



**LUANG PRABANG POWER COMPANY LIMITED**  
Luang Prabang HPP

**Feasibility Study**

Report – Volume 6 – Annex 6.1 Hydrology

For PNP/CA Only



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**VOLUME 1: EXECUTIVE SUMMARY**

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**VOLUME 3: DRAWINGS**

**VOLUME 4: ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT**

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# 1 ANNEX RAINFALL RUNOFF MODEL

## 1.1 Model structure

### 1.1.1 Computation points and sub-catchments



Figure 1 Sub-catchments and computation points of the model

**Table 1 Main features of the model sub-catchments**

Sub-catchment	Computation point	d/s sub-catchment	Area [km <sup>2</sup> ]	Mean Elevation [masl]	Min Elevation [masl]	Max Elevation [masl]
1	Lancang 1	2	75785	4508	2350	5748
2	Xiaowan HPP	3	31108	2613	1036	5972
3	Nuozhadu HPP	4	30874	1567	621	3319
4	Lancang 4	6	22350	1117	495	2359
5	Nam Ma @ Ban Xiengkok	6	1057	1043	448	1932
6	Mekong @ Ban Xiengkok	7	19514	1156	408	2479
7	Mekong @ Chiang Saen	8	9639	835	357	2272
8	Mekong @ Pak Beng	9	34103	716	315	2272
9	Luang Prabang HPP	14	6812	781	284	1851
10	Nam Ou @ Moung Ngoy	11	20173	915	334	1913
11	Nam Ou @ Ban Hat Nga	14	5826	802	296	1794
12	Nam Souang @ Ban Sibounhom	14	5837	865	293	2218
13	Nam Khan @ Ban Mixay	14	7254	972	313	2071
14	Mekong @ Luang Prabang	14	1519	707	272	1612
15	Guongguoqiao HPP	2	14969			
16	Manwan HPP	3	1110			
17	Dachaoshan HPP	3	6902			
18	Jinghong HPP	4	4639			



### 1.1.2 Hydrological response units (HRUs)

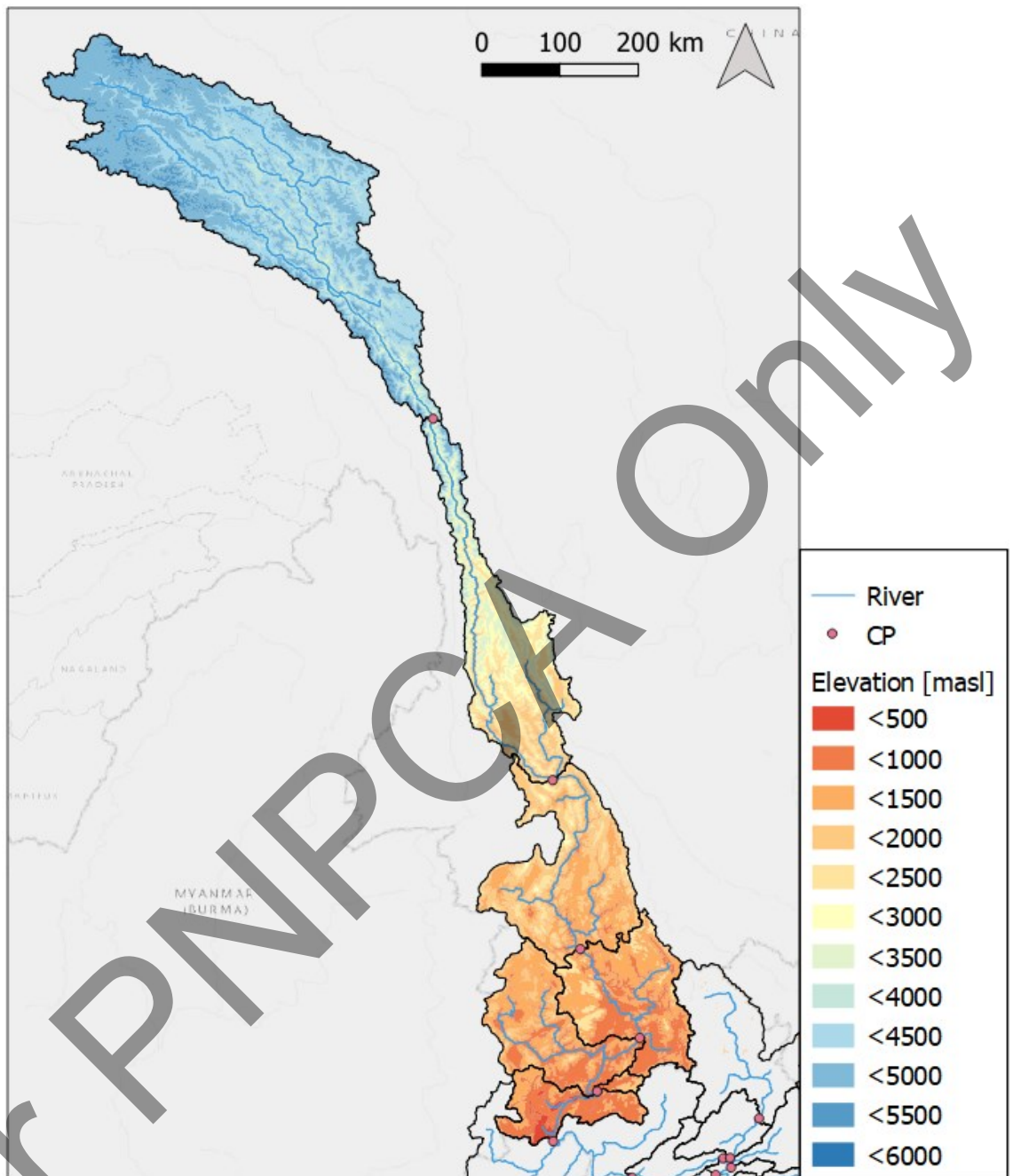


Figure 2 Division into hydrological response units via elevation – 500m elevation bands (sub-catchments 8 to 14 consists of one single HRU, as elevation-dependent HRUs are used mainly for the simulation of snow processes)

### 1.2 Estimation of flow times

Table 2 Estimated flow times

CP	d/s CP	[m] to d/s CP	Flow time [h]
1	15	489,415	68
2	16	56,660	8
3	18	102,896	14
4	6	139,357	19

CP	d/s CP	[m] to d/s CP	Flow time [h]
5	6	600	0
6	7	109,799	15
7	8	192,496	27
8	9	145,398	20
9	14	37,572	5
10	11	75,527	10
11	14	43,344	6
12	14	28,330	4
13	14	27,073	4
14			-
15	2	166,927	23
16	17	93,351	13
17	3	213,739	30
18	4	107,957	15

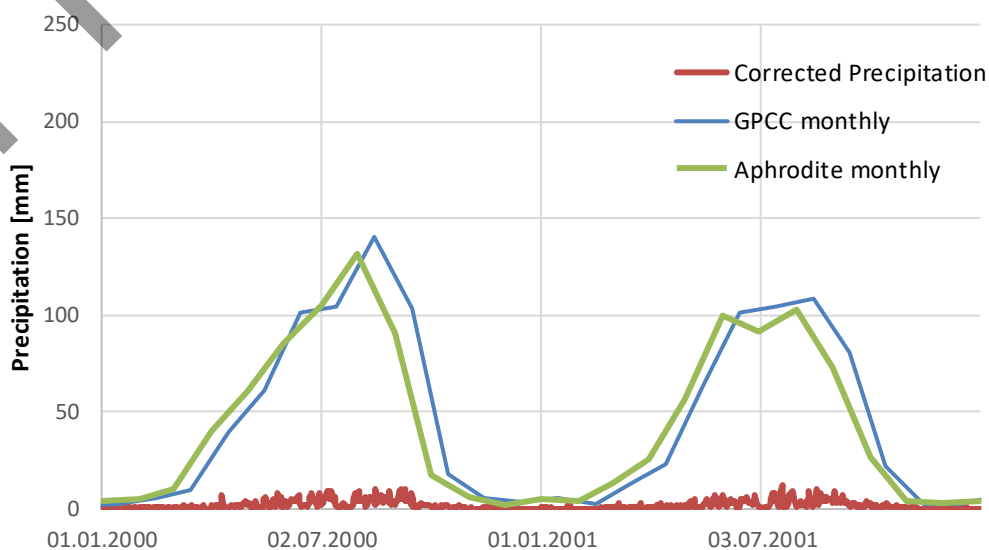
### 1.3 Hydropower plants on the Lancang

Table 3 Model attributes for Lancang hydropower plants (based on internet research)

Model attributes	Gongguoqiao	Xiaowan	Manwan	Dachaoshan	Nuozhadu	Jinghong
Start year of operation	2012	2010	1996	2004	2015	2009
Q Turbine [m <sup>3</sup> /s]	985	1,210	1,230	1,340	1,730	1,820
Installed capacity [MW]	900	4,200	1,570	1,350	5,850	1,750
Net head [m]	72	238	93	76	178	60
Full supply level [masl]	1,311	1,240	994	899	812	602
Total storage [mio. M <sup>3</sup> ]	316	14,560	920	890	23,703	1,140

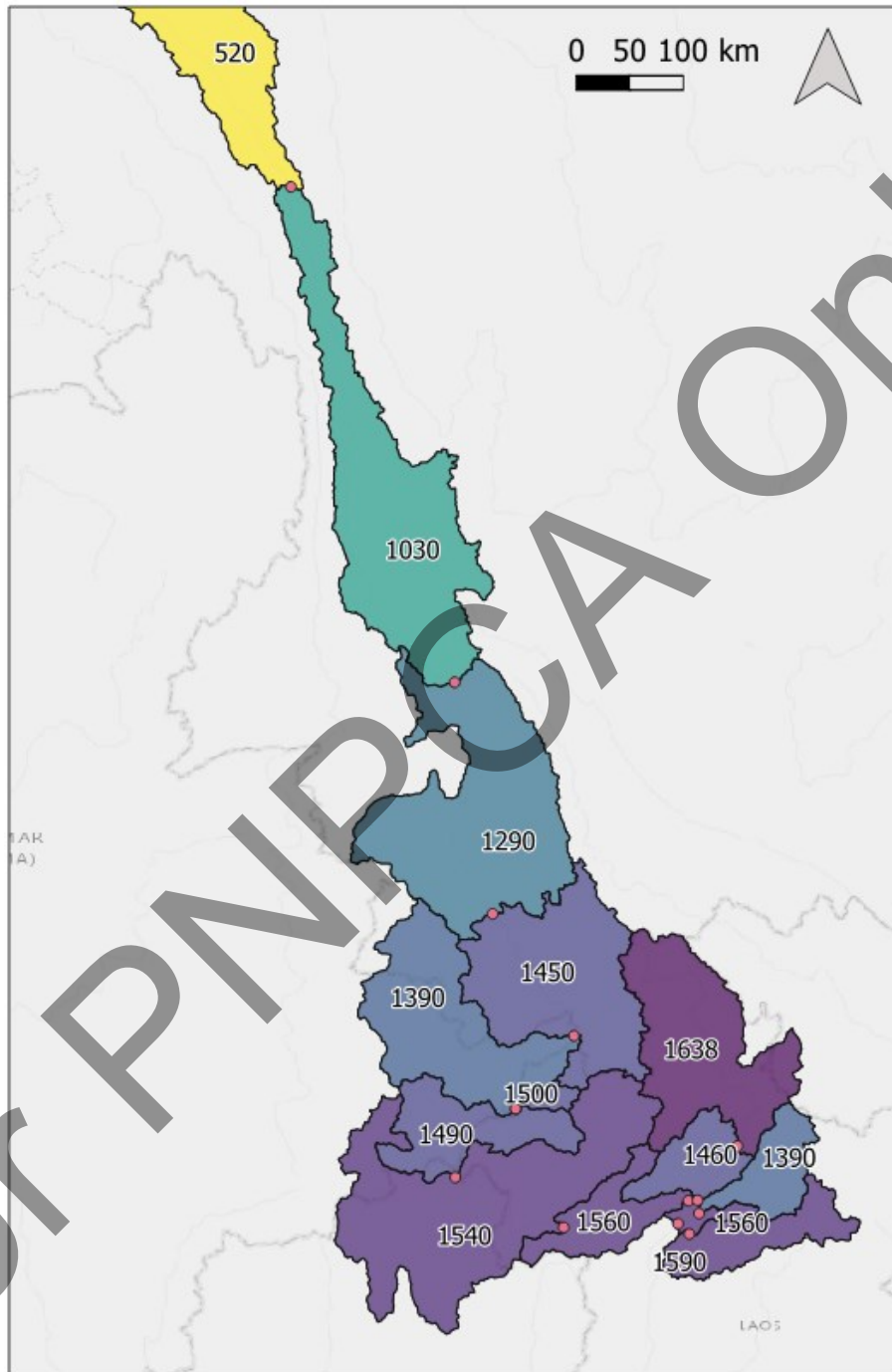
### 1.4 Precipitation input

#### 1.4.1 Correction of Aphrodite precipitation data with GPCC data



**Figure 3 Example of correction of Aphrodite precipitation data with GPC data (Daily Aphrodite data was corrected with the relation of monthly Aphrodite and GPC 0.25 data)**

**1.4.2 Mean annual precipitation**



**Figure 4 Mean annual precipitation in the sub-catchments [mm]**

## 1.5 Temperature input

### 1.5.1 Mean temperature in the sub-catchments

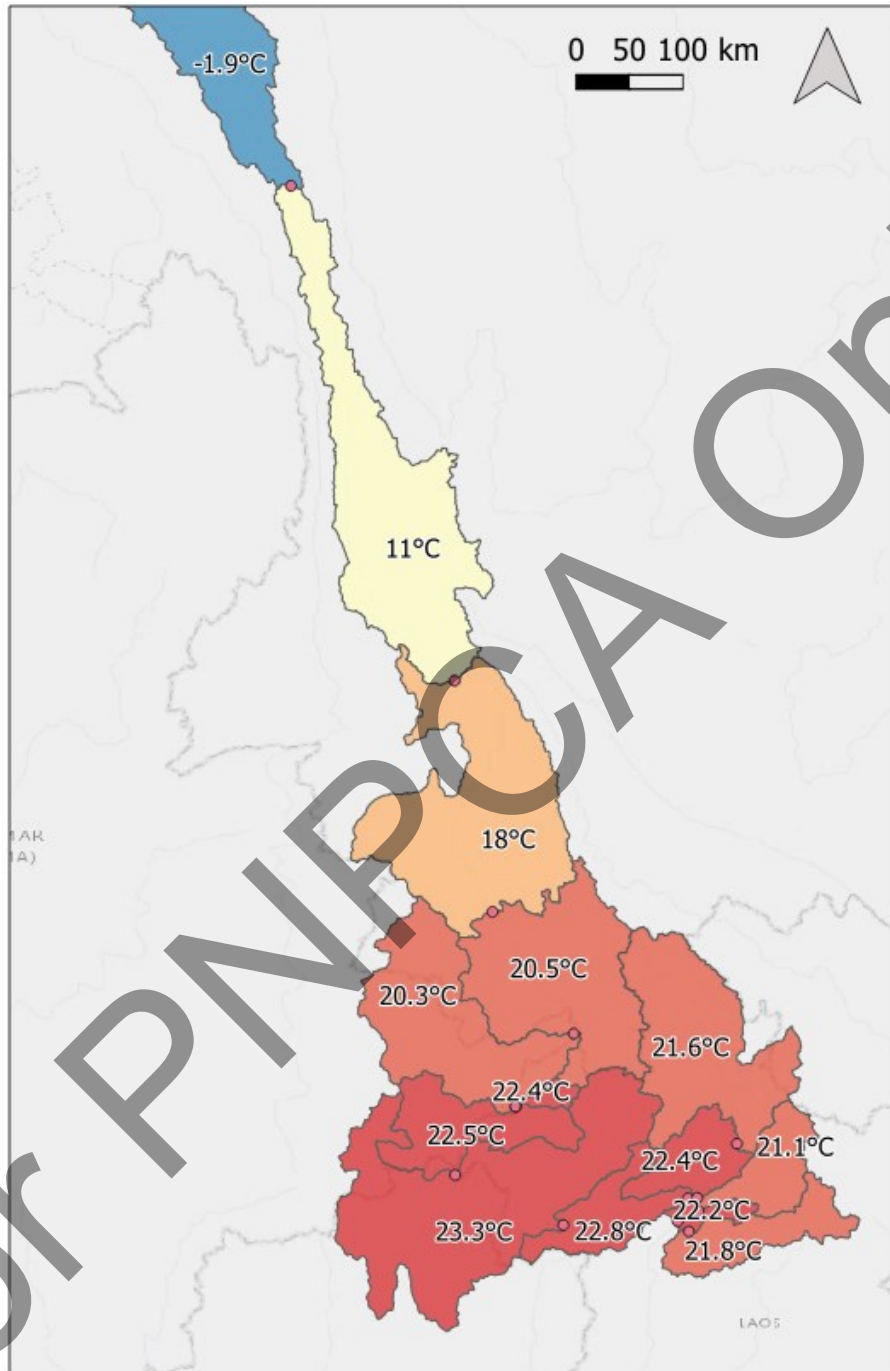


Figure 5 Mean temperature in the sub-catchments

### 1.5.2 Temperature gradient

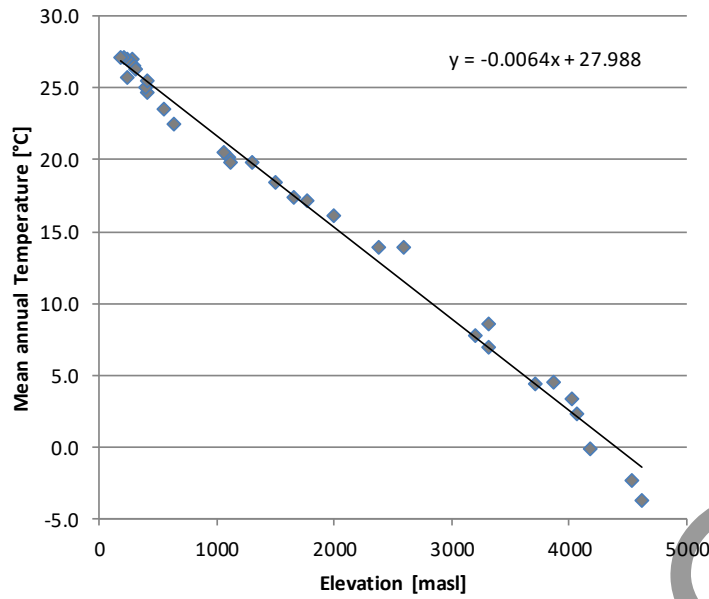


Figure 6 Temperature gradient 0.7°C/100m from station data in the catchment area

### 1.5.3 Daily temperature data

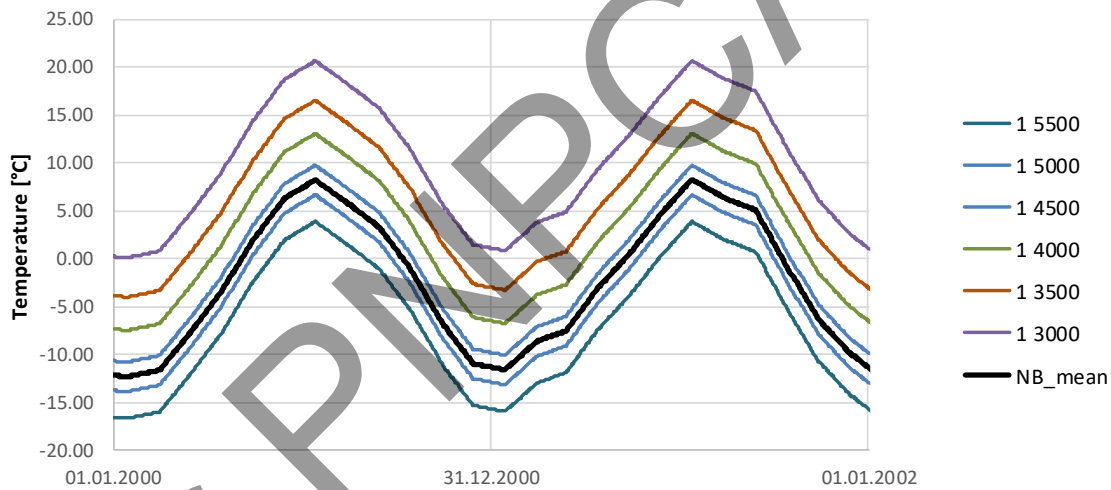


Figure 7 Calculation of the daily temperature time series for each HRU– Example for HRUs in sub-catchment 1 (years 2000-2001). Calculation is based on mean temperature in the sub-catchment and the temperature gradient. Daily mean sub-catchment temperature interpolated from CRU monthly temperature data (extended with interpolated GSOD station data) for each sub-catchment

## 1.6 Evapotranspiration

### 1.6.1 Estimation of evapotranspiration gradient from CRU dataset

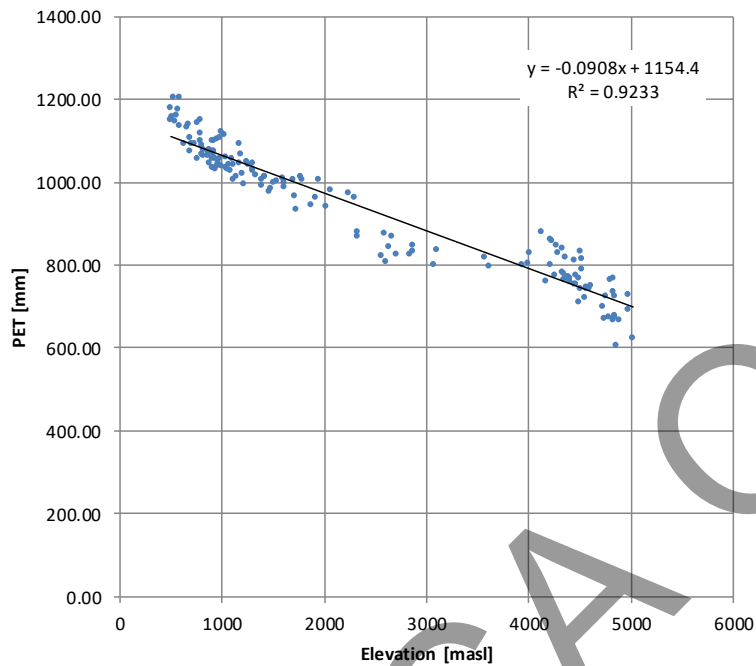


Figure 8 Evapotranspiration gradient from CRU dataset

### 1.6.2 Mean annual potential evapotranspiration (PET)

Table 4 Mean annual Evapotranspiration of each HRU (based on CRU dataset)

NB	Max. Elevation [m]	Mean Elevation [m]	Mean annual PET [mm]
1	3,000	2,732	906
1	3,500	3,321	853
1	4,000	3,818	808
1	4,500	4,291	765
1	5,000	4,732	725
1	5,500	5,131	688
1	6,000	5,555	650
2	1,500	1,355	1031
2	2,000	1,808	990
2	2,500	2,254	950
2	3,500	3,221	862
2	4,000	3,730	816
2	4,500	4,225	771
2	5,000	4,720	726
2	5,500	5,165	685
3	1,000	900	1073
3	1,500	1,270	1039

3	2,000	1,729	997
3	2,500	2,186	956
3	3,000	2,668	912
4	1,000	805	1081
4	1,500	1,217	1044
4	2,500	1,679	1002
5	1,000	744	1087
5	2,000	1,320	1035
6	500	469	1112
6	1,000	808	1081
6	1,500	1,233	1042
6	2,000	1,661	1004
6	2,500	2,121	962
7	500	425	1116
7	1,000	741	1087
7	1,500	1,239	1042
8			1089
9			1084
10			1072
11			1081
12			1076
13			1067
14			1090

### 1.6.3 Estimation of monthly share of evapotranspiration for SB 1 and 2

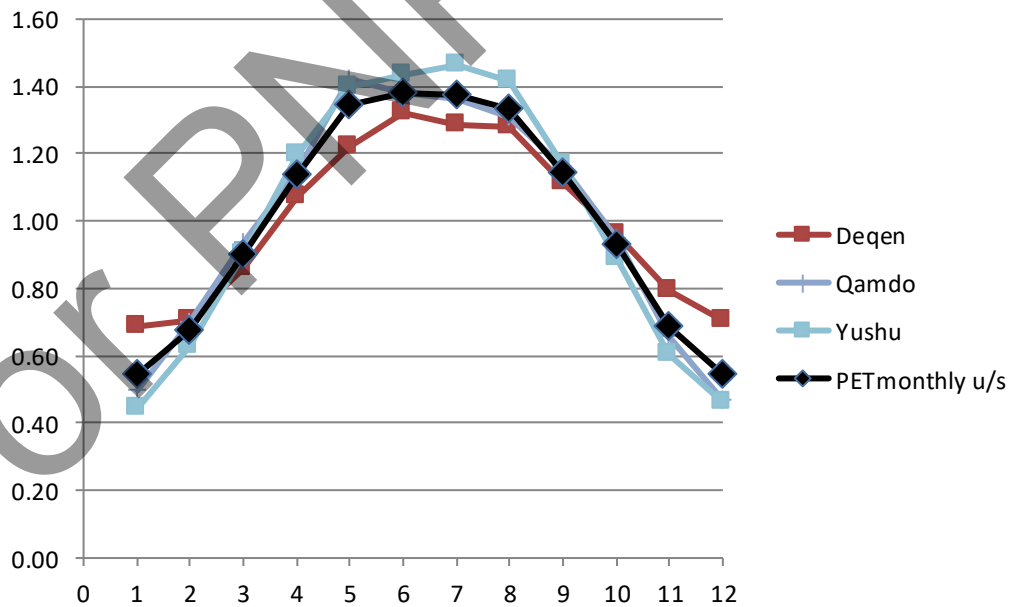


Figure 9 Monthly share of evapotranspiration for SB 1 and 2 (black line) from Climwat/ Cropwat stations (colored lines)

### 1.6.4 Estimation of monthly share of evapotranspiration for SB 3 to 14

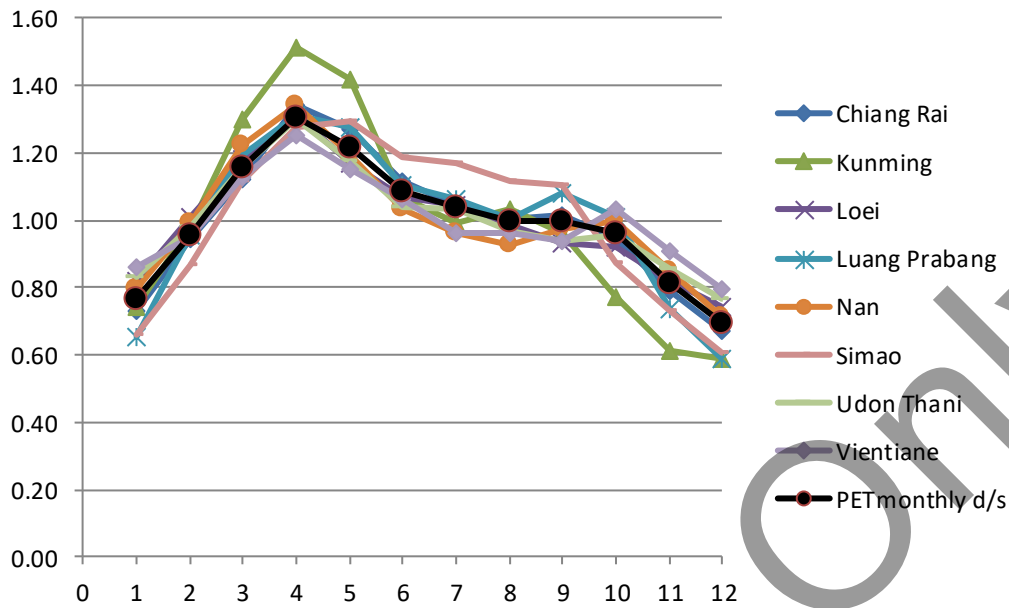


Figure 10 Monthly share of evapotranspiration for SB 3 to 14 (black line) from Climwat/Cropwat stations (colored lines)

### 1.7 Observed monthly discharge data

Table 5 Observed monthly discharge Chiang Saen (CP07)

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
1960					752	2,039	4,479	7,579	6,258	2,990	1,812	1,323	
1961	935	800	765	954	1,249	2,663	4,178	8,051	5,936	4,184	2,409	1,596	2,810
1962	1,106	920	729	796	1,220	3,375	4,120	8,786	5,636	3,439	1,959	1,196	2,773
1963	905	729	653	642	773	2,042	5,345	7,731	4,592	3,995	3,379	1,522	2,692
1964	1,072	876	808	923	1,387	2,139	6,318	7,359	6,642	4,487	2,421	1,554	2,999
1965	1,130	937	730	726	909	2,904	5,223	6,630	5,778	5,134	4,436	2,080	3,051
1966	1,426	1,050	834	838	1,151	3,145	6,150	10,991	11,573	6,041	2,999	1,802	4,000
1967	1,269	922	836	865	1,132	2,010	4,173	6,008	5,000	4,150	2,834	1,765	2,580
1968	1,416	1,133	880	936	1,585	2,437	4,373	6,549	6,089	5,375	3,305	1,613	2,974
1969	1,138	850	652	674	709	2,004	4,230	8,939	4,849	3,007	1,979	1,265	2,525
1970	961	791	733	913	1,813	2,908	6,941	9,236	5,143	3,331	2,543	2,585	3,158
1971	1,428	1,156	914	950	1,352	3,167	7,585	10,995	6,781	3,872	2,442	1,657	3,525
1972	1,251	976	846	935	1,103	1,598	2,904	4,822	3,538	2,679	2,309	2,162	2,093
1973	1,092	902	915	1,004	1,319	2,584	4,476	6,666	6,293	3,062	3,041	1,734	2,757
1974	1,197	924	807	1,019	1,285	2,409	4,361	7,100	6,546	3,397	2,389	1,485	2,743
1975	1,221	947	777	937	1,227	2,290	3,781	4,288	4,326	2,732	2,025	1,271	2,152
1976	1,022	929	842	962	1,333	2,616	3,858	6,419	4,603	3,516	2,214	1,460	2,481
1977	1,077	925	861	1,015	1,197	1,991	3,890	5,104	4,499	3,485	2,345	1,399	2,316
1978	1,224	960	822	872	1,700	2,944	5,236	6,870	5,255	3,709	1,823	1,245	2,722
1979	976	806	697	860	1,103	1,534	2,753	5,165	6,308	4,541	1,950	1,428	2,343
1980	1,076	923	845	1,029	1,242	2,475	4,941	7,135	5,757	4,911	2,236	1,443	2,834
1981	1,121	941	880	907	2,107	3,732	5,514	5,965	5,049	3,087	2,871	1,723	2,825
1982	1,229	1,019	807	979	1,018	2,480	4,100	6,293	4,059	3,833	1,926	1,298	2,420
1983	992	829	898	975	1,216	2,015	3,364	5,452	5,882	3,356	3,701	1,899	2,548



Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
1984	1,480	1,126	863	947	1,097	2,256	6,000	4,650	4,625	3,308	1,952	1,328	2,469
1985	1,075	900	776	948	1,333	3,563	5,306	6,116	7,640	4,100	3,281	1,840	3,073
1986	1,298	1,041	901	979	1,414	1,892	4,371	4,646	4,098	4,253	2,325	1,584	2,400
1987	1,341	1,136	972	1,012	1,089	1,870	2,933	5,273	5,856	3,910	2,600	1,601	2,466
1988	1,177	955	937	1,010	1,702	2,227	3,255	5,404	4,768	3,236	1,900	1,412	2,332
1989	1,051	871	803	809	1,216	2,068	3,618	4,765	4,127	5,066	2,500	1,620	2,376
1990	1,225	1,064	1,007	1,001	1,968	4,099	6,431	4,940	4,303	4,155	2,265	1,489	2,829
1991	1,134	928	846	1,051	1,399	3,007	5,358	8,094	5,784	4,443	3,162	1,842	3,087
1992	1,477	1,246	1,185	1,199	1,177	1,406	3,120	2,860	2,911	3,186	1,987	1,371	1,927
1993	636	552	482	495	733	1,297	3,411	5,209	5,035	3,261	1,992	1,259	2,030
1994	1,088	937	884	1,087	1,357	3,486	4,152	5,153	4,186	3,278	1,737	1,634	2,415
1995	1,144	921	1,049	622	1,688	2,595	5,637	7,455	6,260	4,469	2,962	1,955	3,063
1996	1,272	1,038	971	1,208	1,508	2,283	5,884	7,607	4,991	3,966	2,597	1,684	2,917
1997	1,067	790	718	738	996	1,676	5,037	4,315	4,788	4,250	1,813	1,195	2,282
1998	938	731	655	912	1,497	1,633	5,994	7,077	5,777	2,712	1,711	1,085	2,560
1999	907	717	702	645	1,035	2,114	4,048	5,545	6,869	3,448	3,505	1,634	2,597
2000	1,116	998	920	1,148	2,108	3,484	6,869	6,356	7,449	3,876	2,457	1,523	3,192
2001	1,112	908	912	820	1,842	4,154	6,938	6,320	6,466	4,227	3,675	1,934	3,276
2002	1,385	1,070	901	909	1,998	2,286	6,420	8,408	3,425	3,027	2,226	1,620	2,806
2003	1,427	1,049	860	786	1,020	2,134	3,816	4,304	5,227	2,527	1,417	892	2,121
2004	816	741	551	970	1,673	2,457	4,710	5,464	6,049	3,828	1,887	1,271	2,535
2005	1,012	777	985	1,133	1,235	2,143	3,503	5,891	4,029	3,006	2,282	1,421	2,285
2006	1,108	820	747	592	1,262	3,127	5,238	5,975	5,152	7,091	2,189	1,292	2,883
2007	1,020	902	690	1,024	1,839	1,960	4,206	6,714	7,460	4,840	2,819	1,657	2,928
2008	1,681	1,578	1,476	1,442	2,551	4,569	8,965	14,174	11,146	6,533	6,121	2,940	5,265
2009	1,479	1,110	919	1,184	1,444	2,114	3,591	4,886	4,353	2,435	1,681	1,417	2,218
2010	1,545	881	979	1,338	1,530	2,226	3,647	4,754	4,678	4,055	2,443	1,873	2,496
2011	1,441	1,073	1,345	1,372	2,152	3,029	4,464	5,387	5,289	3,075	2,127	1,528	2,690
2012	1,174	809	749	727	931	1,207	2,928	5,461	3,899	3,016	1,864	1,634	2,033
2013	1,593	1,475	1,182	1,407	1,723	1,775	2,568	4,192	3,657	2,993	3,357	3,035	2,413
2014	2,286	1,968	2,497	2,208	2,478	2,066	2,832	3,694	3,851	3,152	2,429	2,486	2,662
2015	1,654	1,158	2,144	2,234	1,541	2,543	2,898	4,531	3,274	2,134	1,694	1,397	2,267
2016	1,506	1,168	1,781	1,693	1,599	1,545	2,124	3,812	3,117	2,064	2,732	2,014	2,096
2017	1,613	2,013	2,415	2,120	2,483	1,922	2,855	3,935	4,709	2,897	3,161	2,579	2,725
2018	2,243	1,534	1,535	2,350	2,767	2,619	3,460	5,321	5,582	4,282			
MIN	636	552	482	495	709	1,207	2,124	2,860	2,911	2,064	1,417	892	
MEAN	1,238	1,004	963	1,049	1,445	2,446	4,557	6,251	5,377	3,770	2,521	1,647	
MAX	2,286	2,013	2,497	2,350	2,767	4,569	8,965	14,174	11,573	7,091	6,121	3,035	

Table 6 Observed monthly discharge Muong Ngoy (CP10)

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
1988	137	125	119	132	302	486	380	1,197	752	340	174	153	358
1989	161	133	133	122	252	615	494	733	399	234	256	147	307
1990	142	130	137	125	322	822	1,515	777	504	331	229	157	433
1991	142	132	121	130	133	640	1,241	1,216	557	501	267	179	438
1992	159	138	129	120	129	210	597	372	358	262	179	171	235
1993	145	130	121	121	142	183	635	606	542	263	171	176	270
1994	128	117	120	122	149	610	2,211	1,578	763	675	372	253	592

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
1995	128	117	121	149	136	786	966	1,736	728	470	245	177	480
1996	151	137	135	137	174	277	1,160	2,300	1,033	508	291	224	544
1997	173	150	149	180	137	191	1,208	1,173	1,254	645	286	205	479
1998	164	144	125	165	176	445	986	759	739	248	201	159	359
1999	149	131	122	134	225	466	911	1,448	1,318	458	342	192	491
2000	161	136	125	171	220	350	1,556	891	906	343	237	178	440
2001	149	137	140	138	351	744	1,601	1,160	766	497	423	205	526
2002	164	149	140	133	305	561	2,289	2,159	785	427	264	226	633
2003	317	180	161	148	138	233	323	946	800	246	293	248	336
2004	163	126	121	160	379	253	979	1,230	1,488	564	249	180	491
2005	149	125	134	140	144	348	818	1,713	558	408	347	183	422
2006	148	127	117	111	147	246	963	1,444	673	587	220	165	412
2007	138	132	121	158	210	268	610	1,092	806	314	175	153	348
2008	146	152	142	146	181	604	1,505	1,811	1,553	994	681	203	676
2009	182	152	134	181	208	290	1,194	1,093	746	346	208	162	408
2010	145	125	133	205	200	217	393	812	666	356	185	151	299
2011	140	125	140	133	213	327	1,061	893	1,078	409	267	178	414
2012	177	146	135	135	162	365	1,055	1,602	741	318	229	206	439
2013	161	155	139	146	195	237	985	1,504	1,245	396	206	396	480
2014	187	174	152	115	145	182	1,029	1,187	825	391	283	151	402
2015	153	106	104	137	135	207	690	1,367	1,024	366			
MIN	128	106	104	111	129	182	323	372	358	234	171	147	
MEAN	159	137	131	143	200	399	1,048	1,243	843	425	270	192	
MAX	317	180	161	205	379	822	2,289	2,300	1,553	994	681	396	

Table 7 Observed monthly discharge Ban Hat Nga (CP11)

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
2015								1,604	1,150	507	240	181	
2016	140	163	131	103	194	302	558	1,495	1,050	738	386	79	445
2017	105	122	146	190	199	183	835	1,552	1,164	546	562	379	499
2018	249	168	183	204	252	659	1,450	2,960	2,145				
MIN	105	122	131	103	194	183	558	1,495	1,050	507	240	79	
MEAN	165	151	154	166	215	382	948	1,903	1,377	597	396	213	
MAX	249	168	183	204	252	659	1,450	2,960	2,145	738	562	379	

Table 8 Observed monthly discharge Ban Sibounhom (CP12)

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
2015								274	206	118	74	71	
2016	62	53	44	40	51	67	116	549	300	120	82	59	129
2017	58	39	31	38	35	49	158	228	167	73	51	43	81
2018	38	34	30	32	37	484	549	848	609				
MIN	38	34	30	32	35	49	116	228	167	73	51	43	
MEAN	53	42	35	37	41	200	274	475	320	104	69	58	
MAX	62	53	44	40	51	484	549	848	609	120	82	71	

**Table 9 Observed monthly discharge Ban Mixay (CP13)**

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
<b>2015</b>								57	118	105	80	55	
<b>2016</b>	39	32	29	43	60	41	100	530	354	135	90	69	127
<b>2017</b>	37	70	75	67	67	62	144	177	165	126	111	60	97
<b>2018</b>	73	73	76	80	69	97	463	704	393				
<b>MIN</b>	37	32	29	43	60	41	100	57	118	105	80	55	
<b>MEAN</b>	50	58	60	63	65	67	236	367	257	122	94	61	
<b>MAX</b>	73	73	76	80	69	97	463	704	393	135	111	69	

**Table 10 Observed monthly discharge Luang Prabang (CP14)**

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
<b>1960</b>					1,164	2,601	6,146	11,820	10,121	4,636	2,659	2,190	
<b>1961</b>	1,527	1,261	1,065	1,328	1,625	3,977	5,417	10,893	11,622	6,898	3,697	2,495	<b>4,317</b>
<b>1962</b>	1,830	1,453	1,139	1,162	1,740	4,658	5,915	11,509	7,851	4,663	2,825	1,865	<b>3,884</b>
<b>1963</b>	1,381	1,162	1,058	1,005	1,111	2,565	7,470	12,532	7,824	5,469	6,099	2,639	<b>4,193</b>
<b>1964</b>	1,786	1,367	1,193	1,315	1,909	2,868	9,922	11,513	10,805	6,418	3,623	2,530	<b>4,604</b>
<b>1965</b>	1,822	1,471	1,145	1,093	1,225	3,485	6,794	8,664	7,976	6,234	6,637	3,348	<b>4,158</b>
<b>1966</b>	2,165	1,658	1,254	1,171	1,498	3,996	7,763	14,726	16,300	7,888	4,380	2,810	<b>5,467</b>
<b>1967</b>	2,107	1,649	1,395	1,278	1,481	2,442	4,433	7,582	7,143	5,554	3,516	2,357	<b>3,411</b>
<b>1968</b>	1,762	1,294	1,059	1,014	1,657	2,707	5,104	8,175	8,148	6,231	4,003	2,143	<b>3,608</b>
<b>1969</b>	1,497	1,108	899	865	921	2,643	5,470	12,854	7,016	3,996	2,952	1,878	<b>3,508</b>
<b>1970</b>	1,314	968	859	1,014	2,131	4,038	9,341	12,990	8,807	4,905	3,377	3,364	<b>4,426</b>
<b>1971</b>	2,015	1,514	1,109	1,057	1,465	3,595	10,223	16,906	11,304	5,630	3,888	2,520	<b>5,102</b>
<b>1972</b>	1,935	1,474	1,124	1,309	1,445	2,190	3,956	9,907	6,793	5,420	4,062	3,698	<b>3,609</b>
<b>1973</b>	1,875	1,334	1,333	1,173	1,742	3,675	7,573	12,129	13,184	6,246	4,772	2,997	<b>4,836</b>
<b>1974</b>	1,841	1,318	1,020	1,271	1,609	3,123	5,063	9,527	10,399	5,357	3,450	2,078	<b>3,838</b>
<b>1975</b>	1,795	1,186	888	984	1,247	3,193	5,356	7,354	8,442	4,915	3,368	2,077	<b>3,401</b>
<b>1976</b>	1,389	1,199	915	1,006	1,482	3,224	5,209	11,436	7,254	5,740	3,669	2,240	<b>3,730</b>
<b>1977</b>	1,549	1,127	959	1,233	1,583	2,323	6,127	8,614	8,232	6,326	4,278	2,475	<b>3,736</b>
<b>1978</b>	2,152	1,394	1,147	1,067	2,296	4,107	8,628	12,036	9,791	6,844	3,448	2,225	<b>4,595</b>
<b>1979</b>	1,606	1,215	941	989	1,473	2,590	4,024	8,217	10,093	6,857	3,232	2,235	<b>3,623</b>
<b>1980</b>	1,500	1,116	929	1,063	1,383	3,165	7,343	11,210	11,074	7,390	3,741	2,485	<b>4,367</b>
<b>1981</b>	1,786	1,367	1,124	1,122	2,841	5,601	8,431	10,545	9,422	5,853	5,008	3,205	<b>4,692</b>
<b>1982</b>	2,151	1,562	1,106	1,404	1,325	3,574	5,746	11,798	7,662	7,160	3,813	2,486	<b>4,149</b>
<b>1983</b>	1,730	1,309	1,248	1,208	1,481	2,562	4,183	8,126	9,834	5,822	5,687	3,121	<b>3,859</b>
<b>1984</b>	2,378	1,592	1,106	1,101	1,343	2,872	8,368	8,548	8,435	5,818	3,533	2,005	<b>3,925</b>
<b>1985</b>	1,450	1,175	910	1,024	1,566	3,791	6,076	9,840	11,621	5,391	5,005	2,945	<b>4,233</b>
<b>1986</b>	2,235	1,716	1,214	1,028	1,958	2,665	5,654	7,384	6,181	5,669	3,250	2,082	<b>3,420</b>
<b>1987</b>	1,621	1,279	1,051	937	974	1,864	3,405	6,359	7,597	5,662	3,497	2,117	<b>3,030</b>
<b>1988</b>	1,498	1,051	917	1,146	2,101	2,680	4,312	9,109	7,346	4,693	2,748	1,945	<b>3,295</b>
<b>1989</b>	1,289	979	884	874	1,351	2,948	4,887	7,034	6,055	6,702	3,490	2,042	<b>3,211</b>
<b>1990</b>	1,391	1,093	1,017	892	1,899	5,167	8,714	8,344	6,506	5,519	3,280	1,951	<b>3,814</b>
<b>1991</b>	1,487	1,150	1,022	1,309	1,631	3,796	7,701	11,824	8,968	6,472	4,357	2,552	<b>4,356</b>
<b>1992</b>	1,855	1,408	1,288	1,368	1,300	1,597	3,687	3,934	3,911	3,941	2,722	1,983	<b>2,416</b>
<b>1993</b>	1,436	1,122	991	977	1,345	1,871	5,574	8,119	8,712	5,395	3,558	2,066	<b>3,431</b>
<b>1994</b>	1,414	1,125	1,023	1,270	1,527	4,580	7,642	10,612	8,672	5,691	2,693	2,447	<b>4,058</b>
<b>1995</b>	1,648	1,260	1,192	895	1,613	2,894	6,628	12,039	9,725	6,021	3,628	2,414	<b>4,163</b>

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
1996	1,645	1,358	1,134	1,293	1,738	2,529	7,222	12,639	7,839	5,355	3,535	2,276	4,047
1997	1,608	1,151	996	1,072	1,310	1,900	6,848	7,953	8,972	7,011	3,150	2,114	3,674
1998	1,479	1,100	889	1,211	1,774	2,222	7,837	9,348	8,793	3,830	2,659	1,777	3,576
1999	1,395	1,033	914	859	1,437	3,182	5,443	8,231	11,830	5,457	5,154	2,625	3,963
2000	1,749	1,379	1,212	1,361	2,861	4,816	10,487	9,480	11,755	5,599	3,602	2,368	4,723
2001	1,701	1,273	1,241	1,026	2,380	5,616	10,864	11,501	10,463	6,489	5,799	2,938	5,107
2002	2,163	1,641	1,377	1,216	2,636	3,492	13,194	17,732	6,717	5,001	3,608	2,956	5,144
2003	2,424	1,686	1,342	1,194	1,345	2,430	4,814	6,593	8,224	3,994	2,300	1,411	3,146
2004	1,124	980	793	1,098	2,200	3,248	18,207	10,442	11,505	6,339	3,077	2,098	5,093
2005	1,530	1,135	1,225	1,349	1,400	2,516	5,204	11,481	7,799	5,048	3,648	2,119	3,705
2006	1,527	1,142	1,012	910	1,424	2,818	5,767	9,655	7,444	7,274	3,128	1,903	3,667
2007	1,393	1,118	917	1,138	2,031	2,254	4,419	8,530	9,954	6,164	3,506	2,030	3,621
2008	1,342	1,305	1,145	1,131	1,798	3,792	9,348	17,031	11,103	5,955	5,011	2,347	5,109
2009	1,744	1,267	1,060	1,329	1,485	2,235	6,628	7,577	6,746	3,561	2,163	1,607	3,117
2010	1,287	929	904	1,110	1,356	1,865	3,809	7,215	7,213	5,096	2,744	1,786	2,943
2011	1,375	1,158	1,333	1,371	2,318	3,430	6,869	8,787	9,429	4,802	2,910	1,873	3,805
2012	1,504	1,081	969	995	1,271	1,819	4,437	10,687	6,497	4,140	2,638	2,003	3,170
2013	1,662	1,543	1,348	1,335	1,706	2,015	4,144	8,860	7,411	4,057	3,887	3,709	3,473
2014	2,389	1,808	2,206	1,953	2,238	2,109	4,239	6,590	7,228	4,493	3,012	2,644	3,409
2015	1,986	1,426	2,090	2,283	1,784	2,686	3,892	7,899	5,963	3,293	2,275	1,855	3,119
2016	1,669	1,451	1,817	1,786	1,839	2,034	3,196	8,122	6,519	3,456	3,613	2,404	3,159
2017	2,109	2,002	2,509	2,451	2,772	2,276	4,900	7,602	7,539	4,587	3,999	3,021	3,814
2018	2,849	1,998	1,932	2,760	3,427	3,707	6,218	11,081	9,634	5,625			
MIN	1,124	929	793	859	921	1,597	3,196	3,934	3,911	3,293	2,163	1,411	
MEAN	1,722	1,318	1,170	1,227	1,711	3,061	6,547	9,987	8,770	5,526	3,679	2,377	
MAX	2,849	2,002	2,509	2,760	3,427	5,616	18,207	17,732	16,300	7,888	6,637	3,709	

## 1.8 Simulated and observed discharge for the calibration period

### 1.8.1 Daily discharge

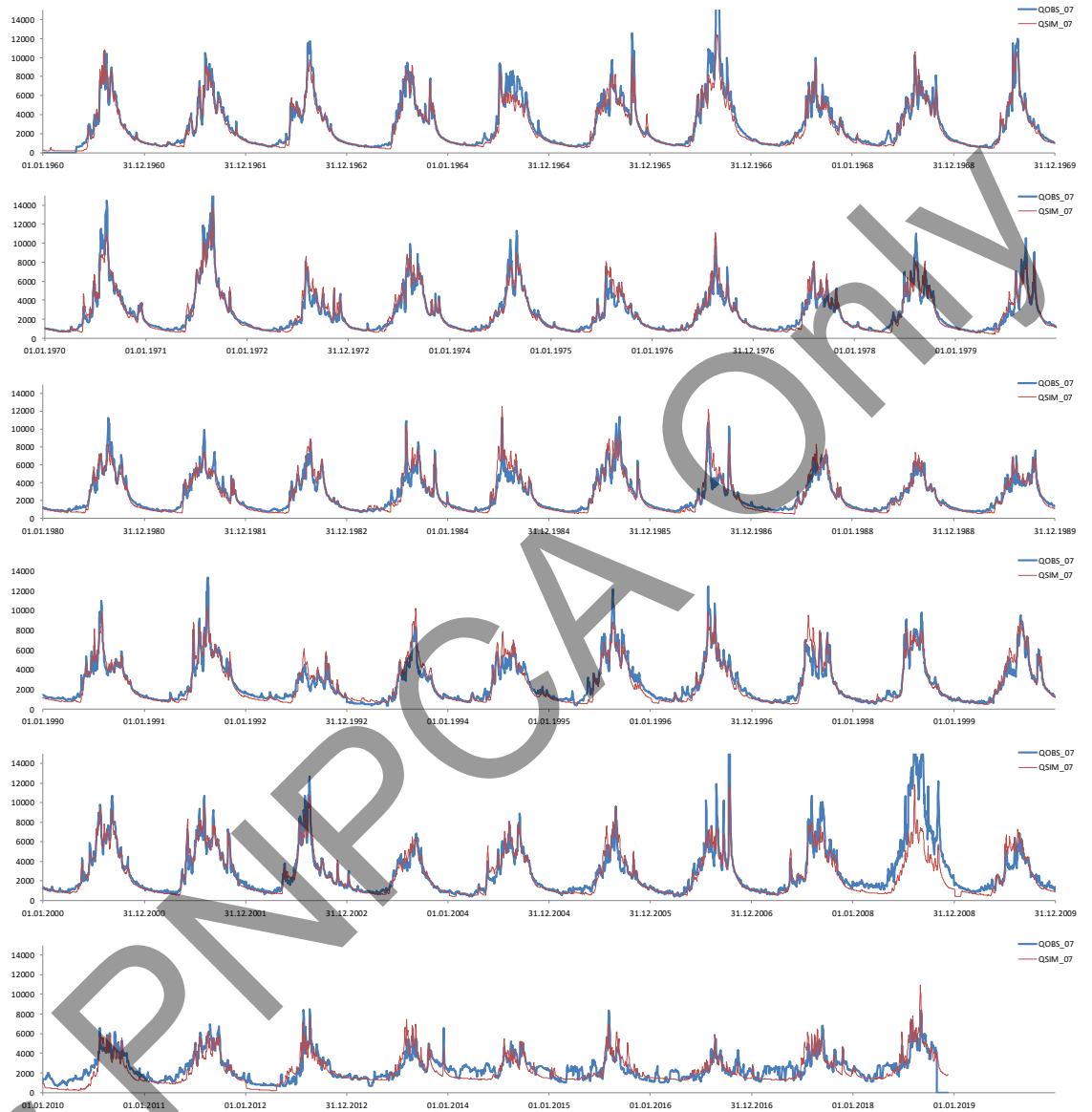


Figure 11 Comparison simulated und observed discharge at Chiang Saen

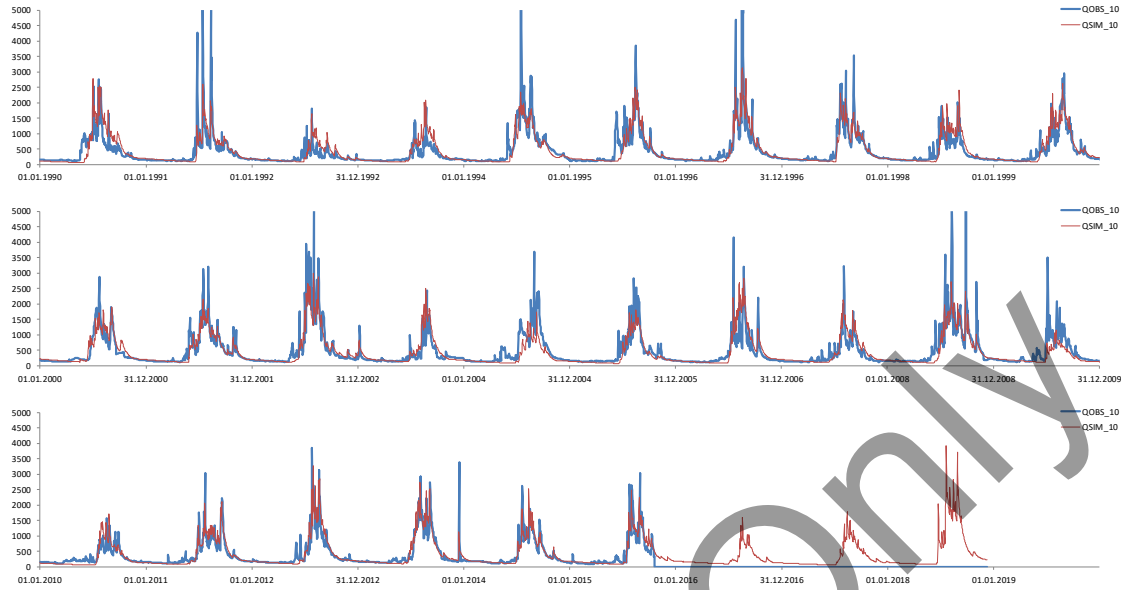


Figure 12 Comparison simulated und observed discharge at Muong Ngoy

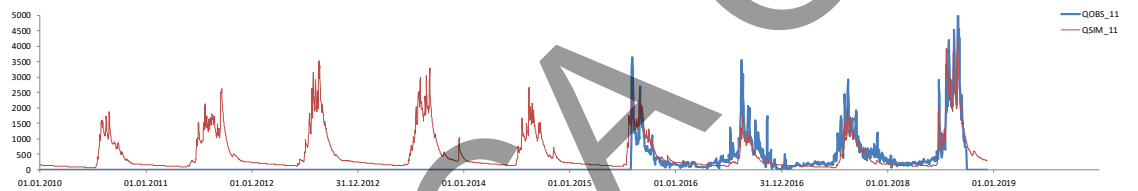


Figure 13 Comparison simulated und observed discharge at Ban Hat Nga

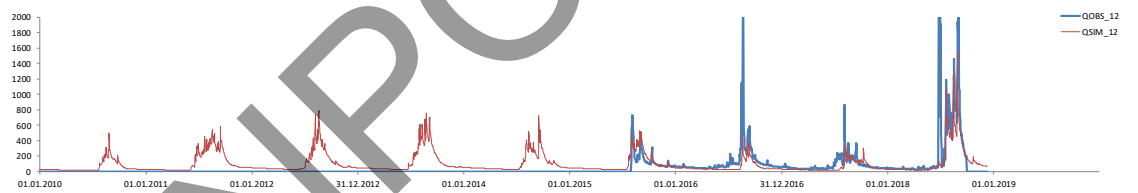


Figure 14 Comparison simulated und observed discharge at Ban Sibounhom

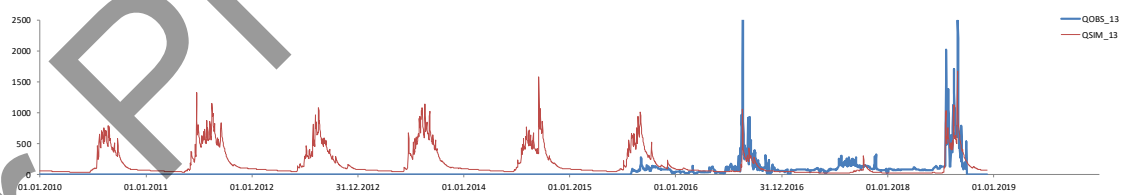


Figure 15 Comparison simulated und observed discharge at Ban Mixay

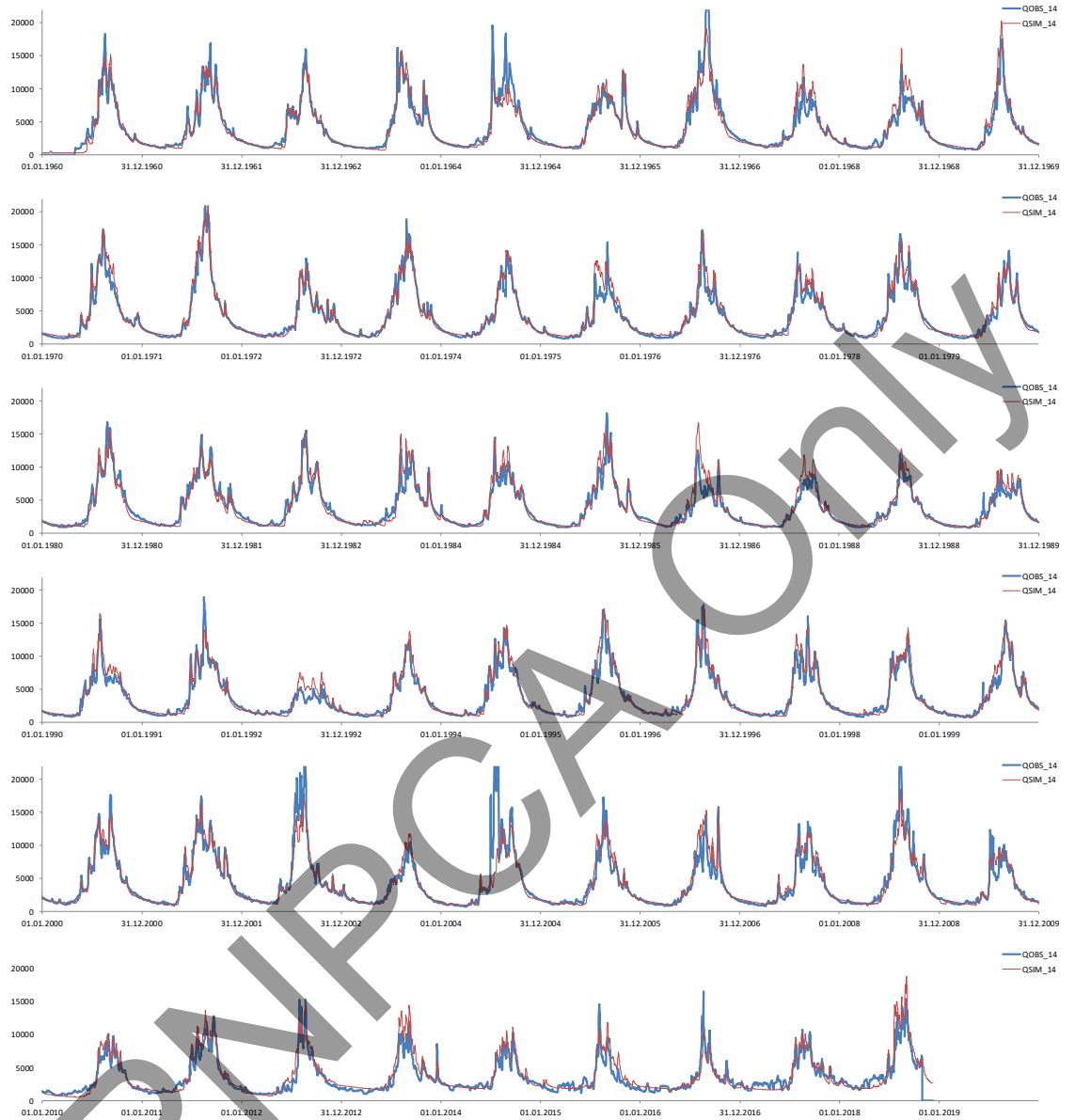


Figure 16 Comparison simulated und observed discharge at Luang Prabang

### 1.8.2 Annual discharge

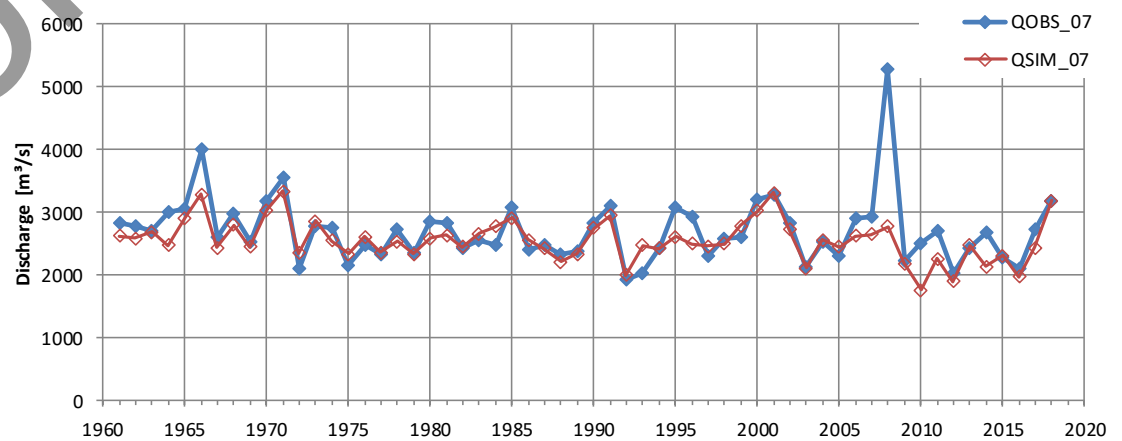


Figure 17 Comparison simulated und observed annual mean discharge at Chiang Saen

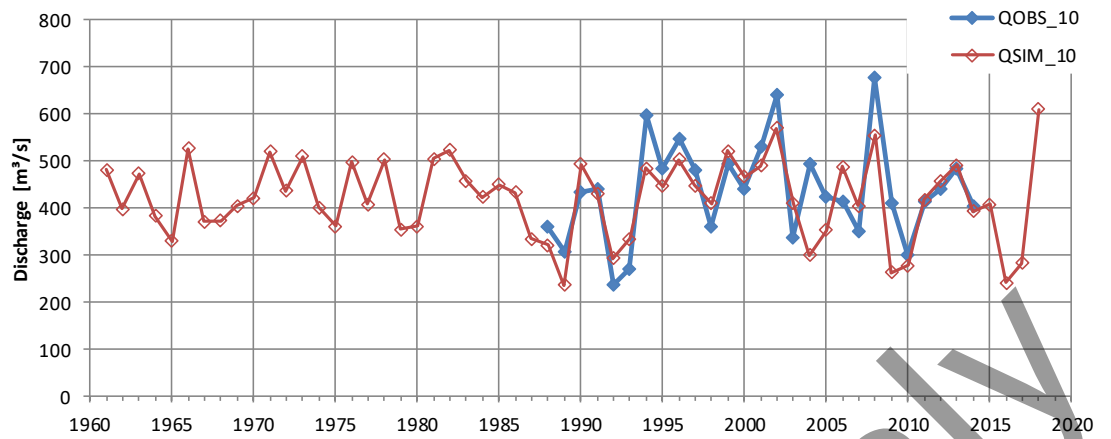


Figure 18 Comparison simulated und observed annual mean discharge at Muong Ngoy

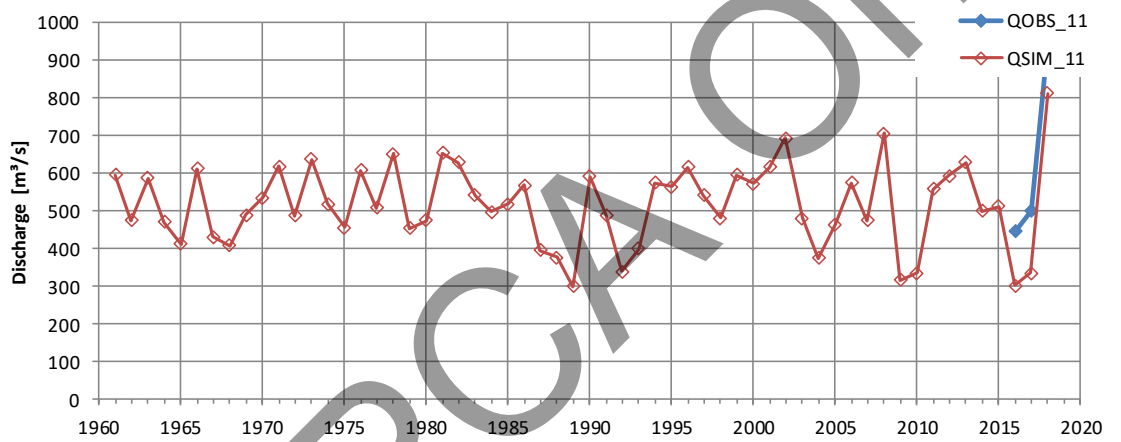


Figure 19 Comparison simulated und observed annual mean discharge at Ban Hat Nga

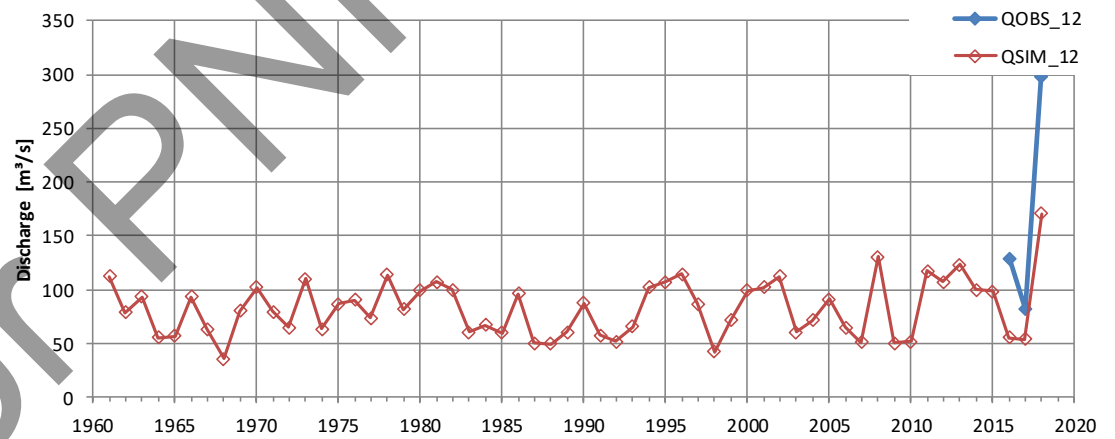


Figure 20 Comparison simulated und observed annual mean discharge at Ban Sibounhom



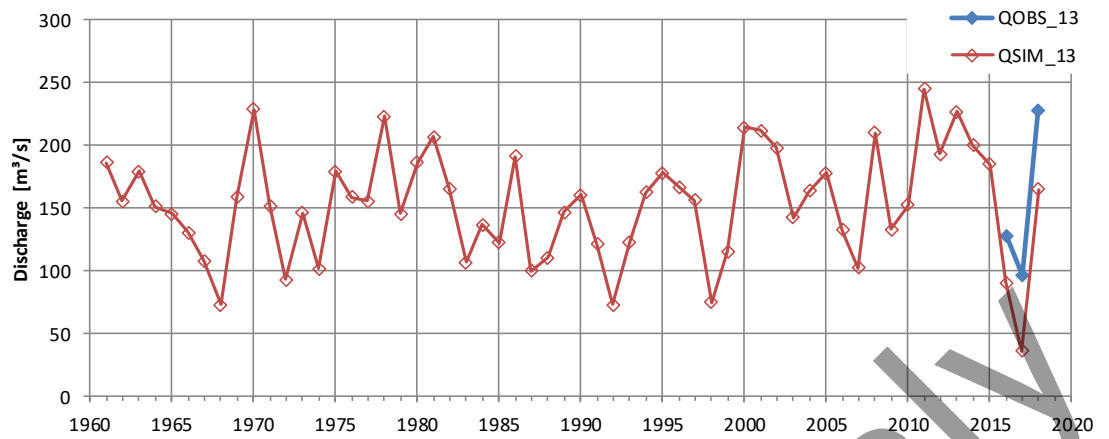


Figure 21 Comparison simulated und observed annual mean discharge at Ban Mixay

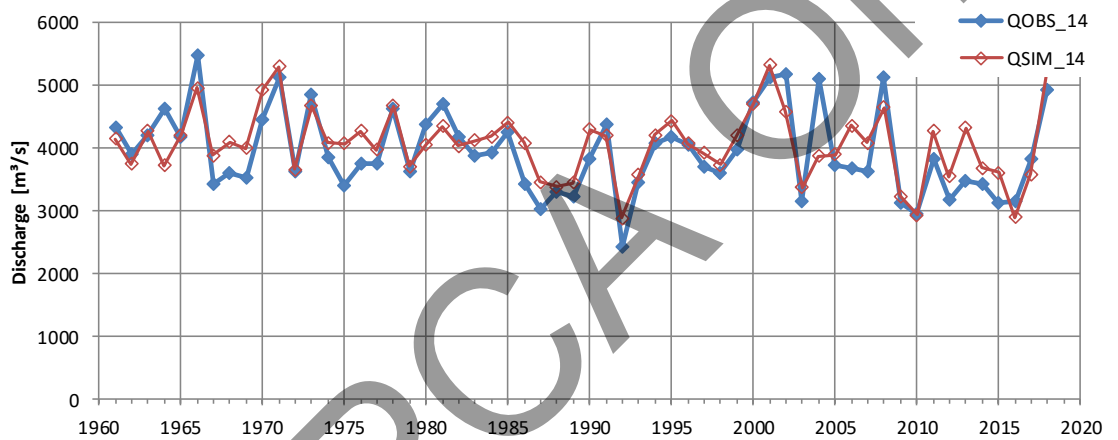


Figure 22 Comparison simulated und observed annual mean discharge at Luang Prabang

### 1.8.3 Flow duration curves

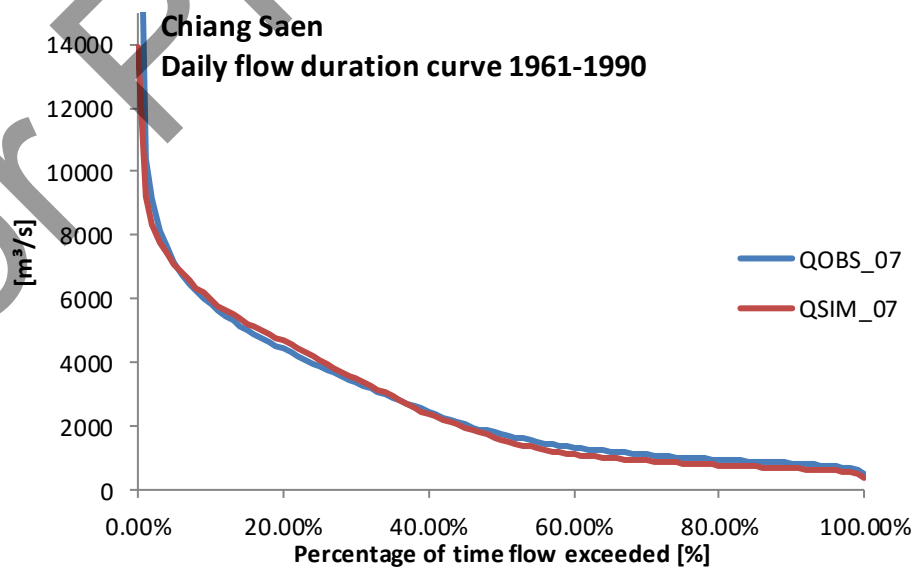


Figure 23 Simulated and observed flow duration curves of Chiang Saen gauge

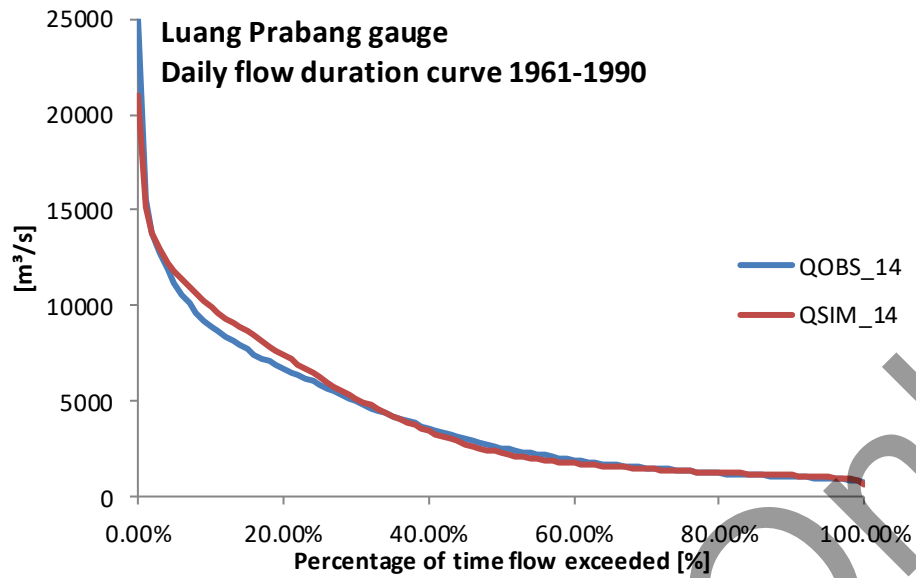


Figure 24 Simulated and observed flow duration curves of Luang Prabang gauge

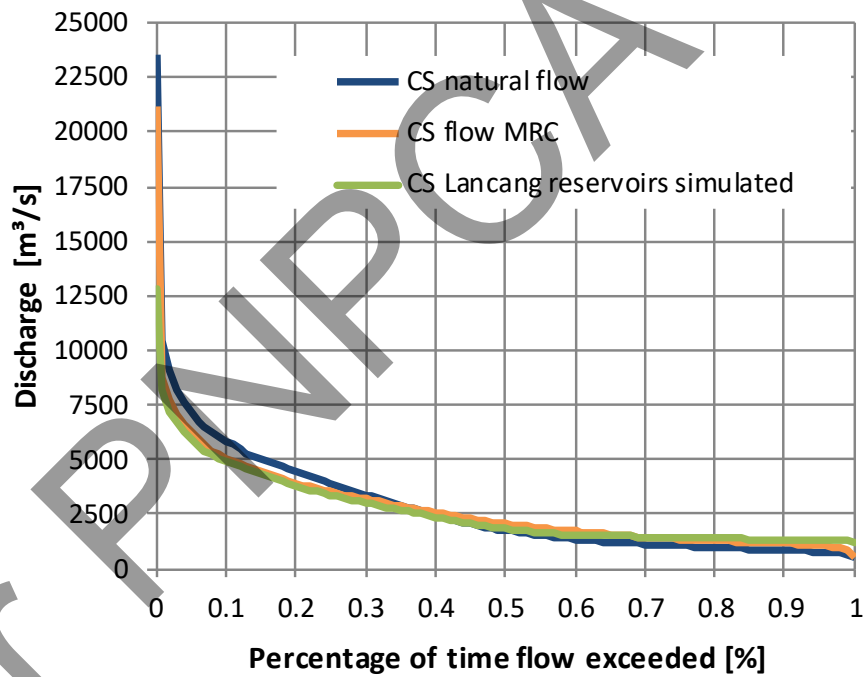


Figure 25 Comparison of flow duration curves of natural flow, flow influenced by Lancang cascade and flow as predicted by MRC

## 1.9 Results

### 1.9.1 Monthly discharge Luang Prabang HPP

**Table 11 Mean monthly discharge Luang Prabang HPP assuming Lancang cascade in operation during the full period 1951 - 2018**

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
1951	1,220	1,194	1,185	1,182	1,255	3,229	5,822	8,411	6,805	5,488	2,539	2,189	3,377
1952	1,883	1,760	1,659	1,567	1,613	2,687	4,971	8,577	8,499	5,567	2,775	2,039	3,633
1953	1,850	1,739	1,641	1,556	1,940	3,202	5,066	7,005	7,717	4,892	2,948	2,006	3,464
1954	1,851	1,736	1,634	1,550	1,884	3,495	3,404	4,965	8,431	4,685	2,251	1,846	3,144
1955	1,731	1,629	1,540	1,476	1,529	3,422	5,943	12,054	8,905	3,890	4,085	2,261	4,039
1956	1,918	1,788	1,674	1,578	2,080	4,194	5,611	8,677	6,378	3,987	2,487	1,964	3,528
1957	1,823	1,705	1,611	1,573	1,510	3,036	4,150	5,382	7,608	6,510	2,461	1,869	3,270
1958	1,753	1,660	1,565	1,490	1,468	2,097	4,756	7,182	6,669	3,842	2,436	1,887	3,067
1959	1,810	1,687	1,594	1,520	1,876	4,343	4,111	6,930	6,912	5,091	3,107	1,989	3,414
1960	1,848	1,757	1,629	1,540	1,498	1,962	3,984	7,393	7,811	3,996	2,351	2,214	3,165
1961	1,807	1,703	1,602	1,525	1,623	2,574	3,099	6,844	7,627	4,994	2,689	2,148	3,186
1962	1,862	1,704	1,607	1,523	1,575	2,493	2,905	7,802	6,252	4,105	2,296	1,723	2,987
1963	1,624	1,536	1,462	1,399	1,351	2,013	3,816	7,263	6,367	5,337	5,475	2,273	3,326
1964	1,870	1,743	1,640	1,556	1,648	2,225	4,881	4,983	5,922	4,971	2,614	2,081	3,011
1965	1,782	1,668	1,579	1,501	1,531	3,212	3,997	6,040	6,901	5,659	5,374	2,673	3,493
1966	1,991	1,784	1,672	1,579	1,679	3,657	4,616	10,017	11,072	5,837	2,992	2,094	4,083
1967	1,885	1,762	1,665	1,589	1,647	2,286	3,754	6,417	7,043	5,192	3,272	2,366	3,240
1968	2,078	1,836	1,703	1,614	1,652	2,686	4,143	6,848	8,181	5,947	3,818	2,084	3,549
1969	1,872	1,748	1,638	1,546	1,493	2,900	4,391	9,798	5,455	3,375	2,426	1,889	3,211
1970	1,767	1,660	1,570	1,493	2,362	4,064	6,148	9,680	8,307	4,357	2,689	3,195	3,941
1971	2,049	1,832	1,722	1,630	1,947	3,325	7,746	12,471	9,300	5,113	3,515	2,260	4,409
1972	2,039	1,880	1,749	1,654	1,608	1,931	2,962	6,150	4,642	4,130	3,796	3,179	2,977
1973	1,905	1,745	1,727	1,602	1,965	2,888	4,797	8,012	8,941	4,660	3,734	2,229	3,684
1974	1,887	1,761	1,655	1,582	2,018	2,851	3,201	6,879	9,096	4,606	2,829	2,002	3,364
1975	1,919	1,730	1,635	1,566	1,601	2,753	5,423	6,692	6,757	4,577	2,784	1,981	3,285
1976	1,841	1,761	1,640	1,563	1,861	2,829	3,113	8,149	7,091	5,304	3,134	2,079	3,364
1977	1,860	1,747	1,643	1,573	1,683	1,911	4,471	5,445	6,435	5,706	3,544	2,110	3,177
1978	2,130	1,808	1,707	1,618	1,859	2,390	5,864	7,560	8,817	5,283	2,414	2,034	3,624
1979	1,889	1,761	1,653	1,559	1,627	2,669	3,543	5,729	5,150	5,343	2,350	1,814	2,924
1980	1,701	1,605	1,517	1,441	1,418	2,359	4,723	6,226	8,198	5,461	2,408	1,827	3,240
1981	1,716	1,628	1,544	1,478	2,253	3,495	4,943	7,209	6,106	3,423	3,581	2,324	3,308
1982	1,843	1,717	1,613	1,563	1,529	2,382	3,173	6,743	6,266	5,539	2,493	2,054	3,076
1983	1,792	1,684	1,597	1,508	1,454	1,807	2,679	6,944	8,294	4,976	5,015	2,446	3,350
1984	2,019	1,770	1,663	1,571	1,548	2,582	6,025	7,323	7,603	4,828	2,592	1,897	3,452
1985	1,771	1,665	1,564	1,498	1,739	2,315	3,731	9,144	8,958	4,695	4,076	2,464	3,635
1986	1,878	1,757	1,649	1,564	1,853	2,467	4,539	7,509	5,309	4,757	2,732	1,840	3,155
1987	1,741	1,646	1,571	1,503	1,454	1,883	2,711	5,105	6,115	5,537	3,145	1,909	2,860
1988	1,695	1,605	1,511	1,448	1,995	2,404	3,627	6,389	4,987	3,991	2,189	1,818	2,805
1989	1,695	1,599	1,521	1,442	1,488	2,361	3,415	4,373	4,947	6,544	3,155	1,832	2,864
1990	1,708	1,616	1,539	1,465	1,703	3,128	5,601	7,379	6,298	5,176	3,166	1,954	3,394
1991	1,770	1,664	1,567	1,507	1,584	2,892	4,444	8,042	7,631	4,957	3,637	1,985	3,473

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	MEAN
1992	1,813	1,679	1,590	1,503	1,447	1,599	2,754	3,667	3,618	3,684	2,987	2,267	2,384
1993	1,818	1,610	1,530	1,471	1,437	1,776	3,365	4,418	8,083	4,966	2,924	1,772	2,931
1994	1,665	1,572	1,497	1,438	1,556	3,161	4,853	8,074	7,455	4,165	2,313	2,409	3,346
1995	1,938	1,771	1,663	1,569	1,520	2,381	3,783	8,427	8,194	5,226	2,835	2,046	3,446
1996	1,843	1,731	1,623	1,543	1,606	2,298	4,142	7,752	6,731	4,336	2,476	1,915	3,166
1997	1,736	1,637	1,550	1,483	1,423	1,510	3,944	5,916	7,458	6,158	2,405	1,888	3,092
1998	1,752	1,650	1,554	1,505	1,566	1,885	4,708	6,840	8,451	3,207	2,205	1,802	3,094
1999	1,699	1,602	1,524	1,460	1,835	2,502	3,296	5,675	9,646	4,363	4,580	2,063	3,354
2000	1,782	1,685	1,600	1,556	2,530	3,555	6,394	8,210	8,645	4,600	2,706	1,913	3,765
2001	1,779	1,667	1,584	1,497	2,476	4,423	6,877	9,686	9,058	5,606	4,901	2,228	4,315
2002	1,969	1,835	1,723	1,626	2,258	2,737	5,162	9,443	5,686	3,828	3,261	3,039	3,547
2003	2,618	1,939	1,756	1,672	1,604	2,032	2,727	4,465	5,787	3,446	2,014	1,730	2,649
2004	1,631	1,541	1,461	1,411	1,870	2,629	3,591	7,025	8,593	4,884	2,191	1,901	3,227
2005	1,739	1,635	1,562	1,503	1,517	2,107	4,214	6,123	6,685	4,442	3,439	2,098	3,089
2006	1,847	1,706	1,607	1,526	1,737	2,474	4,222	8,483	7,404	6,725	2,851	2,051	3,553
2007	1,893	1,768	1,651	1,624	2,321	2,705	3,473	6,232	7,436	6,141	3,292	1,996	3,378
2008	1,836	1,730	1,635	1,578	1,648	2,578	4,754	8,047	7,341	5,191	4,019	2,053	3,534
2009	1,864	1,740	1,633	1,556	1,685	2,482	4,873	4,682	5,981	3,116	1,912	1,738	2,772
2010	1,634	1,546	1,467	1,425	1,437	1,801	2,916	5,413	5,727	5,400	2,552	1,819	2,761
2011	1,709	1,615	1,562	1,495	1,662	2,721	5,664	6,944	6,933	4,189	2,872	2,015	3,282
2012	1,865	1,746	1,642	1,555	1,712	2,556	4,404	7,090	6,352	4,033	2,517	2,034	3,125
2013	1,793	1,697	1,601	1,521	1,506	1,975	3,944	8,022	7,311	5,117	3,635	2,838	3,413
2014	2,040	1,812	1,708	1,605	1,558	1,730	3,433	5,607	7,163	3,895	2,722	1,882	2,930
2015	2,106	1,754	1,611	1,575	1,774	1,906	2,956	5,658	5,714	3,888	2,443	1,949	2,778
2016	1,715	1,626	1,548	1,477	1,502	2,185	2,703	4,916	4,376	2,837	2,456	1,756	2,425
2017	1,846	1,582	1,504	1,458	1,501	1,763	5,387	6,947	5,948	4,402	2,986	2,283	3,134
2018	2,237	1,766	1,669	1,667	2,005	3,191	6,138	9,170	8,599	5,177	3,210	2,205	3,920
MIN	1,220	1,194	1,185	1,182	1,255	1,510	2,679	3,667	3,618	2,837	1,912	1,723	
MEAN	1,842	1,697	1,602	1,529	1,707	2,619	4,338	7,128	7,150	4,785	3,031	2,096	
MAX	1,220	1,939	1,756	1,672	2,530	4,423	7,746	12,471	11,072	6,725	5,475	3,195	

## 2 ANNEX FLOOD FREQUENCY ANALYSIS (FFA)

### 2.1 Flood Frequency Analysis

Table 12 Instantaneous flood peaks – Inputs for FFA

Year	Chiang Saen [m <sup>3</sup> /s]	Luang Prabang [m <sup>3</sup> /s]
1960	11,450	19,000
1961	11,130	18,150
1962	11,850	16,400
1963	10,100	19,950
1964	9,495	20,750
1965	14,300	13,450
1966	24,150	26,200
1967	10,590	12,150
1968	11,695	14,150
1969	12,300	18,000
1970	15,400	17,750
1971	16,050	21,200
1972	9,025	13,750
1973	10,670	22,450
1974	11,750	14,200
1975	8,525	18,450
1976	11,240	18,450
1977	8,380	15,400
1978	11,700	16,800
1979	11,180	14,250
1980	11,875	17,250
1981	10,575	15,350
1982	9,205	16,150
1983	11,860	13,850
1984	12,990	15,350
1985	12,350	18,850
1986	11,100	12,850
1987	7,485	8,990
1988	6,940	12,600
1989	8,280	9,865
1990	11,350	16,300
1991	13,750	20,300
1992	6,100	6,070
1993	8,580	9,713
1994	6,630	13,018
1995	13,250	21,854
1996	13,400	19,897
1997	8,195	23,671
1998	10,220	16,006
1999	9,940	21,502
2000	11,100	16,302
2001	11,360	16,456

Year	Chiang Saen [m <sup>3</sup> /s]	Luang Prabang [m <sup>3</sup> /s]
2002	13,300	17,046
2003	7,120	7,796
2004	9,560	10,762
2005	10,290	12,380
2006	14,470	13,200
2007	9,410	11,800
2008	14,378	23,100
2009	7,295	10,600
2010	7,575	
2011	7,280	
2012	9,570	
2013	7,620	
2014	5,780	
2015	9,520	
2016	5,674	
2017	6,962	
2018	9,273	

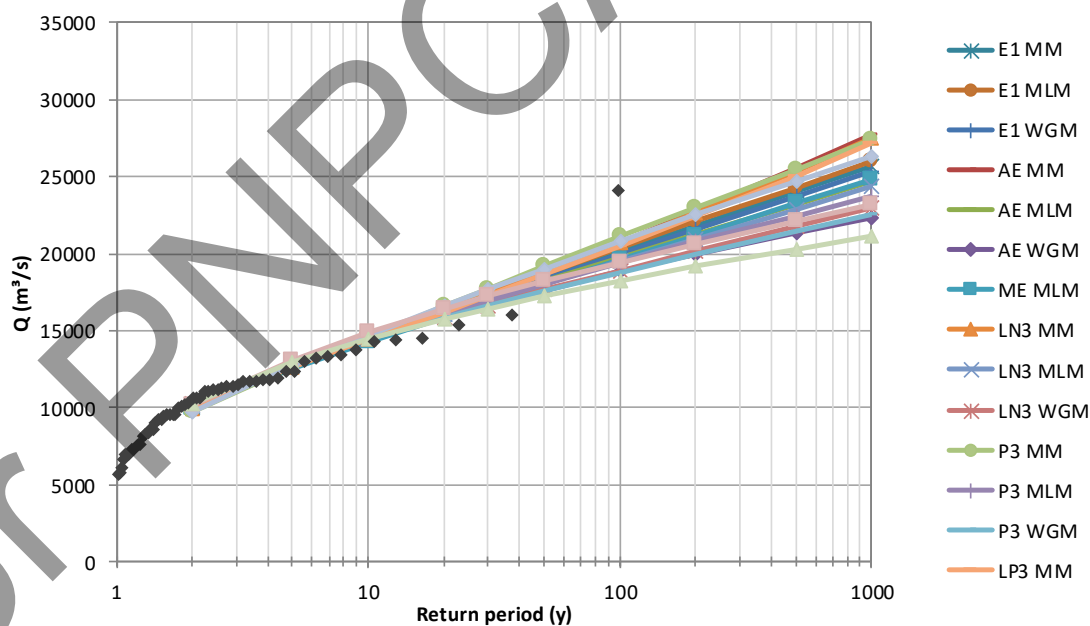


Figure 26 Extreme value distributions fitted to Chiang Saen gauge

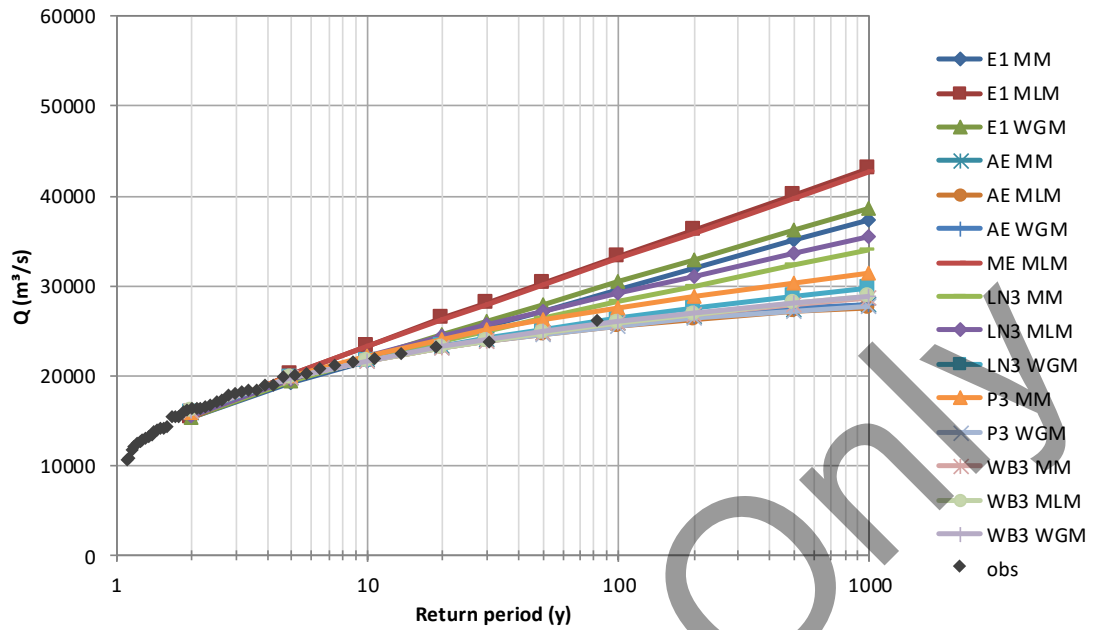


Figure 27 Extreme value distributions fitted to Luang Prabang gauge

Table 13 Calculation of Luang Prabang HPP's flood discharges as the mean of the calculated flood values calculated with Creager from Chiang Saen and Luang Prabang Gauge (median of fitted distributions)

Year	Flood discharge Chiang Saen [m³/s]	Flood discharge Luang Prabang [m³/s]	Creager Factor Chiang Saen	Creager Factor Luang Prabang	Luang Prabang HPP from CS [m³/s]	Luang Prabang HPP from LPG [m³/s]	Luang Prabang Mean [m³/s]
2	11,450	19,000	28.95	41.66	10,530	15,151	12,800
5	11,130	18,150	36.75	52.19	13,368	18,984	16,200
10	11,850	16,400	41.80	58.18	15,205	21,162	18,200
20	10,100	19,950	46.56	63.39	16,933	23,055	20,000
30	9,495	20,750	49.25	66.19	17,914	24,074	21,000
50	14,300	13,450	52.59	69.53	19,129	25,289	22,200
100	24,150	26,200	57.06	73.80	20,753	26,841	23,800
200	10,590	12,150	61.47	77.82	22,358	28,306	25,300
500	11,695	14,150	67.26	82.86	24,464	30,138	27,300
1000	12,300	18,000	71.63	86.50	26,052	31,462	28,800
5000	15,400	17,750	81.78	94.53	29,745	34,384	32,100
10000	16,050	21,200	86.18	97.85	31,344	35,590	33,500

## 2.2 Dry season floods

**Table 14 Dry season flood peaks – Inputs for FFA**

Year	Chiang Saen [m <sup>3</sup> /s]	Luang Prabang [m <sup>3</sup> /s]
1960	1,080	1,720
1961	1,850	2,260
1962	1,980	2,500
1963	1,000	1,580
1964	2,090	2,530
1965	1,480	2,090
1966	1,720	2,620
1967	1,450	2,300
1968	2,320	2,500
1969	1,280	1,740
1970	3,270	4,330
1971	2,350	3,110
1972	1,460	2,200
1973	1,570	2,440
1974	1,700	2,380
1975	1,890	2,640
1976	1,740	1,820
1977	1,350	2,000
1978	2,700	3,480
1979	1,580	2,240
1980	1,470	1,860
1981	4,110	5,510
1982	1,370	2,540
1983	1,700	2,070
1984	2,400	4,230
1985	2,180	2,920
1986	1,780	2,840
1987	1,850	2,440
1988	2,270	3,100
1989	1,710	2,060
1990	3,480	4,260
1991	1,810	2,000
1992	1,720	2,350
1993	1,110	1,801
1994	2,070	2,304
1995	3,170	2,857
1996	2,260	2,331
1997	1,320	1,836
1998	1,890	2,198
1999	1,950	2,419
2000	4,350	5,430
2001	3,790	3,695
2002	3,760	4,885
2003	3,000	4,027



Year	Chiang Saen [m <sup>3</sup> /s]	Luang Prabang [m <sup>3</sup> /s]
2004	3,990	4,759
2005	1,510	1,774
2006	2,160	1,994
2007	4,270	4,373
2008	3,750	2,369
2009	2,140	2,107
2010	2,240	1,848
2011	2,870	2,803
2012	1,900	2,017
2013	2,200	1,959
2014	3,000	2,638
2015	2,768	2,803
2016	2,690	2,631
2017	3,177	3,709
2018	3,069	3,816

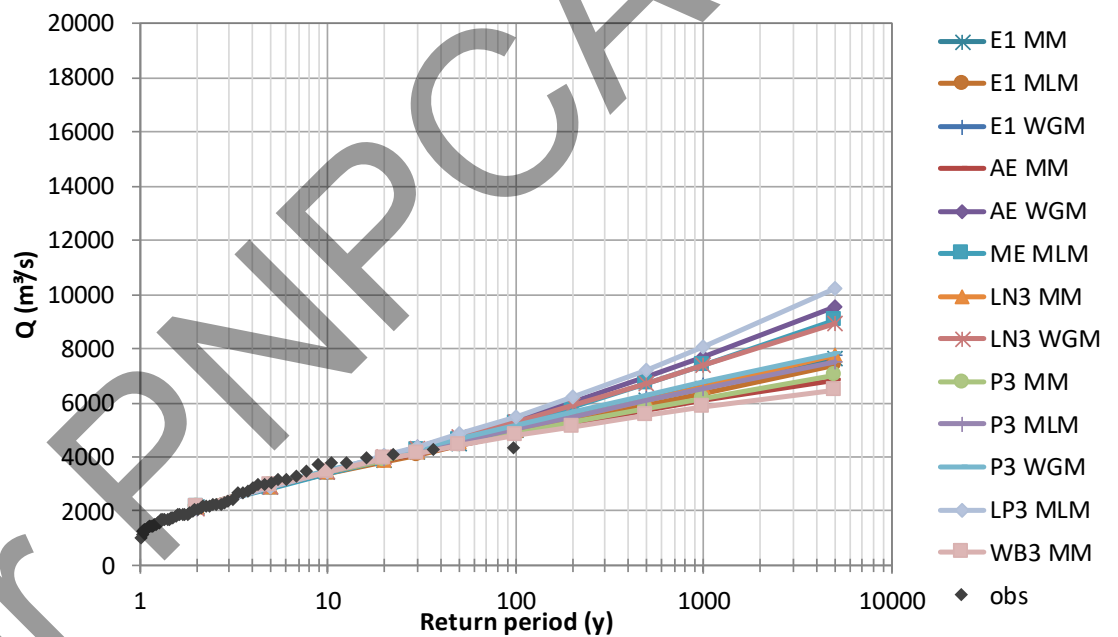


Figure 28 Extreme value distributions fitted to Chiang Saen gauge

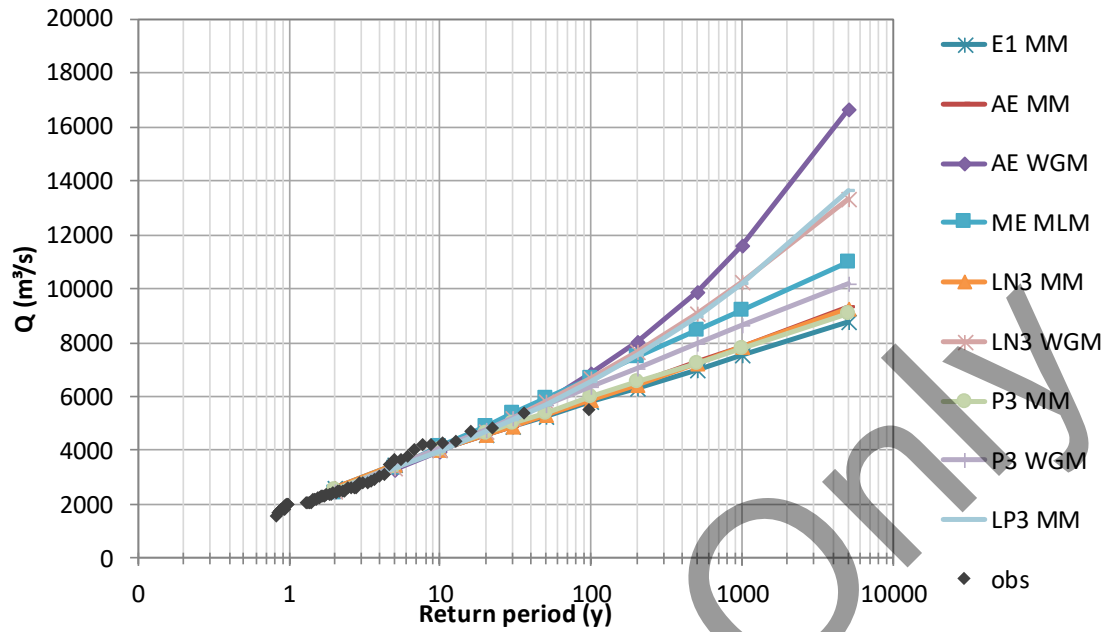


Figure 29 Extreme value distributions fitted to Luang Prabang gauge

Table 15 Calculation of Luang Prabang HPP's dry season flood discharges as the mean of the calculated flood values with Creager from Chiang Saen and Luang Prabang Gauge (median of fitted distributions)

Year	Flood discharge Chiang Saen [m³/s]	Flood discharge Luang Prabang [m³/s]	Creager Factor Chiang Saen	Creager Factor Luang Prabang	Luang Prabang HPP from CS [m³/s]	Luang Prabang HPP from LPG [m³/s]	Luang Prabang Mean [m³/s]
2	2,127	2,508	6.12	6.64	2,228	2,415	2,300
5	2,907	3,376	8.37	8.94	3,044	3,252	3,100
10	3,425	4,020	9.86	10.65	3,587	3,872	3,700
20	3,922	4,674	11.29	12.38	4,107	4,502	4,300
30	4,208	5,066	12.12	13.42	4,407	4,880	4,600
50	4,566	5,572	13.15	14.76	4,782	5,367	5,100
100	5,052	6,286	14.55	16.65	5,291	6,056	5,700
200	5,540	7,038	15.95	18.64	5,803	6,780	6,300
500	6,194	8,100	17.84	21.45	6,488	7,802	7,100
1000	6,696	8,963	19.28	23.74	7,014	8,634	7,800

### 3 ANNEX PROBABLE MAXIMUM FLOOD

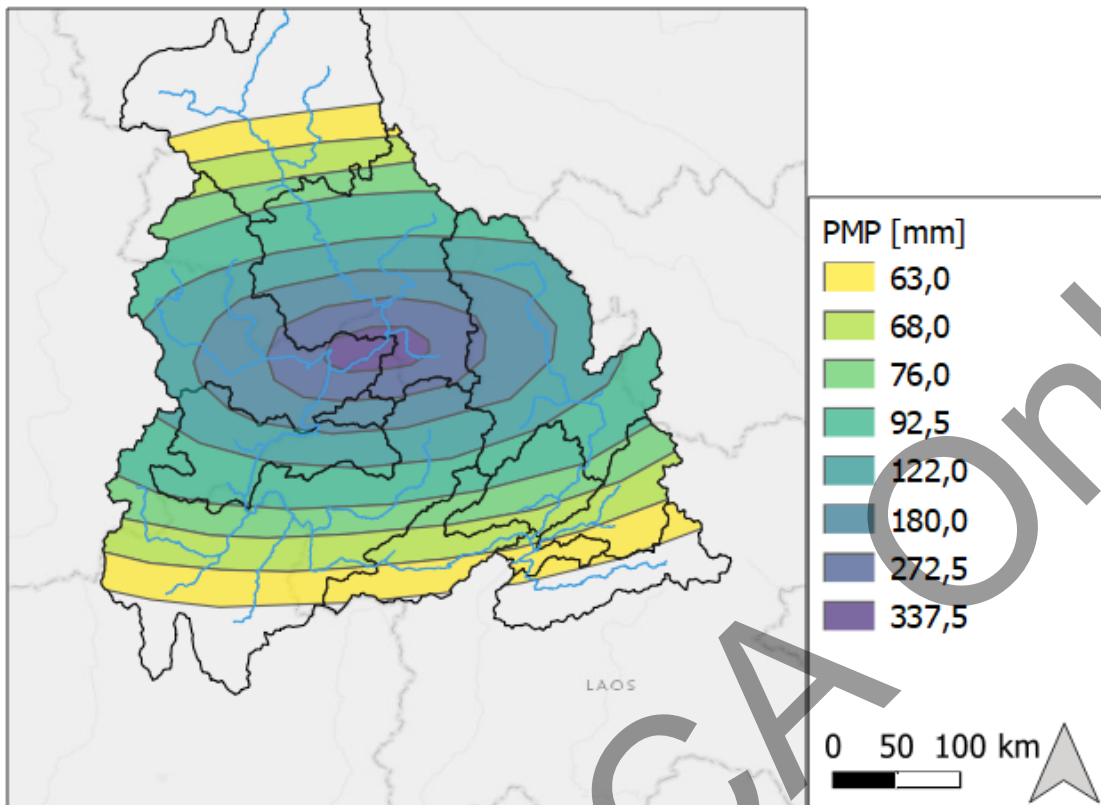


Figure 30 Spatial distribution of 24-hour PMP storm depth (assumed depth in surrounding area is 13.5 mm)

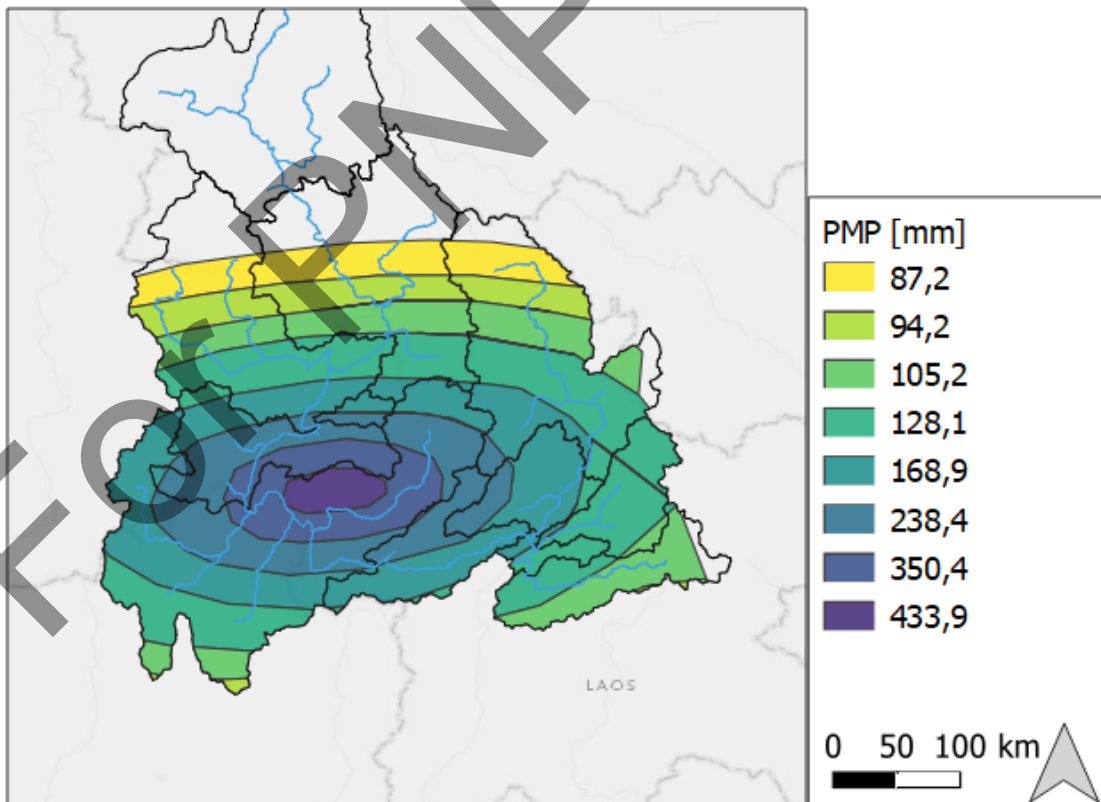


Figure 31 Spatial distribution of 24-hour PMP storm depth – shifted (assumed depth in surrounding area is 13.5 mm)

## 4 ANNEX TREND ANALYSES SEDIMENT CONCENTRATIONS CHIANG SAEN

### 4.1 Used data

**Table 166 Monthly sediment discharge in tons for calendar year 1962-2012, Mekong River at Chiang Saen (Source: Thai Department of Water Resources)**

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Annual.
1962	608,600	305,200	99,500	176,500	801,000	6,241,000	8,405,000	35,309,000	14,704,000	6,042,900	2,121,400	748,800	75,562,900
1963	332,830	125,220	73,870	62,540	186,090	2,631,620	13,936,000	26,833,000	9,936,000	8,437,000	5,962,200	1,298,500	69,814,870
1968	578,600	314,000	161,500	196,230	802,800	2,043,000	6,153,000	15,011,000	11,526,000	9,635,000	3,645,000	793,600	50,859,730
1969	690,900	293,800	136,250	152,200	212,250	2,468,000	9,720,000	38,417,000	11,526,000	4,968,000	2,197,500	878,700	71,660,600
1970	383,350	182,430	147,780	326,490	1,837,200	4,566,700	18,917,000	28,016,000	10,845,000	5,451,000	3,210,800	3,505,400	77,389,150
1971	1,247,100	647,300	299,150	348,280	1,169,900	5,958,900	21,819,000	35,439,000	18,357,000	8,348,000	3,752,200	1,749,100	99,134,930
1972	691,000	227,520	109,000	196,720	417,620	1,503,400	11,885,300	28,398,000	13,245,000	6,953,200	5,168,900	4,745,200	73,540,860
1973	216,910	56,800	123,090	147,370	619,320	3,883,200	10,326,000	18,549,000	16,485,000	5,443,000	5,213,000	1,575,700	62,638,390
1974	823,500	290,490	178,690	478,120	1,032,500	4,550,700	12,985,000	24,651,000	21,677,000	8,808,000	4,422,500	1,526,600	81,424,100
1975	853,400	308,320	147,020	341,260	868,400	4,061,000	10,456,800	12,497,000	12,285,000	5,762,000	3,051,200	937,900	51,569,300
1993	152,130	100,030	80,790	84,610	236,130	844,770	7,213,000	19,631,000	19,620,000	6,353,000	2,231,600	729,400	57,276,460
1994	527,100	346,610	380,290	522,500	935,800	8,180,100	10,624,000	17,088,000	10,357,000	6,649,900	1,449,000	1,340,300	58,400,600
1995	900,000	550,500	797,900	313,580	1,976,300	3,813,300	15,696,000	26,621,000	17,972,000	10,295,000	4,704,000	2,339,600	85,979,180
1996	963,500	602,700	579,600	904,200	1,357,800	2,881,400	20,900,000	30,075,000	12,661,000	8,641,000	3,740,300	1,643,200	84,949,700
1997	601,000	276,930	252,640	260,510	548,490	1,978,900	19,978,000	13,652,000	17,666,000	14,997,000	1,942,400	771,000	72,924,870
1998	626,700	349,900	316,240	573,900	1,524,700	1,869,700	22,163,000	29,105,000	21,444,000	4,711,000	1,945,300	832,900	85,462,340
1999	640,600	350,340	373,110	304,610	939,130	3,751,800	15,024,000	32,909,000	45,444,000	11,008,000	12,151,000	2,223,300	125,118,890
2000	883,100	665,700	598,700	912,900	3,642,300	9,469,200	37,487,000	30,295,000	42,149,000	11,365,000	4,529,200	1,674,700	143,671,800
2001	689,300	404,600	456,360	351,080	2,364,200	11,325,000	32,401,000	27,905,000	27,458,000	12,053,000	9,376,000	2,249,500	127,033,040
2002	799,600	395,010	303,290	302,830	2,158,820	2,496,000	25,863,000	47,032,000	5,763,200	4,681,900	2,346,600	1,144,500	93,286,750
2003	744,400	336,160	247,990	202,360	351,200	1,589,800	4,726,000	6,158,000	8,739,000	2,131,100	652,800	266,920	26,145,730
2004	169,640	124,810	64,654	282,440	1,503,030	2,864,000	14,174,700	19,792,000	25,095,000	8,092,900	1,309,500	505,600	73,978,274
2005	338,870	178,450	330,520	415,870	520,580	1,759,570	4,812,800	14,085,000	6,389,400	3,361,800	1,909,100	692,200	34,794,160
2006	339,560	171,070	162,930	101,140	446,840	2,362,700	6,942,000	8,797,400	6,426,600	18,664,300	1,199,000	450,140	46,063,680
2007	242,440	173,280	109,150	250,260	1,001,340	896,700	5,675,600	11,560,000	13,943,000	5,732,000	1,986,600	655,400	42,225,770
2008	381,120	318,490	297,650	278,600	883,530	2,535,100	9,997,400	22,970,000	14,442,000	5,125,500	4,900,100	1,126,000	63,255,490
2009	339,030	171,610	130,020	210,720	329,050	672,000	2,011,600	3,780,400	2,830,900	920,600	430,310	313,270	12,139,510
2010	238,310	79,850	103,280	176,570	236,180	450,420	1,199,000	1,858,200	1,757,500	1,386,400	536,100	337,200	8,359,010

2011	242,110	107,570	204,870	212,680	626,200	1,344,000	3,536,600	5,364,700	4,921,200	1,542,100	595,000	278,070	18,975,100
2012	419,960	225,760	216,420	200,940	309,950	419,260	1,709,880	3,723,000	2,212,100	1,582,400	775,700	658,200	12,453,570
Mean	555,000	289,000	249,000	310,000	995,000	3,310,000	12,900,000	21,200,000	14,900,000	6,970,000	3,250,000	1,270,000	66,200,000
Minimum	152,000	56,800	64,700	62,500	186,000	419,000	1,200,000	1,860,000	1,760,000	921,000	430,000	267,000	8,360,000
Maximum	1,250,000	666,000	798,000	913,000	3,640,000	11,300,000	37,500,000	47,000,000	45,400,000	18,700,000	12,200,000	4,750,000	143,700,000

**Table 17 Monthly discharge in cubic meters per second for calendar year 1962-2014, Mekong River at Chiang Saen (Source: Thai Department of Water Resources)**

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Annual.
1962	34,300	25,700	22,600	23,900	37,800	101,000	128,000	272,000	169,000	107,000	58,800	37,100	1,020,000
1963	28,100	20,400	20,200	19,200	24,000	61,300	166,000	240,000	138,000	124,000	101,000	47,200	989,000
1964	33,200	25,400	25,100	27,700	43,000	64,200	196,000	228,000	199,000	139,000	72,600	48,200	1,100,000
1965	35,000	26,200	22,600	21,800	28,200	87,100	162,000	206,000	173,000	159,000	133,000	64,500	1,120,000
1966	44,200	29,400	25,800	25,100	35,700	94,400	191,000	341,000	347,000	187,000	90,000	55,900	1,470,000
1967	39,300	25,800	25,900	25,900	35,100	60,300	129,000	186,000	150,000	129,000	85,000	54,700	946,000
1968	43,900	32,900	27,300	28,100	49,200	73,100	136,000	203,000	183,000	167,000	99,200	50,000	1,090,000
1969	35,300	23,800	20,200	20,200	22,000	60,100	131,000	277,000	145,000	93,200	59,400	39,200	927,000
1970	29,800	22,100	22,700	27,400	56,200	87,200	215,000	286,000	154,000	103,000	76,300	80,100	1,160,000
1971	44,300	32,400	28,300	28,500	41,900	95,000	235,000	341,000	203,000	120,000	73,300	51,400	1,290,000
1972	38,800	28,300	26,200	28,100	34,200	47,900	90,000	149,000	106,000	83,100	69,300	67,000	768,000
1973	33,900	25,200	28,400	30,100	40,900	77,500	139,000	207,000	189,000	94,900	91,200	53,700	1,010,000
1974	37,100	25,900	25,000	30,600	39,800	72,300	135,000	220,000	196,000	105,000	71,700	46,100	1,010,000
1975	37,900	26,500	24,100	28,100	38,000	68,700	117,000	133,000	130,000	84,700	60,800	39,400	788,000
1976	31,700	26,900	26,100	28,900	41,300	78,500	120,000	199,000	138,000	109,000	66,400	45,300	911,000
1977	33,400	25,900	26,700	30,400	37,100	59,700	121,000	158,000	135,000	108,000	70,300	43,400	849,000
1978	38,000	26,900	25,500	26,200	52,700	88,300	162,000	213,000	158,000	115,000	54,700	38,600	999,000
1979	30,300	22,600	21,600	25,800	34,200	46,000	85,300	160,000	189,000	141,000	58,500	44,300	859,000
1980	33,400	26,800	26,200	30,900	38,500	74,200	153,000	221,000	173,000	152,000	67,100	44,700	1,040,000
1981	34,800	26,300	27,300	27,200	65,300	112,000	171,000	185,000	151,000	95,700	86,100	53,400	1,040,000
1982	38,100	28,500	25,000	29,400	31,600	74,400	127,000	195,000	122,000	119,000	57,800	40,200	888,000
1983	30,800	23,200	27,800	29,300	37,700	60,500	104,000	169,000	176,000	104,000	111,000	58,900	933,000
1984	45,900	32,600	26,700	28,400	34,000	67,700	186,000	144,000	139,000	103,000	58,600	41,200	907,000
1985	33,300	25,200	24,100	28,400	41,300	107,000	164,000	190,000	229,000	127,000	98,400	57,000	1,130,000
1986	40,300	29,200	27,900	29,400	43,800	56,800	136,000	144,000	123,000	132,000	69,700	49,100	880,000
1987	41,600	31,800	30,100	30,400	33,800	56,100	90,900	163,000	176,000	121,000	78,000	49,600	903,000
1988	36,500	27,700	29,000	30,300	52,800	66,800	101,000	168,000	143,000	100,000	57,000	43,800	856,000

1989	32,600	24,400	24,900	24,300	37,700	62,100	112,000	148,000	124,000	157,000	75,000	50,200	872,000
1990	38,000	29,800	31,200	30,000	61,000	123,000	199,000	153,000	129,000	129,000	67,900	46,200	1,040,000
1991	35,200	26,000	26,200	31,500	43,400	90,200	166,000	251,000	174,000	138,000	94,900	57,100	1,130,000
1992	45,800	36,100	36,700	36,000	36,500	42,200	96,700	88,700	87,300	98,800	59,600	42,500	707,000
1993	19,700	15,400	14,900	14,900	22,700	38,900	106,000	161,000	151,000	101,000	59,800	39,000	745,000
1994	33,700	26,200	27,400	32,600	42,100	105,000	129,000	160,000	126,000	102,000	52,100	50,700	885,000
1995	35,500	25,800	32,500	18,600	52,300	77,900	175,000	231,000	188,000	139,000	88,900	60,600	1,120,000
1996	39,400	30,100	30,100	36,200	46,800	68,500	182,000	236,000	150,000	123,000	77,900	52,200	1,070,000
1997	33,100	22,100	22,300	22,100	30,900	50,300	156,000	134,000	144,000	132,000	54,400	37,100	838,000
1998	29,100	20,500	20,300	27,400	46,400	49,000	186,000	219,000	173,000	84,100	51,300	33,600	940,000
1999	28,100	20,100	21,800	19,400	32,100	63,400	125,000	172,000	206,000	107,000	105,000	50,700	951,000
2000	34,600	29,000	28,500	34,400	65,300	105,000	213,000	197,000	223,000	120,000	73,700	47,200	1,170,000
2001	34,500	25,400	28,300	24,600	57,100	125,000	215,000	196,000	194,000	131,000	110,000	59,900	1,200,000
2002	42,900	30,000	27,900	27,300	61,900	68,600	199,000	261,000	103,000	93,800	66,800	50,200	1,030,000
2003	44,300	29,400	26,700	23,600	31,600	64,000	118,000	133,000	157,000	78,400	42,500	27,600	776,000
2004	25,300	21,500	17,100	29,100	51,900	73,700	146,000	169,000	181,000	119,000	56,600	39,400	930,000
2005	31,400	21,800	30,500	34,000	38,300	64,300	109,000	183,000	121,000	93,200	68,500	44,100	838,000
2006	34,400	23,000	23,200	17,800	39,100	93,800	162,000	185,000	155,000	220,000	65,700	40,000	1,060,000
2007	31,600	25,300	21,400	30,700	57,000	58,800	130,000	208,000	224,000	150,000	84,600	51,400	1,070,000
2008	52,100	45,800	45,800	43,300	79,100	137,000	278,000	439,000	334,000	203,000	184,000	91,100	1,930,000
2009	45,900	31,100	28,500	35,500	44,800	63,400	111,000	151,000	131,000	75,500	50,400	43,900	812,000
2010	47,900	24,700	30,300	40,100	47,400	66,800	113,000	147,000	140,000	126,000	73,300	58,100	915,000
2011	44,700	30,100	41,700	41,200	66,700	90,900	138,000	167,000	159,000	95,300	63,800	47,400	986,000
2012	36,400	23,500	23,200	21,800	28,800	36,200	90,800	169,000	117,000	93,500	55,900	50,700	747,000
2013	49,400	41,300	36,600	42,200	53,400	53,300	79,600	130,000	110,000	92,800	101,000	94,100	883,000
2014	70,900	55,100	77,400	66,300	76,800	62,000	87,800	115,000	116,000	97,700	72,900	77,100	974,000
Mean	37,300	27,500	27,600	29,100	43,800	74,200	146,000	196,000	163,000	119,000	76,100	50,700	991,000
Minimum	19,700	15,400	14,900	14,900	22,000	36,200	79,600	88,700	87,300	75,500	42,500	27,600	707,000
Maximum	70,900	55,100	77,400	66,300	79,100	137,000	278,000	439,000	347,000	220,000	184,000	94,100	1,930,000