27	59.10
AVERAGE	4.21	10.61	13.98	14.05	23.56	38.23	50.49	63.73	72.57	38.36	13.01	18.66
<b>MAQN-3<sup>(a)</sup></b>												
MAX	17.80	11.69	26.49	32.43	40.69	41.79	-	77.17 <sup>(c)</sup>	113.11 <sup>(c)</sup>	41.17	27.64	10.75
AVERAGE	9.25	5.09	15.45	27.11	32.20	30.53	-	68.14	76.12 <sup>(c)</sup>	29.96	17.70	8.42
<b>MAQN-4<sup>(b)</sup></b>												
MAX	5.01	17.53	14.16	27.00	26.04	50.33	-	31.96	50.71	24.35	13.82	8.13
AVERAGE	2.63	10.55	11.56	16.02	23.13	38.40	-	22.64	36.71	18.10	11.88	6.56
<b>MAQN-5</b>												
MAX	13.81	11.10	26.74	37.35	37.97	65.95	37.10	45.14	64.63	30.52	22.27	7.67
AVERAGE	10.51	8.04	15.75	24.61	26.76	53.08	21.66	40.95	46.49	26.04	13.01	6.71
<b>WHO 24-hour (Interim Target 1)</b>	<b>75</b>	<b>75</b>	<b>75</b>	<b>75</b>	<b>75</b>	<b>75</b>	<b>75</b>	<b>75</b>	<b>75</b>	<b>75</b>	<b>75</b>	<b>75</b>

**Notes:**

<sup>(a)</sup> Monitoring was not undertaken at MAQN-3 in January 2015.

<sup>(b)</sup> Monitoring was not undertaken at MAQN-4 in January 2015.

<sup>(c)</sup> WHO 24-hr interim target-1 is exceeded.

In summary, baseline SO<sub>2</sub> levels at Myingyan Project site were considered low (typical of rural area with low emission sources) whilst NO<sub>2</sub> levels were considered high. Tailpipe emissions on the adjacent roads (in particular motorcycle), the operation of the steel mill and the general background are the potential sources of the relatively high measured NO<sub>2</sub> concentration. Background PM levels also showed higher concentrations during winter months (October to February) compared to summer months (July to September). High PM<sub>10</sub> and PM<sub>2.5</sub> concentrations measured is likely due to local activities, especially burning of wood for cooking by nearby residents and unpaved road dust.

The measured NO<sub>2</sub>, SO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> at all the selected baseline air sampling locations from July 2014 to June 2015 have been averaged to represent the background concentrations of the air pollutants at the Project site area for further air quality impact assessment. A summary of the background concentrations of the pollutants monitored is presented in **Table 5.12**.

**Table 5.12** *Background Concentrations of Pollutants*

Pollutant	Estimated Background Concentration (µg/m <sup>3</sup> )	WHO Air Quality Guidelines			
		10-min	1-hour	24-hour	Annual
SO <sub>2</sub>	6.15	500		125	-
NO <sub>2</sub>	53.97	-	200	-	40
PM <sub>10</sub>	43.31	-		150	70
PM <sub>2.5</sub>	26.67	-		75	35

**Notes:**

(a) WHO Interim Target 1 for 24-hr SO<sub>2</sub>, 24-hr PM<sub>10</sub>, 24-hr PM<sub>2.5</sub>, Annual PM<sub>10</sub> and Annual PM<sub>2.5</sub>. WHO Guideline value for 1-hr NO<sub>2</sub>, Annual NO<sub>2</sub> and 10-min SO<sub>2</sub>.

**5.4** *NOISE*

**5.4.1** *Baseline Noise Monitoring Locations and Sampling Methodology*

Four existing noise sensitive receivers (NSRs) located near the Project Site have been identified to be potentially affected by the Project during construction and operation phases. Baseline noise monitoring was conducted at these NSRs to establish the background levels. The locations of baseline monitoring stations are summarised in **Table 5.13** and are shown as sensitive receivers in **Figure 5.9**.

**Table 5.13** *Locations of Baseline Noise Monitoring Locations*

Monitoring Station ID	Noise Monitoring Location	GPS Coordinates	Description of Sampling Location
MAQN-1	Permanent Steel Mill Construction Worker (EPC) Accommodation, Taung Tha Township	21°22'6.25"N 95°22'30.25"E	In the staff housing compound of the steel mill, Myingyan Township
MAQN-2	Monastery and Pagoda, Taung Tha Township	21°21'52.80"N 95°21'57.20"E	In the compound of the monastery, north of Phat Taw village, Taung tha Township
MAQN-3	Hnan Ywa Village, Taung Tha Township	21°22'17.75"N 95°23'14.15"E	In the compound of the monastery in Hnan Ywa village, Taung tha Township
MAQN-4	Sa Ka Village, Myingyan Township	21°23'37.50"N 95°22'58.15"E	In the compound of one residential house located at the western part of Sar kar village, Myingyan Township

Baseline noise monitoring was conducted from July to September 2014 and from February to June 2015. Hourly A-weighted equivalent continuous sound pressure levels ( $L_{Aeq}$ , 1 hour) were recorded continuously over 24 hours at each location during both weekday and weekend. At each location, daytime and night-time  $L_{Aeq}$  were calculated by averaging the hourly sound pressure levels measured between 0700 and 2200 hours and between 2200 to 0700 hours, respectively.

Noise levels ( $L_{Aeq}$ ) were recorded using a type II sound level meter at about 1.5m above ground with no reflecting surface nearby in accordance with IFC guidelines. Sampling frequency was at 10-minute interval for 24 hours continuously. Sound level meter employed for the baseline noise monitoring and the measurement parameter are summarised in **Table 5.14** and the detailed monitoring schedule are shown in **Table 5.15**.

**Table 5.14** *Equipment Used for Baseline Noise Monitoring and Measurement Parameters*

Sound Level Meter	Measurement Parameter
Lutron SL-0423SD	Sound Pressure Level, $L_{Aeq, 1hr}$ , dB(A)

**Table 5.15** *Monitoring Schedule*

Monitoring Station ID	Noise Monitoring Location	Measurement Schedule	
		Weekday	Weekend
MAQN-1	Permanent Steel Mill Construction Worker (EPC) Accommodation, Taung Tha Township	14 <sup>th</sup> to 15 <sup>th</sup> July 2014	12 <sup>th</sup> to 13 <sup>th</sup> July 2014
		11 <sup>th</sup> to 12 <sup>th</sup> August 2014	16 <sup>th</sup> to 17 <sup>th</sup> August 2014
		15 <sup>th</sup> to 16 <sup>th</sup> September 2014	13 <sup>th</sup> to 14 <sup>th</sup> September 2014
		16 <sup>th</sup> to 17 <sup>th</sup> February 2015	14 <sup>th</sup> to 15 <sup>th</sup> February 2015
		16 <sup>th</sup> to 17 <sup>th</sup> March 2015	14 <sup>th</sup> to 15 <sup>th</sup> March 2015
		13 <sup>th</sup> to 14 <sup>th</sup> April 2015	11 <sup>th</sup> to 12 <sup>th</sup> April 2015
		18 <sup>th</sup> to 19 <sup>th</sup> May 2015	16 <sup>th</sup> to 17 <sup>th</sup> May 2015
		15 <sup>th</sup> to 16 <sup>th</sup> June 2015	13 <sup>th</sup> to 14 <sup>th</sup> June 2015

Monitoring Station ID	Noise Monitoring Location	Measurement Schedule	
		Weekday	Weekend
MAQN-2	Monastery and Pagoda, Taung Tha Township	14 <sup>th</sup> to 15 <sup>th</sup> July 2014	12 <sup>th</sup> to 13 <sup>th</sup> July 2014
		11 <sup>th</sup> to 12 <sup>th</sup> August 2014	16 <sup>th</sup> to 17 <sup>th</sup> August 2014
		22 <sup>nd</sup> to 23 <sup>rd</sup> September 2014	20 <sup>th</sup> to 21 <sup>st</sup> September 2014
		16 <sup>th</sup> to 17 <sup>th</sup> February 2015	14 <sup>th</sup> to 15 <sup>th</sup> February 2015
		16 <sup>th</sup> to 17 <sup>th</sup> March 2015	14 <sup>th</sup> to 15 <sup>th</sup> March 2015
		13 <sup>th</sup> to 14 <sup>th</sup> April 2015	11 <sup>th</sup> to 12 <sup>th</sup> April 2015
		18 <sup>th</sup> to 19 <sup>th</sup> May 2015	16 <sup>th</sup> to 17 <sup>th</sup> May 2015
		15 <sup>th</sup> to 16 <sup>th</sup> June 2015	13 <sup>th</sup> to 14 <sup>th</sup> June 2015
MAQN-3	Hnan Ywa Village, Taung Tha Township	21 <sup>st</sup> to 22 <sup>nd</sup> July 2014	19 <sup>th</sup> to 20 <sup>th</sup> July 2014
		18 <sup>th</sup> to 19 <sup>th</sup> August 2014	23 <sup>rd</sup> to 24 <sup>th</sup> August 2014
		15 <sup>th</sup> to 16 <sup>th</sup> September 2014	13 <sup>th</sup> to 14 <sup>th</sup> September 2014
		23 <sup>rd</sup> to 24 <sup>th</sup> February 2015	21 <sup>st</sup> to 22 <sup>nd</sup> February 2015
		23 <sup>rd</sup> to 24 <sup>th</sup> March 2015	21 <sup>st</sup> to 22 <sup>nd</sup> March 2015
		20 <sup>th</sup> to 21 <sup>st</sup> April 2015	18 <sup>th</sup> to 19 <sup>th</sup> April 2015
		25 <sup>th</sup> to 26 <sup>th</sup> May 2015	23 <sup>rd</sup> to 24 <sup>th</sup> May 2015
		22 <sup>nd</sup> to 23 <sup>rd</sup> June 2015	20 <sup>th</sup> to 21 <sup>st</sup> June 2015
MAQN-4	Sa Ka Village, Myingyan Township	21 <sup>st</sup> to 22 <sup>nd</sup> July 2014	19 <sup>th</sup> to 20 <sup>th</sup> July 2014
		18 <sup>th</sup> to 19 <sup>th</sup> August 2014	23 <sup>rd</sup> to 24 <sup>th</sup> August 2014
		22 <sup>nd</sup> to 23 <sup>rd</sup> September 2014	20 <sup>th</sup> to 21 <sup>st</sup> September 2014
		23 <sup>rd</sup> to 24 <sup>th</sup> February 2015	21 <sup>st</sup> to 22 <sup>nd</sup> February 2015
		23 <sup>rd</sup> to 24 <sup>th</sup> March 2015	21 <sup>st</sup> to 22 <sup>nd</sup> March 2015
		20 <sup>th</sup> to 21 <sup>st</sup> April 2015	18 <sup>th</sup> to 19 <sup>th</sup> April 2015
		25 <sup>th</sup> to 26 <sup>th</sup> May 2015	23 <sup>rd</sup> to 24 <sup>th</sup> May 2015
		22 <sup>nd</sup> to 23 <sup>rd</sup> June 2015	20 <sup>th</sup> to 21 <sup>st</sup> June 2015

#### 5.4.2 Results of Baseline Noise Monitoring

Results of the baseline noise monitoring are summarised in **Table 5.16**. The measured background noise levels are in the range of 50 – 69 dB(A) and 44 – 67 dB(A) during daytime and night-time, respectively. The background noise levels are typical of a general rural environment.

**Table 5.16 Results of Baseline Noise Monitoring**

Monitoring Station	LAeq, dB(A) <sup>(a) (b)</sup>															
	Jul-14		Aug-14		Sep-14		Feb-15		Mar-15		Apr-15		May-15		Jun-15	
	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
MAQN-1	57	54	56	49	56	57	51	46	53	47	50	47	54	53	54	51
MAQN-2	48	44	69	67	58	55	53	46	50	44	53	52	56	51	62	63
MAQN-3	59	58	61	57	58	45	60	50	56	60	61	57	58	56	58	58
MAQN-4	54	47	57	54	56	52	55	49	56	51	52	48	56	54	55	55
IFC Noise Level Guidelines, dB(A) <sup>(b)</sup>	55	45	55	45	55	45	55	45	55	45	55	45	55	45	55	45

**Notes:**

- (a) Noise levels are averaged from the data obtained for weekday and weekend without inclusion of highly intrusive noises.
- (b) D (Daytime) refers to the hours from 0700 hrs to 2200 hrs while N (night-time) refers to the hours from 2200 hrs to 0700 hrs next day.

The averaged background noise level at each NSR was obtained by averaging the noise levels measured over the 8 months period. **Table 5.17** compares the background noise levels to the noise limits set out in the IFC Guidelines. Daytime

averaged background noise levels at Monastery and Pagoda (MAQN-2) and Hnan Ywa Village (MAQN-3) exceeded the IFC guideline values, while measured noise levels at Permanent Steel Mill Construction Worker (EPC) Accommodation (MAQN-1) and Sa Ka Village (MAQN-4) also exceeded the IFC Guidelines at some of the months. Night-time averaged background noise levels at all NSRs exceeded the IFC guideline values. The applicable noise limit level with reference to the IFC Guidelines should not result in a maximum increase in background levels of 3 dB(A) at the NSR.

**Table 5.17 Operational Noise Criteria**

NSR	Type of Uses	Averaged Background Noise Levels, dB(A) <sup>(a)</sup>		IFC Operational Noise Level Guidelines, dB(A) <sup>(b)</sup>		Applicable Operational Noise Criteria for the Project, dB(A) (Background Noise + 3dB(A))	
		Daytime	Night-time	Daytime	Night-time	Daytime	Night-time
MAQN-1 Permanent Steel Mill Construction Worker (EPC) Accommodation, Taung Tha Township	Residential	54	50	55	45	<u>57</u>	<u>53</u>
MAQN-2 Monastery and Pagoda, Taung Tha Township	Institutional	56	53	55	45	<u>59</u>	<u>56</u>
MAQN-3 Hnan Ywa Village, Taung Tha Township	Residential	59	55	55	45	<u>62</u>	<u>58</u>
MAQN-4 Sa Ka Village, Myingyan Township	Residential	55	51	55	45	<u>58</u>	<u>54</u>

**Notes:**

- (a) Noise Levels are averaged over 8 months period from July to September 2014 and from February to June 2015.
- (b) The operational noise criteria are based on Table 1.7.1 of the IFC Guidelines.
- (c) Daytime refers to the hours from 0700 hrs to 2200 hrs while night-time refers to the hours from 2200 hrs to 0700 hrs.

## 5.5 SURFACE WATER

### 5.5.1 Hydrology

The Project Study Area is characterised by a flat terrain, with gentle undulating slopes towards the inlands. Elevations of the Project steel mill complex are between 65 – 76 metres above Mean Sea Level (MSL)<sup>(1)</sup>.

<sup>(1)</sup> <http://www.floodmap.net/Elevation/ElevationMap/?gi=1307835>, accessed 18-06-2014

The Project Site is located approximately 10km from the Ayeyarwady River bank. The river is approximately 2,170km long and has a total drainage of approximately 411,000km<sup>2</sup> <sup>(1)</sup>. The catchment above Sangaing (downstream of Mandalay) has a total drainage of 117,900km<sup>2</sup> <sup>(2)</sup> and supplies a mean annual discharge of 8,024m<sup>3</sup>/s<sup>(2)</sup>. During the low water season (December through May), riverine morphology alternates between single and multiple channel reaches, the latter created by sand island deposits that emerge near the mouths of convergent tributaries and above and below channel constrictions. Extensive floodplains border the waterways in many places<sup>(3)</sup>. An irrigation canal runs from the pumping station at the Ayeyarwady River to the north of the Project Site, lying 0.5 km from the boundary at the closest point. The canal distributes water from the Ayeyarwady River to surrounding agricultural fields.

According to local fishermen interviewed at the initial site visit during preparation of the Scoping Report<sup>(4)</sup>, the river floods significantly in the wet season. The last significant flood to affect the area was recorded in 2013, affecting mainly the villages along the banks of the Ayeyarwady River<sup>(5)</sup>. No further details are available on this flood event at this stage. Based on observations during the scoping phase and baseline surveys, it did not appear that any measures had been taken to prevent future flooding, nor has drainage been modified or improved.

#### **Baseline Flow Measurements in Ayeyarwady River**

Flow measurements in the southern channel of the Ayeyarwady River were conducted at the surface, mid-depth and bottom of the water column twice a month from July to December 2014 during preparation of the Scoping Report<sup>(5)</sup>. Subsequently, river flow measurements were again conducted at the same location during February to April 2015, as part of the ESIA. One additional flow measurement was taken at a separate location in June 2015. Flow monitoring locations for all sampling periods are shown in **Table 5.18**, and in **Figure 5.10** and **Figure 5.11**.

**Table 5.18** **Surface Water Flow Rate Monitoring Locations**

Monitoring Location	Monitoring Period	GPS Coordinates
W1: About 300m upstream of the Seik Nyan Pumping Station in Ayeyarwady River	July-December 2014, and February-April 2015	21° 24' 38.2" N 95° 16' 40.8" E
MRF-1	June 2015	21° 24' 35.19" N 95° 16' 34.40" E

<sup>(1)</sup> Vorosmarty C. J., Fekete & B. A. Tucker, (1998) River Discharge Database, Version 1.1. (RivDis,V1 supplement).

<sup>(2)</sup> Vorosmarty C. J., Fekete & B. A. Tucker, (1998) *Op cite*

<sup>(3)</sup> Smith B. D., Hobbs L., (2002), Status of Irrawaddy dolphins *Orcaella Brevirostris* in the upper reaches of the Ayeyarwady River, Myanmar, *The Raffles Bulletin of Zoology*, Supplement No. 10

<sup>(4)</sup> Myingyan IPP Project – Environmental & Social Consultancy Services in support of Transaction Advisory Services for Private Sector Participation – Scoping Report – Revision 4 – 18<sup>th</sup> May 2015

<sup>(5)</sup> <http://c4i.me/site/2013/09/18/flash-flood-asia-myanmar-burma-3/>, C4I For Humanity, accessed 20-06-2014

The flow measurement results from the above two sampling periods have been used to estimate the flow rate across both the wet season and dry season in the southern channel of the Ayeyarwady River, near the withdrawal location for the Project. A surface channel width of the southern river channel of 410m, based on satellite imagery, has been assumed to estimate the flow rates. Flow rates at the sampling location have been estimated to be in the range of 64m<sup>3</sup>/s (measured on March 28, 2015) to 660m<sup>3</sup>/s (measured on August 8, 2014), as shown in **Table 5.19**.

It is important to note that the flow rates were calculated based on the following approach and assumptions:

- The flow rates have been estimated based on the surface channel width measured on Google Earth satellite imagery of approximately 410m.
- The surface channel width was only measured for the southern channel of the river and therefore flow conditions only represent the flow conditions of the southern river channel.

**Table 5.19 Estimated Flow Rates in Southern Channel Ayeyarwady River**

Date	Channel Depth (m)	Sample Depth (m)	Velocity (m/s)	Width (m)	Estimated Flow Rate (m <sup>3</sup> /s)
12/7/2014	7.3	1	0.22	410	526.809
		3	0.182		
		6	0.163		
24/7/2014	9.9	1	0.071	410	194.914
		5	0.057		
		9	0.036		
8/8/2014	8.7	1	0.19	410	659.69
		4.3	0.19		
		7.7	0.18		
22/8/2014	10.1	1	0.05	410	208.075
		5	0.057		
		9	0.045		
12/9/2014	6.4	1	0.056	410	148.174
		3.2	0.053		
		5.4	0.059		
22/9/2014	6.0	1	0.067	410	129.56
		3	0.06		
		5	0.043		
12/10/2014	7.2	1	0.052	410	170.888
		3.5	0.066		
		6	0.054		
22/10/2014	8.0	1	0.121	410	442.8
		4	0.153		
		7	0.125		
15/11/2014	6.2	1	0.043	410	81.262
		3	0.036		
		5.5	0.026		
29/11/2014	7.4	1	0.095	410	211.273
		3.5	0.087		
		6.5	0.052		
10/12/2014	6.7	1	0.04	410	87.084
		3	0.027		
		6	0.032		
22/12/2014	7.4	1	0.078	410	169.084
		3.5	0.062		
		7	0.046		
17/2/2015	4.8	1	0.04	410	74.21
		2	0.043		
		4	0.035		
28/2/2015	5.0	1	0.042	410	73.8
		2	0.039		
		4	0.033		
14/3/2015	4.7	1	0.052	410	136.817
		2	0.063		
		4	0.081		
28/3/2015	4.8	1	0.038	410	64.616
		2	0.03		
		4	0.032		
11/4/2015	4.6	1	0.088	410	125.952
		2	0.071		
		4	0.057		
25/4/2015	5.0	1	0.042	410	79.54
		2	0.056		
		4	0.032		
17/6/2015	8.4	1	0.163	410	370.07
		4	0.138		
		8	0.074		

In the Mandalay region, populations may have access to water supply through a network of piped water system and private wells and moat water <sup>(1)</sup>. The source of the piped water supply is from ground water, mainly from tube wells pumping along the banks of the Ayeyarwady River. Until 2006, only 60% of the city area was covered by piped water supply. While those residing in the cities, not covered by the piped water supply had to rely on water from tube wells dug by WSD/MCDC and international donor projects, those residing outside the urban areas have to rely on sources such as open dug wells, springs, rivers and ponds. In Myingyan, the source of irrigation is a piped water supply from canals and streams.

Fishing is not a popular activity in the Project area villages, with the exception of Tha Pyay Thar, as it is the village located closest to the Ayeyarwady River, and Gyoke Pin. Further details on fisheries in the Project area are provided in **Chapter 6**.

The Dry Zone of Myanmar faces challenges regarding reliable supply of safe drinking water, as well as access to water for agriculture <sup>(2)</sup>. The Dry Zone is prone to droughts. During dry periods, water sources and reservoirs are sufficient for household consumption, but not for livestock and agriculture. The main sources of freshwater in the region are the Ayeyarwady River and groundwater, which the villagers extract through wells in the dry season.

In the Project Study Area, potential sources of water contamination include boat vessel discharges in the navigable waterways (such as the Ayeyarwady River), as well as mercury from gold mining operations, which are known to occur in Sagaing Region, 90km upstream of the Project Site<sup>(3)</sup>. It is not currently known if similar operations take place within Myingyan. Research undertaken by the International Union of Conservation of Nature (IUCN) found relatively high levels of Tetrahydrogestrinone (THg) and Ethylene glycol (MeHg) in the muscle of fish sampled from fishermen's catches and fish markets along the Ayeyarwady River <sup>(4)</sup>.

### **Surface Water Quality Baseline Surveys**

#### **Sampling Methodology and Locations**

For the environmental baseline surveys carried out between July 2014 and December 2014 and February 2015 and April 2015, water quality monitoring was conducted near the Project's planned cooling water intake in the Ayeyarwady River as shown in **Table 5.20** and **Figure 5.10**. Surface water quality was also monitored in June 2015 within the intake channel and at a location further south of the Ayeyarwady River, as shown in **Table 5.20** and **Figure 5.11**.

<sup>(1)</sup> In the old capital of Burmese King, there is a palace surrounded by moat and water from moat was used for water supply in the past as a main source of water (drinking and domestic use).

<sup>(2)</sup> United Nations Development Programme - Myanmar (2013); Adaptation Fund - Addressing climate change risks on water resources and food security in the Dry Zone of Myanmar

<sup>(3)</sup> IUCN (2014), <http://www.iucnredlist.org/details/44556/0>, accessed 20-06-2014

<sup>(4)</sup> IUCN (2014), *Op cite*

**Table 5.20 Surface Water Quality Monitoring Locations**

Monitoring Location	Monitoring Period	GPS Coordinates	Description
W1: About 300m upstream of the Seik Nyan Pumping Station in Ayeyarwady River	July-December 2014, and February-April 2015	21°24' 39.38"N 95°16' 41.92"E	Sampling was conducted in the middle of the Ayeyarwady River, upstream of the Seik Nyan floating pumping station; Approximately 10.5 km from the Project site At the time of sampling, one pumping station was operated by the Water Resources and Utilisation Department (WRUD) which pumped freshwater from the River up to the irrigation channel.
MSW-1	June 2015	21° 24' 19.63" N 95° 16' 43.32" E	In irrigation canal of Seik Nyan water gate
MSW-2	June 2015	21° 24' 19.20" N 95° 15' 27.50" E	In Ayeyarwady river, about 2 km downstream of MRF-1

Parameters that were sampled and analyzed include pH, DO, COD, BOD5, Oil and Grease, TN, TP, TSS, Total Coliform, water temperature, channel depth and flow velocity. Water samples were collected by Alpha horizontal water sampler, and kept in sterilized sample containers. All sampling containers were stored in iced boxes within 2-4 C refrigerators and transported to either the Government of Myanmar MOAI Soil and Water Analytical Laboratory in Myanmar, or SGS laboratories Thailand, depending on parameters to be analyzed. Note that temperature was only monitored at a single depth/location for each sample, which does not allow for determination of temperature gradients. However, the Project's current design will discharge cooling tower wastewater into the irrigation canal substantially downstream of the Ayeyarwady River, with ultimate fate to be used as irrigation water for surrounding agricultural lands. Therefore the determination of a well-defined mixing zone in the Ayeyarwady River is not necessary for the purposes of assessing the impact of thermal discharge.

Figure 5.10 Monitoring Locations for Surface Water Quality and Flow Rate (1 of 2)

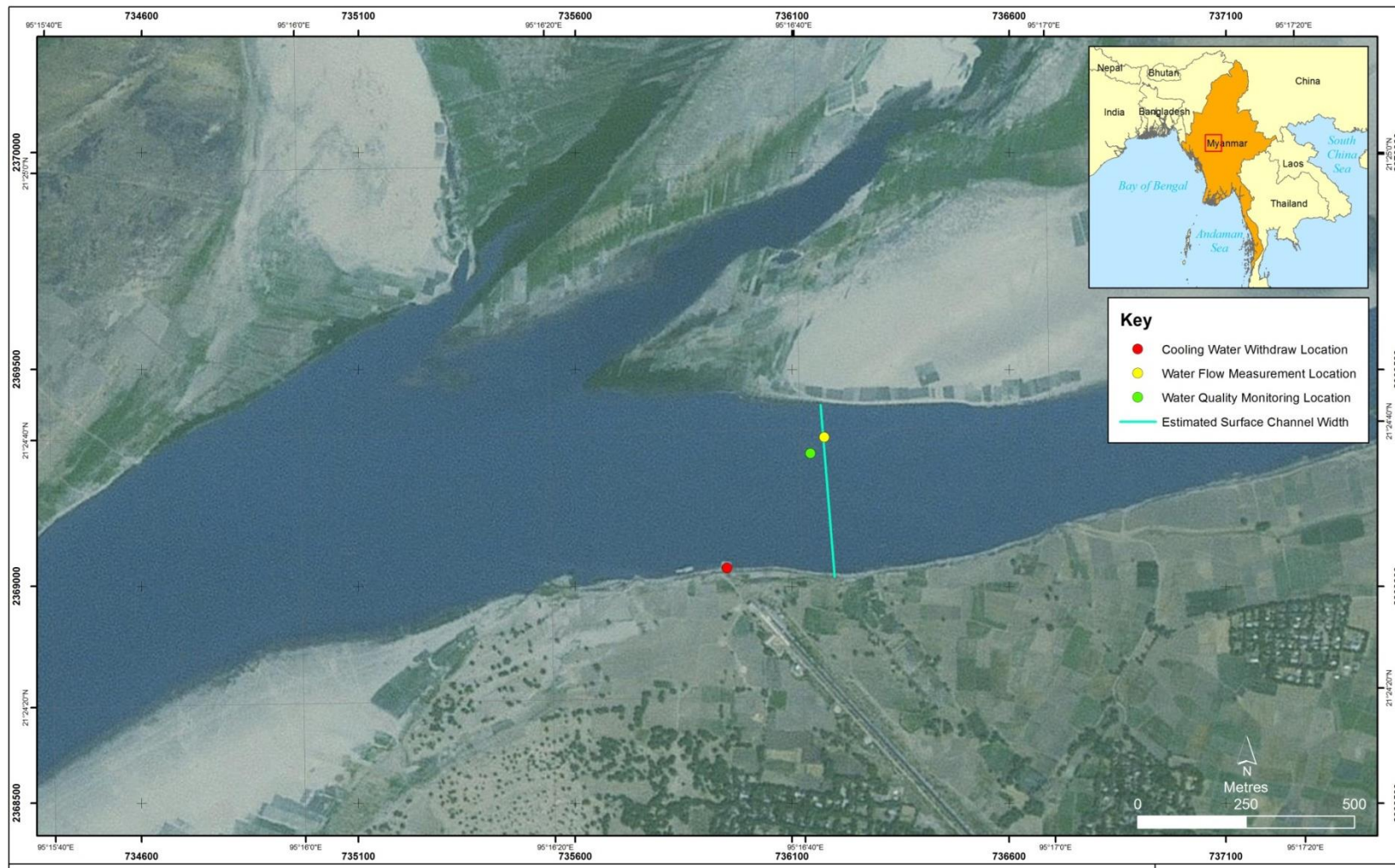


Figure 5.11 **Monitoring Locations for Surface Water Quality and Flow Rate (2 of 2)**



### Analysis Results and Discussion

**Table 5.21** presents the baseline monitoring results for surface water quality sampled during the surveys from July 2014 to December 2014, February 2015 to April 2015, and in June 2015. The laboratory reports are provided in **Annex B**. With the exception of TSS, total coliform bacteria, and iron, all other monitored parameters were found to be below the WBG/IFC guideline values. Some of the water analysis parameters are discussed below in further detail.

**Total Suspended Solids (TSS):** Measured TSS levels from July 2014 to December 2014 and February 2015 to June 2015 were found to be in the range of 4.4mg/L to 264mg/L. Many of the TSS values, particularly during high flow rates in the rainy season, were above WBG/IFC guideline value of 50mg/L. TSS can be composed of a variety of materials, including silt, decaying plants and animal matter, industrial waste and sewage. The high TSS concentrations measured are likely due to naturally high silt load in the Ayeyarwady River, which tends to be worse during high flow rates. Higher concentrations of TSS can cause or be associated with high turbidity, reduced light and photosynthesis, reduced DO, higher bacteria content and increased water temperature.

**pH:** All results for pH in the surface water fell within the permissible limits of 6 to 9.

**Biochemical Oxygen Demand (BOD):** The BOD levels ranged between 0.2 to 7.4 mg/L, and were all below the limit of 30mg/L from the WBG/IFC guideline values.

**Coliform Levels:** The measured total coliform levels ranged from <1.8 MPN/100 mL (in December 2014 and March 2015) to 1,100 MPN/100 mL (in July 2014). Measurements conducted on 12 July and 8 August 2014 exceeded WBG/IFC guidance limit of 400 MPN/100 mL. This indicates that there is at least some existing faecal contamination of the Ayeyarwady River. Sources of total coliform include sewage waste from humans and fecal matter from warm-blooded animals such as livestock, both of which could either be directly discharged into the river or carried in runoff

during rainfall. It is likely that the coliform levels in the Ayeyarwady River are primarily due to runoff, as indicated by the higher levels observed during the rainy season (July to October) in comparison to other months.

**Heavy Metals:** Among the heavy metals analysed, all were found to be below the relevant WBG/IFC guideline values, with the exception of iron at MSW-2 in June 2015. Iron was measured to have concentration of 2.63mg/L at MSW-2, which is more than double the WBG/IFC guideline value of 1.0mg/L. Although iron occurs naturally in soil, sediments and ground water, it may also be released to water from natural deposits, industrial wastes, refining of iron ores, and corrosion of iron containing metals. Potential discharges or leaching from the nearby Steel Mill may represent a source of increased iron levels at this location of the Ayeyarwady River.

**Table 5.21 Monitoring Results of Baseline Surface Water Quality**

No.	Sample No./ Physical Parameter	Unit	Detection Limit	IFC Guidelines	Results																				
					W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	MSW-1, Irrigation Canal	MSW-2, Ayeyarwady River
1	Location	-	-	-	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	W1, Ayeyarwady River	MSW-1, Irrigation Canal	MSW-2, Ayeyarwady River
2	Date/Time of Sample Collection	-	-	-	12/7/2014 10:00 a.m.	24/7/2014 9:30 a.m.	8/8/2014 10:00 a.m.	22/8/2014 10:00 a.m.	12/9/2014 10:35 a.m.	22/9/2014 11:00 a.m.	12/10/2014 10:30 a.m.	22/10/2014 10:45 a.m.	15/11/2014 10:15 a.m.	29/11/2014 10:25 a.m.	10/12/2014 10:00 a.m.	22/12/2014 9:45 a.m.	17/02/2015 09:30am	28/02/2015 09:00am	14/03/2015 09:30am	28/03/2015 09:00am	11/04/2015 11:40am	25/04/2015 09:00am	17.06.2015 10:30 am	17.06.2015 09:35 am	
3	Weather	-	-	-	Partly Cloudy	Partly Cloudy	Sunny	Sunny	Sunny	Sunny	Cloudy	Sunny	Partly Cloudy	Sunny	Partly Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Partly cloudy	Sunny
4	Water Depth	m	-	-	9.3	9.9	8.4	8.9	5.8	5.4	6.8	7.4	6	6.6	5.7	6.5	4.8	5.0	4.7	4.8	4.6	5.0	-	6.3	
5	Depth of Sample	m	-	-	1.75	2	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00	1.00	-	1.00	
6	Water Temperature	°C	-	-	27.12	26.65	28.34	28.8	29.1	28.4	29.36	28.8	26.1	25.42	24.6	22.4	23.6	23.4	26.0	26.2	26.7	27.2	30.71	25.44	
7	Air Temperature	°C	-	-	34.0	31	35	31	32.5	32	31	32	29.5	30.5	29.5	32	26.5	25.5	36	32	38	30	37	37	
8	pH	-	-	6 – 9*	7.71	8.62	8.03	8.03	8.1	8.05	7.98	8.55	8.21	8.48	8.6	8.42	7.87	7.80	7.70	7.89	7.65	7.73	8.0	7.81	
9	Electrical Conductivity	µs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	153	178	124	145	122	129	61	60	
10	Dissolved Oxygen	mg/L	-	-	7.26	5.19	6.98	6.86	7.2	8.1	7.23	9.28	3.29	4.28	5.49	6.1	6.02	6.81	8.82	9.28	12.6	9.28	4.59	2.86	
11	Turbidity	FNU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.2	9.4	18.1	14.2	31.7	35.1	90.2	226	
12	Biochemical Oxygen Demand (BOD)	mg/L	-	30**	2.4	4.5	2	5.2	7	7.4	3	2.8	3.5	5.5	3.8	5.2	0.6	0.8	1.2	0.6	2.4	2.4	0.6	0.2	
13	Chemical Oxygen Demand (COD)	mg/L	5.0	125**	6.7	12	5	9.5	17.5	16	7.5	7.5	8.2	13.5	9.5	10.5	20.8	<5.0	9.2	17.5	<5.0	8.0	6.4	12.7	
14	Total Nitrogen	mg/L	1.0	10**	ND	ND	ND	ND	0.6	2.24	ND	0.65	ND	ND	ND	0.91	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
15	Total Phosphorus	mg/L	0.005	2**	ND	0.05	0.09	0.05	ND	ND	ND	ND	ND	ND	ND	ND	0.023	0.011	0.025	0.0039	0.016	0.006	0.026	0.032	
16	Oil & Grease	mg/L	5.0	10*	ND	2.2	5.9	5.5	5.8	7.1	ND	5.1	6	ND	ND	ND	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
17	Total Suspended Solids (TSS)	mg/L	2.5	50*	<b>162</b>	<b>264</b>	<b>101</b>	<b>162</b>	<b>158</b>	<b>141</b>	<b>156</b>	<b>146</b>	<b>148</b>	<b>96</b>	25	<b>135</b>	7.0	4.4	8.6	5.6	18.8	20.6	11.5	<b>74.0</b>	
18	Total Coliform Bacteria (TCB)	MPN/100 mL	1.8	400**	<b>1,100</b>	110	<b>490</b>	130	140	170	49	240	11	23	<1.8	13	7.8	4.5	7.8	<1.8	4.5	110	130	68	
19	Total Residual Chlorine	mg/L	0.01	0.2*	-	-	-	-	-	-	-	-	-	-	-	-	0.07	<0.01	<0.01	0.05	0.02	0.02	<0.01	<0.01	
20	Total Chromium (Cr)	mg/L	0.0005	0.5*	-	-	-	-	-	-	-	-	-	-	-	-	0.0010	0.0011	0.0005	<0.0005	0.0021	0.0020	0.0012	0.0039	
21	Copper (Cu)	mg/L	0.03	0.5*	-	-	-	-	-	-	-	-	-	-	-	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	
22	Iron (Fe)	mg/L	0.05	1.0*	-	-	-	-	-	-	-	-	-	-	-	-	0.30	0.31	0.34	0.22	0.62	0.83	0.96	<b>2.63</b>	
23	Zinc (Zn)	mg/L	0.01	1.0*	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
24	Lead (Pb)	mg/L	0.0020	0.5*	-	-	-	-	-	-	-	-	-	-	-	-	0.0030	0.0118	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0033	
25	Cadmium (Cd)	mg/L	0.00005	0.1*	-	-	-	-	-	-	-	-	-	-	-	-	0.00008	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	
26	Mercury	mg/L	0.0003	0.005*	-	-	-	-	-	-	-	-	-	-	-	-	0.0006	<0.0003	<0.0003	0.00016	<0.0003	0.0010	<0.0003	<0.0003	
27	Arsenic	mg/L	0.0002	0.5*	-	-	-	-	-	-	-	-	-	-	-	-	0.0010	<0.0002	0.0006	0.0010	0.0003	0.0004	<0.0002	<0.0002	

\* IFC EHS Guidelines Thermal Power Plants (2008).

\*\* IFC General EHS Guideline: Environmental Wastewater and Ambient Water Quality (2007).

ND = Not Detectable

## 5.6 SOILS

### 5.6.1 Soil Landscape

Based on soil surveys conducted across Myanmar in 1965<sup>1</sup>, soils in the Project Study Area are classified as Vertisol Soils (see **Figure 5.12**). The soils are deep and mostly composed of clayey materials. Their low fertility and declining organic matter level make them difficult for farming, especially under excessively dry or wet conditions. Areas with Vertisol soils that contain natural savannah are used for low volume grazing. Infiltration in the soils is poor, and the soil is alkaline (pH ranging from 7 to 9). Vertisol soils tend to be deficient in nitrogen and phosphorus, but are high in calcium, magnesium, and potassium. Degraded soils have low aggregate stability and are prone to erosion if exposed to rainfall, making preservation of the surface soil organic matter important for the region. Vertisol soils are generally better for perennial crops rather than annual crops. According to Food and Agriculture Organization (FAO), certain types of crop cultivation in the region further contribute to soil erosion, such as cassava, sweet potato and ground nut <sup>(2)</sup>.

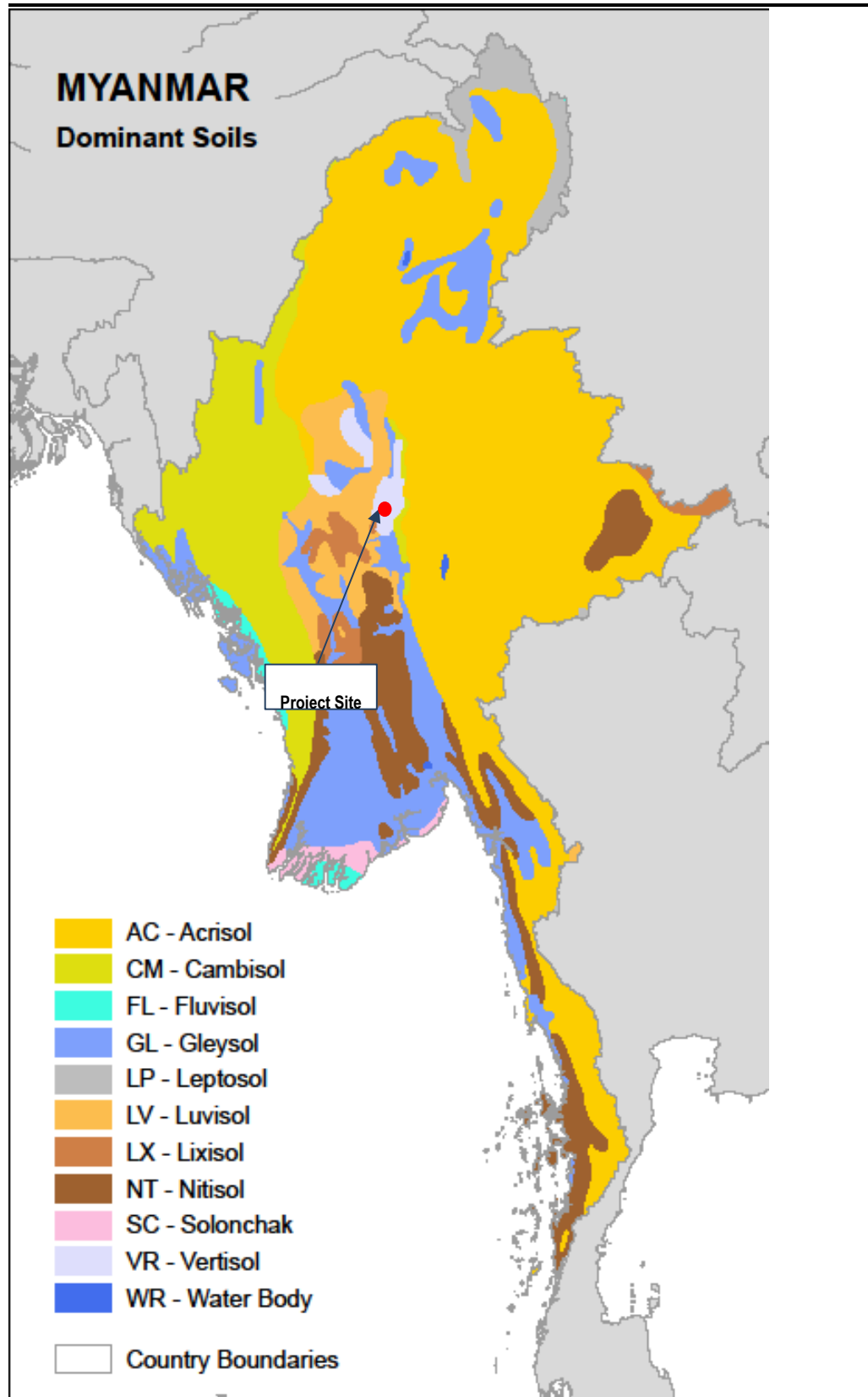
### 5.6.2 Soil Quality

During site visits over the period from 2014-2015, it was observed that in numerous locations throughout the site, soil has been almost completely removed by wind and water erosion. Surface runoff is likely to be high across the Project Site and vicinity. Removal of the natural savannah vegetation may have exacerbated the rate of erosion, which is more intensive at the start of the monsoon rains on bare soils.

(1) <http://www.unccd.int/ActionProgrammes/myanmar-eng2005.pdf>

(2) Mineral Soils conditioned by a Wet (Sub) Tropical Climate – Major landforms in sub humid tropics. FAO Corporate Document Repository. Available online, accessed 17<sup>th</sup> December 2014. <http://www.fao.org/docrep/003/y1899e/y1899e08a.htm>

Figure 5.12 Myanmar Dominant Soils



Source: Food and Agriculture Organisation of the United Nations <sup>(1)</sup>

<sup>(1)</sup> FAO and Natural Resources and Management and Environment Department, accessed online 17<sup>th</sup> December 2014

[http://www.fao.org/nr/myanmar/SoilMap\\_Myanmar\\_300dpi.jpg](http://www.fao.org/nr/myanmar/SoilMap_Myanmar_300dpi.jpg)

## Soil Baseline Surveys

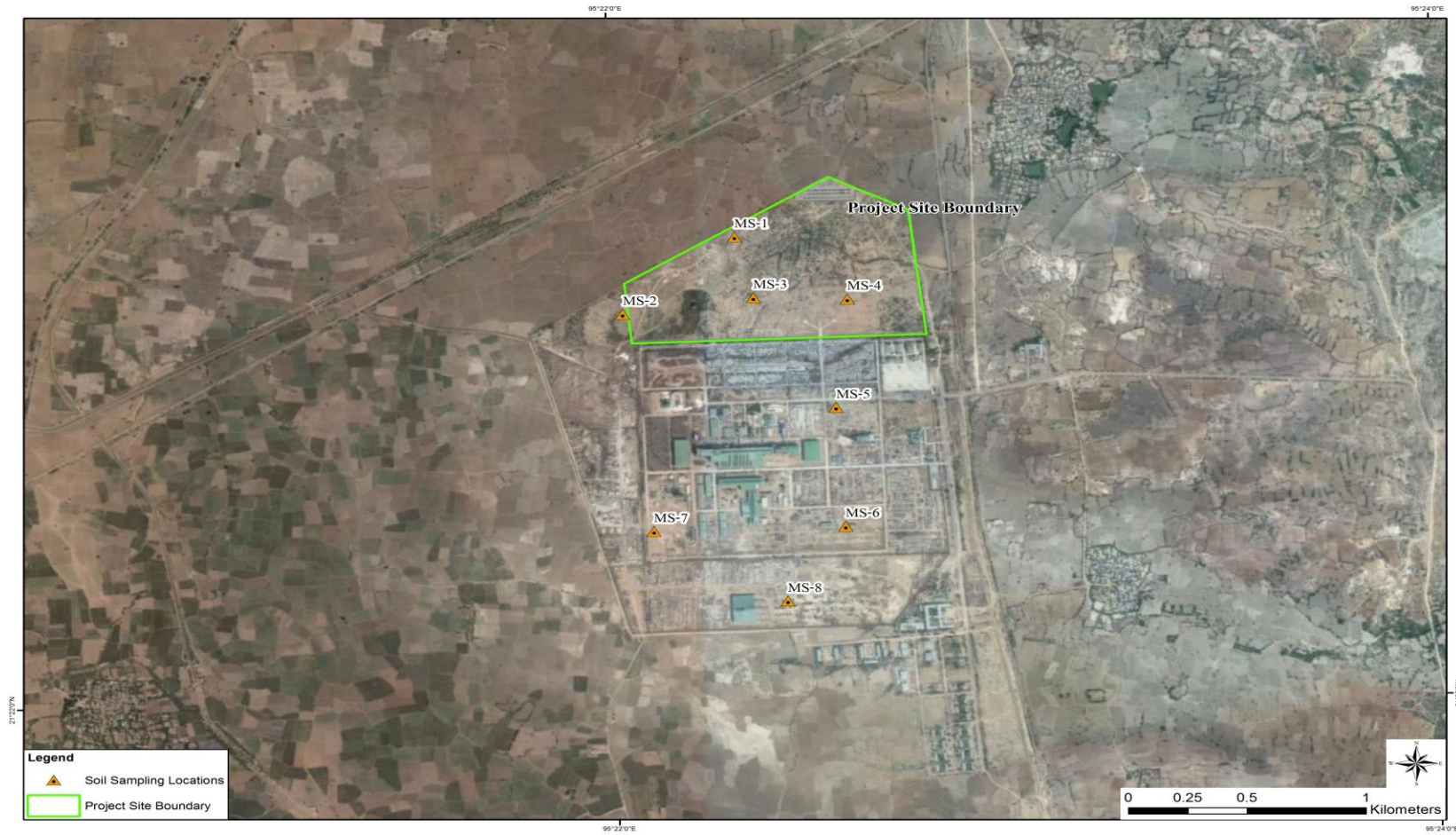
### Sampling Methodology and Locations

The location of the soils samples are shown in **Figure 5.13** and are described in **Table 5.22**. Soil sampling was undertaken in accordance with standard operating procedure of U.S. EPA (SOP-2013, SOP2016, and SOP 2003). Soil samples were taken using the standard agricultural sampler (Soil Auger). Top soil was collected from 10 - 30cm in depth and sub soil from 2.7 - 3.0m in depth.

**Table 5.22** *Location of Soil Samples*

Sampling Point	Coordinates	Description of Sampling Point
MS-1	21° 23' 17.56" N 95° 22' 18.27" E	Northern most part of the Project Site.
MS-2	21° 23' 4.88" N 95° 22' 1.76" E	Near existing MOGE gas station; northwestern part of Project Site.
MS-3	21° 23' 7.39" N 95° 22' 20.87" E	Northern part of the Project Site.
MS-4	21° 23' 6.99" N 95° 22' 34.58" E	At proposed Power Plant area, northeastern part of Project Site.
MS-5	21° 22' 48.90" N 95° 22' 32.67" E	Near sub-station within existing steel mill.
MS-6	21° 22' 29.04" N 95° 22' 33.73" E	At southern part of existing steel mill
MS-7	21° 22' 28.59" N 95° 22' 5.73" E	At southwestern part of existing steel mill.
MS-8	21° 22' 16.69" N 95° 22' 25.13" E	At southern part of Project Site

Figure 5.13 Soil Sampling Locations



## Guidelines/Standards for Comparison

There are no Myanmar soil or groundwater regulations/standards. In the absence of local country standards, it is ERM's practice to use globally recognized 'Dutch Ministry of Public Housing, Land-use and Environmental Guidelines - Soil and Groundwater Standards' to assess soil quality and to determine the need, if any, for remedial action.

## Analysis Results and Discussions

As well as the overall soil landscape (refer to **Section 5.6.1**) the soil structure and type was described for each sample location, these are summarised as:

- **MS-1** was on a generally flat region and was primarily a silty clay, characterised by light gray colourations in the top soil layer and brown coloured soil in the sub soil. Organic materials such as roots and peat occurred to a depth of approximately 500mm.
- **MS-2** was on a flat region and was predominately a sandy clay. The colour varied from a red-brown top soil to a brown in the sub soil layers.
- **MS-3** is located in the future expansion area of the existing steel mill and is flat barren land. The soil at this location was a clay which occurred in both top and sub-soil layers. It was noted to be very stiff due to a low moisture content.
- **MS-4** is located similarly to MS-3. Both top and sub-soil layers are characterised as light gray coloured silty clay with very low moisture content.
- **MS-5** was collected within the compound of the existing steel mill. This silty clay was gray to dark gray through throughout the soil profile. It was also noted to have a very low moisture content.
- **MS-6** was characterized by sandy silts, with a yellowish to buff coloured top soil and brown coloration within the subsoil. It was noted that this site and surrounding areas showed features of having previously been excavated.
- **MS-7** was collected on a flat area at the south western part of the existing steel mill. The top soil was a light gray coloured sandy clay, with the sub soil being a dark brown coloured silty clay.
- **MS-8** was collected from the wall of a pit excavated for the foundations of a new structure. This was a yellow coloured sandy clay in the top soil, with a brown colouration in the silty clay sub-soil.

**Organic content:** aside from some roots and peats noted as occurring within MS-1, none of the other test pits were noted as containing any visible organic matter. No specific analysis was undertaken with regards to soil minerals and nutrients to allow for an in-depth understanding of overall soil fertility to be gained. Additionally, no soil pH investigations were undertaken.

**Heavy metals and hydrocarbons:** specific analysis was undertaken for a range of hydrocarbons and heavy metals. Almost all of those analysed were found to be either well below the relevant guidelines values, or below detection limits. An exception is mercury, which was detected at levels slightly above Dutch Target Values (level at which there is a sustainable soil quality) at Stations MS-7T, MS-7B, MS-8T, and MS-8B. However, levels were well below Dutch Intervention Values (level of contamination above which there is a serious case of soil contamination). The analysis results of physico-chemical parameters of soil samples are presented in **Table 5.23**. The laboratory reports are provided in **Annex B**.

**Table 5.23 Soil Quality Results**

Parameter	LOQ	Standard 1	Standard 2	Results															
				MS-1T	MS-1B	MS-2T	MS-2B	MS-3T	MS-3B	MS-4T	MS-4B	MS-5T	MS-5B	MS-6T	MS-6B	MS-7T	MS-7B	MS-8T	MS-8B
Oil & Grease	200	N/A	N/A	853	329	363	<200	<200	317	380	239	252	<200	<200	231	<200	282	<200	205
- Kerosene Range Hydrocarbons	20.8-23.8	N/A	N/A	<22.5	<22.4	<22.5	<23.8	<21.7	<21.1	<21.5	<21.1	<21.6	<22.3	<20.8	<21.7	<21.3	<22.8	<20.8	<21.2
- Diesel Range Hydrocarbons	20.8-23.8	N/A	N/A	<22.5	<22.4	<22.5	<23.8	<21.7	<21.1	<21.5	<21.1	<21.6	<22.3	<20.8	<21.7	<21.3	<22.8	<20.8	<21.2
- Heavy Oil Range Hydrocarbons	83.1-95.3	N/A	N/A	<89.8	<89.6	<89.8	<95.3	<86.7	<84.4	<86.0	<84.5	<86.5	<89.0	<83.1	<86.7	<85.1	<91.4	<83.3	<84.7
- Gasoline Range Hydrocarbons	13.6-16.6	N/A	N/A	<16.7	<15.2	<16.5	<16.6	<16.1	<14.3	<16.1	<15.4	<13.9	<14.4	<13.6	<14.5	<15.5	<16.0	<14.3	<13.7
- Benzene	0.181-0.221	1	0.01	<0.223	<0.203	<0.220	<0.221	<0.215	<0.191	<0.215	<0.206	<0.185	<0.193	<0.181	<0.194	<0.207	<0.213	<0.191	<0.183
- Toluene	0.181-0.221	130	0.01	<0.223	<0.203	<0.220	<0.221	<0.215	<0.191	<0.215	<0.206	<0.185	<0.193	<0.181	<0.194	<0.207	<0.213	<0.191	<0.183
- Ethylbenzene	0.181-0.221	50	0.03	<0.223	<0.203	<0.220	<0.221	<0.215	<0.191	<0.215	<0.206	<0.185	<0.193	<0.181	<0.194	<0.207	<0.213	<0.191	<0.183
- Xylenes (total)	0.544-0.664	25	0.1	<0.668	<0.608	<0.659	<0.664	<0.644	<0.572	<0.645	<0.618	<0.555	<0.578	<0.544	<0.581	<0.621	<0.640	<0.573	<0.550
Cadmium (Cd)	1.00	12	0.8	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Chromium (Cr)	2.50	380	100	28.22	33.55	22.68	33.69	26.37	31.00	36.88	26.56	28.83	33.38	29.73	27.52	34.52	38.27	42.51	29.38
Hexavalent Chromium (Cr <sup>+6</sup> )	0.10	78	N/A	<0.10	<0.10	0.14	<0.10	<0.10	0.19	<0.10	<0.10	<0.10	<0.01	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Lead (Pb)	5.00	530	85	5.32	5.50	<5.00	5.62	<5.00	<5.00	5.35	<5.00	5.02	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5.54
Mercury (Hg)	0.10	10	0.3	0.13	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<b>0.42</b>	<b>0.33</b>	<b>0.61</b>	<b>0.38</b>
Nickel (Ni)	2.00	210	35	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00

Parameter	LOQ	Standard 1	Standard 2	Results															
				MS-1T	MS-1B	MS-2T	MS-2B	MS-3T	MS-3B	MS-4T	MS-4B	MS-5T	MS-5B	MS-6T	MS-6B	MS-7T	MS-7B	MS-8T	MS-8B
Selenium (Se)	0.01	100	0.7	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver (Ag)	1.5	15	N/A	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50
Arsenic	0.0020	55	29	0.52	0.53	0.47	0.63	0.50	0.56	0.71	0.63	0.63	0.74	0.81	0.50	0.86	0.89	0.97	0.37
Barium (Ba)	5.00	625	160	46.19	44.21	30.03	64.53	39.69	28.71	48.68	36.55	33.38	41.56	37.51	31.21	45.03	52.75	50.05	38.89
Copper (Cu)	1.50	190	36	19.00	22.12	12.81	23.40	15.17	18.25	21.15	16.23	23.19	22.42	17.03	13.39	24.10	28.63	25.16	26.62
Iron (Fe)	2.50	N/A	N/A	34,363	36,311	22,012	35,831	27,496	28,472	28,962	24,282	33,875	34,176	29,418	25,437	34,913	39,723	35,984	33,344
Manganese (Mn)	1.00	N/A	N/A	562.14	744.63	516.65	837.21	532.60	687.80	713.52	660.60	666.93	618.48	610.36	534.03	691.41	815.65	716.34	746.77
Zinc (Zn)	0.50	720	140	87.89	78.42	56.46	81.98	59.01	66.22	81.14	67.80	99.15	79.89	61.85	55.02	85.93	98.36	84.24	94.02

Notes on Source, Parameters and Abbreviations

1. Source -
2. All parameters expressed as mg/kg dry
3. All Standards expressed as mg/kg
4. All Standards based on Circular for Soil Remediation Target and Intervention Values from the Dutch Standards
5. Standard 1 adopted are Intervention Values (from Annex A of Circular on Target Values and Intervention Values for Soil Remediation (Dutch Standards, 2000))
6. Standard 2 adopted are Target Values (from Annex A of Circular on Target Values and Intervention Values for Soil Remediation (Dutch Standards, 2000))
7. LOQ – Limits of Quantification
8. T – topsoil
9. B – bottom soil

Source: Lab Analysis Report STS Green, 2015

## 5.7

### GROUNDWATER

#### 5.7.1

#### Hydrogeology

On the basis of stratigraphy, there are 13 different types of aquifers in Myanmar, namely Alluvium, Irrawaddian, Peguan, Limestone, Igneous (or Volcanic) and Other Minor Aquifers. The Project Study area is underlain by Irrawadian and Peguan aquifers (**Figure 5.14**).

Quality and quantity of groundwater varies depending on the lithology and depositional environments. Groundwater quality of Irrawadian aquifers is generally suitable for domestic use and irrigation purposes, while groundwater quality from Peguan aquifers is not suitable for drinking water purposes<sup>1</sup>. Groundwater aquifers are prone to leaching during the monsoon periods, especially on impervious surfaces, e.g. clay seams, clay layers, bedrocks, etc. Rising groundwater can cause saturation of the soil and can cause very high pore-water pressure in slopes in sedimentary deposits.

The estimated groundwater potential in the Lower Ayeyarwady Region is 153km<sup>3</sup>, while the potential in the Upper Ayeyarwady Region is 92.60km<sup>3</sup>, as shown in **Table 5.24**.

**Table 5.24** *Estimated Groundwater Potential across Myanmar*

Sr	River Basin	Catchment Area (km <sup>2</sup> )	Groundwater Potential (km <sup>3</sup> )
1	Chiuindwin	115,300	57.58
2	Ayeyarwady (Upper)	193,300	92.60
3	Ayeyarwady (Lower)	95,600	153.25
4	Sittoung	48,100	28.40
5	Rivers in Rakhine State	58,300	41.77
6	Rivers in Tanintharyi Region	40,600	39.28
7	Thanlwin (within Myanmar)	158,000	74.78
8	Mekong (within Myanmar)	28,600	7.05
<b>Total</b>		<b>737,800</b>	<b>494.71</b>

Source: FAO<sup>2</sup>

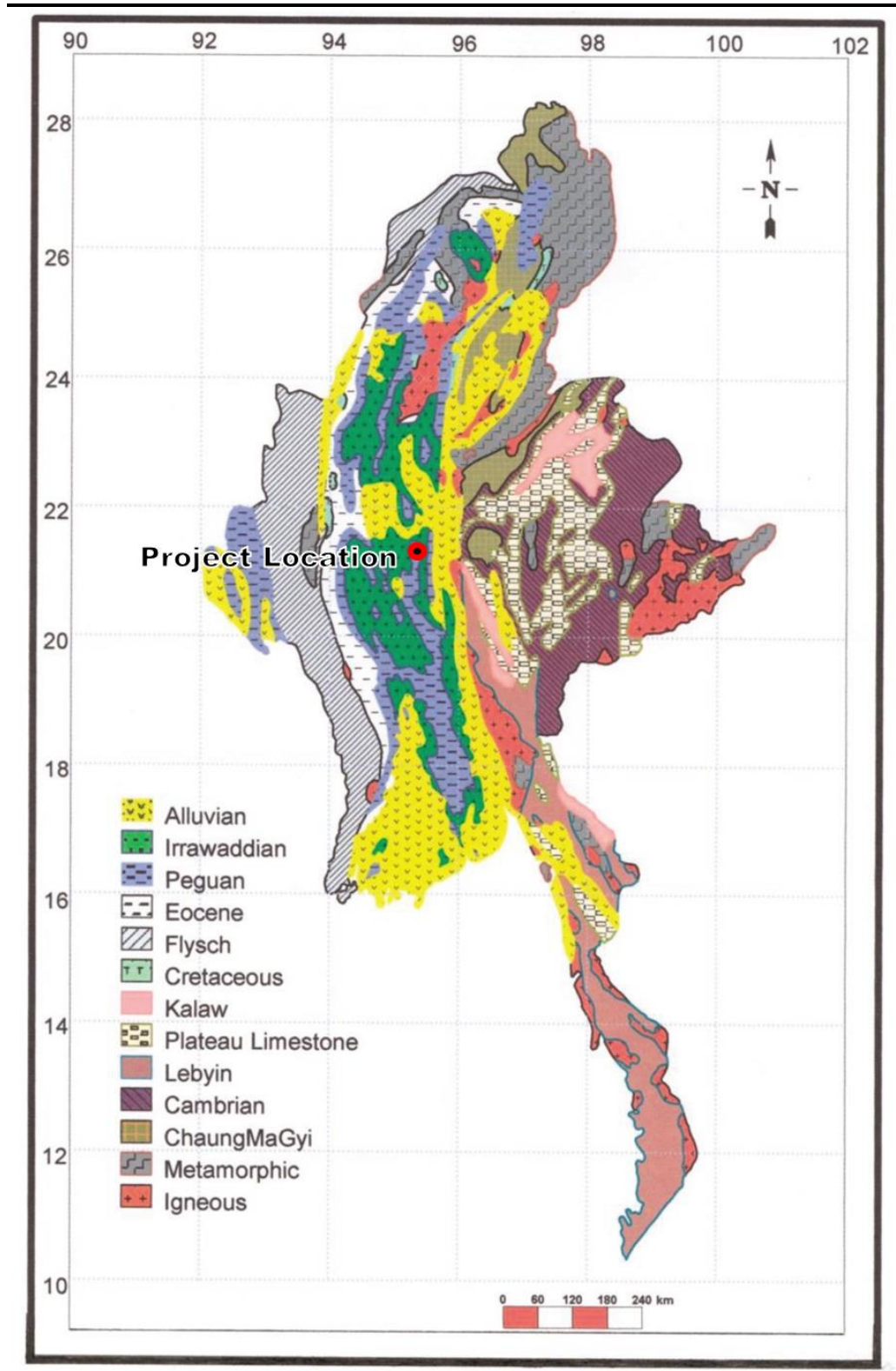
Groundwater in the Myingyan region is dependent upon natural recharge from Ayeyarwady River and the upper watershed<sup>(3)</sup>. Declining groundwater levels in the region have occurred due to associated environmental degradation of water sources, as well as uncontrolled excessive pumping of wells. Siltation, accumulation of waste, and encroachment on the channel areas contribute to reduced drainage capacity.

(1) <http://danishwater.dk/wp-content/uploads/2013/09/Ministry-of-Agriculture-and-Irrigation-Department-of-Water-Resources-Utilization-Sustainable-Development-and-Management-of-Groundwater-in-Myanmar.pdf>. Retrived on 28 January 2015

(2) <http://www.fao.org/docrep/008/ae546e/ae546e04.htm>

(3) JICA (2003) *Op cite*, pp:2-136

**Figure 5.14 Major Aquifers of Myanmar Relative to Project Study Area**



Source: Adapted from <http://danishwater.dk/wp-content/uploads/2013/09/Ministry-of-Agriculture-and-Irrigation-Department-of-Water-Resources-Utilization-Sustainable-Development-and-Management-of-Groundwater-in-Myanmar.pdf>. Retrieved on 28 January 2015

## 5.7.2

### Groundwater Use

Exploitation of Myanmar's aquifers has thus far been limited to municipal water supply and intensive irrigation of vegetables and other high value crops from hand-dug wells<sup>1</sup>. Water use in Myanmar has been increasing, particularly in the agricultural and industrial sectors. **Table 5.25** shows the water use in different sectors for the year 2008-09. As much as 89% of water use is tapped for irrigation purposes, while about 8% is for domestic consumption and 3 % is for industry.

Initially, the water supply for domestic purposes during construction shall be extracted from the underground tube wells and purified for domestic consumption. Once the water supply pipeline is in operation the raw water from the Ayeyarwady River will be treated to the required specification for domestic consumption.

**Table 5.25** Water Use by Different Sectors

Sector	Surface Water	Groundwater	Total
Domestic	1.15 (3%)	2.55 (68%)	3.7 (8%)
Industrial	1.17 (3%)	0.33 (9%)	1.5 (3%)
Irrigation	41.97 (94%)	0.85 (23%)	42.82 (89%)
<b>Total</b>	<b>44.29</b>	<b>3.73</b>	<b>48.02</b>

Source: Ministry of Agriculture and Irrigation<sup>2</sup>

## 5.7.3

### Groundwater Quality

There is very limited secondary data available regarding groundwater quality in Myanmar. However, studies in some regions of Myanmar, including the Ayeyarwady Region, have shown that there exists some arsenic contamination in the groundwater<sup>3</sup>. This is a potential indication that there could also be groundwater contamination within Mandalay Region.

While conducting site surveys during the preparation of the Scoping Report for the Project, it was noted that there were a large number of scrap cars and metal piled on site associated with the neighboring steel mill operations. This could potentially pose a risk of contamination to soil and groundwater at the site as well as nearby villages.

### 5.7.3.1

#### Groundwater Quality Baseline Surveys

##### Sampling Methodology and Locations

Groundwater quality was monitored at eight (8) locations in the Project area, from 16<sup>th</sup> to 20<sup>th</sup> June, 2015. The locations of the groundwater samples are shown in **Figure 5.15** and are described in **Table 5.26**.

(1) <http://www.fao.org/nr/water/espim/country/myanmar/print1.stm>

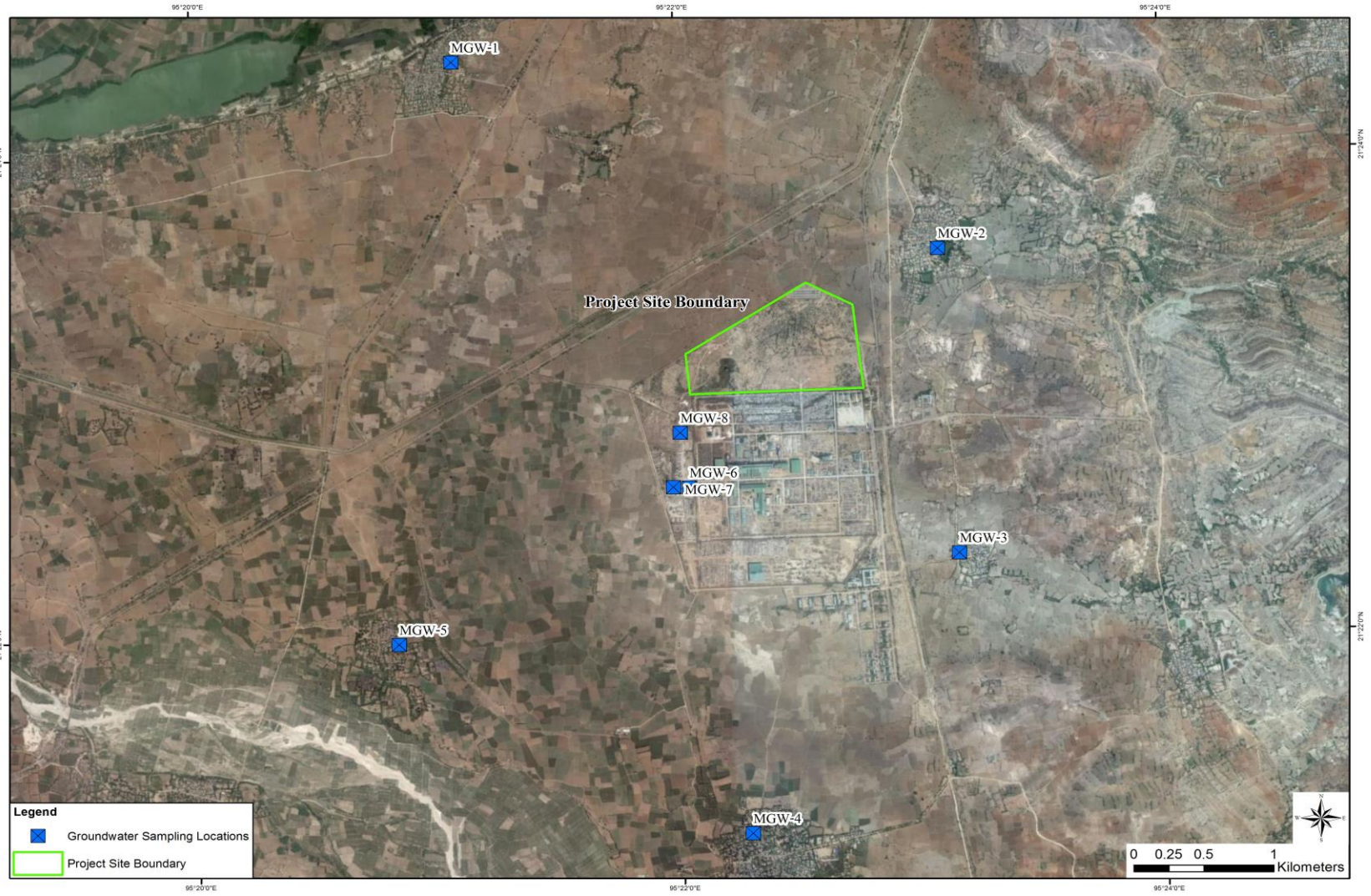
(2) <http://danishwater.dk/wp-content/uploads/2013/09/Ministry-of-Agriculture-and-Irrigation-Department-of-Water-Resources-Utilization-Sustainable-Development-and-Management-of-Groundwater-in-Myanmar.pdf>

(3) <http://wedc.lboro.ac.uk/resources/conference/29/Tun.pdf>

**Table 5.26 Description of Groundwater Sampling Locations**

Sampling Point	Coordinates	Description of Sampling Point
GW-1	21° 24' 23.29" N 95° 21' 5.07" E	Tube well in monastery compound of Gyoke Pin village, Myingyan township.
GW-2	21° 23' 35.49" N 95° 23' 5.00" E	Well in Shwegyaung monastery compound of Sakha village, Myingyan township.
GW-3	21° 22' 19.73" N 95° 23' 9.27" E	Tube well in Hnan Ywa village, Myingyan township.
GW-4	21° 21' 10.60" N 95° 22' 17.00" E	Tube well in Phat Taw village, Taungtha township.
GW-5	21° 21' 58.67" N 95° 20' 50.00" E	Well in Nyaung Kan village, Taungtha township
GW-6	21° 22' 36.81" N 95° 22' 2.55" E	Tube well in compound of Steel Mill.
GW-7	21° 22' 36.92" N 95° 21' 58.62" E	Tube well in compound of Steel Mill.
GW-8	21° 22' 50.41" N 95° 22' 0.50" E	Tube well in compound of Steel Mill.

Figure 5.15 Groundwater Sampling Locations



## Guidelines/Standards for Comparison

The Government of Myanmar has not yet established numerical standards for environmental parameters, although there are some pending guidelines. In the absence of national standards, the Ministry of Environmental Conservation and Forestry (MOECAF) typically recommends that internationally accepted numerical environmental standards, such as the World Bank Group (WBG) / International Finance Corporation (IFC) and World Health Organisation (WHO) guidelines, should be adopted for environmental assessments.

As part of the WBG guidelines, **Section 3.1 Water Quality and Availability** indicates that:

*“Where the project includes the delivery of water to the community or to users of facility infrastructure (such as hotel hosts and hospital patients), where water may be used for drinking, cooking, washing, and bathing, water quality should comply with national acceptability standards or in their absence the current edition of WHO Drinking Water Guidelines.”*

Therefore, WHO guidelines for drinking water quality have been considered applicable for the evaluation of baseline groundwater quality.

## Analysis Results and Discussion

The results of groundwater samples collected from the baseline surveys are shown in **Table 5.27**. The laboratory reports are provided in **Annex B**.

**Table 5.27 Groundwater Quality Analysis**

Item/Sample Name	WHO Standard	MGW-1	MGW-2	MGW-3	MGW-4	MGW-5	MGW-6	MGW-7	MGW-8
Date /Time	N/A	16/6/2015 16:35	16/6/2015 14:15	16/6/2015 15:20	16/6/2015 15:45	16/6/2015 17:10	20/6/2015 8:15	20/6/2015 8:25	20/6/2015 8:35
Weather	N/A	Slightly cloudy	sunny	sunny	sunny	cloudy	Slightly raining	Slightly raining	Cloudy
Transparency	N/A	high	high	high	high	high	high	high	high
Water level in depth (m)	N/A	57	7	150	35	30	40	38	41
Temperature_Water (°C)	N/A	28.98	26.57	29.26	27.57	28.16	28.57	27.81	28.55
Temperature_Atm (°C)	N/A	37	39	38	38	36	26	26	26
pH	NOC	7.57	7.20	7.78	7.81	7.48	7.43	7.35	8.07
EC (µs)	N/A	1860	923	1209	1516	1166	1983	1871	970

Item/Sample Name	WHO Standard	MGW-1	MGW-2	MGW-3	MGW-4	MGW-5	MGW-6	MGW-7	MGW-8
DO (mg/l)	N/A	3.00	3.1	3.4	3.18	2.25	2.89	2.65	2.46
Turbidity (FNU)	N/A	1.6	0.7	4.8	35.2	36.0	3.3	1.1	0.9
BOD5 (mg/l)	N/A	0.2	0.4	0.4	0.3	0.2	0.1	0.1	0.2
COD (mg/L)	N/A	11.1	<5.0	12.7	6.4	12.7	15.9	8.0	<5.0
TSS (mg/L)	50	<2.5	<2.5	<2.5	<2.5	10	<2.5	<2.5	<2.5
TDS (mg/L)	NOC	966	456	660	844	856	1,176	1,120	1,218
Total Hardness (mg/L as CaCO3)	NOC	395	243	203	390	454	253	295	185
Cyanide (mg/L)	0.07	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Fluoride (mg/L)	1.5	0.44	0.52	0.50	0.45	0.56	0.61	0.84	0.85
Sulfide (mg/L)	N/A	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Organics (mg/L)	N/A	<1.0	1.9	<1.0	<1.0	<1.0	1.2	1.2	1.1
Ammonia Nitrogen (Mg/L)	NOC	<0.10	<0.010	<0.010	0.024	<0.010	0.016	0.019	0.024
Sulfate (mg/L)	N/A	355	164	162	444	452	407	402	402
Nitrate (mg/L)	50	1.19	0.426	1.20	3.07	0.695	2.70	3.94	1.88
Hexavalent Chromium (mg/L)	N/A		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Calcium (mg/l)	N/A	72.04	47.27	28.52	80.17	78.75	26.68	33.79	17.24
Magnesium (mg/L)	N/A	59.34	21.05	39.28	45.36	57.51	36.75	42.61	28.19
Sodium (mg/L)	N/A	291.01	108.76	171.56	199.14	90.75	422.16	347.59	401.54
Potassium (mg/L)	N/A	3.98	19.37	1.59	4.12	3.02	3.08	2.65	2.44
Mercury (mg/L)	0.006	<0.003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Lead (mg/L)	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cadmium (mg/L)	0.003	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper (mg/L)	2	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Iron (mg/L)	N/A	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Tin (mg/L)	N/A	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

Item/Sample Name	WHO Standard	MGW-1	MGW-2	MGW-3	MGW-4	MGW-5	MGW-6	MGW-7	MGW-8
Manganese (mg/L)	NOC	<0.02	0.21	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Nitrogen (mg/L)	N/A	1.1	<1.0	<1.0	2.9	<1.0	2.3	4.4	1.5
Total Phosphorus (mg/L)	N/A	<0.005	0.028	<0.005	0.024	0.018	0.010	0.006	0.017
Zinc (mg/L)	N/A	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel (mg/L)	0.07	0.0063	0.0033	0.0032	0.0050	0.0039	0.0067	0.0073	0.0069
Arsenic (mg/L)	0.01	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0004	<0.0002	0.0007
Chloride (mg/L)	NOC	<1.0	<1.0	<1.0	1.4	44.6	<1.0	<1.0	<1.0
Total Coliform Bacteria MPN/100ml	400	17,000	4.0	130	<1.8	16,000	13	40	21
Oil & Grease (mg/L)	N/A	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Source: Lab Analysis Report STS Green, 2015

N/A – Not Applicable Standard Detailed in WHO Guidelines

NOC – Not of Concern according to WHO Standards

\* Source: Lab Analysis Report STS Green, 2015

The key parameters in groundwater are discussed below, compared with the WBG/IFC/WHO guidelines Standards for drinking water.

All results for pH were similar for every sampling location and fell within the permissible limits of 6 to 9.

For a range of commonly measured and reported parameters including (but not limited to) BOD, TSS, Total Hardness, metals, arsenic, cyanide and fluoride, all were noted to be within the appropriate WBG/IFC/WHO guidelines for drinking water. However, three key parameters exceeded the established guidelines, two of them substantially. These are Chemical Oxygen Demand (COD), Total Coliform and Sulfates.

**COD:** COD levels in 6 of the sampled wells exceed the establish standard of 4mg/L. In the case of MGW-6, the COD level was up to 15.9mg/L. A high COD result is generally indicative of the presence of an abundance or organic material and bacteria within the water samples.

**Coliform:** As with the high COD levels, and as also noted with regards to the surface water baseline discussed previously, extremely elevated of total coliforms were noted. In particular, MGW-1 and MGW-5 had levels of 17,000 and 16,000 MPN/100ml respectively, far exceeding the WBG/IFC/WHO guidance limit of 400PMN/100ml. As these levels are far higher than levels for all other monitored wells (between 1.8 and 130 MPN/100ml) this may indicate that these wells are contaminated by a source of coliforms at or very near the surface. As noted previously, sources of total coliform include sewage waste from humans and faecal matter from warm-blooded animals such as livestock, both of which can make their way into water courses.

**Sulfate:** Sulfate levels of over 400mg/L were recorded in five of the wells which are still within the appropriate WBG/IFC/WHO guideline of 500mg/L. Generally accepted safe sulfate levels are in the order of 250mg/L (US Environmental Protection Agency). Given that the area has a long history of agriculture, it is likely that these elevated sulfate levels are associated with use of sulfate containing compounds as fertilisers.

## 5.8

### LANDSCAPE AND VISUAL

In the Mandalay region, land is characterized as forestland and agricultural land, which is in line with typical Myanmar land use patterns. The division has 94 forest reserves spread across more than 2.4 million acres and 800,000 acres of preserved forests outside the reserved forests. The forests in the region are classified as Mountain forests, Tropical forests, Indaing forests and bush forests. In addition, Cactus-like plants are known to grow in arid areas of the Ayeyarwady River bank. The Mandalay region is characterized by frequent droughts and increasing land degradation due to loss of natural vegetation, soil erosion and decreasing soil fertility.

The Project Study Area described in **Section 5.1** is characterized by flat terrain, with gentle undulating slopes towards the inlands. The Project Study Area is also regarded

as predominately rural comprising of agricultural land and scattered village settlements.

The elevation of the Project site is between 65-76 m meters above Mean Sea Level (MSL). The Project site is predominately disused cultivated land used for informal grazing, supporting grassland, low shrubs and minimal tree cover, therefore the area is a highly modified habitat. The Project site also comprises the Aggreko 95 MW temporary gas-fired power plant which began operation in April 2015. The temporary gas-fired power plant will be decommissioned once the Power Plant is in operation. The existing steel mill, transmission lines and transmission towers are the most dominant features in the landscape. The construction activities associated with Phase 2 of the steel mill are also dominant features.

## 5.9

### **WASTE**

The construction and operation of the Project is expected to generate solid and liquid hazardous and non-hazardous wastes that require off-site disposal. During construction, the EPC contractor is responsible for appropriate handling and waste disposal. During operation, the Sponsor is responsible for appropriate handling and waste disposal.

The Mandalay City Development Committee is the responsible agency for waste management in the Mandalay region. Currently, there are existing problems in the Municipal Waste Management system due to a lack of equipment (e.g. vehicles) and personnel, improper collection and management of disposal sites, which are mostly run as semi-landfill systems, lack of awareness and cooperation from the public, and lack of awareness in solid waste management. There are currently no recycling facilities in Myanmar.

The feature of solid waste collection in Myanmar is essentially labour-intensive work and mainly relies on manual labor and non-specialized vehicles. Waste collection systems include block collection, communal depot collection, house-to-house collection, limited collection, and street sweeping. Currently, recycling of municipal waste is not fully and systematically developed as the budget allocation covers only routine works. Also, a framework for hazardous waste management has yet to be developed in Myanmar.

## 5.10

### **TERRESTRIAL AND MARINE BIODIVERSITY**

#### 5.10.1

##### *EcoRegion Description*

The Project Study Area resides within the dry zone of central Myanmar. According to the World Wide Fund for Nature (WWF) Wildfinder database, it is located in the Ecoregion known as the Irrawaddy Dry Forests, which have been under intensive conversion pressure to agriculture. In recent years the larger mammal fauna have been hunted to the brink of extinction. The conversion of forests to agricultural land and illegal cutting of timber causes loss and fragmentation of the habitat, while intense poaching of protected animals and the lack of political will to conserve this and other ecoregions in Myanmar leaves the remaining forests devoid of wildlife.

This ecoregion has a harsh climate and is extremely dry, with rarely more than

fifteen days of rain per year. The forests are dominated by dry forests where rainfall is less than 800 mm. The stands are low in stature, with thorny trees. These commonly include *Terminalia oliveri* and *Tectona homiltoniana*. There are also two types of dipterocarp forests: high Indaing and low Indaing, which is more common in the dry zone. Wildlife found in the protected areas include medium and small mammals, such as numerous species of deer and primates. Mid-sized predators such as the jungle cat, Asiatic jackal, and perhaps leopard also persist. Over 300 species of birds are known to live here, including two rare wetland birds: the black stork and the woolly-necked stock (WWF, 2015).

This ecoregion is surrounded by the Irrawaddy Moist Deciduous Forests, which have also been intensively cultivated and its forests converted. Consequently, most of the region's biodiversity has been extirpated, and very little information on its biodiversity is known due to political forces. Moist deciduous forests dominate this ecoregion, of which the dominant species of trees are teak and Pyinkado or ironwood. Species composition is varied and intimately mixed with bamboo groves.

Wildlife is intensively exploited outside protected areas of this ecoregion, and most information about the remaining wildlife comes from work within national parks. Asian elephants survive here, but their numbers have slowly decreased with their habitat. A few wild species that persist in its national parks include the guar, sambar, serow, golden cat, masked palm civet, marbled cat, and leopard cat. There are no endemic mammals, but almost 350 species of birds (WWF, 2015).

#### 5.10.2 *Key Biodiversity Areas*

In Myanmar, Key Biodiversity Areas (KBAs) fall in different land management categories including protected areas, public protected forests, community-conserved forests, community forests, reserve forests and other resource and land use areas. Therefore, they accommodate different management systems such as government, private, community-led and joint management. Within the last decade, KBAs were reviewed and updated in order to identify and prioritize investment opportunities for biodiversity conservation in Myanmar. A total of 132 KBAs were identified for Myanmar and prioritized based on Species-based Vulnerability and Site-based Vulnerability. A total of three KBAs were identified under Alliance for Zero Extinction (AZE), one as a Ramsar site, 53 important bird areas, and six ASEAN Heritage Parks.

The KBAs closest to the Project Site include the Ayeyarwady River (Bagan Section), Minsontaung Wildlife Sanctuary (W.S.), and Popa Mountain Park (Critical Ecosystem Partnership Fund, 2012). The Ayeyarwady River is the country's largest river and home to a large diversity of animals, including about 43 fish species. The Bagan Section of the river is recognized as a high priority KBA and is about 60km away from the Project Site. It is one of the only areas of river protected in this region of Myanmar. Minsontaung W.S. occupies an area of 23km<sup>2</sup> and is categorized as a medium priority KBA. The sanctuary protects the endangered Eld's Deer and the Burmese star tortoise, and is made up of mostly dry forest. It is located approximately 43 km from the Project Site. Popa Mountain Park is a medium priority national park, approximately 54km from the project site and 129km<sup>2</sup> in size. Home of Mount Popa, this area serves as a popular destination for tourists and Burmese

pilgrims and is home to barking deer, wild pigs, wild dogs, jungle cats and 140 species of birds.

### 5.10.3 Protected Areas

Myanmar currently has a total of 57 Protected Areas (PAs), which account for only 4% of the country's total surface area (Protected Planet, 2014-15). The few protected areas surrounding the Project Site are the same as those described as KBAs in the previous section. Popa National Park was designated as a PA in 1989, and Minsontaung W.S. in 2001. The Lawkananda W.S. is a PA approximately 0.5km<sup>2</sup> in size, located along the Bagan Section of the Ayeyarwady River. It helps to protect the Burmese star tortoise, a Critically Endangered species. All three of these PAs are classified as an IUCN category IV protected area, which are those aiming to protect particular species or habitats and management reflects this priority (IUCN, 2014).

### 5.10.4 Species of Conservation Significance

Species of conservation significance found within the EcoRegion is outlined in **Table 5.28**. This species are restricted to mammals, birds and reptiles. There is insufficient information on the conservation status for plant species in Myanmar.

**Table 5.28 Species of Conservation Significance found in the Project EcoRegion**

Common Name	Conservation Status	Common Name	Conservation Status
Asiatic Black Bear	VU	Asiatic Elephant	EN
Baer's Porchard	EN	Banteng	EN
Binturong	VU	Burmese Peacock Softshell	EN
Chinese Pangolin	EN	Clouded Leopard	VU
Dhole	EN	Fishing Cat	EN
Great Safety Woodpecker	VU	Greater Adjutant	EN
Hog Deer	EN	Indian Skimmer	VU
Jerdon's Babbler	VU	King Cobra	VU
Large-spotted Civet	VU	Lesser Adjutant	VU
Long-billed Vulture	CR	Malayan Pangolin	EN
Marbled Cat	VU	Pale-capped Pigeon	VU
Phayre's Leaf Monkey	EN	Pink-headed Duck	CR
Sambar	VU	Sarus Crane	VU
Smooth-coated Otter	VU	Sun Bear	VU
Tiger	EN	Vordermann's Flying Squirrel	VU
White-bellied Heron	CR	White-winged Duck	EN
Yellow-breasted Bunting	VU	<i>Geochelone platynota</i>	CR
<i>Macaca leonina</i>	VU	<i>Nycticebus bengalensis</i>	VU
<i>Trachypithecus shortridgei</i>	EN		

### 5.10.5

#### *Invasive Species*

Invasive species are any species that are –non-native to a particular ecosystem and whose introduction and spread causes, or are likely to cause, socio-cultural, economic or environmental harm or harm to human health (FAO, 2013). Invasive species are naturalized species that reproduce often in large numbers and are spread over a large area, damaging native species (FAO, 2005).

Invasive species have the capacity to exacerbate their role in ecosystem degradation through combination threats by habitat change, climate change over-exploitation of ecosystem resources and pollution, which further enhances their threat to biodiversity and the human condition (Emerton and Howard, 2008).

The taxa or types of organisms that can become invasive are animals (vertebrates and invertebrates), plants and micro-organisms (including those are free-living as well as those that cause disease in plants, animals, and people) (Emerton and Howard, 2008).

According to the Global Invasive Species Database (GISD) (2015), 97 species have been identified as invasive species in Myanmar. A checklist of invasive species is provided in **Annex C**. However, the database does not specifically mention on which part of Myanmar that the invasive species are being introduced.

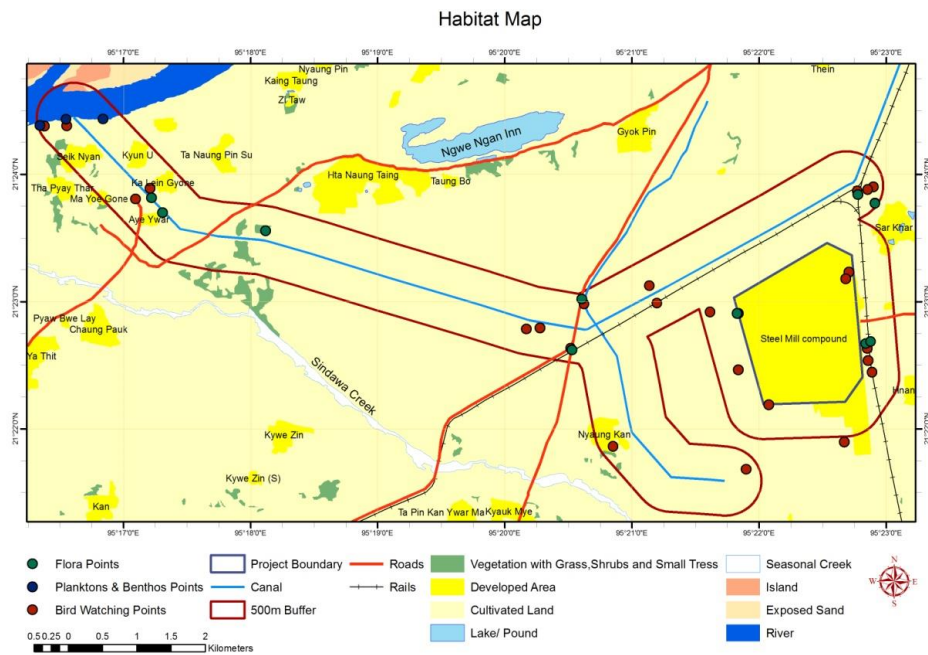
### 5.10.6

#### *Flora*

##### **Sampling Sites**

The habitat types identified within the Project Study Area are shown in **Figure 5.16**.

**Figure 5.16** *Sampling and Habitat Types within the Project Study Area*



**Methodology**

A Global Positioning System was used to navigate and mark coordinates between sample plots around the Project Study Area. In order to obtain essential ecological data for flora, habitat types were classified. Three habitat types were identified in the Project Study Area: area of vegetation with grass, shrubs and small trees; cultivated land; and developed area.

A total of 10 sample plots (3mx3m in size) were set up and observed during the study period. Care has been taken to cover overall spectrum of species diversity.

**Species Identification**

Flowering plant families were identified using a key issued by the Department of Botany, Yangon University (1994). Specimen identification was performed with the use of literatures by Backer et al., 1963, and Kress et al. 2003 and confirmed at the Herbarium in the Department of Botany, University of Yangon.

**Table 5.29** *Location of Sample Plots*

Plot	Latitude	Longitude	Elevation
1	N 21° 23' 46.3"	E 095° 22' 54.7"	99 M
2	N 21° 23' 50.4"	E 095° 22' 46.6"	90 M
3	N 21° 22' 40.2"	E 095° 22' 50.3"	97 M
4	N 21° 22' 41.2"	E 095° 22' 52.7"	95 M
5	N 21° 23' 48.8"	E 095° 17' 13.1"	69 M
6	N 21° 23' 41.8"	E 095° 17' 18.3"	71 M
7	N 21° 23' 48.4"	E 095° 20' 15.4"	82 M

Plot	Latitude	Longitude	Elevation
8	N 21° 22' 37.2"	E 095° 20' 31.6"	85 M
9	N 21° 23' 01.2"	E 095° 20' 36.3"	85 M
10	N 21° 22' 54.4"	E 095° 21' 49.6"	87 M

### 5.10.7

#### Data Analysis

#### Evaluation of Density and Relative Density

The density of a species is the numerical representation of its individual quantity within a unit area. The density of a species indicates the adequacy of its different requirements and the availability of space. Density is determined by:

$$\text{Density (D)} = \frac{\text{No. of individuals of the species in all the sample plots}}{\text{Total no. sample plots studied}}$$

$$\text{Relatively Density (R.D)} = \frac{\text{No. of individuals of the species}}{\text{Total no. individuals of all the species}}$$

#### Evaluation of Frequency and Relative Frequency

The frequency of a species is expressed as the percentage of occurrence of its individuals in a number of observations. The following calculations are used in order to obtain the frequency of different species growing in a community:

$$\text{Frequency (F)} = \frac{\text{No. of sample plots in which the species occurs}}{\text{Total no. of plots sampled}}$$

$$\text{Relative Frequency (F)} = \frac{\text{No. of occurrences of the species}}{\text{No. of occurrences of all the species}} \times 100$$

#### Calculation of Species Diversity

Shannon-Wiener Index (1963)

$$H = -\sum_{i=1}^s (P_i) (\log_2 P_i)$$

Simpson Index (1949)

$$D = 1 - \sum_{i=1}^s (P_i)^2$$

H = Shannon-Wiener's index of species diversity

S = number of species

P<sub>i</sub> = proportion of total sample belonging to the i<sup>th</sup> species

D = Simpson's index of species diversity

Evenness (Shannon-Wiener function, 1963)

$$E = \frac{H}{H_{\max}} \quad H_{\max} = \text{Log}_2 S$$

- E* = evenness (range 0-1)  
*H* = index of species diversity  
*H<sub>max</sub>* = species diversity under conditions of maximal equitability  
*S* = number of species

#### 5.10.8 Results

##### Important Value Index (IVI) of tree species in study area

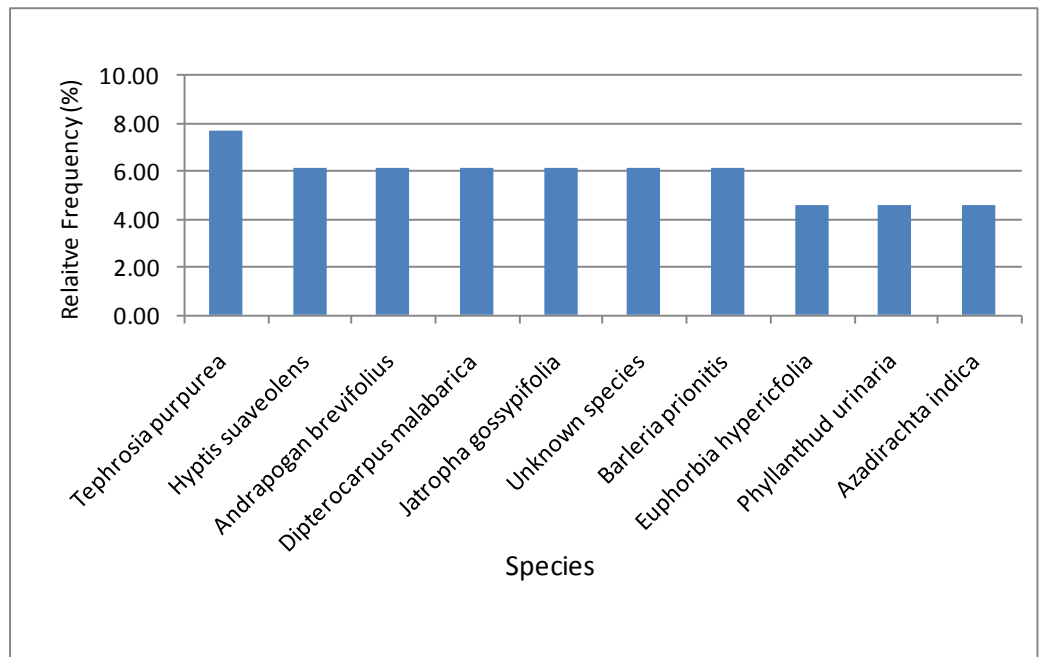
The total number of tree species with GBH >10cm was 28. Ranking of ecological significance by IVI of tree species in the study area are given in **Table 5.30**. The tree layer in the study area is dominated by *Tephrosia purpurea* (IVI= 30.42%), *Hyptis suaveolens* (IVI = 23.197%) and *Andrapogan brevifolius* (22.454%). There were twelve species greater than 10% and 10% IVI value **Figure 5.17**. Those species could be considered as ecological indicator species of the study area.

**Table 5.30** Relative Frequency, Relative Density and IVI Value of the Study Area

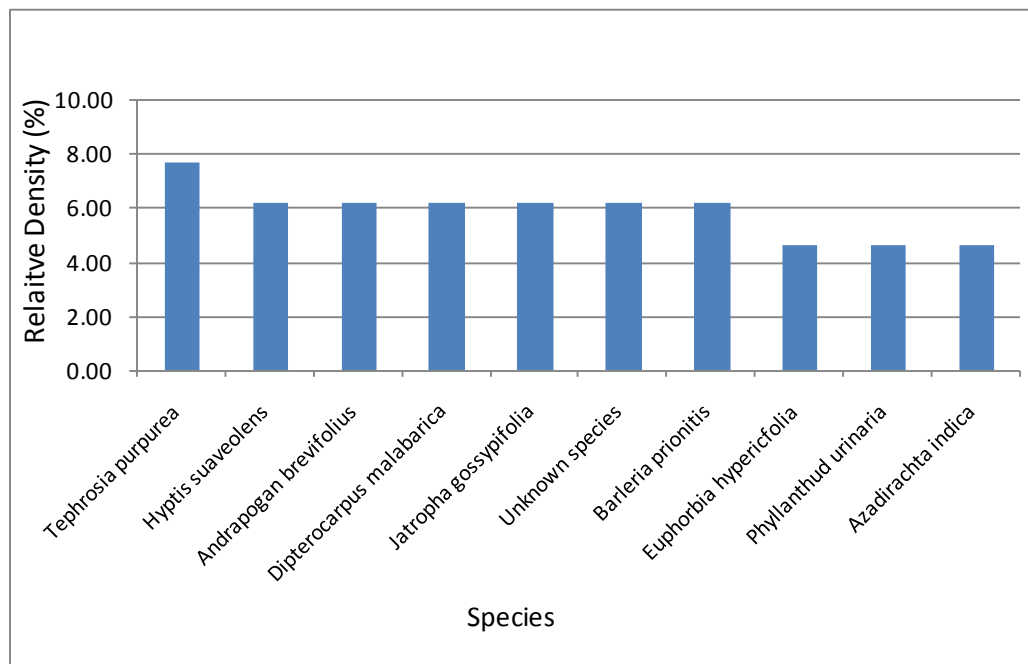
Sr. No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	I.V.I Value
1	<i>Tephrosia purpurea</i>	10.0372	7.6923	12.6904	30.4198
2	<i>Hyptis suaveolens</i> (L.)	8.9219	6.1538	8.1218	23.1976
3	<i>Andrapogan brevifolius</i> L.	8.1784	6.1538	8.1218	22.4541
4	<i>Dipterocarpus malabarica</i>	7.0632	6.1538	8.1218	21.3389
5	<i>Jatropha gossypifolia</i> L.	5.6506	6.1538	8.1218	19.9262
6	Unknown species A	5.1301	6.1538	8.1218	19.4058
7	<i>Barleria prionitis</i> L.	4.0892	6.1538	8.1218	18.3649
8	<i>Euphorbia hypericifolia</i> L.	5.2045	4.6154	4.5685	14.3884
9	<i>Phyllanthud urinaria</i> L.	4.8327	4.6154	4.5685	14.0166
10	<i>Azadirachta indica</i> A. Juss.	4.4610	4.6154	4.5685	13.6449
11	<i>Flueggea leucopyrus</i> Willd.	3.3457	4.6154	4.5685	12.5296
12	Unknown species B	3.3457	4.6154	4.5685	12.5296
13	<i>Cocculus villosus</i> DC.	4.8327	3.0769	2.0305	9.9401
14	<i>Panicum stagninum</i> Retz.	4.4610	3.0769	2.0305	9.5683
15	<i>Diectomis fastigiata</i> Sw.Kunth	3.3457	3.0769	2.0305	8.4531
16	<i>Centella asiatica</i> (L.) Urb.	2.6022	3.0769	2.0305	7.7096
17	<i>Angustiafolium</i> vahl.	2.6022	3.0769	2.0305	7.7096

Sr. No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	I.V.I Value
18	<i>Abutilon indicum</i> (L.) Sweet.	2.2305	1.5385	0.5076	4.2766
19	<i>Virgaatus stapf</i>	1.4870	1.5385	0.5076	3.5331
20	<i>Cardiospermum corindum</i> L	1.4870	1.5385	0.5076	3.5331
21	<i>Eleusine aegyptiaca</i> Desf.	1.4870	1.5385	0.5076	3.5331
22	Unknown species C	1.4870	1.5385	0.5076	3.5331
23	<i>Capparis xanthophylla</i>	0.7435	1.5385	0.5076	2.7896
24	<i>Albiza lebbek</i> (L.) Benth.	0.7435	1.5385	0.5076	2.7896
25	<i>Acacia Chundra</i>	0.7435	1.5385	0.5076	2.7896
26	Unknown species D	0.7435	1.5385	0.5076	2.7896
27	<i>Virgatus sp.</i>	0.3717	1.5385	0.5076	2.4178
28	<i>Emblica officinalis</i> Gaertn.	0.3717	1.5385	0.5076	2.4178
		100	100	100	300

**Figure 5.17 Top Ten Relative Frequencies of Plant Species**



**Figure 5.18 Top Ten Relative Densities of Plant Species**



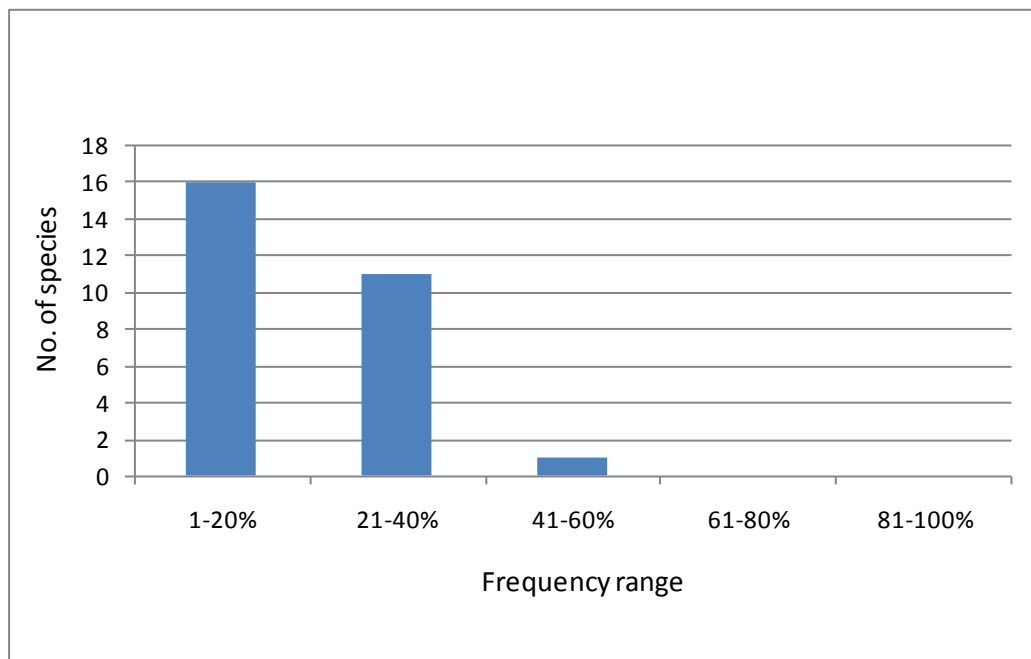
**Species distribution by frequency classes**

In order to clarify the homogeneity or heterogeneity of the floristic distribution in the area, species distribution by frequency classes was examined. According to the outcome of the frequency chart, 96% of the total number of species was in the lower frequency classes A and B, while 4% was observed only in the higher frequency class C (Table 5.31, Figure 5.19). No species was found in frequency classes D and E. This indicates that the plant species in the study area are floristically heterogeneous, according to Lamprecht (1989). The species that fall in the highest frequency class C can be considered the most common species in the area.

**Table 5.31 Species Distribution by Frequency Classes**

Frequency Class	Frequency range	No. of species	% of total species frequency distribution
A	1-20%	16	57
B	21-40%	11	39
C	41-60%	1	4
D	61-80%	0	0
E	81-100%	0	0

**Figure 5.19 Plant Species Distribution by Frequency Classes**



**Diversity indices and evenness**

The floristic diversity of the plant species was analyzed using the Shannon Wiener index (H), Simpsons index (D), and Shannon Wiener evenness (E) because these indices do not only take taxa richness into account but also depend on the relative distribution of individuals. The value of diversity indices and evenness indices were shown in **Table 5.32**. According to the result, the diversity indices of the study area were high.

**Table 5.32 Plant Species Diversity Index Values**

Item	Value
Total number of sample plot	10
Shannon-Wiener Diversity (H')	4.417
Simpson Diversity(1-D)	0.946
Camargo Evenness (E')	0.595
No. of equally common species	21
Margalef species richness	8.103

**Area of Vegetation with grass, shrubs, and small trees**

A total of 53 plant species were noted in the area of vegetation with grass, shrubs and small trees. No threatened species was recorded in the area. All plant species observed have been recorded in **Table 5.33** in order of abundance.

**Table 5.33 Plant Species Recorded in the Area of Vegetation with Grass, Shrubs, and Small Trees**

Sr. No.	Scientific Name	Family Name	Local Name	Habitat	IUCN Status
1	<i>Acacia carechu</i>	Mimosaceae	Shar	T	NE
2	<i>Azadirachta indica</i>	Meliaceae	Tama	T	NE
3	<i>Delonix regia</i>	Caesalpiniceae	Sein-pan	T	NE
4	<i>Lebbek Benth</i>	Mimosaceae	Kokko	T	NE
5	<i>Ardisia colorata</i>	Myrsinaceae	Kyet-ma-kouk	T	NE
6	<i>Tamarindus indica</i>	Caesalpiniceae	Magyi	T	NE
7	<i>Ficus religiosa</i>	Moraceae	Nyaung	T	NE
8	<i>Zizyphus jujuba</i>	Rhamnaceae	Zee	T	NE
9	<i>Acacia leucophloea</i>	Mimosaceae	Hta-naung	T	NE
10	<i>Crossipes Solms</i>	Pontederiaceae	Banda	T	NE
11	<i>Bombax ceiba</i>	Bombacaceae	Let-pan	T	NE
12	<i>Cassia mimosoides</i>	Caesalpiniceae	Mae-zeli	T	NE
13	<i>Tectona grandis L.f.</i>	Verbenaceae	Kyun	T	NE
14	<i>Cocos nucifera Linn</i>	Palmae	Ohn	T	NE
15	<i>Emblica officinalis</i>	Euphorbiaceae	Zibyu	T	NE
16	<i>Leucaena glauca</i>	Mimosaceae	Bawsakaing	ST	NE
17	<i>Terminalia pyrifolia</i>	Combretaceae	Lae	T	NE
18	<i>Albiza lebbek</i>	Mimosaceae	Anyar-kokko	T	NE
19	<i>Oroxylum indicum</i>	Bignoniaceae	Kyaung-shar	T	NE
20	<i>Mangifera indica</i>	Anacardiaceae	Thayat	T	DD
21	<i>Holoptelea integrifolia</i>	Solanaceae	Phyouk-seik	T	NE
22	<i>Acacia Chundra</i>	Mimosaceae	Gandaya	ST	NE
23	<i>Boscia variabilis</i>	Capparaceae	Thamone	ST	NE
24	<i>Leucaena leucocephala</i>	Mimosaceae	Awayar	ST	NE
25	<i>Morinda angustifolia</i>	Rubiaceae	Yae-yo	ST	NE
26	<i>Abutilon sp.A</i>	Malvaceae	Bauk-sein-gyi	H	NE
27	<i>Jatropha gossypifolia</i>	Euphorbiaceae	Kana-kho	H	NE
28	<i>Xylocarpus sp.</i>	Malvaceae	Kyat-Noe	H	NE
29	<i>Phyllanthus urinaria</i>	Euphorbiaceae	Myay-zeephyu	H	NE
30	<i>Solanum virginianum</i>	Solanaceae	Myay-poke-kayan	H	NE
31	<i>Abutilon indicum</i>	Malvaceae	Bauk-khwe	H	NE
32	<i>Abutilon sp.B</i>	Malvaceae	Bauk-sein-kalay	H	NE
33	<i>Barleria prionitis</i>	Acanthaceae	Leik-su-shwe	H	NE
34	<i>Hyptis suaveolens</i>	Lamiaceae	Nan-saw	H	NE
35	<i>Euphorbia hypericifolia</i>	Euphorbiaceae	Hmin-sae	H	NE
36	<i>Flueggea leucopyrus</i>	Euphorbiaceae	Kone-chinya	S	NE
37	<i>Atalantia monophylla</i>	Rutaceae	Taw-shouk	S	NE
38	<i>Abutilum asiaticum</i>	Malvaceae	Baug-mae	S	NE

Sr. No.	Scientific Name	Family Name	Local Name	Habitat	IUCN Status
39	<i>Centella asiatica</i>	Apiaceae	Myin-kwar	S	NE
40	<i>Angustiafolium</i>	Oleaceae	Taw-sabal	S	NE
41	<i>Tephrosia purpurea</i>	Fabaceae	Tapin-shwehti	S	NE
42	<i>Dipterocarpus malabarica</i>	Graminae	Myat-cho	G	NE
43	<i>Andropogon brevifolius</i>	Poaceae	Zein-Myat	G	NE
44	<i>Virgaatus</i> sp.	Gremineae	Myat-nan	G	NE
45	<i>Eleusine aegyptiaca</i>	Graminae	Myat-laykwa	G	NE
46	<i>Diectomis fastigiata</i>	Graminae	Myauk-myar	G	NE
47	<i>Panicum stagninum</i>	Graminae	Myat-thi	G	NE
48	<i>Cynodon dactylon</i>	Graminae	Myaysar-Myat	G	NE
49	<i>Eragrotis pilosa</i>	Graminae	Myat-sat	G	NE
50	<i>Cardiospermum corindum</i>	Sapindaceae	Kalar-myatsi	CI	NE
51	<i>Capparis xanthophylla</i>	Capparaceae	Madi-thanlyat	CI	NE
52	<i>Cocculus villosus</i>	Menispermaceae	Kywet-nabaung	CI	NE
53	<i>Mimosa pudica</i>	Mimosaceae	Hti-ka-yone	CI	NE

CI - Cultivated Land  
T - Trees  
ST - Small Trees  
H - Heath  
S - Shrubs  
G - Grassland  
NE - Not Evaluated  
DD - Data Deficient (IUCN)

### **Developed area**

Plant species in the developed area were dominated by *Areca catechu* L., *Azadirachta indica* and *Mangifera indica*. A total of 54 species under 29 families were listed in the developed area (**Table 5.34**).

**Table 5.34 Plant Species Recorded in the Developed Areas**

Sr. No.	Scientific Name	Family Name	Local Name	Habit	IUCN Status
1	<i>Acacia catechu</i>	Mimosaceae	Shar	T	NE
2	<i>Azadirachta indica</i>	Meliaceae	Tama	T	NE
3	<i>Delonix regia</i>	Caesalpiniceae	Sein-pan	T	NE
4	<i>Lebbek Benth</i>	Mimosaceae	Kokko	T	NE
5	<i>Tamarindus indica</i>	Caesalpiniceae	Magyi	T	NE
6	<i>Ficus religiosa</i>	Moraceae	Nyaung	T	NE
7	<i>Eucalyptus camaldulensis</i>	Myrtaceae	U-ka-lit	T	NE
8	<i>Zizyphus jujuba</i>	Rhamnaceae	Zee	T	NE
9	<i>Acacia leucophloea</i>	Mimosaceae	Hta-naung	T	NE
10	<i>Crossipes Solms</i>	Pontederiaceae	Banda	T	NE
11	<i>Bombax ceiba</i>	Bombacaceae	Let-pan	T	NE

Sr. No.	Scientific Name	Family Name	Local Name	Habit	IUCN Status
12	<i>Cassia mimosoides</i>	Caesalpiniceae	Mae-zeli	T	NE
13	<i>Tectona grandis L.f.</i>	Verbenaceae	Kyun	T	NE
14	<i>Polyalthia longifolia</i>	Annonaceae	Thinbaw-tae	T	NE
15	<i>Cocos nucifera Linn</i>	Palmae	Ohn	T	NE
16	<i>Borassus flabellifer</i>	Palmae	Htan	T	NE
17	<i>Acacia auriculiformis</i>	Fabaceae	Malasia-patauk	T	NE
18	<i>Emblica officinalis</i>	Euphorbiaceae	Zibyu	T	NE
19	<i>Leucaena glauca</i>	Mimosaceae	Bawsakaing	ST	NE
20	<i>Terminalia pyrifolia</i>	Combretaceae	Lae	T	NE
21	<i>Albiza lebbek</i>	Mimosaceae	Anyar-kokko	T	NE
22	<i>Oroxylum indicum</i>	Bignoniaceae	Kyaung-shar	T	NE
23	<i>Mangifera indica</i>	Anacardiaceae	Thayat	T	DD
24	<i>Acacia Chundra</i>	Mimosaceae	Gandaya	ST	NE
25	<i>Boscia variabilis</i>	Capparaceae	Thamone	ST	NE
26	<i>Leucaena leucocephala</i>	Mimosaceae	Awayar	ST	NE
27	<i>Morinda angustifolia</i>	Rubiaceae	Yae-yo	ST	NE
28	<i>Abutilon sp.A</i>	Malvaceae	Bauk-sein-gyi	H	NE
29	<i>Jatropha gossypifolia</i>	Euphorbiaceae	Kana-kho	H	NE
30	<i>Phyllanthud urinaria</i>	Euphorbiaceae	Myay-zeephyu	H	NE
31	<i>Solanum virginanum</i>	Solanaceae	Myay-poke-kayan	H	NE
32	<i>Abutilon indicum</i>	Malvaceae	Bauk-khwe	H	NE
33	<i>Abutilon sp.B</i>	Malvaceae	Bauk-sein-kalay	H	NE
34	<i>Barleria prionitis</i>	Acanthaceae	Leik-su-shwe	H	NE
35	<i>Hyptis suaveolens</i>	Lamiaceae	Nan-saw	H	NE
36	<i>Euphorbia hypericifolia</i>	Euphorbiaceae	Hmin-sae	H	NE
37	<i>Flueggea leucopyrus</i>	Euphorbiaceae	Kone-chinya	S	NE
38	<i>Atalantia monophylla</i>	Rutaceae	Taw-shouk	S	NE
39	<i>Neriifolia L.</i>	Euphorbiaceae	Tazaung-minthar	S	NE
40	<i>Euphorbia antiquarum</i>	Euphorbiaceae	Tazaung-pyathat	S	NE
41	<i>Centella asiatica</i>	Apiaceae	Myin-kwar	S	NE
42	<i>Angustiafolium</i>	Oleaceae	Taw-sabal	S	NE
43	<i>Tephrosia purpurea</i>	Fabaceae	Tapin-shwehti	S	NE
44	<i>Dipterocarpus malabarica</i>	Graminae	Myat-cho	G	NE
45	<i>Andropogon brevifolius</i>	Poaceae	Zein-Myat	G	NE
46	<i>Virgaatus sp.</i>	Gremineae	Myat-nan	G	NE
47	<i>Eleusine aegyptiaca</i>	Graminae	Myat-laykwa	G	NE
48	<i>Diectomis fastigiata</i>	Graminae	Myauk-myar	G	NE
49	<i>Panicum stagninum</i>	Graminae	Myat-thi	G	NE
50	<i>Cynodon dactylon</i>	Graminae	Myaysar-Myat	G	NE
51	<i>Eragrotis pilosa</i>	Graminae	Myat-sat	G	NE

Sr. No.	Scientific Name	Family Name	Local Name	Habit	IUCN Status
52	<i>Cardiospermum corindum</i>	Sapindaceae	Kalar-myatsi	CI	NE
53	<i>Cocculus villosus</i>	Menispermaceae	Kywet-nabaung	CI	NE
54	<i>Mimosa pudica</i>	Mimosaceae	Hti-ka-yone	CI	NE

CI - Cultivated Land  
T - Trees  
ST - Small Trees  
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G - Grassland  
NE - Not Evaluated (IUCN)  
DD - Data Deficient (IUCN)

### Cultivated land

Agricultural land is cultivated land in the Project Study Area where some crops such as beans and *Oryza sativa L.* were observed. No big or small trees were normally found in this area. A total of 21 species under 29 families were listed in the agricultural land (**Table 5.35**).

**Table 5.35 Plant Species Recorded in the Cultivated Land**

Sr. No.	Scientific Name	Family Name	Local Name	Habit	IUCN Status
1	<i>Eucalyptus camaldulensis</i>	Myrtaceae	U-ka-lit	T	NE
2	<i>Tectona grandis L.f.</i>	Verbenaceae	Kyun	T	NE
3	<i>Borassus flabellifer</i>	Palmae	Htan	T	NE
4	<i>Mangifera indica</i>	Anacardiaceae	Thayat	T	DD
5	<i>Abutilon sp.A</i>	Malvaceae	Bauk-sein-gyi	H	NE
6	<i>Solanum virginanum</i>	Solanaceae	Myay-poke-kayan	H	NE
7	<i>Hyptis suaveolens</i>	Lamiaceae	Nan-saw	H	NE
8	<i>Centella asiatica</i>	Apiaceae	Myin-kwar	S	NE
9	<i>Tephrosia purpurea</i>	Fabaceae	Tapin-shwehti	S	NE
10	<i>Dipterocarpus malabarica</i>	Graminae	Myat-cho	G	NE
11	<i>Andropogon brevifolius</i>	Poaceae	Zein-Myat	G	NE
12	<i>Virgaatus sp.</i>	Gremineae	Myat-nan	G	NE
13	<i>Eleusine aegyptiaca</i>	Graminae	Myat-laykwa	G	NE
14	<i>Diectomis fastigiata</i>	Graminae	Myauk-myar	G	NE
15	<i>Panicum stagninum</i>	Graminae	Myat-thi	G	NE
16	<i>Cynodon dactylon</i>	Graminae	Myaysar-Myat	G	NE
17	<i>Eragrotis pilosa</i>	Graminae	Myat-sat	G	NE
18	<i>Zea mays</i>	Poaceae	Pyaung	G	NE
19	<i>Oryza sativa</i>	Poaceae	Rice	G	NE
20	<i>Piper betle</i>	Piperaceae	Kon	CI	NE
21	<i>Mimosa pudica</i>	Mimosaceae	Hti-ka-yone	CI	NE

CI - Cultivated Land

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- H - Heath
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- G - Grassland
- NE - Not Evaluated
- DD - Data Deficient (IUCN)

### Discussion

The plant species recorded varied among the habitat types, as did the dominant plant species. A total of 62 plant species under 30 families were listed in the study area (**Table 5.36**).

The tree layer in the study area is dominated by *Tephrosia purpurea*, *Hyptis suaveolens* and *Andropogon brevifolius*. These species could be considered as ecological indicator species of the study area.

**Table 5.36 Plant Species Composition in the Proposed Area**

Sr. No	Scientific Name	Family Name	Local Name	Habitat	IUCN Status
1	<i>Acacia carechu Willd.</i>	Mimosaceae	Shar	T	NE
2	<i>Azadirachta indica A. Juss.</i>	Meliaceae	Tama	T	NE
3	<i>Delonix regia</i> (Bojer ex Hook.)Raf.	Caesalpiniceae	Sein-pan	T	NE
4	<i>Lebbek Benth</i>	Mimosaceae	Kokko	T	NE
5	<i>Ardisia colorata Roxb.</i>	Myrsinaceae	Kyet-ma-kouk	T	NE
6	<i>Tamarindus indica L.</i>	Caesalpiniceae	Magyi	T	NE
7	<i>Ficus religosa Linn.</i>	Moraceae	Nyaung	T	NE
8	<i>Eucalyptus camaldulensis</i> Dehnh.	Myrtaceae	U-ka-lit	T	NE
9	<i>Zizyphus jujuba lamk</i>	Rhamnaceae	Zee	T	NE
10	<i>Acacia leucophloea</i> (Roxb)Willd	Mimosaceae	Hta-naung	T	NE
11	<i>Crossipes Solms</i>	Pontederiaceae	Banda	T	NE
12	<i>Bombax ceiba L.</i>	Bombacaceae	Let-pan	T	NE
13	<i>Cassia mimosoides L.</i>	Caesalpiniceae	Mae-zeli	T	NE
14	<i>Tectona grandis L.f.</i>	Verbenaceae	Kyun	T	NE
15	<i>Polyalthia longifolia</i> (Lam.) Benth. & Hook. F.	Annonaceae	Thinbaw-tae	T	NE
16	<i>Cocos nucifera Linn</i>	Palmae	Ohn	T	NE
17	<i>Borassus flabellifer Linn</i>	Palmae	Htan	T	NE
18	<i>Acacia auriculiformis</i> Cunn. Ex Benth.	Fabaceae	Malasia-patauk	T	NE
19	<i>Emblica officinalis</i> Gaertn.	Euphorbiaceae	Zibyu	T	NE
20	<i>Leucaena glauca</i> Benth.	Mimosaceae	Bawsakaing	ST	NE
21	<i>Terminalia pyrifolia Kz.</i>	Combretaceae	Lae	T	NE
22	<i>Albiza lebbek</i> (L.) Benth.	Mimosaceae	Anyar-kokko	T	NE
23	<i>Oroxylum indicum</i> (L.) Kurz	Bignoniaceae	Kyaung-shar	T	NE

Sr. No	Scientific Name	Family Name	Local Name	Habitat	IUCN Status
24	<i>Mangifera indica</i> L.	Anacardiaceae	Thayat	T	DD
25	Unknownn species A		Phyouk-seik	T	NE
26	<i>Acacia Chundra</i>	Mimosaceae	Gandaya	ST	NE
27	<i>Boscia variabilis</i> Cillett & Hemsl.	Capparaceae	Thamone	ST	NE
28	<i>Leucaena leucocephala</i> (Lam.) De Wit	Mimosaceae	Awayar	ST	NE
29	<i>Morinda angustifolia</i> Roxb.	Rubiaceae	Yae-yo	ST	NE
30	<i>Abutilon</i> sp. A	Malvaceae	Bauk-sein-gyi	H	NE
31	<i>Jatropha gossypifolia</i> L.	Euphorbiaceae	Kana-kho	H	NE
32	Unknownn species A		Kyat-Noe	H	NE
33	<i>Phyllanthud urinaria</i> L.	Euphorbiaceae	Myay-zeephyu	H	NE
34	<i>Solanum virginanum</i> L.	Solanaceae	Myay-poke-kayan	H	NE
35	<i>Abutilon indicum</i> (L.) Sweet.	Malvaceae	Bauk-khwe	H	NE
36	<i>Abutilon siamensis</i>	Malvaceae	Bauk-sein-kalay	H	NE
37	<i>Barleria prionitis</i> L.	Acanthaceae	Leik-su-shwe	H	NE
38	<i>Hyptis suaveolens</i> (L.) Poit	Lamiaceae	Nan-saw	H	NE
39	<i>Euphorbia hypericifolia</i> L.	Euphorbiaceae	Hmin-sae	H	NE
40	<i>Flueggea leucopyrus</i> Willd.	Euphorbiaceae	Kone-chinya	S	NE
41	<i>Atalantia monophylla</i> A. DC.	Rutaceae	Taw-shouk	S	NE
42	<i>Nerifolia</i> L.	Euphorbiaceae	Tazaung-minthar	S	NE
43	<i>Euphorbia antiquarum</i> L.	Euphorbiaceae	Tazaung-pyathat	S	NE
44	<i>Abutilon</i> sp. B	Malvaceae	Baung-mae	S	NE
45	<i>Centella asiatica</i> (L.) Urb.	Apiaceae	Myin-kwar	S	NE
46	<i>Angustiafolium</i> vahl.	Oleaceae	Taw-sabal	S	NE
47	<i>Tephrosia purpurea</i> pers.	Fabaceae	Tapin-shwehti	S	NE
48	<i>D.Indica Spreng D.malabarica</i> L. Merr.	Graminae	Myat-cho	G	NE
49	<i>Andrapogan brevifolius</i> L.	Poaceae	Zein-Myat	G	NE
50	<i>Virgaatus</i> sp.	Gremineae	Myat-nan	G	NE
51	<i>Eleusine aegyptiaca</i> Desf.	Graminae	Myat-laykwa	G	NE
52	<i>Diectomis fastigiata</i> Sw.Kunth	Graminae	Myauk-myar	G	NE
53	<i>Panicum stagninum</i> Retz.	Graminae	Myat-thi	G	NE
54	<i>Cynodon dactylon</i> (L.)	Graminae	Myaysar-Myat	G	NE
55	<i>Eragrotis pilosa</i>	Graminae	Myat-sat	G	NE
56	<i>Zea mays</i> L.	Poaceae	Pyaung	G	NE
57	<i>Oryza sativa</i> L	Poaceae	Rice	G	NE
58	<i>Cardiospermum corindum</i> L	Sapindaceae	Kalar-myatsi	CI	NE
59	<i>Capparis xanthophylla</i> Collett&Hemsl.	Capparaceae	Madi-thanlyat	CI	NE
60	<i>Cocculus villosus</i> DC.	Menispermaceae	Kywet-nabaung	CI	NE

Sr. No	Scientific Name	Family Name	Local Name	Habitat	IUCN Status
61	<i>Piper betle</i> L.	Piperaceae	Kon	CI	NE
62	<i>Mimosa pudica</i> L.	Mimosaceae	Hti-ka-yone	CI	LC

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G - Grassland  
NE - Not Evaluated  
DD - Data Deficient (IUCN)  
LS - Least Concern (IUCN)

#### 5.10.9 *Habitats*

Three habitat types were identified in the Project Study Area: cultivated land; developed area; and the area of vegetation with grass, shrubs and small trees. All are considered as modified habitat as defined by IFC PS6.

##### **Vegetation with grass, shrubs and small tree**

The area was found in small patches of the study area. The recorded plant species showed that tree species occurred in relatively large numbers. The vegetation patches were observed among the cultivated lands.

##### **Developed area**

The plant species in the developed area was dominated by *Areca catechu* L. and *Azadirachta indica* and *Mangifera indica*. Most of the recorded plant species were grown by local villagers.

##### **Agricultural land**

Agricultural land is cultivated land in the Project Study Area where the dominant land cover is paddy fields. Some cropland patches growing mustard, chili and beans also exist. No big or small trees were normally found in this area.

Threatened communities include water bodies, soil and biodiversity that support the ecosystem services and function. Solid and liquid waste may have an effect on the community. Biodiversity may be affected during construction and operation phases due to the disturbance and clearance of land. Ecosystem services of the River and remnant vegetation patches are still maintained in nature although there are disturbances.

#### 5.10.10 *Fauna*

##### **Bird survey**

A Random Point count method was used to survey and photograph birds in the area shown in **Figure 5.16**. Birds were observed with binoculars and identified with aid of a field guide. Nocturnal birds were observed at dusk. Point count and opportunistic

methods were used to census the species richness, and point and transect counting used to get the relative measure of bird abundance.

### **Mammal survey**

Distribution and presence of mammals were examined by conducting track and sign surveys. Sighting of prey species, tracks, scats, droppings were undertaken as data gathering in the field. A Questionnaire Survey was conducted and the results of each individual informant were treated as a distinct sample.

### **Reptile and Amphibian survey**

The study of reptilian and amphibian species was based on active search and trapping methods. Stratification of the habitat was relatively similar to that of the mammal study. Reptilian and amphibian species were actively searched during the survey period. The collected specimens were preserved in 10% formalin for further identification in the laboratory.

### **Butterfly survey**

Butterflies were collected using hand-nets along the transect lines set up at various areas in the proposed project site. The specimens were photographed and kept in paper envelopes for further identification in the laboratory.

### **Fish survey**

Fish were collected with the help of fishermen as shown at the sampling location shown in **Figure 5.16** above. Some fish samples, which could not be identified in the field, were preserved in a plastic bottle or a jar containing 10% formalin solution. The bottle was labelled with information such as date of sampling, station code, and name of collector and time of collection. The samples were sent to a laboratory for species identification. In the laboratory, fish sampled from each station were identified using a magnifier, dissection microscope and classification guidance books. Their productivity in the river was recorded.

### **Plankton sampling**

Plankton sampled from those stations was conducted using a plankton net of 50 µm mesh size. Approximately 5 x 1 L containers of river surface water were collected and passed through the 50 µm mesh size plankton net at each point. Samples were preserved in a plastic bottle containing 5% formalin solution. Information such as the code of sampling station and date were marked on the bottle. The specimens were sent to a laboratory for species identification and density assessment.

### **Benthic sampling**

Benthic fauna at each station was sampled using a local dredge and sieving method. The samples were sifted through a 1 mm-mesh sieve. Each specimen was preserved in a separate bottle containing 7% formalin solution. Necessary information was labelled on the bottle. They were then delivered to a laboratory for species identification and density assessment.

## Birds

A total of 46 bird species were recorded during the survey period. The species *Metopidius indicus*, *Acridotheres tristis*, *Columba livia*, *Hirundo rustica* were the most common in the area (**Table 5.37**). Population sizes of birds were higher in cultivated land and developed areas. No threatened species was found in the Project Study Area. Shannon species diversity index value was 4.499 and Evenness index value was 0.370 (**Table 5.38**).

**Table 5.37 Bird Species Recorded during the Survey Period**

Sr. No.	Scientific Name	Common Name(s)	Family	IUCN Status
1	<i>Corurnix coturnix</i>	Common Quail	PHASIANIDAE	NE
2	<i>Buteo buteo</i>	Common Buzzard	ACCIPITRIDAE	LC
3	<i>Milvus migrans</i>	Black kite	ACCIPITRIDAE	LC
4	<i>Threskiornis melanocephalus</i>	Black-headed Ibis	THRESKIORNITHIDAE	NT
5	<i>Plegadis falcinellus</i>	Glossy Ibis	THRESKIORNITHIDAE	LC
6	<i>Egretta gazetta</i>	Eastern Cattle Egret	ARDEIDAE	NE
7	<i>Ardea alba</i>	Little Egret	ARDEIDAE	LC
8	<i>Ardeola bacchus</i>	Chinese pond-heron	ARDEIDAE	NE
9	<i>Ardeola grayii</i>	Indian pond-heron	ARDEIDAE	LC
10	<i>Phalacrocorax niger</i>	Little Cormorant	PHALACROCORACIDAE	LC
11	<i>Amaurionis phoenicurus</i>	White-breasted Waterhen	RALLIDAE	NE
12	<i>Streptopelia orientalis</i>	Oriental Turtle Dove	COLUMBIDAE	LC
13	<i>Metopidius indicus</i>	Spotted Dove	COLUMBIDAE	LC
14	<i>Streptopelia tranquebarica</i>	Red-Collared Dove	COLUMBIDAE	LC
15	<i>Columba livia</i>	Rock Pigeon	COLUMBIDAE	LC
16	<i>Hirundo rustica</i>	Barn swallow	HIRUNDINIDAE	LC
17	<i>Vanellus indicus</i>	Red-wattled Lapwing	CHARADRIIDAE	LC
18	<i>Lanius cristatus</i>	Brown Shrike	LANIIDAE	LC
19	<i>Lanius collurioides</i>	Burmese Shrike	LANIIDAE	LC
20	<i>Halcyon smyrnensis</i>	White-throated Kingfisher	HALCYONIDAE	LC
21	<i>Coracias benghalensis</i>	Indian roller	CORACIIDAE	LC
22	<i>Oxylophus jacobinus</i>	Pied Cuckoo	CUCULIDAE	LC
23	<i>Merops orientalis</i>	Little green bee-eater	MEROPIDAE	LC
24	<i>Merops philippinus</i>	Blue-tailed Bee-eater	MEROPIDAE	LC
25	<i>Centropus sinensis</i>	Greater Coucal	CENTROPADIDAE	LC
26	<i>Corvus splendens</i>	House Crow	CORVINAE	LC
27	<i>Aegithina tiphia</i>	Common Iora	AEGITHININAE	LC
28	<i>Copsychus saularis</i>	Oriental Magpie-Robin	SAXICOLIDAE	LC
29	<i>Pyconotus jocosus</i>	Red-Whiskered Bulbul	PYCNONTIDAE	NE
30	<i>Pyconotus cafer</i>	Red-Vented Bulbul	PYCNONTIDAE	NE

Sr. No.	Scientific Name	Common Name(s)	Family	IUCN Status
31	<i>Pyconotus blanfordi</i>	Streak-eared Bulbul	PYCNONTIDAE	NE
32	<i>Acridotheres burmannicus</i>	Vinous-breasted Myna	STURNIDAE	NE
33	<i>Acridotheres tristis</i>	Common Myna	STURNIDAE	LC
34	<i>Acridotheres fuscus</i>	Jungle Myna	STURNIDAE	LC
35	<i>mirafra crythrocephala</i>	Burmese bushlark	ALAUDIDAE	NE
36	<i>Saxicola maura</i>	Siberian Stonechat	SAXICOLIDAE	NE
37	<i>Saxicola caprata</i>	Pie bushchat	MUSCICAPIDAE	LC
38	<i>Prinia flaxiventris</i>	Plain prinia	MUSCICAPIDAE	NE
39	<i>Cisticola juncidis</i>	Zitting Cisticola	CISTICOLIDAE	LC
40	<i>Orthotomus sutorius</i>	Common Tailorbird	SYLVIIDAE	LC
41	<i>Turdoides gularis</i>	White- throated Babbler	SYLVINEE	LC
42	<i>Chrysomma sinense</i>	Yellow-eyed Babbler	SYLVINEE	LC
43	<i>Passer montanus</i>	Eurasian Tree-sparrow	PASSERIDAE	LC
44	<i>Passer domesticus</i>	House Sparrow	PASSERIDAE	LC
45	<i>Motacilla alba</i>	White Wagtail	MOTACILLINEE	LC
46	<i>Lonchura punctulata</i>	Scaly-breasted Munia	ESTRILDINEE	LC

NE - Not Evaluated (IUCN)

DD - Data Deficient (IUCN)

LC - Least Concern (IUCN)

**Table 5.38 Species Diversity Index Values of Birds in the Project Study Area**

Index/Item	Value
Shannon Diversity H' (range)	4.499
Simpson's Index (1-D)	0.937
Brillouin's H	4.414
Evenness E'	0.370
Number of equally common species	23
No. of species	46
N	1718

### **Mammals**

Three mammal species were recorded around the Project Study Area (**Table 5.39**). Among the recorded mammal species, the most common was *Callosciurus pygerithrus*. No threatened mammal species was found around the Project Study Area.

**Table 5.39 Mammal Species Recorded during the Survey Period**

No	Scientific Name	Family	Common Name	Remark	IUCN Status
1	<i>Lepuspe guensis</i>	Leporidae	Burmese hare	Pellets observed	LC
2	<i>Echinosorex gymnurus</i>	Erinaceidae	Moon rat	Interview	LC
3	<i>Callosciurus pygerithrus</i>	Sciuridae	Gray squirrel	Observed	LC

NE - Not Evaluated (IUCN)

DD - Data Deficient (IUCN)

LC - Least Concern (IUCN)

### **Reptiles and Amphibians**

In the study of reptiles and amphibians, 4 snake species, 3 amphibian species, 1 skink species, and 1 lizard species were recorded around the Project Study Area. Among the recorded species, *Daboia russelii* and *Calotes versicolor* were found as common species within the Project Study Area (**Table 5.40**).

**Table 5.40 Reptile and Amphibian Species Recorded during the Survey Period**

Sr. No.	Scientific name	Common name	Family name	IUCN Status	Remark
	<b>Snake</b>				
1	<i>Daboia russelii</i>	Russell's viper	Viperidae	LC	Observed
2	<i>Ptyas korros</i>	Indochinese rat snake	Colubridae	NE	Interview
3	<i>Xenochrophis piscator</i>	Checkered keelback	Colubridae	NE	Observed
4	<i>Xenochrophis sp</i>	Water snake	Colubridae	NE	Interview
	<b>Amphibians</b>				
5	<i>Fejervarya limnocharis</i>	Crickets frog	Rannidae	LC	Interview
6	<i>Bufo melanostictus</i>	Common toad	Bufoidae	LC	Observed
7	<i>Kaloula pulchra</i>	Painted bull frog	Microhylidae	LC	Interview
	<b>Skink</b>				
8	<i>Eutropis multifasciata</i>	Common sun skink	Lacertidae	NE	Observed
	<b>Lizard</b>				
9	<i>Calotes versicolor</i>	Garden lizard	Agamidae	NE	Observed

NE - Not Evaluated (IUCN)

DD - Data Deficient (IUCN)

LC - Least Concern (IUCN)

### **Butterflies**

Ten common butterfly species were listed around the Project Study Area (**Table 5.41**). Butterfly population was large in developed areas and cultivated land. No threatened butterfly species was found in the area. Shannon species diversity index value was 3.107 and Evenness index value was 0.696 (**Table 5.42**).

**Table 5.41 Butterfly Species Recorded during the Survey Period**

Sr. No.	Species	Common name	Family	General Status
1	<i>Danaus chrysippus</i> ( Linnaeus, 1758)	Plain Tiger	Danaidae	Very Common
2	<i>Danaus genutia</i> ( Cramer, 1779)	Common Tiger or Striped Tiger	Danaidae	Common
3	<i>Papilio demoleus</i> Linnaeus, 1758	Lime butterfly	Papilionidae	Very Common
4	<i>Junonia almana</i> ( Linnaeus, 1758 )	Peacock Pansy	Nyamphalidae	Common
5	<i>Junonia atlites</i> Linnaeus, 1758	Grey Pansy	Nyamphalidae	Common
6	<i>Eurema hecabe</i> (Linnaeus, 1758 )	Common Grass Yellow	Pieridae	Very Common
7	<i>Catopsilia pomonacomelius</i> Fabricius, 1787	Orange Emigrant	Pieridae	Common
8	<i>Catopsilia pomona</i> Fabricius, 1775	Emigrant	Peridae	Very Common
9	<i>Cepora nerissa</i>	Common gull	Pieridae	Common
10	<i>Elymnias hypermnestra</i>	Palmfly	Amathusiidae	Common

**Table 5.42 Species Diversity Index Values of Butterflies in the Project Study Area**

Index/Item	Value
Shannon Diversity H' (range)	3.107
Simpson's Index (1-D)	0.883
Brillouin's H	2.743
Evenness E'	0.696
Number of equally common species	9
No. of species	10
N	57

### **Fish**

A total of 26 fish species were recorded from the River. Three near-threatened species, *Ompok bimaculatus*, *Wallago attuwere* and *Bagarius bagarius* were found in the River. Commercially important fish species recorded in the area were *Catla catla*, *Mystus gulio*, and *Cirrhinus mrigala*. No threatened species was found in the area.

**Table 5.43 Fish Species Recorded during the Survey Period**

Sr. No.	Scientific name	Common name	Family	IUCN status
1	<i>Channa striata</i>	Snakehead Murrel	Channidae	LC
2	<i>Heteropneustes fossilis</i>	Stinging catfish	Heteropneustidae	LC
3	<i>Notopterus notopterus</i>	Bronze featherback	Notopteridae	LC
4	<i>Barbodes binotatus</i>	Spotted barb	Cyprinidae	LC
5	<i>Lepidocephalichthys berdmorei</i>	Burmese loach	Cobitidae	LC

Sr. No.	Scientific name	Common name	Family	IUCN status
6	<i>Wallago attu</i>	Wallago	Siluridae	NT
7	<i>Osteobrama alfredianus</i>	Carplet	Cyprinidae	LC
8	<i>Clarias Batrachus</i>	Walking catfish	Clariidae	LC
9	<i>Xenentodon cancila</i>	Freshwater garfish	Belontiidae	LC
10	<i>Mystus vittatus</i>	Striped dwarf catfish	Bagridae	LC
11	<i>Ompok bimaculatus</i>	Butter catfish	Siluridae	NT
12	<i>Glossogobius giurus</i>	Tank goby	Gobiidae	LC
13	<i>Macrogathus zebrinus</i>	Zebra spiny eel	Mystacembelidae	LC
14	<i>Anabas testudineus</i>	Climbing perch	Anabantidae	DD
15	<i>Oreochromis niloticus</i>	Nile tilapia	Cichlidae	LC
16	<i>Monopterus albus</i>	Swamp eel	Synbranchidae	LC
17	<i>Cirrhinus mrigala</i>	Mrigal	Cyprinidae	LC
18	<i>Parambassis ranga</i>	Indian glassy fish	Ambassidae	LC
19	<i>Channa orientalis</i>	Walking snakehead	Channidae	LC
20	<i>Silonia silondia</i>	Silond catfish	Schilbeidae	LC
21	<i>Mastacembelus unicolor</i>	Colorful eel	Mastacembelidae	LC
22	<i>Catla catla</i>	Catla	Cyprinidae	LC
23	<i>Bagarius bagarius</i>	Dwarf goonch	Sisoridae	NT
24	<i>Sperata seenghala</i>	Long-whiskered catfish	Bagridae	LC
25	<i>Mystus gulio</i>	Long whiskers Catfish	Bagridae	LC
26	<i>Trichogaster pectoralis</i>	Snakeskin gourami	Osphronemidae	LC

NE - Not Evaluated (IUCN)

DD - Data Deficient (IUCN)

LC - Least Concern (IUCN)

### **Plankton**

Nine zooplankton and 12 phytoplankton species were identified from the collected samples. Most of the plankton species were recorded from the samples collected from upstream, downstream and sites parallel to the project site (**Table 5.43** to **Table 5.46**). Two benthos species were recorded from the samples (**Table 5.47**).

**Table 5.44** **Sampling Points of Plankton and Benthos**

Item	Latitude	Longitude	Elevation	Site No.
Upstream	N 21 24 26.0	E 095 16 50.2	58 m	I
Mid-point	N 21 24 25.9	E 095 16 32.8	59 m	II
Downstream	N 21 24 23.0	E 095 16 20.5	59 m	III

**Table 5.45** **Zooplankton Species Recorded during the Survey Period**

Sr. No.	Species	Phylum	Station
1	<i>Monostyla lunaris</i>	Rotifer	II, III
2	<i>Spirostomum minus</i>	Protozoa	I,III

Sr. No.	Species	Phylum	Station
3	<i>Cyclops vicinus</i>	Arthropoda	III
4	<i>Cyclops sternuns</i>	Arthropoda	I,II,III
5	<i>Bosminopsis sp</i>	Arthropoda	II, III
6	<i>Daphnia sp</i>	Arthropoda	I,II,III
7	<i>Daphnia pulex</i>	Arthropoda	I,II,III
8	<i>Brachionus havanaensis</i>	Rotifer	I
9	<i>Lecane unguolata</i>	Rotifer	II, III

**Table 5.46 Phytoplankton Species Recorded during the Survey Period**

Sr. No.	Species	Class	Station
1	<i>Diatoma elongaum</i>	Bacillariophyceae	I,III
2	<i>Campsopogan caeruleus</i>	Rhodophyceae	I,III
3	<i>Synedra affinis</i>	Chrysophyta	II
4	<i>Dinobryon divergens</i>	Chrysophyta	I,II,III
5	<i>Staurastrum leptopus</i>	Chlorophyceae	II,III
6	<i>Spirogyra cylindrospora</i>	Chlorophyceae	III
7	<i>Spirogyra prolifica</i>	Chlorophyceae	I,III
8	<i>Spirogyra azygospora</i>	Chlorophyceae	II,III
9	<i>Oscillatoria laete-virens</i>	Cyanophyceae	I,II,III
10	<i>Oscillatoria subbrevis</i>	Cyanophyceae	I,II
11	<i>Planktothrix raciborskii</i>	Cyanophyceae	I,III
12	<i>Treubaria crassispina</i>	Cyanophyceae	I,II,III

**Table 5.47 Benthos Species Recorded during the Survey Period**

Sr. No.	Species	Family	Group	Remark
1	<i>Trithemis aurora</i>	Libellulidae	Dragonfly nymph	Common
2	<i>Ictinogomphus sp.</i>	Gomphidae	Dragonfly nymph	Common