AMARA Mining Plc

ESIA Report
Yaoure Gold Project, Côte d'Ivoire

Appendix 4
Climate and Meteorological Baseline Study

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1. INTRODUCTION

1.1 TERMS OF REFERENCE

Amec Foster Wheeler Earth and Environment (UK) Ltd (Amec Foster Wheeler) have been commissioned by Amara Mining Plc (Amara) to carry out the Environment and Social Impact Assessment (ESIA) for the Yaoure gold project (Yaouré) in Côte d'Ivoire. This Climate and Meteorological Baseline Study provides key inputs to both the ESIA, and the Prefeasibility Study (PFS). It provides a summary of climate data, focusing on rainfall and key weather parameters in and around the concession area at Yaouré. Specifically this report presents an analysis of climatological data to derive statistics and extreme event design values including Probable Maximum Precipitation (PMP).

1.2 INPUT DATA

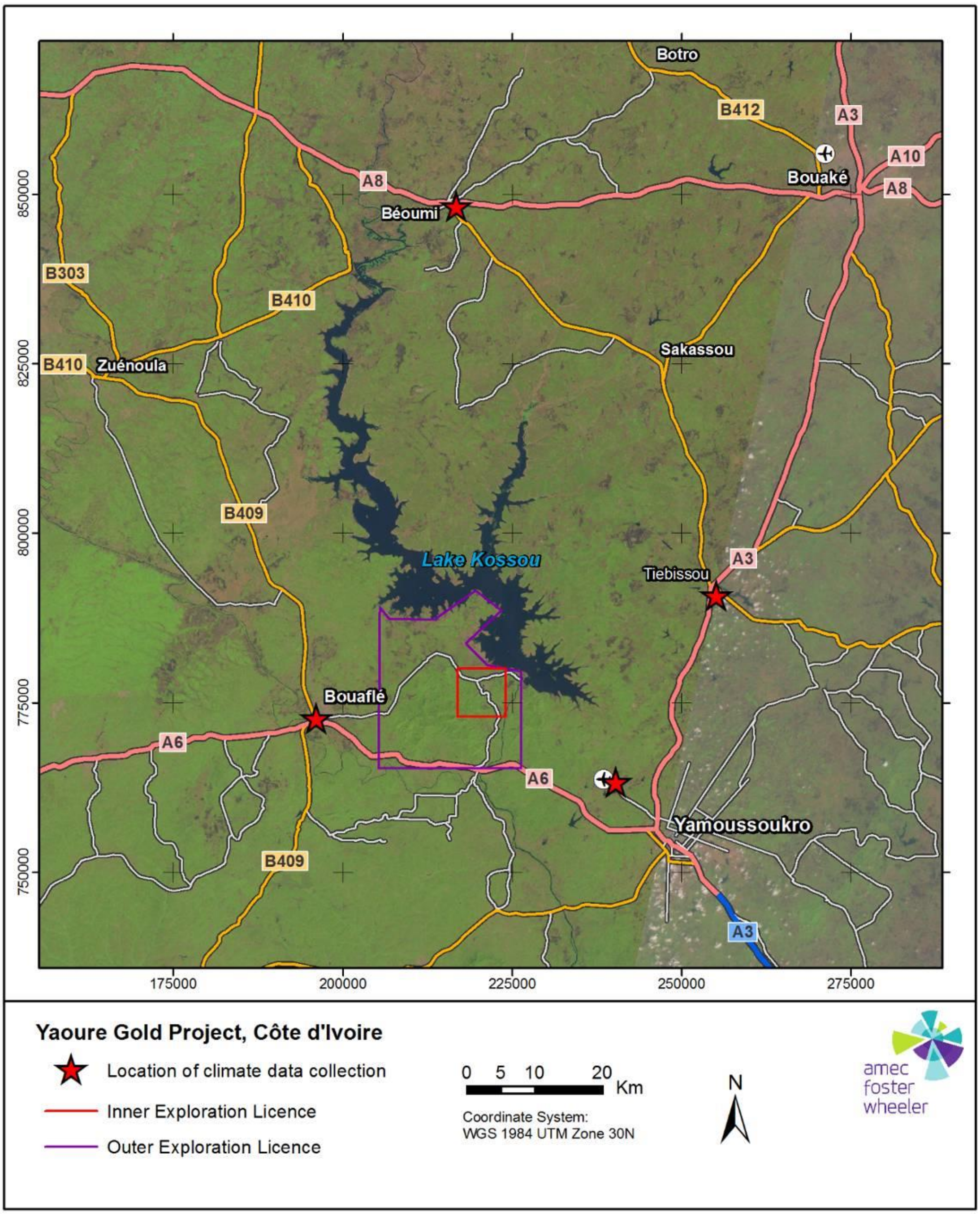
Long term weather records are available from each of the four weather stations near to the Yaoure site. Basic information related to the datasets and weather stations is provided in Table 1.1 below. The location of each of the weather stations relative to the site is shown on Figure 1.1.

Table 1.1
Input Data

Location and record length	Approximate coordinates	Altitude (m ASL)	Comments
Béoumi 1939-1997	Lat: 07°40 Long: 05°34	223	Excluded: 1939, 1993
Bouaflé 1924-1997	Lat: 06°59 Long: 05°45	187	Excluded: 1993
Tiébissou 1953-1996	Lat: 07°09 Long: 05°13	190	Multiple years missing data. Data set not considered further.
Yamoussoukro 1975-1997	Lat: 06°54 Long: 05°21	196	Excludes 1988-1992

Site data was provided, but the timeframe was determined to be too short (July 2014 to January 2015) to be of use in these statistical analyses at this stage. In future, with the data record extended and in addition to there being some contemporaneous data from Bouaflé, then it will be possible to undertake a partial validation of the applicability of using Bouaflé as a surrogate for the monthly and intensity duration frequency (IDF) data (in 1 hour time-steps) analyses. However, its wider use would be very much limited.

Figure 1.1
Climate Dataset Locations



At the time of writing, Amec Foster Wheeler has just received (21 May 2015) rainfall data for the Kossou Dam, but too late to be analysed and included in this report.

2. RAINFALL ANALYSES

2.1 SCOPE

This section presents the methods and results from a number of rainfall analyses that include:

- Summary of monthly observed rainfall data (mean, standard deviation, maximum, minimum, wet days) from the vicinity of the Yaoure site;
- Determination of the most applicable data for use in Extreme Value Analysis (EVA);
- EVA to determine 24 hour rainfall depths for a variety of return periods, including the Probable Maximum Precipitation (PMP) event; and
- Intensity Duration Frequency (IDF) analysis.

2.2 MONTHLY RAINFALL ANALYSES

The data made available for this study are outlined in Section 1.2. Only the Yamoussoukro Airport, Bouaflé and Béoumi data have been considered for analysis, the Tiébissou data being too incomplete.

All of the analysed stations are located within 30 km of the Yaoure site and are of comparable altitude. The sites are also all located within the same rainfall region of Côte d'Ivoire (Type II – Baouleen climate) as given in Soro *et al.* (2010). Because of the relatively short record length of Yamoussoukro (1975-1997) compared with Bouaflé and Béoumi, results for Bouaflé and Béoumi are also presented for that 1975-1997 period as well as for their entire record lengths, to provide for a direct comparison. The entire monthly record for Bouaflé from 1924 to 1996 is attached as Appendix A.

The results are presented in Table 2.1. All of the mean annual rainfall depths are comparable, and there is good correlation between all of the monthly mean rainfall depths, the strongest correlation being between Yamoussoukro and Bouaflé (1975-1997) at 0.95. Despite this, differences in the distribution of monthly averages are observed. Notably, wetter Aprils are observed at Bouaflé (mean of 141 mm (1975-1997) and 144 mm (1924-1997)) compared to Yamoussoukro at 108 mm. Yet mean rainfall in July – the wettest month in the region – is greater at Yamoussoukro (183 mm) than Bouaflé (143 mm) for the 1975-1997 period, albeit the difference is much less for the Bouaflé (1924-1997) data which has a mean of 177 mm in July. Moreover, the maximum monthly rainfall in July is significantly higher at Bouaflé (410 mm for both datasets) than at Yamoussoukro (281 mm).

The mean annual number of wet days (deemed to be days with rainfall >0.4mm) is also significantly higher at Yamoussoukro (100 days) than at Bouaflé (74 days, 1975-1997 and 86 days,1924-1997) and at Béoumi – 70 days, 1975-1997 and 69 days, 1940-1997).

Table 2.1
Summary of Monthly Rainfall Data from Yamoussoukro Airport, Bouaflé and Béoumi

Station & Dates	Stat	J	F	M	A	M	J	J	A	S	O	N	D	ANN	ADM
Yamoussoukro (1975-1997)	Mean (mm)	14	47	92	108	167	183	110	90	152	118	39	15	1135	75
	SD (mm)	26	28	53	56	88	64	84	74	74	61	30	18	203	20
	Max (mm)	95	101	182	249	390	281	282	258	260	262	125	54	1439	118
	Min (mm)	0	0	0	0	0	89	6	7	5	41	3	0	676	42
	Mean wet days	1	4	8	8	12	14	10	11	14	12	5	2	100	NA
Bouaflé (1975-1997)	Mean (mm)	10	48	104	141	151	143	96	113	154	99	38	13	1123	91
	SD (mm)	14	42	48	57	73	55	68	87	82	46	41	23	229	42
	Max (mm)	116	203	287	264	347	410	328	302	440	296	194	153	1930	223
	Min (mm)	0	0	18	26	22	40	1	3	16	9	0	0	818	47
	Mean wet days	1	3	6	8	9	10	7	7	10	8	3	1	74	NA
Bouaflé (1924-1997)	Mean (mm)	16	61	117	144	160	177	91	104	202	129	47	26	1280	87
	SD (mm)	25	46	55	56	70	78	69	67	92	66	42	31	259	31
	Max (mm)	116	203	287	264	347	410	328	302	440	296	194	153	1930	223
	Min (mm)	0	0	18	26	22	40	1	3	16	9	0	0	818	47
	Mean wet days	1	3	7	8	10	11	7	8	13	10	4	2	86	NA

Table 2.1
Summary of Monthly Rainfall Data from Yamoussoukro Airport, Bouaflé and Béoumi

Station & Dates	Stat	J	F	M	A	M	J	J	A	S	O	N	D	ANN	ADM
Béoumi (1975-1997)	Mean (mm)	5	36	79	112	128	108	121	141	184	99	25	9	1047	94
	SD (mm)	11	34	35	44	63	54	85	91	78	43	21	11	203	31
	Max (mm)	65	157	340	294	291	294	307	322	450	242	131	103	1607	175
	Min (mm)	0	0	0	48	18	45	0	18	48	16	0	0	529	49
	Mean wet days	1	3	5	7	8	8	7	9	11	8	3	1	70	NA
Béoumi (1940-1997)	Mean (mm)	8	47	93	121	126	129	104	125	209	115	41	18	1136	92
	SD (mm)	15	39	58	53	58	63	76	78	80	55	33	24	228	28
	Max (mm)	65	157	340	294	291	294	307	322	450	242	131	103	1607	175
	Min (mm)	0	0	0	48	18	45	0	18	48	16	0	0	529	49
	Mean wet days	1	3	5	7	7	8	6	9	11	8	3	1	69	NA

(ANN = Annual rainfall, ADM = Annual Daily Maxima). Mean Wet days determined on the basis of days with gauged rainfall in excess of 0.4mm.

2.3 SELECTION OF SURROGATE DATASET FOR SUBSEQUENT RAINFALL ANALYSES

The Bouaflé rainfall data were selected as the basis for the extraction of three year monthly time series for water balance modelling, Extreme Value Analysis (EVA), Probable Maximum Precipitation (PMP) and IDF analyses for the following reasons:

- The mine site is equidistant from Bouaflé and Yamoussoukro Airport. Bouaflé is further from the site, and therefore less likely to be representative of the site;
- The rain gauge at Bouaflé is approximately 40 km from Yamoussoukro Airport and the stations are at comparable altitudes (187 m ASL and 196 m ASL respectively);
- Monthly annual rainfall for Yamoussoukro and Bouaflé is similar for the period 1975-1997 (1153 mm and 1123 mm respectively);

- The distribution of monthly mean rainfall values for Bouaflé and Yamoussoukro are comparable, albeit with the exception that, at Bouaflé, April is wetter than Yamoussoukro (141 mm and 108 mm respectively), and in June, Yamoussoukro is wetter than Bouaflé (183 mm and 143 mm respectively); and
- Bouaflé has a longer running dataset than Yamoussoukro.

This analysis is undertaken on the basis of available data at the time of the PFS. Further analyses should be undertaken when the Kossou dam rainfall data (not received in time for this report) are processed.

2.4 RAINFALL FOR WATER BALANCE MODELLING

For the PFS mine-wide water balance modelling, it has been necessary to assess a range of possible rainfall scenarios over a three year period in order to:

- Make PFS level judgements regarding water resource sustainability, and requirements for water supply and discharge; and
- Inform the preliminary assessment of infrastructure requirements, in particular the Tailings Management Facility (TMF).

The monthly rainfall scenarios were extracted from the Bouaflé dataset from 1924 to 1996 (excluding 1993) and are shown in Table 2.2 below.

Table 2.2
Minimum, mean and maximum consecutive 3 year period monthly rainfall scenarios (at Bouaflé) for use with PFS water balance modelling

Year	Month	Minimum	Mean	Maximum
Year 1	Jan	14.9	36	0
	Feb	78.4	3	138.9
	Mar	132.7	91	90.6
	Apr	121.5	92.9	190.8
	May	175.9	209.3	39.9
	Jun	62.8	141.1	274.9
	Jul	41.6	50	90.6
	Aug	51.6	136.5	108.3
	Sep	132.8	440.1	200.1
	Oct	91.1	139.5	149.8
	Nov	4.8	164.9	99.8
	Dec	15.7	20.4	14
Year 2	Jan	0	4	115.6
	Feb	75.2	50.9	117.8
	Mar	153.1	34	86.8
	Apr	26	168.4	241.8
	May	123.4	180.5	280.7
	Jun	112.6	197	91.3
	Jul	137.3	119.7	327.8
	Aug	28.8	80.9	83.9
	Sep	144.1	83.3	208.8
	Oct	30.1	75.7	283.7
	Nov	13.3	29	48.8
	Dec	7	71	42.8
Year 3	Jan	33.6	0	31.3
	Feb	55.3	47.4	39.5
	Mar	64.9	144.4	223
	Apr	105.2	233.8	70.1
	May	178.3	182.8	155.8
	Jun	152	132.3	234.9
	Jul	17.2	92.8	48.5
	Aug	53.5	160.2	171.1
	Sep	39.3	96.8	170.6
	Oct	143.1	98.4	59.1
	Nov	94.1	30.3	64.7
	Dec	0	4.5	72

Notes: Minimum: 1974-1976, mean: 1962-1964, maximum: 1938-1940.

3. EXTREME VALUE ANALYSIS

3.1 METHOD

The Bouaflé daily data were taken forward to the extreme value analysis (EVA). The whole period from 1924 to 1997 was used, with the exception of 1993 which was omitted because the record was incomplete in that year. In total, 72 observed years were included in the analysis, which is considered more than sufficient for this approach.

Both Gumbel (EV1) and Generalized Extreme Value (GEV) distributions were fitted to the annual daily maxima data from Bouaflé. All of the data points fell within the +/- 5 percentile confidence limit with the exception of the third highest value (~+7 %). The EV1 distribution was considered the more appropriate at this stage due to the inability to verify the veracity of the GEV parameters at this location in the absence of sub-daily rainfall for Bouaflé.

The EVA results are shown in Table 3.1. It is noted that the 1:10,000 and 1: 1,000,000 year return period events were not produced within the analysis framework but were extrapolated by fitting a curve through the data that were generated during the analysis.

Table 3.1
Extreme Value Analysis (EVA) results for Bouaflé

Return Period (years)	24 Hr Rain Depth (mm)
1.01	36
1.1	52
2	82
5	109
10	127
15	137
20	144
25	149
50	166
80	177
100	183
200	199
500	221
1,000	238
10,000	293
1,000,000	414

3.2 SYNTHESIS OF INTENSITY DURATION FREQUENCY (IDF) CURVES

3.2.1 Methodology

The formula of Sherman (1931) was used to generate the IDF curves. For a given return period, rainfall intensity (I, mm/h) is related to duration (T, hours) by means of three empirically determined constants (a, b and n):

$$I = \frac{a}{(b+T)^n}$$

If the rainfall depth for any given duration is compared with the daily total rainfall, the constant 'a' can be eliminated and a rainfall ratio determined instead which uses only two constants (b and n) as follows:

$$RR_T = \frac{I_T \times T}{I_{24} \times 24} = \frac{T}{24}\left(\frac{b+24}{b+T}\right)^n$$

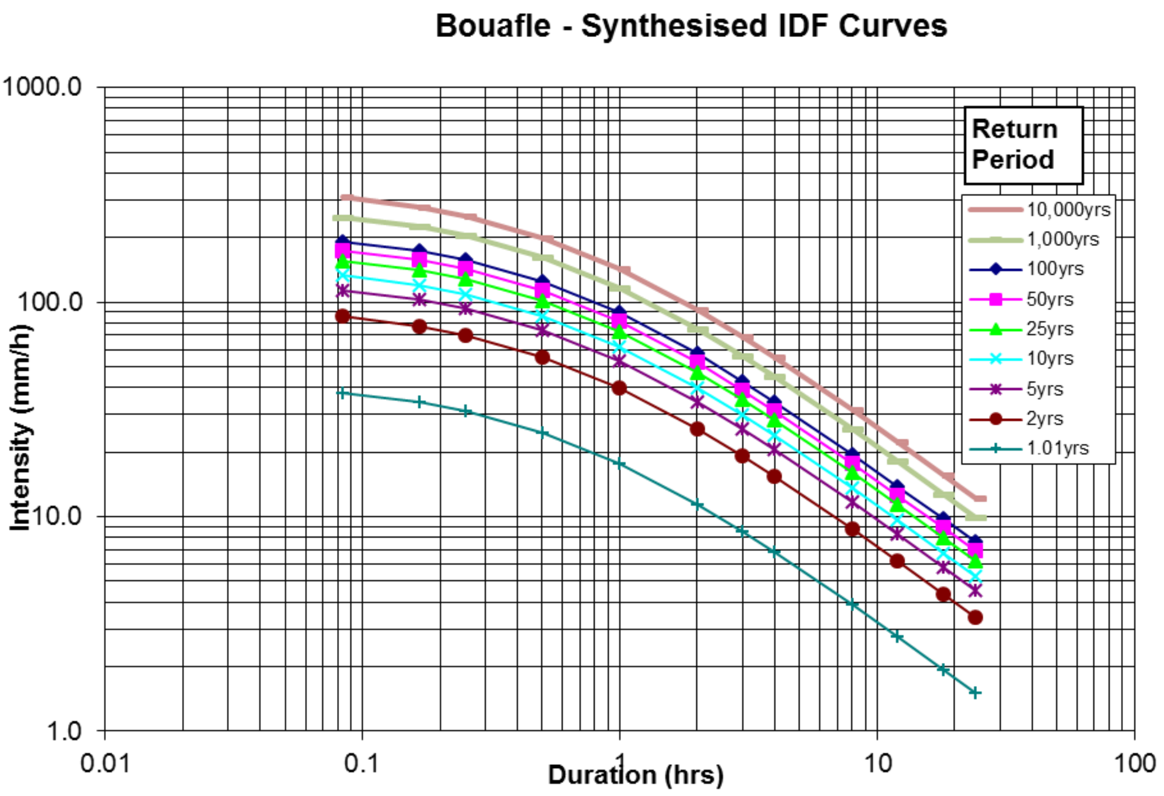
Values of b and n vary between locations, but studies have found values to be similar within a region. Values are published in the literature but are often hard to find. It is better if the values can be back analysed from data for the location, or a similar location nearby. For comparison, published values for 14 stations in Ghana are b = 0.60 and n = 0.86 to 1.03. Values of b=0.6 and n=0.9 have been used at this stage subject to further analyses on assessment of the additional rainfall data from Kossou dam.

The resultant table of IDF data and corresponding curves are shown below in Table 3.2 and Figure 3.1.

Table 3.2
IDF results (rainfall intensity in mm/hr)

Return Period	Duration (mins)								
	5	10	20	30	60	120	180	720	1440
1	37.9	34.2	31.2	24.7	17.6	11.4	8.5	2.8	1.5
2	85.4	77.0	70.2	55.7	39.7	25.7	19.2	6.2	3.4
5	113.9	102.6	93.5	74.2	52.9	34.2	25.5	8.3	4.5
10	132.7	119.6	109.0	86.4	61.7	39.8	29.7	9.6	5.3
20	156.4	141.0	128.5	101.9	72.7	47.0	35.1	11.4	6.2
50	174.0	156.9	143.0	113.4	80.9	52.3	39.0	12.6	6.9
100	191.5	172.7	157.4	124.8	89.1	57.5	42.9	13.9	7.6
1,000	249.4	224.8	204.9	162.5	116.0	74.9	55.9	18.1	9.9
10,000	307.1	276.9	252.3	200.1	142.8	92.2	68.8	22.3	12.2

Figure 3.1
Synthesised rainfall IDF curves for Bouaflé



3.3 PROBABLE MAXIMUM PRECIPITATION

3.3.1 Introduction

Probable Maximum Precipitation (PMP) is conceptually defined as the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of year (WMO, 1986). From the practical perspective of this project, there is a requirement to estimate the PMP for the catchments in which critical mine infrastructure is located, for example, for calculating the probable maximum flood (PMF) through the TMF for sizing spillway structures using rainfall-runoff modelling approaches.

A variety of techniques exist for the estimation of PMP as summarised in the WMO Manual for Estimation of Probable Maximum Precipitation (WMO, 1986). Most of these techniques were developed for large drainage basins in mid-latitude regions and require synthesis of a range of meteorological data such as dew point and wind speed at a range of altitudes to arrive at PMP estimates. Procedures are presented which can be used to adapt these techniques to tropical regions. However, the WMO manual notes that regions with limited data such as Côte d'Ivoire present particular difficulties in applying these techniques. Nevertheless, an alternative statistically based method for smaller areas (<1,200 km^2) is also presented, which is based on recorded annual precipitation maxima alone. It is this approach that has been adopted for estimation of PMP for this study, based on the Bouaflé data described above.

3.3.2 Methodology

The point PMP for a given storm duration is estimated as a function of the mean and standard deviation of the annual rainfall maxima series as follows:

$$X_m = \overline{X}_n + K_m S_n$$

where X_m is the PMP; $\dot{X}_n$ and S_n are the mean and standard deviation (with the maximum value removed) of a series of n annual maxima, and K_m is a scaling factor. A study of 24-hour rainfall from 2,700 climate stations, of which 90% were in the USA, was used in the estimation of K_m. This was found to vary inversely with mean annual maximum daily rainfall. The technique also involves application of correction factors to adjust the mean and standard deviations for the effects of possible outliers and sample size, and adjustment of the final point PMP value to reflect the effect of a fixed observational time interval. Finally, an areal reduction factor is required to convert to point PMP for a particular catchment area, should this be required. Values of K_m and the various other factors required are estimated from a number of graphs presented in Chapter 4 of WMO (1986).

3.3.3 Results

The approach described above was applied to the Bouaflé annual daily maxima series with incomplete years removed. The following values were estimated:

$\overline{X}_n$ = 84.63 mm (n =71)

S_n = 26.14 mm (n =71)

K_m = 12 (based on the 2 year 1 hour rainfall derived from IDF table)

PMP = 450 mm

Given that the record length exceeded 50 years, no adjustments were required to the mean and standard deviation for record length, and the long record length also meant that a significant impact from outliers could be discounted. An adjustment factor for a fixed observation interval of 1.13 was applied. This yielded a value for the daily PMP for Yaoure of 450 mm. It is noted that, based on the mean annual daily maxima from Bouaflé, K_m takes a value of 16 which would have resulted in a corresponding PMP of 568 mm – this is considered overly conservative however.

As identified above, the final value of PMP using the technique applied here is sensitive to the estimation of a single parameter K_m. Given the different climatic conditions under which this relationship was derived (the relationship between $\dot{X}_n$ and K_m was largely derived on data from the USA), its use in a tropical climate must be treated with some caution. By way of comparison, extrapolation of the EV1 best-fit curve for data presented in Section 3.1 to return periods of 10,000 and 1,000,000 years yields respective daily rainfall totals of 293 mm and 414 mm. This would suggest that the value of 450 mm obtained above may be an overestimate of the actual point PMP for Yaoure but is nonetheless in the order of the 1:1,000,000 value.

3.3.4 Operational Use of PMP Estimate

The value derived above is a point value for daily rainfall at Yaoure. For practical application, the following issues need to be addressed:

- Values need to be derived for a range of storm durations. It is by no means clear that the meteorological circumstances that would lead to the generation of a PMP event would conform to the IDF relationship derived in Section 4.3. However, in the absence of any other information, it is suggested that the relationship developed above is used for current purposes;
- Point values should be adjusted by an areal reduction factor to account for the catchment area they are being applied to. However, given that the catchments of interest in this study are small, it is suggested that application of the areal reduction factor can be neglected. This would yield a conservative estimate of the resulting PMF.

4. CLIMATE

4.1 OTHER CLIMATE DATA

Table 4.1 to Table 4.5 summarise average monthly data for temperature, evaporation, humidity, wind speed and sunshine hours. Other climate data for Yamoussoukro are included in the SGS EIS (2007).

Table 4.1
Yamoussoukro Temperatures, 1975-1997 (SGS, 2007)

MONTH	Maximum Temperature (°C)			Minimum Temperature (°C)		
	Mean minimum	Mean maximum	Mean	Mean minimum	Mean maximum	Mean
JAN	32.36	34.8	33.56	10.6	20.7	17.53
FEB	32.92	36.9	35.02	14.7	22.1	20.23
MAR	31.2	37.0	34.26	16.5	23.62	21.51
APR	31.7	35.13	33.56	16.2	23.55	21.54
MAY	31.3	33.6	32.27	15.3	22.95	21.27
JUN	29.11	32.2	30.56	14.3	22.41	20.96
JUL	21.6	30.3	28.73	13.0	29.07	20.69
AUG	27.74	30.9	29.22	17.1	21.76	20.51
SEP	29.0	32.8	30.25	18.5	21.9	20.90
OCT	29.74	33.3	31.02	18.4	22.01	20.80
NOV	30.43	33.8	31.79	16.2	21.45	19.79
DEC	30.76	33.4	31.92	12.4	20.46	17.78

Table 4.2
Yamoussoukro Average Evaporation, 1994-2001 (SGS, 2007)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
Evap (mm)	104.2	117.8	108.3	80.2	63.7	48.3	48.1	46.3	47.6	50.3	54.7	59.7	829.0

Notes: Measured with a Piche Evaporimeter – glass 'U' tube filled with water and closed at one end.

Table 4.3
Yamoussoukro Average Relative Humidity, 1977-1997 (SGS, 2007)

MONTH	Maximum Humidity (%)			Minimum Humidity (%)		
	Minimum	Maximum	Mean	Min	Max	Mean
JAN	87.6	99.4	95.8	16.5	49.2	31.8
FEB	90.0	98.5	94.8	23.4	42.3	33.4
MAR	88.7	98.8	95.6	27.6	50.1	41.8
APR	92.8	99.2	96.9	42.3	56.5	49.1
MAY	95.3	99.6	97.9	49.7	61.5	55.6
JUN	95.6	99.7	98.1	54.9	64.4	60.3
JUL	94.9	99.6	97.6	50.3	68.0	62.7
AUG	91.8	99.4	97.1	53.4	69.1	62.0
SEP	95.5	99.3	97.8	47.4	66.8	58.8
OCT	95.5	99.7	98.3	45.9	62.5	56.2
NOV	96.6	99.7	98.7	41.2	60.8	52.0
DEC	96.1	99.5	98.3	25.3	51.9	40.8

Table 4.4
Yamoussoukro Average Wind Speed, 1994-2001 (SGS, 2007)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
Speed (m/s)	1.00	1.60	1.80	1.90	1.60	1.70	1.80	2.00	1.80	1.10	2.30	1.10	1.60
Direction	NSW	SW	SSW	SSW	SSW	SSW	SW	SW	SW	SW	SSW	W	
Type	H - M	M			M	M	M	M	M			H	

H – Harmattan, M – Monsoon

Table 4.5 Yamoussoukro Average Sunshine Hours, 1981-1997 (SGS, 2007)			
MONTH	**Mean**	**Min**	**Max**
JAN	198.3	126.4	245.8
FEB	197.1	144.6	245.8
MAR	204.0	156.5	251.8
APR	208.4	174.5	237.5
MAY	210.5	157.7	241.4
JUN	151.5	121.7	182.3
JUL	111.6	72.1	154.9
AUG	97.9	40.0	135.5
SEP	116.5	88.1	38.1
OCT	171.0	126.8	201.0
NOV	179.2	153.2	216.7
DEC	166.4	91.2	217.6

Temperature has been monitored at the Yaoure site since 2009.

Mean monthly temperature for the period 2009-2013 is shown in Table 4.6.

Table 4.6 Yaoure Monthly Temperature 2009-2013 (Amara data)												
	Mean monthly temperature (ºC)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2009	39.8	29.4	28.5	28.4	27.7	27.3	25.3	25.3	26.2	26.8	26.9	27.8
2010	28.5	29.3	29.8	29.5	28.8	27.1	25.8	25.7	26.6	27.3	28.0	27.3
2011	26.6	29.0	29.1		28.0	27.0	25.4	25.8	26.9	27.3	27.9	26.5
2012	27.4	28.8	29.8	28.5	22.2	26.5	25.3	25.0	26.5	26.9	22.2	26.9
2013	26.7	29.7	29.0	29.0	27.7	26.8	25.5	25.1	26.1	27.1	27.5	26.8

5. SUMMARY

Climatic parameters for use in the ESIA and PFS are summarised in Table 5.1 below.

Table 5.1
Summary of Climatic Parameters

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Minimum rainfall[1] (mm)	0	0	18	26	22	40	1	3	16	9	0	0	818
Mean rainfall[1] (mm)	16	61	117	144	160	177	91	104	202	129	47	26	1280
Maximum rainfall[1] (mm)	116	203	287	264	347	410	328	302	440	296	194	153	1930
24 hour probable maximum precipitation[2] (mm)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	450
Mean minimum temperature[3] (°C)	17.5	20.2	21.5	21.5	21.3	21.0	20.7	20.5	20.9	20.8	19.8	17.8	N/A
Mean maximum temperature[3] (°C)	33.6	35.0	34.3	33.6	32.3	30.6	28.7	29.2	30.3	31.0	31.8	31.9	N/A
Average evaporation[4] (mm)	104.2	117.8	108.3	80.2	63.7	48.3	48.1	46.3	47.6	50.3	54.7	59.7	829.0
Minimum relative humidity[5] (%)	31.8	33.4	41.8	49.1	55.6	60.3	62.7	62	58.8	56.2	52	40.8	N/A
Maximum relative humidity[5] (%)	95.8	94.8	95.6	96.9	97.9	98.1	97.6	97.1	97.8	98.3	98.7	98.3	N/A
Average wind speed (m/s)	1.00	1.60	1.80	1.90	1.60	1.70	1.80	2.00	1.80	1.10	2.30	1.10	1.60
Average sunshine hours (min) (hours)	126.4	144.6	156.5	174.5	157.7	121.7	72.1	40.0	88.1	126.8	153.2	91.2	N/A
Average sunshine hours (mean) (hours)	198.3	197.1	204.0	208.4	210.5	151.5	111.6	97.9	116.5	171.0	179.2	166.4	N/A

Average sunshine hours (max) (hours)	245.8	245.8	251.8	237.5	241.4	182.3	154.9	135.5	38.1	201.0	216.7	217.6	N/A

Notes

[1] Rainfall data obtained from the Bouaflé 1924-1997 dataset, as presented in Table 2.1. Minimum and maximum values are highest points on the record, not average minima and maxima.

[2] PMP was determined using the Bouaflé annual daily maxima series (with incomplete years removed), as described in Section 3.3.

[3] Temperature data obtained from the Yamoussoukro average temperature dataset (1975-1997), as presented in Table 4.1.

[4] Evaporation data obtained from the Yamoussoukro 1994-2001 dataset, as presented in Table 4.2.

[5] Relative humidity data obtained from the Yamoussoukro 1977-1997 dataset, as presented in Table 4.3.

[6] Wind speed data obtained from the Yamoussoukro 1994-2001 dataset, as presented in Table 4.4.

[7] Sunshine hours obtained from the Yamoussoukro 1981-1997 dataset, as presented in Table 4.5.

6. REFERENCES

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Attachment 1
Monthly Rainfall for Bouafle, 1924 - 1996

YEAR	RAINFALL (mm)												
	J	F	M	A	M	J	J	A	S	O	N	D	ANN
1924	12	128	193	175	187	320	23	93	365	137	51	10	1694
1925	0	11	287	195	84	284	158	82	403	103	7	0	1613
1926	8	5	94	148	162	266	38	37	398	43	21	3	1223
1927	14	24	95	116	192	200	65	39	142	294	37	20	1236
1928	56	35	114	87	121	240	189	152	311	232	27	45	1609
1929	0	127	123	84	204	358	133	46	175	237	27	0	1514
1930	69	98	52	115	142	163	76	64	138	53	90	0	1058
1931	30	83	196	199	212	157	37	237	144	48	44	41	1429
1932	0	60	111	102	203	95	93	48	103	147	35	30	1027
1933	15	48	163	134	49	238	307	121	97	90	194	30	1487
1934	10	35	138	140	188	208	89	134	176	121	0	19	1255
1935	12	19	98	243	143	229	70	136	141	178	13	18	1300
1936	20	83	30	204	264	109	18	33	252	76	91	0	1180
1937	0	0	66	132	207	210	25	66	269	175	86	46	1282
1938	36	3	91	93	209	141	50	137	440	140	165	20	1525
1939	4	51	34	168	181	197	120	81	83	76	29	71	1094
1940	0	47	144	234	183	132	93	160	97	98	30	5	1224
1941	28	2	50	168	168	193	134	74	173	55	40	59	1144
1942	26	91	193	42	274	101	13	69	135	146	67	46	1203
1943	18	94	136	66	208	239	154	97	137	142	47	22	1358
1944	3	100	206	90	26	102	66	97	245	105	15	35	1089
1945	0	19	144	156	173	112	46	79	230	240	21	0	1221
1946	51	62	66	161	199	65	19	26	248	150	49	5	1101

1947	0	33	71	111	87	141	43	117	274	115	119	153	1263
1948	0	13	107	264	226	91	19	109	259	141	61	50	1340
1949	0	94	142	110	343	239	96	166	354	255	75	24	1898
1950	0	22	107	140	139	186	53	125	149	237	29	85	1271
1951	7	97	81	86	94	187	136	184	216	265	11	14	1376
1952	0	38	83	229	131	176	155	42	244	137	73	17	1325
1953	5	203	120	34	200	299	87	82	126	155	25	4	1340
1954	10	134	205	255	169	131	22	80	195	200	55	10	1464
1955	97	37	42	197	281	274	143	185	251	106	18	75	1704
1956	1	81	107	200	127	174	48	98	229	142	31	45	1283
1957	3	85	123	116	234	279	167	215	216	179	78	26	1720
1958	101	65	146	192	79	40	1	19	138	77	140	2	1000
1959	7	105	155	170	190	175	109	48	388	71	55	128	1600
1960	35	29	148	202	22	410	49	136	301	50	16	73	1469
1961	0	0	144	127	122	148	70	17	190	159	33	17	1027
1962	0	139	91	191	40	275	91	108	200	150	100	14	1398
1963	116	118	87	242	281	91	328	84	209	284	49	43	1930
1964	31	40	223	70	156	235	49	171	171	59	65	72	1341
1965	63	69	142	178	153	130	32	90	250	118	26	1	1252
1966	0	35	185	151	183	274	146	88	295	100	51	31	1537
1967	0	58	101	98	122	192	32	42	237	40	44	30	995
1968	0	160	96	92	186	258	186	292	268	212	113	51	1913
1969	0	167	35	104	26	113	38	88	162	296	90	0	1118
1970	23	37	185	79	167	169	16	61	287	115	22	33	1193
1971	11	96	232	162	156	208	85	92	228	121	16	52	1457

1972	28	92	133	142	229	365	162	41	96	188	5	42	1524
1973	4	59	36	84	73	116	73	128	368	130	5	0	1075
1974	15	78	133	122	176	63	42	52	133	91	5	16	924
1975	0	75	153	26	123	113	137	29	144	30	13	7	851
1976	34	55	65	105	178	152	17	54	39	143	94	0	937
1977	1	9	117	83	183	131	51	95	186	98	0	14	968
1978	0	34	64	225	97	169	10	3	240	87	10	50	987
1979	5	4	50	200	140	317	133	40	220	93	14	21	1236
1980	19	112	156	71	347	60	265	164	215	206	82	4	1701
1981	0	18	119	115	98	148	86	55	259	99	7	0	1004
1982	0	104	182	119	166	209	44	254	68	129	50	0	1324
1983	0	4	42	156	303	93	33	3	143	9	29	4	818
1984	0	36	52	179	143	137	201	231	99	138	15	0	1231
1985	16	0	105	126	136	183	178	302	290	77	89	0	1500
1986	0	94	139	158	117	54	39	167	139	30	2	0	940
1987	31	31	62	44	243	196	61	189	304	93	11	0	1265
1988	31	11	162	228	113	132	90	131	210	88	48	14	1258
1989	0	30	139	184	117	119	160	166	206	109	0	0	1229
1990	8	9	18	179	32	101	54	104	54	73	162	35	829
1991	0	46	83	229	190	104	153	62	82	107	62	9	1126
1992	40	98	46	161	97	130	68	27	148	130	45	0	989
1994	0	120	87	102	183	139	130	134	82	160	16	0	1153
1995	0	37	147	151	142	178	64	206	127	125	31	96	1304
1996	13	121	152	137	100	156	135	55	16	41	0	19	944