JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF INDUSTRY, MINES AND ENERGY
PHNOM PENH WATER SUPPLY AUTHORITY

THE STUDY
ON
THE MASTER PLAN
OF
GREATER PHNOM PENH WATER SUPPLY
(PHASE 2)
IN
THE KINGDOM OF CAMBODIA

FINAL REPORT

VOLUME III

SUPPORTING REPORT
PART A

FEBRUARY 2006

NJS CONSULTANTS CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.

Supporting Report Part A

Supporting Report – 1

Population Projections

Supporting Report 1.1 Existing and Future Population Distribution Based on the Urbanization Policies for Communes (1)

Census Code No.	Province/ District/ Commune	Total Area (ha)	Land Area (ha)	Water Surface (ha)	2005		2020		Basic Urbanization Policies for Districts and Communes
					Population	Density (L) (pers/ha)	Population	Density (L) (pers/ha)	
120000	**Phnom Penh**	**38,190**	**34,201**	**3,989**	**1,334,892**	**39.0**	**2,006,009**	**58.7**	
	Phnom Penh Central	2,708	2,428	280	715,532	294.7	683,360	281.4	
	Phnom Penh Suburbs	35,482	31,773	3,709	619,360	19.5	1,322,649	41.6	
120100	**Chamkar Mon**	**959**	**897**	**62**	**237,822**	**265.1**	**231,680**	**258.3**	**Government Offices, Embassies, Generally Stable**
120101	TonleBasak	316	283	33	55,719	196.9	56,600	200	(Government offices, embassies) Stable
120102	Boeng Keng Kang Muoy	100	100	0	18,032	180.3	22,000	220	Densification
120103	Boeng Keng Kang Pir	34	34	0	15,915	468.1	13,600	400	Commercialization
120104	Boeng Keng Kang Bei	64	64	0	29,969	468.3	25,600	400	Commercialization
120105	Oulampik	30	30	0	12,937	431.2	9,000	300	Commercialization
120106	Tuol Svay Prey Muoy	56	56	0	17,463	311.8	17,360	310	Stable
120107	Tuol Svay Prey Pir	38	38	0	15,300	402.6	13,300	350	Commercialization
120108	Tumnob Tuek	82	82	0	17,175	209.5	17,220	210	Stable
120109	Tuol Tumpung Pir	45	45	0	10,453	232.3	10,800	240	Densification
120110	Tuol Tumpung Muoy	59	59	0	12,677	214.9	14,160	240	(Russian Market) Densification
120111	Boeng Trabaek	49	41	8	11,832	288.6	11,890	290	Stable
120112	Phsar Daeum Thkov	86	65	21	20,350	313.1	20,150	310	Stable
120200	**Doun Penh**	**734**	**539**	**195**	**156,691**	**290.7**	**141,380**	**262.3**	**Commercialization**
120201	Phsar Thmei Muoy	18	18	0	9,058	503.2	6,480	360	(Central Market) Commercialization
120202	Phsar Thmei Pir	11	11	0	9,451	859.2	7,040	640	Commercialization
120203	Phsar Thmei Bei	34	34	0	15,998	470.5	10,880	320	Commercialization
120204	Boeng Reang	38	38	0	9,657	254.1	9,880	260	Stable
120205	Phsar Kandal Muoy	41	27	14	13,242	490.4	10,800	400	Commercialization
120206	Phsar Kandar Pir	15	15	0	9,384	625.6	9,000	600	Commercialization
120207	Chakto Mukh	111	86	25	14,750	171.5	12,900	150	(Large detached houses) Commercialization
120208	Chey Chumneah	77	50	27	14,929	298.6	15,000	300	(Royal Palace) Stable
120209	Phsar Chas	10	10	0	9,624	962.4	8,000	800	Commercialization
120210	Srah Chak	315	195	120	40,253	206.4	40,950	210	Stable
120211	Voat Phnum	64	55	9	10,345	188.1	10,450	190	(Wat) Infrastructure, Stable
120300	**Prampir Meakkara**	**220**	**214**	**6**	**118,664**	**554.5**	**97,190**	**454.2**	**Commercialization**
120301	Ou Ruessei Muoy	8	8	0	11,093	1386.6	6,400	800	(Ou Ruessei Market) Commercialization
120302	Ou Ruessei Pir	8	8	0	13,041	1630.1	8,000	1000	Commercialization
120303	Ou Ruessei Bei	5	5	0	10,362	2072.4	6,500	1300	Commercialization
120304	Ou Ruessei Buon	10	10	0	11,096	1109.6	7,000	700	Commercialization
120305	Monourom	16	16	0	15,788	986.8	11,200	700	Commercialization
120306	Mittakpheap	40	40	0	14,312	357.8	14,400	360	(Min. Defense) Infrastructure, Stable
120307	Veal Vong	96	91	5	27,522	302.4	28,210	310	Stable
120308	Boeng Prolit	37	36	1	15,450	429.2	15,480	430	(Monivong) Stable

Supporting Report 1.1 Existing and Future Population Distribution Based on the Urbanization Policies for Communes (2)

Census Code No.	Province/ District/ Commune	Total Area (ha)	Land Area (ha)	Water Surface (ha)	2005		2020		Basic Urbanization Policies for Districts and Communes
					Population	Density (L) (pers/ha)	Population	Density (L) (pers/ha)	
120400	**Tuol Kouk**	**795**	**778**	**17**	**202,355**	**260.1**	**213,110**	**273.9**	**Densification**
120401	Phsar Depou Muoy	32	32	0	13,016	406.8	13,120	410	(Railways) Stable
120402	Phsar Depou Pir	20	20	0	12,449	622.5	12,600	630	Stable
120403	Phsar Depou Bei	30	30	0	12,389	413.0	12,600	420	Stable
120404	Tuek L'ak Muoy	91	89	2	16,538	185.8	17,800	200	Densification
120405	Tuek L'ak Pir	44	44	0	13,880	315.5	14,080	320	Stable
120406	Tuek L'ak Bei	113	111	2	21,019	189.4	22,200	200	Densification
120407	Boeng Kak Muoy	160	157	3	25,697	163.7	31,400	200	Densification
120408	Boeng Kak Pir	169	168	1	35,678	212.4	36,960	220	Densification
120409	Phsar Daeum Kor	47	47	0	21,121	449.4	21,150	450	Stable
120410	Boeng Salang	89	80	9	30,568	382.1	31,200	390	Stable
120500	**Dangkao**	**18,791**	**18,094**	**697**	**118,466**	**6.5**	**387,948**	**21.4**	**Extension of Industrial Development**
120501	Dangkao	1,383	1,194	189	13,289	11.1	23,876	20	(Cheung Aek Lake and industries) Densification
120502	Trapeang Krasang	905	905	0	4,016	4.4	13,575	15	North of Route 4
120503	Kouk Roka	3,267	2,999	269	6,174	2.1	44,978	15	North-west
120504	Phleung Chheh Roteh	963	961	2	4,852	5.0	9,610	10	West agricultural
120505	Chaom Chau	2,260	2,260	0	26,308	11.6	113,000	50	(Industrial route)
120506	Kakab	1,342	1,342	0	22,063	16.4	67,100	50	(Airport)
120507	Pong Tuek	1,114	1,114	0	7,413	6.7	16,710	15	South agricultural
120508	Prey Veaeng	907	902	5	3,578	4.0	13,530	15	South agricultural
120509	Samraong Kraom	1,219	1,219	0	5,090	4.2	18,285	15	West agricultural
120510	Prey Sa	1,323	1,315	8	6,247	4.8	19,725	15	Center south
120511	Krang Thnong	660	660	0	3,605	5.5	9,900	15	Freight station
120512	Krang Pongro	696	653	43	2,438	3.7	3,265	5	Preaek Thnot south-west
120513	Prateah Lang	842	832	10	4,791	5.8	8,320	10	South-west agricultural
120514	Sak Sampov	586	544	42	2,281	4.2	8,160	15	South agricultural
120515	Cheung Aek	1,324	1,194	130	6,321	5.3	17,915	15	South villags

Supporting Report 1.1 Existing and Future Population Distribution Based on the Urbanization Policies for Communes (3)

Census Code No.	Province/ District/ Commune	Total Area (ha)	Land Area (ha)	Water Surface (ha)	2005		2020		Basic Urbanization Policies for Districts and Communes
					Population	Density (L) (pers/ha)	Population	Density (L) (pers/ha)	
120600	**Mean Chey**	**5,086**	**3,910**	**1,176**	**233,348**	**59.7**	**395,779**	**101.2**	**Densification**
120601	Stueng Mean Chey	1,200	1,153	47	55,441	48.1	98,005	85	Densification and industries
120602	Boeng Tumpun	443	404	39	49,286	122.0	60,600	150	Densification
120603	Preaek Pra	839	610	229	15,354	25.2	24,400	40	South-east Bassac River: Long term extension
120604	Chbar Ampov Muoy	49	41	8	13,702	334.2	14,350	350	Densification
120605	Chbar Ampov Pir	132	90	42	32,785	364.3	31,500	350	Commercialization
120606	Chak Angrae Leu	309	192	117	21,354	111.3	24,934	130	North Bassac River: Densification
120607	Chak Angrae Kraom	953	679	274	27,453	40.4	67,910	100	South of Bassac River
120608	Nirouth	1,161	741	420	17,973	24.3	74,080	100	Chaktomuk and north-east Bassac River: Center
120700	**Ruessei Kaev**	**11,605**	**9,770**	**1,835**	**267,546**	**27.4**	**538,922**	**55.2**	**Densification and Housing Development (subdivisions)**
120701	Khmuonh	1,991	1,863	129	8,399	4.5	37,250	20	Squatters town
120702	Tuol Sangkae	276	252	24	35,047	139.1	50,400	200	North of Tuol Kouk and east of Pumpeay Lake
120703	Svay Pak	397	341	56	16,506	48.3	27,312	80	Di Po general: Housing development
120704	Kiloumaetr Lekh Prammuoy	564	511	53	23,357	45.7	25,545	50	Route 5 center Sap River: Densification
120705	Phnom Penh Thmei	2,055	1,887	168	26,238	13.9	150,889	80	West of Tuol Kouk: Densification
120706	Ruessei Kaev	518	420	98	31,812	75.7	37,800	90	South of Route 5:
120707	Tuek Thla	674	674	0	56,251	83.5	67,400	100	West Phnom Penh, Northbridge
120708	Praek Lieb	2,013	1,396	617	14,629	10.5	27,916	20	North of Chrouy Changva: Densification, restaurant
120709	Praek Ta Sek	1,511	1,309	202	6,035	4.6	26,172	20	North of Chrouy Changva, South Sap: Slow densification
120710	Chrouy Changva	962	530	432	21,840	41.2	53,000	100	Chrouy Changva public space and river
120711	Chrang Chamreh Muoy	230	217	13	9,788	45.0	13,038	60	Route 5 + Sap: Densification
120712	Chrang Chamreh Pir	414	370	44	17,644	47.7	22,200	60	Route 5 + Sap: Densification

Source: Study Team Estimates based on the Land Data from Transport Master Plan and the BAU's Targeted Population Density by Commune

Supporting Report 1.2 Future Population Growth by District and Commune, 2000-2020 (1)

Census Code	Province/District/ Commune	Area (ha)	Projected Mid-year Population					Annual Average Growth Rate (%)				Density (pers/ha)	
			2000	2005	2010	2015	2020	2000-05	2005-10	2010-15	2015-20	2005	2020
	Study Area Total	**58,430**	**1,306,633**	**1,529,999**	**1,774,891**	**2,034,868**	**2,303,826**	**3.21**	**3.01**	**2.77**	**2.51**	**26.2**	**39.4**
120000	**Phnom Penh**	**38,190**	**1,133,525**	**1,334,892**	**1,551,479**	**1,776,646**	**2,006,009**	**3.32**	**3.05**	**2.75**	**2.46**	**35.0**	**52.5**
	Phnom Penh Central	**2,708**	**646,412**	**715,532**	**704,810**	**694,088**	**683,360**	**2.05**	**-0.30**	**-0.31**	**-0.31**	**264.2**	**252.3**
	Phnom Penh Suburbs	**35,482**	**487,113**	**619,360**	**846,669**	**1,082,558**	**1,322,649**	**4.92**	**6.45**	**5.04**	**4.09**	**17.5**	**37.3**
120100	**Chamkar Mon**	**959**	**212,104**	**237,822**	**235,775**	**233,728**	**231,680**	**2.32**	**-0.17**	**-0.17**	**-0.18**	**248.0**	**241.6**
120200	**Doun Penh**	**734**	**149,556**	**156,691**	**151,587**	**146,483**	**141,380**	**0.94**	**-0.66**	**-0.68**	**-0.71**	**213.5**	**192.6**
120300	**Prampir Meakkara**	**220**	**109,057**	**118,664**	**111,507**	**104,350**	**97,190**	**1.70**	**-1.24**	**-1.32**	**-1.41**	**539.4**	**441.8**
120400	**Tuol Kouk**	**795**	**175,695**	**202,355**	**205,941**	**209,527**	**213,110**	**2.87**	**0.35**	**0.35**	**0.34**	**254.5**	**268.1**
120500	**Dangkao**	**18,791**	**104,827**	**118,466**	**206,458**	**296,599**	**387,948**	**2.48**	**11.75**	**7.51**	**5.52**	**6.3**	**20.6**
120501	Dangkao	1,383	11,958	13,289	16,670	20,232	23,876	2.13	4.64	3.95	3.37	9.6	17.3
120502	Trapeang Krasang	905	3,416	4,016	7,139	10,336	13,575	3.29	12.19	7.68	5.60	4.4	15.0
120503	Kouk Roka	3,267	5,842	6,174	18,940	31,894	44,978	1.11	25.13	10.99	7.12	1.9	13.8
120504	Phleung Chheh Roteh	963	4,127	4,852	6,381	7,979	9,610	3.29	5.63	4.57	3.79	5.0	10.0
120505	Chaom Chau	2,260	22,378	26,308	54,719	83,689	113,000	3.29	15.77	8.87	6.19	11.6	50.0
120506	Kakab	1,342	20,044	22,063	36,748	51,818	67,100	1.94	10.74	7.11	5.30	16.4	50.0
120507	Pong Tuek	1,114	6,305	7,413	10,419	13,537	16,710	3.29	7.05	5.38	4.30	6.7	15.0
120508	Prey Veaeng	907	3,416	3,578	6,835	10,162	13,530	0.93	13.82	8.26	5.89	3.9	14.9
120509	Samraong Kraom	1,219	4,774	5,090	9,405	13,817	18,285	1.29	13.07	8.00	5.76	4.2	15.0
120510	Prey Sa	1,323	4,786	6,247	10,645	15,154	19,725	5.47	11.25	7.32	5.41	4.7	14.9
120511	Krang Thnong	660	3,382	3,605	5,653	7,761	9,900	1.29	9.41	6.54	4.99	5.5	15.0
120512	Krang Pongro	696	2,286	2,438	2,690	2,971	3,265	1.30	1.99	2.01	1.91	3.5	4.7
120513	Prateah Lang	842	4,075	4,791	5,915	7,103	8,320	3.29	4.31	3.73	3.21	5.7	9.9
120514	Sak Sampov	586	2,177	2,281	4,203	6,169	8,160	0.94	13.00	7.98	5.75	3.9	13.9
120515	Cheung Aek	1,324	5,861	6,321	10,096	13,977	17,915	1.52	9.82	6.72	5.09	4.8	13.5

Supporting Report 1.2 Future Population Growth by District and Commune, 2000-2020 (2)

Census Code	Province/District/ Commune	Area (ha)	Projected Mid-year Population					Annual Average Growth Rate (%)				Density (pers/ha)	
			2000	2005	2010	2015	2020	2000-05	2005-10	2010-15	2015-20	2005	2020
120600	**Mean Chey**	**5,086**	**178,125**	**233,348**	**285,361**	**339,983**	**395,779**	**5.55**	**4.11**	**3.56**	**3.09**	**45.9**	**77.8**
120601	Stueng Mean Chey	1,200	35,985	55,441	69,010	83,349	98,005	9.03	4.48	3.85	3.29	46.2	81.7
120602	Boeng Tumpun	443	32,921	49,286	52,590	56,480	60,600	8.41	1.31	1.44	1.42	111.3	136.8
120603	Preaek Pra	839	12,863	15,354	18,207	21,260	24,400	3.60	3.47	3.15	2.79	18.3	29.1
120604	Chbar Ampov Muoy	49	11,766	13,702	13,918	14,134	14,350	3.09	0.31	0.31	0.30	279.6	292.9
120605	Chbar Ampov Pir	132	27,467	32,785	32,357	31,929	31,500	3.60	-0.26	-0.27	-0.27	248.4	238.6
120606	Chak Angrae Leu	309	18,819	21,354	22,349	23,593	24,934	2.56	0.92	1.09	1.11	69.1	80.7
120607	Chak Angrae Kraom	953	22,464	27,453	40,578	54,134	67,910	4.09	8.13	5.93	4.64	28.8	71.3
120608	Nirouth	1,161	15,840	17,973	36,352	55,104	74,080	2.56	15.13	8.68	6.10	15.5	63.8
120700	**Ruessei Kaev**	**11,605**	**204,161**	**267,546**	**354,850**	**445,976**	**538,922**	**5.56**	**5.81**	**4.68**	**3.86**	**23.1**	**46.4**
120701	Khmuonh	1,991	6,788	8,399	17,857	27,497	37,250	4.35	16.28	9.02	6.26	4.2	18.7
120702	Tuol Sangkae	276	30,888	35,047	39,811	45,014	50,400	2.56	2.58	2.49	2.29	127.0	182.6
120703	Svay Pak	397	13,828	16,506	19,931	23,573	27,312	3.60	3.84	3.41	2.99	41.6	68.8
120704	Kiloumaetr Lekh Prammuoy	564	15,160	23,357	23,874	24,659	25,545	9.03	0.44	0.65	0.71	41.4	45.3
120705	Phnom Penh Thmei	2,055	20,102	26,238	67,191	108,818	150,889	5.47	20.69	10.12	6.76	12.8	73.4
120706	Ruessei Kaev	518	21,249	31,812	33,510	35,583	37,800	8.41	1.05	1.21	1.22	61.4	73.0
120707	Tuek Thla	674	37,573	56,251	59,439	63,291	67,400	8.41	1.11	1.26	1.27	83.5	100.0
120708	Praek Lieb	2,013	12,037	14,629	18,890	23,355	27,916	3.98	5.25	4.33	3.63	7.3	13.9
120709	Praek Ta Sek	1,511	5,596	6,035	12,635	19,364	26,172	1.52	15.93	8.91	6.21	4.0	17.3
120710	Chrouy Changva	962	18,624	21,840	31,943	42,385	53,000	3.24	7.90	5.82	4.57	22.7	55.1
120711	Chrang Chamreh Muoy	230	8,200	9,788	10,775	11,882	13,038	3.60	1.94	1.98	1.87	42.6	56.7
120712	Chrang Chamreh Pir	414	14,116	17,644	18,994	20,555	22,200	4.56	1.49	1.59	1.55	42.6	53.6

Appendix 1.2 Future Population Growth by District and Commune, 2000-2020 (3)

Census Code	Province/District/ Commune	Area (ha)	Projected Mid-year Population					Annual Average Growth Rate (%)				Density (pers/ha)	
			2000	2005	2010	2015	2020	2000-05	2005-10	2010-15	2015-20	2005	2020
080000	**Kandal within Study Area**	**20,240**	**173,108**	**195,107**	**223,412**	**258,222**	**297,817**	**2.42**	**2.75**	**2.94**	**2.89**	**9.6**	**14.7**
080100	**Kandal Stueng (part)**	**3,195**	**13,977**	**16,068**	**18,726**	**21,926**	**25,459**	**2.83**	**3.11**	**3.21**	**3.03**	**5.0**	**8.0**
080110	Kong Noy	321	1,337	1,518	1,745	2,014	2,307	2.57	2.83	2.91	2.75	4.7	7.2
080114	Preaek Kampis	1,122	6,350	7,341	8,607	10,140	11,841	2.94	3.23	3.33	3.15	6.5	10.6
080119	Roluos	450	2,039	2,368	2,790	3,303	3,875	3.04	3.33	3.43	3.25	5.3	8.6
080124	Spean Thma	783	2,377	2,725	3,166	3,695	4,277	2.77	3.05	3.14	2.97	3.5	5.5
080126	Tien	519	1,874	2,116	2,418	2,774	3,159	2.46	2.70	2.79	2.63	4.1	6.1
080200	**Kien Svay (part)**	**6,711**	**53,042**	**57,765**	**63,382**	**69,666**	**76,093**	**1.72**	**1.87**	**1.91**	**1.78**	**8.6**	**11.3**
080205	Kbal Kaon	3,191	16,174	17,619	19,338	21,262	23,230	1.73	1.88	1.92	1.79	5.5	7.3
080209	Preaek Aeng	860	14,065	15,341	16,861	18,564	20,309	1.75	1.91	1.94	1.81	17.8	23.6
080210	Preaek Thmei	1,966	15,258	16,592	18,176	19,945	21,751	1.69	1.84	1.87	1.75	8.4	11.1
080212	Veal Sbov	694	7,545	8,213	9,007	9,895	10,803	1.71	1.86	1.90	1.77	11.8	15.6
080800	**Angk Snuol (part)**	**6,511**	**29,892**	**37,892**	**49,314**	**64,930**	**84,546**	**4.86**	**5.41**	**5.66**	**5.42**	**5.8**	**13.0**
080801	Baek Chan	1,359	9,105	11,289	14,261	18,091	22,588	4.39	4.78	4.87	4.54	8.3	16.6
080802	Boeng Thum	1,647	5,522	6,466	7,670	9,116	10,696	3.21	3.47	3.51	3.25	3.9	6.5
080805	Kamboul	1,845	6,008	8,607	12,744	19,055	27,837	7.45	8.17	8.38	7.88	4.7	15.1
080806	Kantaok	1,660	9,257	11,530	14,639	18,668	23,425	4.49	4.89	4.98	4.64	6.9	14.1
080900	**Ponhea Lueu**	**656**	**12,964**	**14,427**	**16,215**	**18,276**	**20,451**	**2.16**	**2.36**	**2.42**	**2.27**	**22.0**	**31.2**
080909	Preaek Pnov	656	12,964	14,427	16,215	18,276	20,451	2.16	2.36	2.42	2.27	22.0	31.2
081100	**Ta Khmau**	**3,167**	**63,233**	**68,955**	**75,775**	**83,424**	**91,268**	**1.75**	**1.90**	**1.94**	**1.81**	**21.8**	**28.8**
081101	Ta Kdol	248	4,615	5,027	5,517	6,066	6,628	1.72	1.88	1.92	1.79	20.3	26.7
081102	Preaek Ruessei	212	8,162	8,900	9,780	10,767	11,779	1.75	1.90	1.94	1.81	42.0	55.6
081103	Daeum Mien	319	11,872	12,940	14,212	15,638	17,100	1.74	1.89	1.93	1.80	40.6	53.6
081104	Ta Khmau	1,023	24,648	26,906	29,601	32,627	35,733	1.77	1.93	1.97	1.84	26.3	34.9
081105	Preaek Hour	1,013	6,356	6,921	7,593	8,345	9,115	1.72	1.87	1.91	1.78	6.8	9.0
081106	Kampong Samnanh	352	7,580	8,261	9,072	9,981	10,913	1.74	1.89	1.93	1.80	23.5	31.0

Source: Study Team Estimates based on the NIS Projections and BAU's Targeted Population Density by Commune

Appendix 1.3 Future Number of Households and Household Size by District and Commune, 2000-2020 (1)

Census Code No.	Province/ District/ Commune	2000		2005		2010		2015		2020	
		Number of Households	Household Size	Number of Households	Household Size	Number of Households	Household Size	Number of Households	Household Size	Number of Households	Household Size
	Study Area Total	**230,936**	**5.66**	**275,154**	**5.56**	**324,111**	**5.48**	**374,961**	**5.43**	**428,433**	**5.38**
120000	**Phnom Penh**	**198,472**	**5.71**	**238,039**	**5.61**	**281,343**	**5.51**	**325,161**	**5.46**	**370,563**	**5.41**
	Phnom Penh Central	**111,643**	**5.79**	**126,643**	**5.65**	**127,683**	**5.52**	**126,890**	**5.47**	**126,081**	**5.42**
	Phnom Penh Suburbs	**86,829**	**5.61**	**111,396**	**5.56**	**153,660**	**5.51**	**198,271**	**5.46**	**244,482**	**5.41**
120100	**Chamkar Mon**	**37,140**	**5.71**	**42,677**	**5.57**	**43,345**	**5.44**	**43,409**	**5.38**	**43,474**	**5.33**
120200	**Doun Penh**	**25,476**	**5.87**	**27,380**	**5.72**	**27,113**	**5.59**	**26,438**	**5.54**	**25,749**	**5.49**
120300	**Prampir Meakkara**	**18,965**	**5.75**	**21,150**	**5.61**	**20,324**	**5.49**	**19,172**	**5.44**	**18,000**	**5.40**
120400	**Tuol Kouk**	**30,062**	**5.84**	**35,436**	**5.71**	**36,901**	**5.58**	**37,871**	**5.53**	**38,858**	**5.48**
120500	**Dangkao**	**19,967**	**5.25**	**22,813**	**5.19**	**39,720**	**5.20**	**57,299**	**5.18**	**75,412**	**5.14**
120501	Dangkao	2,313	5.17	2,601	5.11	3,273	5.09	3,996	5.06	4,749	5.03
120502	Trapeang Krasang	630	5.42	749	5.36	1,336	5.34	1,946	5.31	2,574	5.27
120503	Kouk Roka	1,214	4.81	1,298	4.76	3,995	4.74	6,767	4.71	9,611	4.68
120504	Phleung Chheh Roteh	790	5.22	940	5.16	1,240	5.15	1,560	5.11	1,892	5.08
120505	Chaom Chau	3,859	5.80	4,590	5.73	9,577	5.71	14,730	5.68	20,030	5.64
120506	Kakab	3,620	5.54	4,031	5.47	6,735	5.46	9,552	5.42	12,457	5.39
120507	Pong Tuek	1,197	5.27	1,424	5.21	2,008	5.19	2,624	5.16	3,262	5.12
120508	Prey Veaeng	640	5.34	678	5.28	1,299	5.26	1,943	5.23	2,605	5.19
120509	Samraong Kraom	921	5.18	993	5.13	1,841	5.11	2,720	5.08	3,625	5.04
120510	Prey Sa	1,014	4.72	1,339	4.67	2,289	4.65	3,278	4.62	4,297	4.59
120511	Krang Thnong	641	5.28	691	5.22	1,087	5.20	1,501	5.17	1,928	5.13
120512	Krang Pongro	524	4.36	566	4.31	626	4.30	695	4.27	769	4.25
120513	Prateah Lang	870	4.68	1,034	4.63	1,281	4.62	1,547	4.59	1,825	4.56
120514	Sak Sampov	468	4.65	497	4.59	919	4.57	1,357	4.55	1,808	4.51
120515	Cheung Aek	1,266	4.63	1,382	4.57	2,214	4.56	3,083	4.53	3,980	4.50

Appendix 1.3 Future Number of Households and Household Size by District and Commune, 2000-2020 (2)

Census Code No.	Province/ District/ Commune	2000		2005		2010		2015		2020	
		Number of Households	Household Size	Number of Households	Household Size	Number of Households	Household Size	Number of Households	Household Size	Number of Households	Household Size
120600	**Mean Chey**	**31,196**	**5.71**	**41,363**	**5.64**	**50,654**	**5.63**	**60,624**	**5.61**	**71,009**	**5.57**
120601	Stueng Mean Chey	6,311	5.70	9,840	5.63	12,289	5.62	14,929	5.58	17,680	5.54
120602	Boeng Tumpun	5,854	5.62	8,867	5.56	9,492	5.54	10,254	5.51	11,080	5.47
120603	Preaek Pra	2,238	5.75	2,703	5.68	3,215	5.66	3,776	5.63	4,364	5.59
120604	Chbar Ampov Muoy	1,994	5.90	2,349	5.83	2,394	5.81	2,445	5.78	2,500	5.74
120605	Chbar Ampov Pir	5,034	5.46	6,078	5.39	6,018	5.38	5,973	5.35	5,935	5.31
120606	Chak Angrae Leu	3,311	5.68	3,801	5.62	3,991	5.60	4,238	5.57	4,511	5.53
120607	Chak Angrae Kraom	3,582	6.27	4,429	6.20	6,567	6.18	8,812	6.14	11,133	6.10
120608	Nirouth	2,872	5.52	3,296	5.45	6,688	5.44	10,197	5.40	13,806	5.37
120700	**Ruessei Kaev**	**35,666**	**5.72**	**47,220**	**5.67**	**63,286**	**5.61**	**80,348**	**5.55**	**98,061**	**5.50**
120701	Khmuonh	1,273	5.33	1,594	5.27	3,400	5.25	5,266	5.22	7,184	5.19
120702	Tuol Sangkae	5,333	5.79	6,121	5.73	6,975	5.71	7,933	5.67	8,945	5.63
120703	Svay Pak	2,455	5.63	2,965	5.57	3,592	5.55	4,273	5.52	4,986	5.48
120704	Kiloumaetr Lekh Prammuoy	2,690	5.64	4,192	5.57	4,298	5.55	4,465	5.52	4,658	5.48
120705	Phnom Penh Thmei	3,627	5.54	4,790	5.48	12,305	5.46	20,044	5.43	27,991	5.39
120706	Ruessei Kaev	3,762	5.65	5,697	5.58	6,020	5.57	6,430	5.53	6,879	5.49
120707	Tuek Thla	6,246	6.02	9,460	5.95	10,028	5.93	10,740	5.89	11,519	5.85
120708	Praek Lieb	1,970	6.11	2,422	6.04	3,137	6.02	3,901	5.99	4,696	5.94
120709	Praek Ta Sek	1,039	5.39	1,134	5.32	2,382	5.30	3,672	5.27	4,998	5.24
120710	Chrouy Changva	3,381	5.51	4,011	5.45	5,885	5.43	7,854	5.40	9,891	5.36
120711	Chrang Chamreh Muoy	1,487	5.51	1,795	5.45	1,982	5.44	2,198	5.41	2,429	5.37
120712	Chrang Chamreh Pir	2,403	5.87	3,039	5.81	3,282	5.79	3,572	5.75	3,885	5.71

Appendix 1.3 Future Number of Households and Household Size by District and Commune, 2000-2020 (3)

Census Code No.	Province/ District/ Commune	2000		2005		2010		2015		2020	
		Number of Households	Household Size	Number of Households	Household Size	Number of Households	Household Size	Number of Households	Household Size	Number of Households	Household Size
080000	**Kandal within Study Area**	**32,464**	**5.33**	**37,115**	**5.26**	**42,768**	**5.22**	**49,800**	**5.19**	**57,870**	**5.15**
080100	**Kandal Stueng (part)**	**2,888**	**4.84**	**3,360**	**4.78**	**3,927**	**4.77**	**4,627**	**4.74**	**5,401**	**4.71**
080110	Kong Noy	260	5.14	299	5.08	345	5.06	400	5.04	461	5.00
080114	Preaek Kampis	1,228	5.17	1,437	5.11	1691	5.09	2004	5.06	2,354	5.03
080119	Roluos	462	4.41	543	4.36	641	4.35	765	4.32	901	4.30
080124	Spean Thma	513	4.63	596	4.57	694	4.56	816	4.53	950	4.50
080126	Tien	425	4.41	485	4.36	556	4.35	642	4.32	735	4.30
080200	**Kien Svay (part)**	**10,200**	**5.20**	**11,238**	**5.14**	**12,372**	**5.12**	**13,688**	**5.09**	**15,047**	**5.06**
080205	Kbal Kaon	3,069	5.27	3,382	5.21	3726	5.19	4121	5.16	4,537	5.12
080209	Preaek Aeng	2,726	5.16	3,008	5.10	3319	5.08	3676	5.05	4,046	5.02
080210	Preaek Thmei	2,917	5.23	3,209	5.17	3522	5.16	3896	5.12	4,273	5.09
080212	Veal Sbov	1,488	5.07	1,639	5.01	1805	4.99	1995	4.96	2,191	4.93
080800	**Angk Snuol (part)**	**5,770**	**5.18**	**7,384**	**5.13**	**9,621**	**5.13**	**12,713**	**5.11**	**16,644**	**5.08**
080801	Baek Chan	1,686	5.40	2,114	5.34	2681	5.32	3420	5.29	4,302	5.25
080802	Boeng Thum	1,208	4.57	1,434	4.51	1704	4.50	2039	4.47	2,409	4.44
080805	Kamboul	1,129	5.32	1,636	5.26	2432	5.24	3657	5.21	5,384	5.17
080806	Kantaok	1,747	5.30	2,200	5.24	2804	5.22	3597	5.19	4,549	5.15
080900	**Ponhea Lueu**	**2,396**	**5.41**	**2,697**	**5.35**	**3042**	**5.33**	**3448**	**5.30**	**3,888**	**5.26**
080909	Preaek Pnov	2,396	5.41	2,697	5.35	3042	5.33	3448	5.30	3,888	5.26
081100	**Ta Khmau**	**11,210**	**5.64**	**12436**	**5.54**	**13806**	**5.49**	**15,324**	**5.44**	**16,890**	**5.40**
081101	Ta Kdol	851	5.42	938	5.36	1033	5.34	1,142	5.31	1,258	5.27
081102	Preaek Ruessei	1,465	5.57	1618	5.50	1781	5.49	1,976	5.45	2,173	5.42
081103	Daeum Mien	2,162	5.49	2387	5.42	2627	5.41	2,912	5.37	3,202	5.34
081104	Ta Khmau	4,149	5.94	4647	5.79	5230	5.66	5,826	5.60	6,438	5.55
081105	Preaek Hour	1,177	5.40	1296	5.34	1427	5.32	1,578	5.29	1,736	5.25
081106	Kampong Samnanh	1,406	5.39	1550	5.33	1708	5.31	1,890	5.28	2,083	5.24

Source: Study Team Estimates

Supporting Report 1.4.1 Served Population in Peri-Urban in 2005

District	Commune	2005 Population	Served by piped and well water					Remaining non-served population
			Piped water supply		Served pops. By JICA wells	Total served population	Total coverage (%)	
			population	coverage				
Study Area (Phnom Penh + Kandal)		**1,529,999**	**1,035,932**	**67.7%**	**34,650**	**1,070,582**	**70.0%**	**459,417**
Municipality of Phnom Penh		**1,334,892**	**1,024,789**	**76.8%**	**34,650**	**1,059,439**	**79.4%**	**275,453**
	Phnom Penh Central	**715,532**	**715,532**	**100.0%**	**0**	**715,532**	**100.0%**	**0**
	Phnom Penh Suburbs	**619,360**	**309,257**	**49.9%**	**34,650**	**343,907**	**55.5%**	**275,453**
	(excluding Ta Khmau)							
Chamkar Mon		**237,822**	**237,822**	**100.0%**	**0**	**237,822**	**100.0%**	**0**
Doun Penh		**156,691**	**156,691**	**100.0%**	**0**	**156,691**	**100.0%**	**0**
Prampir Meakkara		**118,664**	**118,664**	**100.0%**	**0**	**118,664**	**100.0%**	**0**
Tuol Kouk		**202,355**	**202,355**	**100.0%**	**0**	**202,355**	**100.0%**	**0**
Dangkao		**118,466**	**30,506**	**25.8%**	**25,410**	**55,916**	**47.2%**	**62,550**
	Dangkao	13,289	5,979	45.0	0	5,979	45.0	7,310
	Trapeang Krasang	4,016		0.0	2,100	2,100	52.3	1,916
	Kouk Roka	6,174		0.0	5,460	5,460	88.4	714
	Phleung Chheh Roteh	4,852		0.0	1,470	1,470	30.3	3,382
	Chaom Chau	26,308	11,189	42.5	1,470	12,659	48.1	13,649
	Kakab	22,063	10,022	45.4	1,680	11,702	53.0	10,361
	Pong Tuek	7,413		0.0	0	0	0.0	7,413
	Prey Veaeng	3,578		0.0	840	840	23.5	2,738
	Samraong Kraom	5,090		0.0	5,040	5,040	99.0	50
	Prey Sa	6,247	2,393	38.3	2,940	5,333	85.4	914
	Krang Thnong	3,605	923	25.6	0	923	25.6	2,682
	Krang Pongro	2,438		0.0	420	420	17.2	2,018
	Prateah Lang	4,791		0.0	1,050	1,050	21.9	3,741
	Sak Sampov	2,281		0.0	2,100	2,100	92.1	181
	Cheung Aek	6,321		0.0	840	840	13.3	5,481
Mean Chey		**233,348**	**128,957**	**55.3%**	**840**	**129,797**	**55.6%**	**103,551**
	Stueng Mean Chey	55,441	33,265	60.0	840	34,105	61.5	21,336
	Boeng Tumpun	49,286	29,572	60.0	0	29,572	60.0	19,714
	Preaek Pra	15,354	3,552	23.1	0	3,552	23.1	11,802
	Chbar Ampov Muoy	13,702	8,221	60.0	0	8,221	60.0	5,481
	Chbar Ampov Pir	32,785	19,671	60.0	0	19,671	60.0	13,114
	Chak Angrae Leu	21,354	12,812	60.0	0	12,812	60.0	8,542
	Chak Angrae Kraom	27,453	16,472	60.0	0	16,472	60.0	10,981
	Nirouth	17,973	5,392	30.0	0	5,392	30.0	12,581
Ruessei Kaev		**267,546**	**149,794**	**56.0%**	**8,400**	**158,194**	**59.1%**	**109,352**
	Khmuonh	8,399	2,520	30.0	4,620	7,140	85.0	1,259
	Tuol Sangkae	35,047	21,028	60.0	0	21,028	60.0	14,019
	Svay Pak	16,506	9,904	60.0	0	9,904	60.0	6,602
	Kiloumaetr Lekh Prammuoy	23,357	14,014	60.0	0	14,014	60.0	9,343
	Phnom Penh Thmei	26,238	15,743	60.0	3,780	19,523	74.4	6,715
	Ruessei Kaev	31,812	19,087	60.0	0	19,087	60.0	12,725
	Tuek Thla	56,251	33,751	60.0	0	33,751	60.0	22,500
	Praek Lieb	14,629	8,777	60.0	0	8,777	60.0	5,852
	Praek Ta Sek	6,035	1,811	30.0	0	1,811	30.0	4,224
	Chrouy Changva	21,840	11,993	54.9	0	11,993	54.9	9,847
	Chrang Chamreh Muoy	9,788	5,873	60.0	0	5,873	60.0	3,915
	Chrang Chamreh Pir	17,644	5,293	30.0	0	5,293	30.0	12,351
Kandal Province in the Study Area		**195,107**	**11,143**	**5.7%**	**0**	**11,143**	**5.7%**	**183,964**
Kandal Stueng		**16,068**	**0**	**0.0%**	**0**	**0**	**0.0%**	**16,068**
	Kong Noy	1,518						
	Preaek Kampis	7,341						
	Roluos	2,368						
	Spean Thmei	2,725						
	Tien	2,116						
Kien Svay		**57,765**	**0**	**0.0%**	**0**	**0**	**0.0%**	**57,765**
	Kbal Kaon	17,619						
	Preaek Aeng	15,341						
	Preaek Thmei	16,592						
	Veal Sbov	8,213						
Angk Snuol		**37,892**	**0**	**0.0%**	**0**	**0**	**0.0%**	**37,892**
	Baek Chan	11,289						
	Boeng Thum	6,466						
	Kamboul	8,607						
	Kantaok	11,530						
Ponhea Lueu		**14,427**	**0**	**0.0%**	**0**	**0**	**0.0%**	**14,427**
	Preaek Pnov	14,427						
Ta Khmau		**68,955**	**11,143**	**16.2%**	**0**	**11,143**	**16.2%**	**57,812**
	Ta Kdol	5,027						
	Preaek Ruessei	8,900						
	Daeum Mien	12,940						
	Ta Khmau	26,906						
	Preaek Hour	6,921						
	Kampong Samnanh	8,261						
Peri-urban area (P.P. suburbs +Kandal)		**814,467**	**320,400**	**39.3%**	**34,650**	**355,050**	**43.6%**	**459,417**
					TTL Nos. of Wells			**165**

*1: Served population; coverage to all population in commune or district
UNICEF/NGO well: a few, one in one village and detriolated in 2020; negligible
UWC for rural area: 40 l/c/d, Supply population by one well: 210 persons/well

Supporting Report 1.4.2 Served Population in Peri-Urban in 2010

District	Commune	2010 Population	Served by piped and well water					New well up to 2010		Served in 2010	
			Piped water supply		Served pops. by JICA wells	Total served population	Total coverage (%)	Number of well	Served population by new	TTL served population	TTL served coverage
			population	coverage							
Study Area (Phnom Penh + Kandal)		**1,774,891**	**1,244,738**	**70.1%**	**34,650**	**1,279,388**	**72.1%**	**201**	**42,210**	**1,321,598**	**74.5%**
Municipality of Phnom Penh		**1,551,479**	**1,200,056**	**77.3%**	**34,650**	**1,234,706**	**79.6%**	**0**	**0**	**1,234,706**	**79.6%**
	Phnom Penh Central	**704,810**	**704,810**	**100.0%**	**0**	**704,810**	**100.0%**	**0**	**0**	**704,810**	**100.0%**
	Phnom Penh Suburbs	**846,669**	**495,246**	**58.5%**	**34,650**	**529,896**	**62.6%**	**0**	**0**	**529,896**	**62.6%**
	(excluding Ta Khmau)										
Chamkar Mon		**235,775**	**235,775**	**100.0%**	**0**	**235,775**	**100.0%**			**235,775**	**100.0%**
Doun Penh		**151,587**	**151,587**	**100.0%**	**0**	**151,587**	**100.0%**			**151,587**	**100.0%**
Prampir Meakkara		**111,507**	**111,507**	**100.0%**	**0**	**111,507**	**100.0%**			**111,507**	**100.0%**
Tuol Kouk		**205,941**	**205,941**	**100.0%**	**0**	**205,941**	**100.0%**			**205,941**	**100.0%**
Dangkao		**206,458**	**82,583**	**40.0%**	**25,410**	**107,993**	**52.3%**	**0**	**0**	**107,993**	**52.3%**
	Dangkao	16,670	8,335	50.0	0	8,335	50.0				
	Trapeang Krasang	7,139	714	10.0	2,100	2,814	39.4				
	Kouk Roka	18,940	3,343	17.7	5,460	8,803	46.5				
	Phleung Chheh Roteh	6,381		0.0	1,470	1,470	23.0				
	Chaom Chau	54,719	38,303	70.0	1,470	39,773	72.7				
	Kakab	36,748	25,724	70.0	1,680	27,404	74.6				
	Pong Tuek	10,419		0.0	0	0	0.0				
	Prey Veaeng	6,835		0.0	840	840	12.3				
	Samraong Kraom	9,405	941	10.0	5,040	5,981	63.6				
	Prey Sa	10,645	1,065	10.0	2,940	4,005	37.6				
	Krang Thnong	5,653	1,131	20.0	0	1,131	20.0				
	Krang Pongro	2,690		0.0	420	420	15.6				
	Prateah Lang	5,915		0.0	1,050	1,050	17.8				
	Sak Sampov	4,203		0.0	2,100	2,100	50.0				
	Cheung Aek	10,096	3,029	30.0	840	3,869	38.3				
Mean Chey		**285,361**	**199,753**	**70.0%**	**840**	**200,593**	**70.3%**	**0**	**0**	**200,593**	**70.3%**
	Stueng Mean Chey	69,010	48,307	70.0	840	49,147	71.2				
	Boeng Tumpun	52,590	36,813	70.0	0	36,813	70.0				
	Preaek Pra	18,207	12,745	70.0	0	12,745	70.0				
	Chbar Ampov Muoy	13,918	9,743	70.0	0	9,743	70.0				
	Chbar Ampov Pir	32,357	22,650	70.0	0	22,650	70.0				
	Chak Angrae Leu	22,349	15,644	70.0	0	15,644	70.0				
	Chak Angrae Kraom	40,578	28,405	70.0	0	28,405	70.0				
	Nirouth	36,352	25,446	70.0	0	25,446	70.0				
Ruessei Kaev		**354,850**	**212,910**	**60.0%**	**8,400**	**221,310**	**62.4%**	**0**	**0**	**221,310**	**62.4%**
	Khmuonh	17,857	10,714	60.0	4,620	15,334	0.9				
	Tuol Sangkae	39,811	23,887	60.0	0	23,887	60.0				
	Svay Pak	19,931	11,959	60.0	0	11,959	60.0				
	Kiloumaetr Lekh Prammuoy	23,874	14,324	60.0	0	14,324	60.0				
	Phnom Penh Thmei	67,191	40,315	60.0	3,780	44,095	65.6				
	Ruessei Kaev	33,510	20,106	60.0	0	20,106	60.0				
	Tuek Thla	59,439	35,663	60.0	0	35,663	60.0				
	Praek Lieb	18,890	11,334	60.0	0	11,334	60.0				
	Praek Ta Sek	12,635	7,581	60.0	0	7,581	60.0				
	Chrouy Changva	31,943	19,166	60.0	0	19,166	60.0				
	Chrang Chamreh Muoy	10,775	6,465	60.0	0	6,465	60.0				
	Chrang Chamreh Pir	18,994	11,396	60.0	0	11,396	60.0				
Kandal Province		**223,412**	**44,682**	**20.0%**	**0**	**44,682**	**20.0%**	**201**	**42,210**	**86,892**	**38.9%**
Kandal Stueng		**18,726**		**0.0%**	**0**	**0**	**0.0%**	**0**	**0**	**0**	**0.0%**
	Kong Noy	1,745									
	Preaek Kampis	8,607									
	Roluos	2,790									
	Spean Thmei	3,166									
	Tien	2,418									
Kien Svay		**63,382**		**0.0%**	**0**	**0**	**0.0%**	**201**	**42,210**	**42,210**	**66.6%**
	Kbal Kaon	19,338									
	Preaek Aeng	16,861									
	Preaek Thmei	18,176									
	Veal Sbov	9,007									
Angk Snuol		**49,314**	**4,931**	**10.0%**	**0**	**4,931**	**10.0%**	**0**	**0**	**4,931**	**10.0%**
	Baek Chan	14,261									
	Boeng Thum	7,670									
	Kamboul	12,744									
	Kantaok	14,639									
Ponhea Lueu		**16,215**		**0.0%**	**0**	**0**	**0.0%**	**0**	**0**	**0**	**0.0%**
	Preaek Pnov	16,215									
Ta Khmau		**75,775**	**39,751**	**52.5%**	**0**	**39,751**	**52.5%**	**0**	**0**	**39,751**	**52.5%**
	Ta Kdol	5,517									
	Preaek Ruessei	9,780									
	Daeum Mien	14,212									
	Ta Khmau	29,601									
	Preaek Hour	7,593									
	Kampong Samnanh	9,072									
Peri-urban area (P.P. suburbs +Kandal)		**1,070,081**	**539,928**	**50.5%**	**34,650**	**574,578**	**53.7%**	**201**	**42,210**	**616,788**	**57.6%**

*1: Served population; coverage to all population in commune or district
UNICEF/NGO well: a few, one in one village and detriolated in 2020; negligible
UWC for rural area: 40 l/c/d, Supply population by one well: 210 persons/well

TTL Served Pops by Wells)	**76,860**
TTL Nos. of Wells	**366**

Supporting Report 1.4.3 Served Population in Peri-Urban in 2015

District	Commune	2015 Population	Served by piped and well water					New well up to 2015		Served in 2015	
			Piped water supply		Served pops. By JICA wells	Total served population	Total coverage (%)	Number of well	Served population by new	TTL served population	TTL served coverage
			population	coverage							
Study Area (Phnom Penh + Kandal)		**2,034,868**	**1,491,114**	**73.3%**	**34,650**	**1,525,764**	**75.0%**	**552**	**115,920**	**1,641,684**	**80.7%**
Municipality of Phnom Penh		**1,776,646**	**1,426,558**	**80.3%**	**34,650**	**1,461,208**	**82.2%**	**0**	**0**	**1,461,208**	**82.2%**
	Phnom Penh Central	**694,088**	**694,089**	**100.0%**	**0**	**694,089**	**100.0%**	**0**	**0**	**694,089**	**100.0%**
	Phnom Penh Suburbs	**1,082,558**	**732,469**	**67.7%**	**34,650**	**767,119**	**70.9%**	**0**	**0**	**767,119**	**70.9%**
	(excluding Ta khmau)										
Chamkar Mon		**233,728**	**233,728**	**100.0%**	**0**	**233,728**	**100.0%**			**233,728**	**100.0%**
Doun Penh		**146,483**	**146,484**	**100.0%**	**0**	**146,484**	**100.0%**			**146,484**	**100.0%**
Prampir Meakkara		**104,350**	**104,350**	**100.0%**	**0**	**104,350**	**100.0%**			**104,350**	**100.0%**
Tuol Kouk		**209,527**	**209,527**	**100.0%**	**0**	**209,527**	**100.0%**			**209,527**	**100.0%**
Dangkao		**296,599**	**148,300**	**50.0%**	**25,410**	**173,710**	**58.6%**	**0**	**0**	**173,710**	**58.6%**
	Dangkao	20,232	10,116	50.0	0	10,116	50.0				
	Trapeang Krasang	10,336	2,067	20.0	2,100	4,167	40.3				
	Kouk Roka	31,894	9,654	30.3	5,460	15,114	47.4				
	Phleung Chheh Roteh	7,979	798	10.0	1,470	2,268	28.4				
	Chaom Chau	83,689	66,951	80.0	1,470	68,421	81.8				
	Kakab	51,818	41,454	80.0	1,680	43,134	83.2				
	Pong Tuek	13,537	1,354	10.0	0	1,354	10.0				
	Prey Veaeng	10,162		0.0	840	840	8.3				
	Samraong Kraom	13,817	2,763	20.0	5,040	7,803	56.5				
	Prey Sa	15,154	2,273	15.0	2,940	5,213	34.4				
	Krang Thnong	7,761	3,881	50.0	0	3,881	50.0				
	Krang Pongro	2,971		0.0	420	420	14.1				
	Prateah Lang	7,103		0.0	1,050	1,050	14.8				
	Sak Sampov	6,169		0.0	2,100	2,100	34.0				
	Cheung Aek	13,977	6,989	50.0	840	7,829	56.0				
Mean Chey		**339,983**	**271,985**	**80.0%**	**840**	**272,825**	**80.2%**	**0**	**0**	**272,825**	**80.2%**
	Stueng Mean Chey	83,349	66,679	80.0	840	67,519	81.0				
	Boeng Tumpun	56,480	45,184	80.0	0	45,184	80.0				
	Preaek Pra	21,260	17,008	80.0	0	17,008	80.0				
	Chbar Ampov Muoy	14,134	11,307	80.0	0	11,307	80.0				
	Chbar Ampov Pir	31,929	25,543	80.0	0	25,543	80.0				
	Chak Angrae Leu	23,593	18,874	80.0	0	18,874	80.0				
	Chak Angrae Kraom	54,134	43,307	80.0	0	43,307	80.0				
	Nirouth	55,104	44,083	80.0	0	44,083	80.0				
Ruessei Kaev		**445,976**	**312,183**	**70.0%**	**8,400**	**320,583**	**71.9%**	**0**	**0**	**320,583**	**71.9%**
	Khmuonh	27,497	19,248	70.0	4,620	23,868	86.8				
	Tuol Sangkae	45,014	31,510	70.0	0	31,510	70.0				
	Svay Pak	23,573	16,501	70.0	0	16,501	70.0				
	Kiloumaetr Lekh Prammuoy	24,659	17,261	70.0	0	17,261	70.0				
	Phnom Penh Thmei	108,818	76,173	70.0	3,780	79,953	73.5				
	Ruessei Kaev	35,583	24,908	70.0	0	24,908	70.0				
	Tuek Thla	63,291	44,304	70.0	0	44,304	70.0				
	Praek Lieb	23,355	16,349	70.0	0	16,349	70.0				
	Praek Ta Sek	19,364	13,555	70.0	0	13,555	70.0				
	Chrouy Changva	42,385	29,670	70.0	0	29,670	70.0				
	Chrang Chamreh Muoy	11,882	8,317	70.0	0	8,317	70.0				
	Chrang Chamreh Pir	20,555	14,389	70.0	0	14,389	70.0				
Kandal Province		**258,222**	**64,556**	**25.0%**	**0**	**64,556**	**25.0%**	**552**	**115,920**	**180,476**	**69.9%**
Kandal Stueng		**21,926**	**0**	**0.0%**	**0**	**0**	**0.0%**	**97**	**20,370**	**20,370**	**92.9%**
	Kong Noy	2,014									
	Preaek Kampis	10,140									
	Roluos	3,303									
	Spean Thmei	3,695									
	Tien	2,774									
Kien Svay		**69,666**	**0**	**0.0%**	**0**	**0**	**0.0%**	**254**	**53,340**	**53,340**	**76.6%**
	Kbal Kaon	21,262									
	Preaek Aeng	18,564									
	Preaek Thmei	19,945									
	Veal Sbov	9,895									
Angk Snuol		**64,930**	**12,986**	**20.0%**	**0**	**12,986**	**20.0%**	**201**	**42,210**	**55,196**	**85.0%**
	Baek Chan	18,091									
	Boeng Thum	9,116									
	Kamboul	19,055									
	Kantaok	18,668									
Ponhea Lueu		**18,276**	**1,516**	**8.3%**	**0**	**1,516**	**8.3%**	**0**	**0**	**1,516**	**8.3%**
	Preaek Pnov	18,276									
Ta Khmau		**83,424**	**50,054**	**60.0%**	**0**	**50,054**	**60.0%**	**0**	**0**	**50,054**	**60.0%**
	Ta Kdol	6,066									
	Preaek Ruessei	10,767									
	Daeum Mien	15,638									
	Ta Khmau	32,627									
	Preaek Hour	8,345									
	Kampong Samnanh	9,981									
Peri-urban area (P.P. suburbs +Kandal)		**1,340,780**	**797,025**	**59.4%**	**34,650**	**831,675**	**62.0%**	**552**	**115,920**	**947,595**	**70.7%**

*1: Served population; coverage to all population in commune or district
UNICEF/NGO well: a few, one in one village and detriolated in 2020; negligible
UWC for rural area: 40 l/c/d, Supply population by one well: 210 persons/well

TTL Served Pops by Wells)	**150,570**
TTL Nos. of Wells	**717**

Supporting Report 1.4.4 Served Population in Peri-Urban Area in 2020

District	Commune	2020 Population	Served by piped and well water					New well up to 2020		Served in 2020	
			Piped water supply		Served pops. by JICA	Total served population	Total coverage (%)	Number of well	Served population by new	TTL served population	TTL served coverage
			population	coverage							
Study Area (Phnom Penh + Kandal)		**2,303,826**	**1,866,102**	**81.0%**	**34,650**	**1,900,752**	**82.5%**	**867**	**182,070**	**2,082,822**	**90.4%**
Municipality of Phnom Penh		**2,006,009**	**1,776,757**	**88.6%**	**34,650**	**1,811,407**	**90.3%**	**156**	**32,760**	**1,844,167**	**91.9%**
	Phnom Penh Central	**683,360**	**683,360**	**100.0%**	**0**	**683,360**	**100.0%**	**0**	**0**	**683,360**	**100%**
	Phnom Penh Suburbs	**1,322,649**	**1,093,397**	**82.7%**	**34,650**	**1,128,047**	**85.3%**	**156**	**32,760**	**1,160,807**	**88%**
	(excluding Ta khmau)										
Chamkar Mon		**231,680**	**231,680**	**100.0%**	**0**	**231,680**	**100.0**			231,680	**100%**
Doun Penh		**141,380**	**141,380**	**100.0%**	**0**	**141,380**	**100.0**			141,380	**100%**
Prampir Meakkara		**97,190**	**97,190**	**100.0%**	**0**	**97,190**	**100.0**			97,190	**100%**
Tuol Kouk		**213,110**	**213,110**	**100.0%**	**0**	**213,110**	**100.0**			213,110	**100%**
Dangkao		**387,948**	**252,166**	**65.0%**	**25,410**	**277,576**	**71.5%**	**156**	**32,760**	**310,336**	**80.0%**
	Dangkao	23,876	19,101	80.0	0	19,101	80.0				
	Trapeang Krasang	13,575	8,145	60.0	2,100	10,245	75.5		0	10,245	75.5%
	Kouk Roka	44,978	23,031	51.2	5,460	28,491	63.3		0	28,491	63.3%
	Phleung Chheh Roteh	9,610	961	10.0	1,470	2,431	25.3	16	3,360	5,791	60.3%
	Chaom Chau	113,000	101,700	90.0	1,470	103,170	91.3				
	Kakab	67,100	60,390	90.0	1,680	62,070	92.5				
	Pong Tuek	16,710	1,671	10.0	0	1,671	10.0	40	8,400	10,071	60.3%
	Prey Veaeng	13,530		0.0	840	840	6.2	35	7,350	8,190	60.5%
	Samraong Kraom	18,285	10,971	60.0	5,040	16,011	87.6				
	Prey Sa	19,725	3,945	20.0	2,940	6,885	34.9	24	5,040	11,925	60.5%
	Krang Thnong	9,900	7,920	80.0	0	7,920	80.0				
	Krang Pongro	3,265		0.0	420	420	12.9	8	1,680	2,100	64.3%
	Prateah Lang	8,320		0.0	1,050	1,050	12.6	19	3,990	5,040	60.6%
	Sak Sampov	8,160		0.0	2,100	2,100	25.7	14	2,940	5,040	61.8%
	Cheung Aek	17,915	14,332	80.0	840	15,172	84.7				
Mean Chey		**395,779**	**356,201**	**90.0%**	**840**	**357,041**	**90.2%**	**0**	**0**	**357,041**	**90.2%**
	Stueng Mean Chey	98,005	88,205	90.0	840	89,045	90.9				
	Boeng Tumpun	60,600	54,540	90.0	0	54,540	90.0				
	Preaek Pra	24,400	21,960	90.0	0	21,960	90.0				
	Chbar Ampov Muoy	14,350	12,915	90.0	0	12,915	90.0				
	Chbar Ampov Pir	31,500	28,350	90.0	0	28,350	90.0				
	Chak Angrae Leu	24,934	22,441	90.0	0	22,441	90.0				
	Chak Angrae Kraom	67,910	61,119	90.0	0	61,119	90.0				
	Nirouth	74,080	66,672	90.0	0	66,672	90.0				
Ruessei Kaev		**538,922**	**485,030**	**90.0%**	**8,400**	**493,430**	**91.6%**	**0**	**0**	**493,430**	**91.6%**
	Khmuonh	37,250	33,525	90.0	4,620	38,145	102.4				
	Tuol Sangkae	50,400	45,360	90.0	0	45,360	90.0				
	Svay Pak	27,312	24,581	90.0	0	24,581	90.0				
	Kiloumaetr Lekh Prammuo	25,545	22,991	90.0	0	22,991	90.0				
	Phnom Penh Thmei	150,889	135,800	90.0	3,780	139,580	92.5				
	Ruessei Kaev	37,800	34,020	90.0	0	34,020	90.0				
	Tuek Thla	67,400	60,660	90.0	0	60,660	90.0				
	Praek Lieb	27,916	25,124	90.0	0	25,124	90.0				
	Praek Ta Sek	26,172	23,555	90.0	0	23,555	90.0				
	Chrouy Changva	53,000	47,700	90.0	0	47,700	90.0				
	Chrang Chamreh Muoy	13,038	11,734	90.0	0	11,734	90.0				
	Chrang Chamreh Pir	22,200	19,980	90.0	0	19,980	90.0				
Kandal Province		**297,817**	**89,345**	**30.0%**	**0**	**89,345**	**30.0%**	**711**	**149,310**	**238,655**	**80.1%**
Kandal Stueng		**25,459**	**0**	**0.0%**	**0**	**0**	**0.0%**	**97**	**20,370**	**20,370**	**80.0%**
	Kong Noy	2,307									
	Preaek Kampis	11,841									
	Roluos	3,875									
	Spean Thmei	4,277									
	Tien	3,159									
Kien Svay		**76,093**	**7,609**	**10.0%**	**0**	**7,609**	**10.0%**	**254**	**53,340**	**60,949**	**80.1%**
	Kbal Kaon	23,230									
	Preaek Aeng	20,309									
	Preaek Thmei	21,751									
	Veal Sbov	10,803									
Angk Snuol		**84,546**	**25,364**	**30.0%**	**0**	**25,364**	**30.0%**	**201**	**42,210**	**67,574**	**79.9%**
	Baek Chan	22,588									
	Boeng Thum	10,696									
	Kamboul	27,837									
	Kantaok	23,425									
Ponhea Lueu		**20,451**	**1,611**	**7.9%**	**0**	**1,611**	**7.9%**	**71**	**14,910**	**16,521**	**80.8%**
	Preaek Pnov	20,451									
Ta Khmau		**91,268**	**54,761**	**60.0%**	**0**	**54,761**	**60.0%**	**88**	**18,480**	**73,241**	**80.2%**
	Ta Kdol	6,628									
	Preaek Ruessei	11,779									
	Daeum Mien	17,100									
	Ta Khmau	35,733									
	Preaek Hour	9,115									
	Kampong Samnanh	10,913									
Peri-urban area (P.P. suburbs +Kandal)		**1,620,466**	**1,182,742**	**73.0%**	**34,650**	**1,217,392**	**75.1%**	**867**	**182,070**	**1,399,462**	**86.4%**

TTL Served Pops by Wells)	**216,720**
TTL Nos. of Wells	**1,032**

*1: Served population; coverage to all population in commune or district
UNICEF/NGO well: a few, one in one village and detriolated in 2020; negligible
UWC for rural area: 40 l/c/d, Supply population by one well: 210 persons/well

Supporting Report – 2

Review of Water Supply System

Supporting Report 2.1 Raw Water Sources

1 Raw Water Sources of PPWSA

1.1 Water Level and Flow

In Phnom Penh, there are three river water sources, namely, the Mekong River, the Tonle Sap and the Tonle Basak. These three rivers are confluent at Phnom Penh, and the largest, Mekong River, affects the flow and water levels of the two other rivers.

PPWSA has three water treatment plants, each drawing water from each of the three rivers. The Phum Prek Treatment Plant takes water from Tonle Sap; Chrouy Changva Treatment Plant, from, Mekong River; and Chamkar Mon Treatment Plant, from Tonle Basak.

The Mekong River Committee implemented a study named "Consolidation of Hydro-Metrological Data and Multi-Functional Hydrologic Roles of Tonle Sap Lake and its Vicinities (Basinwide)" in 2003. Applying the study results, flows and water levels of three rivers from 1993 to 2004 are shown in the following chart.

The Mekong River seasonally changes the flow and water level. During rainy season (July to October), the flow increases to a maximum discharge of about 35,000 m^3/sec. During the dry season (November to June), flow reduces to 2,000 m^3/sec. This high difference between the maximum and the minimum flow and water levels along the Mekong causes flow reversal of the Tonle Sap along the section between the confluence point to the Tonle Sap Lake during the rainy season from July to October.

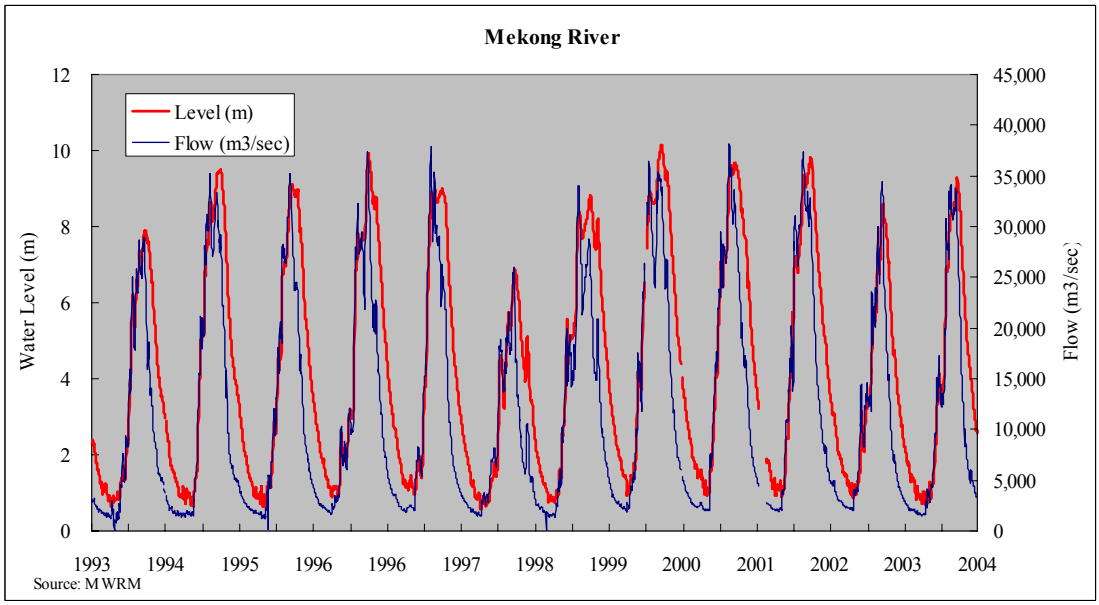


Figure SR2.1.1 Mekong River – Water Level and Flow

During Phase 1 Master Plan Study gauge height was applied to evaluate water level, but Hatien sea level is applied as the standard level. Hatien sea level is 1.08 m lower than gauge level at Chrouy Changva. The record from 1993 to 2004 shows maximum water level was 10.13 m on September 21, 2000 and minimum was 0.57 m on April 11, 1998.

The following figure shows the flow and water level the Tonle Sap. The river flows normally from the Tonle Sap Lake to the Mekong River during most of the year. However, its flow reverses from end of dry season to the middle of rainy season. The relationship between the river water level and actual flow of the Tonle Sap is still under study, but the intermediate results are indicated in the following figure.

Normal flow rises to about 10,000 m^3/sec in October, subsides, and then reverses from May to August with flow of about -8,000 m^3/sec.

The record from 1993 to 2004 at Phnom Penh Port shows maximum water level was 10.09 m and minimum was 0.45 m by Hatien sea level.

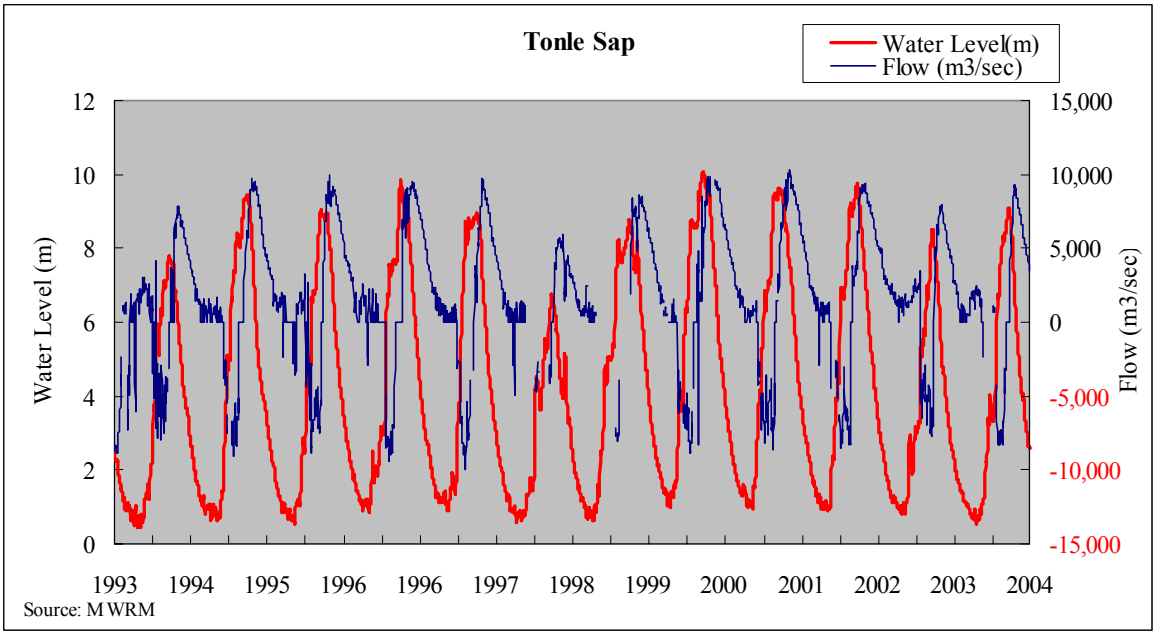


Figure SR2.1.2 Tonle Sap – Water Level and Flow

Tonle Basak generally has the same water level and flow characteristics as those of the Mekong River, but the flow is much small.

The record from 1993 to 2004 at Chakto Mukh shows maximum water level was 10.18 m and minimum was 0.5 m by Hatien sea level.

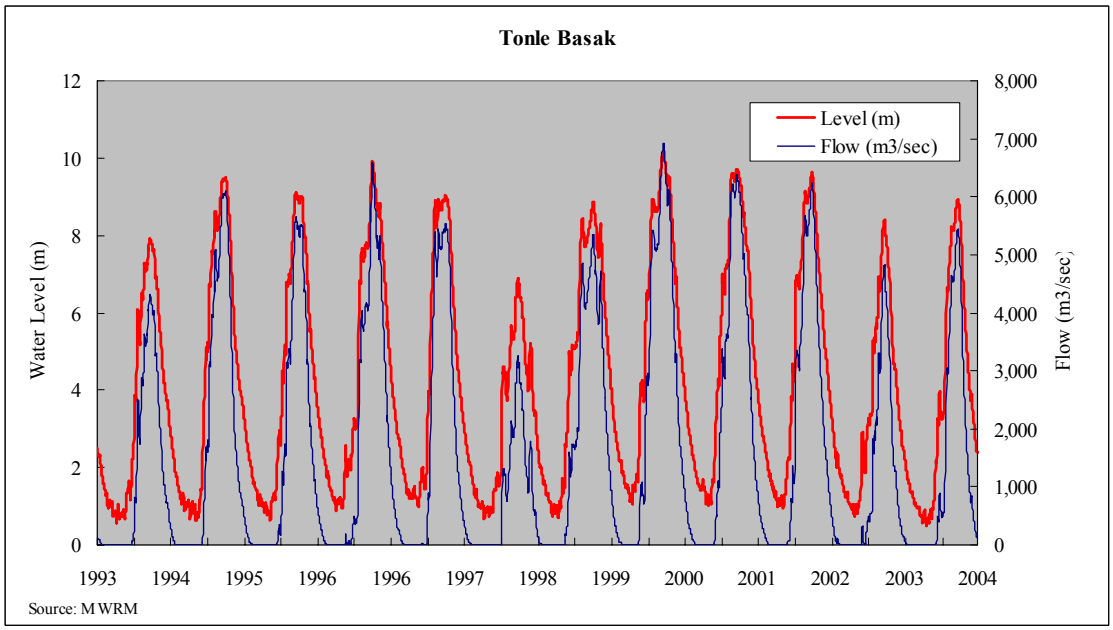


Figure SR2.1.3 Tonle Basak – Water Level and Flow

1.2 River Water Quality

As for the river water quality, the pH level of raw water from Mekong River (for Chrouy Changva), at 8.0, is significantly higher than that of the other two rivers (Tonle Sap, for Phum Prek and Tonle Basak, for Chamkar Mon), at about 7.0. During the rainy season, the three rivers have similar pH due to mixing of the water. The three sources also have similar turbidity characteristics during the rainy season. However, there is a significant difference in turbidity during the dry season and the rainy season.

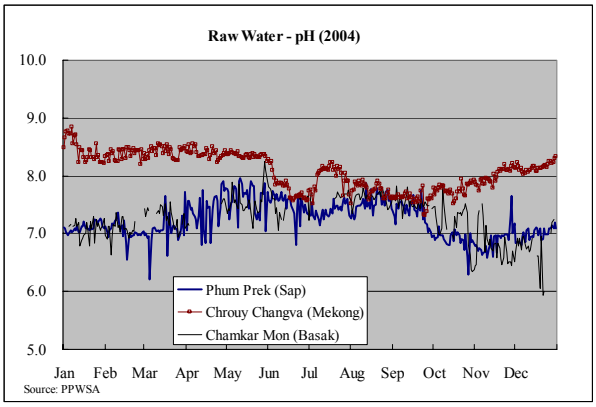


Figure SR2.1.4 pH in Rivers

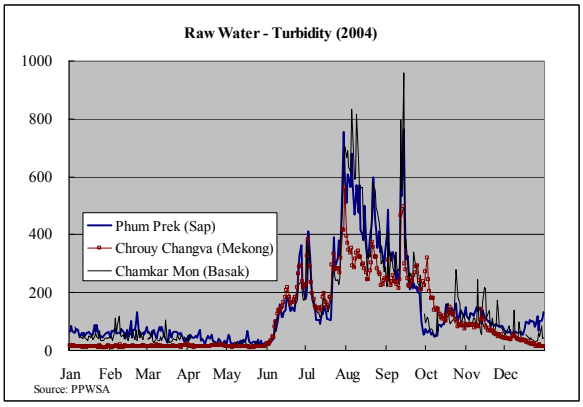


Figure SR2.1.5 Turbidity in Rivers

During the dry season from November to June, turbidity levels average about NTU 56. During the rainy season from July to October, it rose to NTU 281 in 2004. Turbidity and pH at three raw water sources in 2004 are shown in the following figures. This pattern recurs every year.

Since population and human activities in Phnom Penh have been rapidly increasing in last decade, some water contamination can be expected in this area. BOD and COD levels in three

rivers recorded by the Ministry of Environment for last two and half years are shown in the following figures.

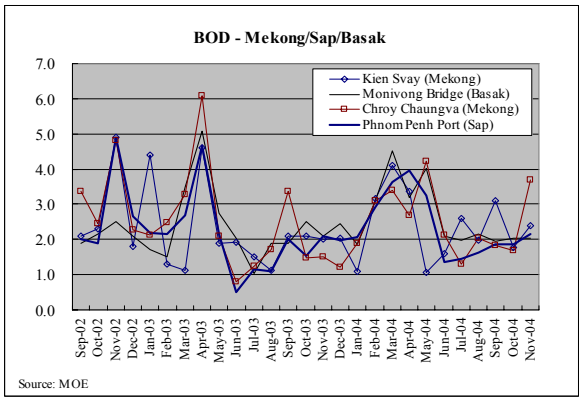


Figure SR2.1.6 BOD in Rivers

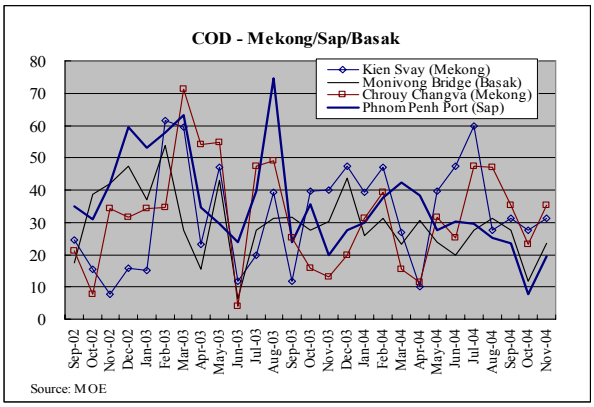


Figure SR2.1.7 COD in Rivers

Differences in BOD levels among the water sources are more significant during the dry seasons than during the rainy seasons at all sampling points. BOD raises 4 to 5 mg/l during dry season and it drops 1 to 2 mg/l. BOD of 4 to 5 mg/l are almost upper limitation of water sources for water supply.

Data from the Ministry of Water Resources & Meteorology on NH_4 in three rivers shows a slight increase of NH_4 in last four years at Phnom Penh Port and Chakto Mukh. Chrouy Changva shows a relatively lower value than the other two locations. This characteristic indicates some contamination in the Tonle Sap and the Tonle Basak in Phnom Penh.

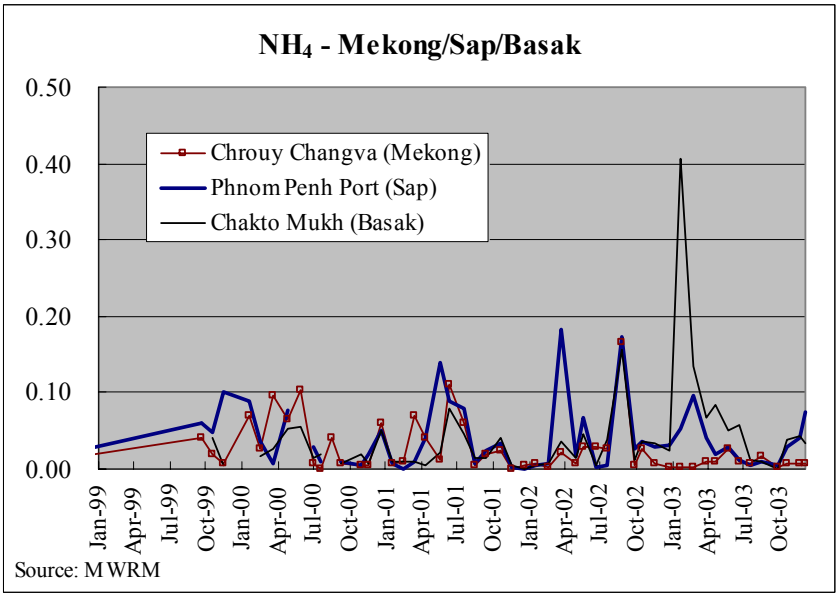


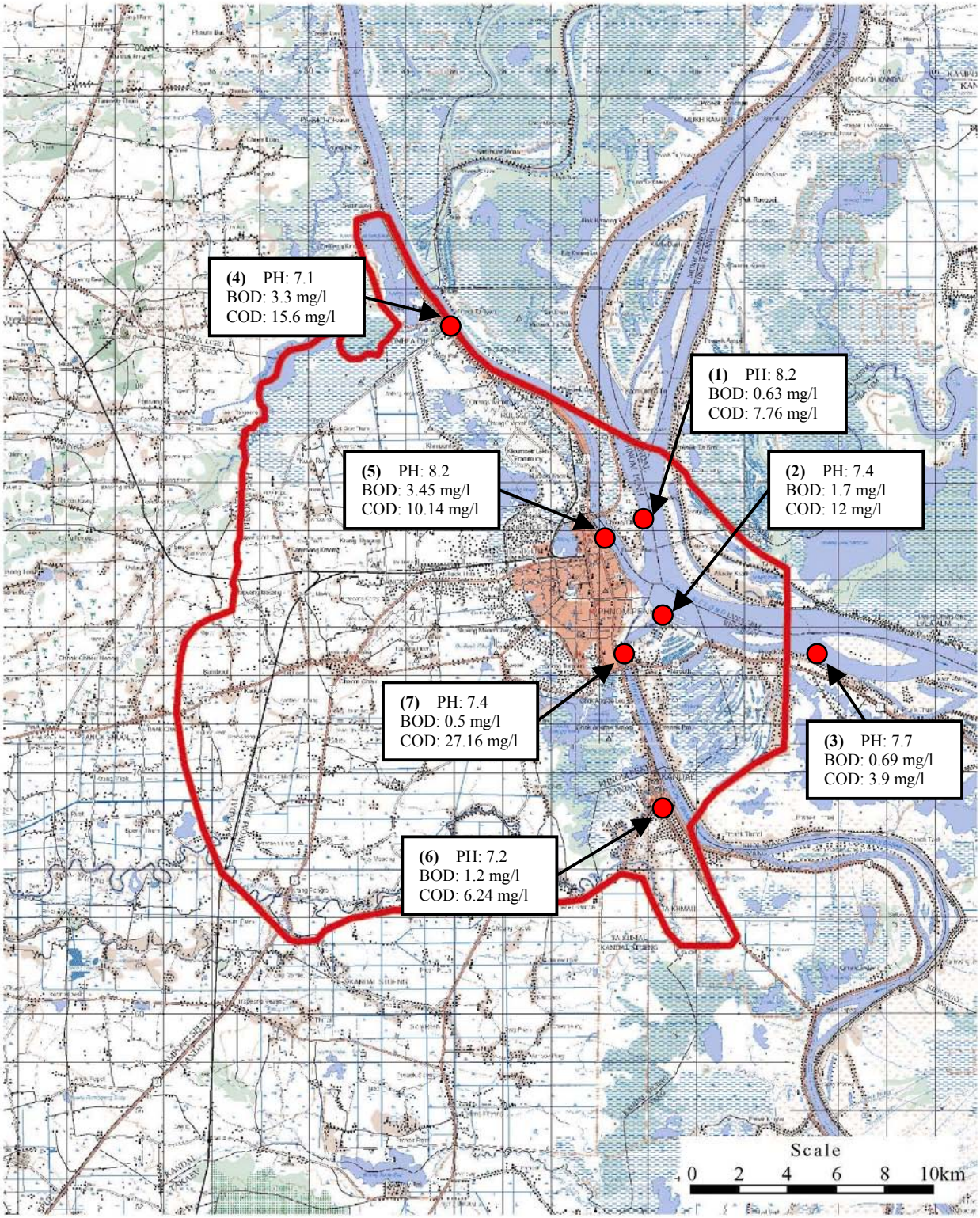
Figure SR2.1.8 NH_4 in Rivers

A water quality survey was implemented in December 2004 and January 2005. Three sampling points were located along the Mekong River; and two each along Tonle Sap and Tonle Basak. The survey covers microbial aspects, chemicals, organic matter etc.

The following figure summarizes BOD and COD at seven sampling points on the rivers.

The Mekong River shows the better quality based on BOD and COD compared with the other two rivers. This finding clearly indicates some contamination by the population and its activities in Phnom Penh. It also requires conserving the existing water sources from contamination by human activities.

In the light of both quantity and quality for the water source of water supply the Mekong River is the best option for the future water source.


(4) PH: 7.1
BOD: 3.3 mg/l
COD: 15.6 mg/l
(1) PH: 8.2
BOD: 0.63 mg/l
COD: 7.76 mg/l
(5) PH: 8.2
BOD: 3.45 mg/l
COD: 10.14 mg/l
(2) PH: 7.4
BOD: 1.7 mg/l
COD: 12 mg/l
(7) PH: 7.4
BOD: 0.5 mg/l
COD: 27.16 mg/l
(3) PH: 7.7
BOD: 0.69 mg/l
COD: 3.9 mg/l
(6) PH: 7.2
BOD: 1.2 mg/l
COD: 6.24 mg/l
Scale
0 2 4 6 8 10km

Supporting Report 2.2 Existing Water Treatment Plants

1. Water Treatment Plants in Phnom Penh

The facilities in the three treatment plants – Phum Prek, Chamkar Mon and Chrouy Changva – are relatively new or recently rehabilitated.

Water production from 2000 to 2004 is illustrated in Figure SR2.2.1. Water production was rapidly increased in the last five years to keep pace with the increase of population and extension of service area. Especially after construction of new plant in Phum Prek in 2003, water production shows significant fluctuation between dry and rainy seasons. It seems the production met actual water demand in 2004.

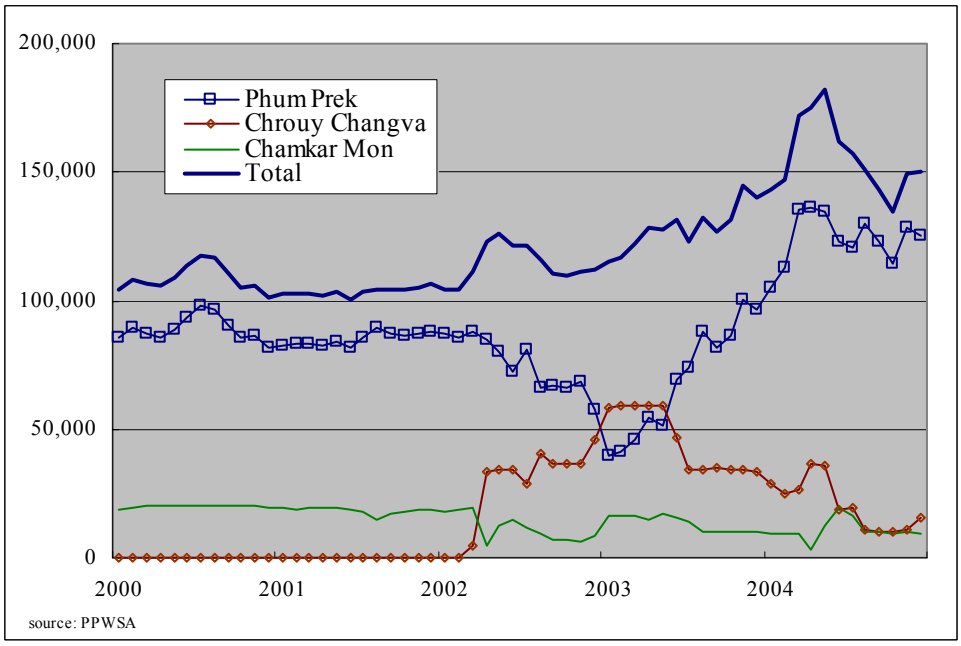


Figure SR2.2.1 Water Production 2000 – 2004

1,2 Phum Prek WTP

Phum Prek Water Treatment Plant was constructed in two stages. The old plant, with production capacity of 100,000 m^3/day, was constructed 1965, and rehabilitated in 1988 and in 1995. New treatment facilities with additional production capacity of 50,000 m^3/day was constructed in 2003. Raw water is taken from Tonle Sap near Phnom Penh Port

The plant has rapid mixing, flocculation, sedimentation, filtration and chlorination facilities and detail are shown in the following table.

In general, both old and new plants are properly operated. All treatment processes were designed following appropriate technical standards and criteria with same allowances. Therefore, facilities and equipment are easy to operate and maintain.

As for the old plant, six sets of vertical flocculators were not replaced during the rehabilitation in 1995. Parts of the driving gears have since worn out and required replacement.

All equipment in the new plant are properly operated except filters. Influent and effluent control system of the filters does not seem to be properly adjusted, causing significant flow imbalance and shortening filtration period. Presently, filters run about 24 hours in dry season and 12 hours in rainy season, which is only half of the filtration period expected.

During dry seasons, raw water is slightly poorer. Smell and algae, which are removed by pre-chlorination, can be detected.

This plant is operating in three shifts and each shift consists of an operator at intake station and five operators at treatment plant.

Layout, hydraulic profile, outline and process analysis of Phum Prek Water Treatment Plant are shown in Figures SR2.2.3, SR2.2.4, Tables SR2.2.5 and SR2.2.6, respectively.

1.3 Chamkar Mon WTP

Chamkar Mon Water Treatment Plant was also constructed in two stages. The old plant, with a production capacity of 10,000 m^3/day, was constructed 1957 and rehabilitated in 1988. Additional treatment facilities was constructed 1995 raising production capacity to 20,000 m^3/day.

Raw water intake pump station is located near the Thai Embassy along Tonle Basak. The plant has rapid mixing, flocculation, sedimentation, filtration and chlorination facilities and detail are shown in the following table.

The Chamkar Mon Plant follows a modular water treatment process and requires more complicated operations to maintain the quality of treated water. Eight (8) small filters require laborious daily washing of the filters. Operators are facing difficulties for proper operation and good maintenance.

This plant operation consists of three shifts and each shift has three operators for the treatment plant an intake station.

Layout, hydraulic profile, outline and process analysis of Chamkar Mon Water Treatment Plant are shown in Figures SR2.2.5, SR2.2.6, Tables SR2.2.7 and SR2.2.8, respectively.

1.4 Chrouy Changva WTP

The following table shows outline of Chrouy Changva Water Treatment Plant.

Chrouy Changva Water Treatment Plant was constructed in 2002 with a production capacity of 65,000 m^3/day. Land is available for future expansion of capacity by another 65,000 m^3/day.

Intake pump station is located just in front of the plant along the Mekong River.

This plant has better raw water quality than others, but it has some difficulties due to algae growth in the sedimentation tanks because of exposure to sunlight.

This plant operation consists of three shifts and each shift has three operators for the treatment plant an intake station.

Layout, hydraulic profile, outline and process analysis of Chrouy Changva Water Treatment Plant are shown in Figures SR2.2.7, SR2.2.8, Tables SR2.2.9 and SR2.2.10, respectively.

2. Water Treatment Plant Operation

Figure 9-11 shows water production in 2004. After construction of new plant in Phum Prek, water production matched water demand. Annual fluctuation of water demand is clearly indicated in the figure. During the dry season from March to June, the production increases to over 180,000 m^3/day in April, and in other months, it decreases to around 145,000 m^3/day.

Operation records indicate a daily average production of 155,124 m^3/d and a daily maximum production of 192,951 m3/d. Peak-day factor is 1.24.

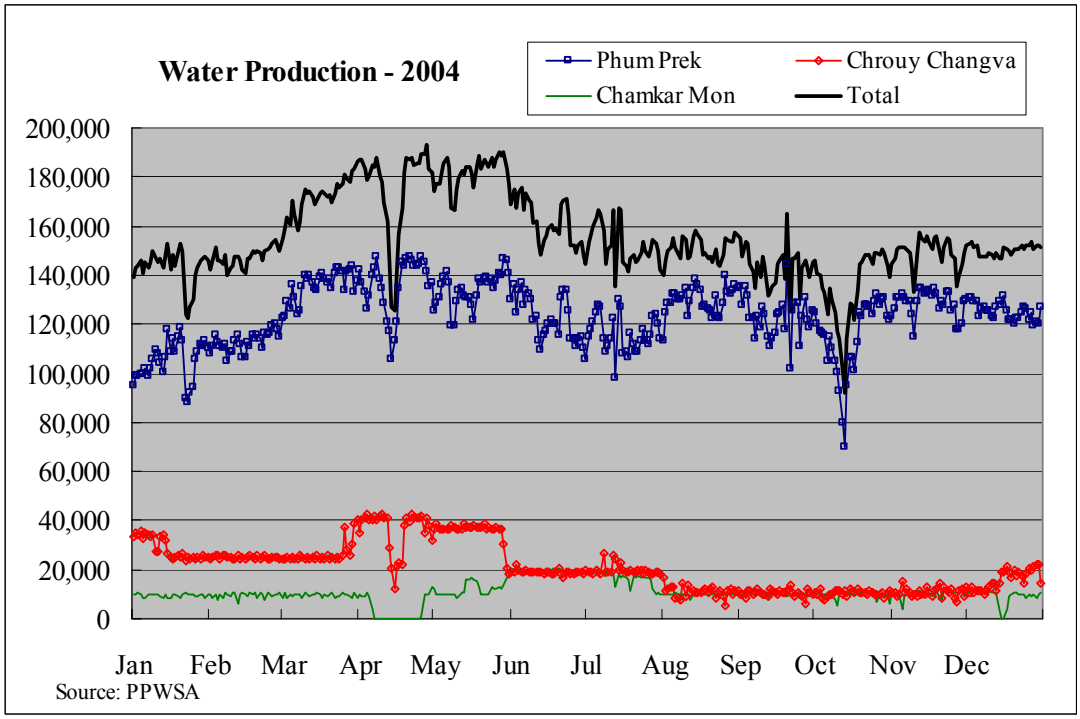


Figure SR2.2.2 Water Production in 2004

As for raw water intake pump stations, low water levels of intake pump stations at Phum Prek and Chamkar Mon are set 1.58 m and 1.5 m respectively, but the record from 1993 to 2004 shows minimum water level of 0.45 m at Phnom Penh Port and minimum water level of 0.5 m at Chakto Mukh. Since design low water level at these pump stations are lower than the actual low water level, the design capacities of the intake pump stations cannot be supplied when the

Tonle Sap and Tonle Basak is lower than the design low water levels.

All treatment processes were designed appropriate technical standards and criteria.

The following table summarized typical criteria for water treatment process, and they are reasonable range of the design.

Table SR2.2.1 Typical Design Criteria of Treatment Process

Process	Phum Prek	Chamkar Mon	Chrouy Changva
Sedimentation			
Type	Horizontal Flow	Up Flow Sludge Blanket	Up Flow with Inclined Tube
Retention Time	2.1 hrs & 2.4 hrs	1.6 hrs	1.7 hrs
Filter			
Type	Gravity, Single Media	Pressured Single Media	Gravity, Single Media
Filtration Speed	6.5 m/hr & 5.3 m/hr	6.9 m/hr	5.9 m/hr

There is no critical problem for three treatment plants, but same adjustment are required for filters in Phum Prek new treatment plant. Influent and effluent control system of the filters does not seem to be properly adjusted, causing significant flow imbalance and shortening filtration period.

The existing treatment plants do not equip any waste water and sludge treatment facilities, such as backwash water recovery tank, sludge lagoon, sludge drying bed etc. It is preferable to provide those facilities to minimize high turbid water or sludge discharging streams or rivers.

In 2004, only Phum Prek Plant was operated with full capacity, and Chamkar Mon and Chrouy Changva Plant were operate at the half of the original production capacity, possibly to reduce overall production cost.

The following table shows power consumption of three plants during high capacity operation.

Table SR2.2.2 Average Power Consumption

Plant	Power Consumption (W/m3)	Production (m3/day)	Month/Year
Phum Prek	211	136,008	March/2004
Chamkar Mon	391	16,649	January/2003
Chrouy Changva	300	59,514	January/2003

Turbidity of raw water varies each plant due to different water source. Turbidity for each plant in 2004 are summarized in the following table.

Table SR2.2.3 Turbidity in 2004

Plant	Maximum	Average	Median	Minimum
Phum Prek	766	141	80.0	13.0
Chamkar Mon	960	153	76.3	15.0
Chrouy Changva	562	108	42.8	9.8

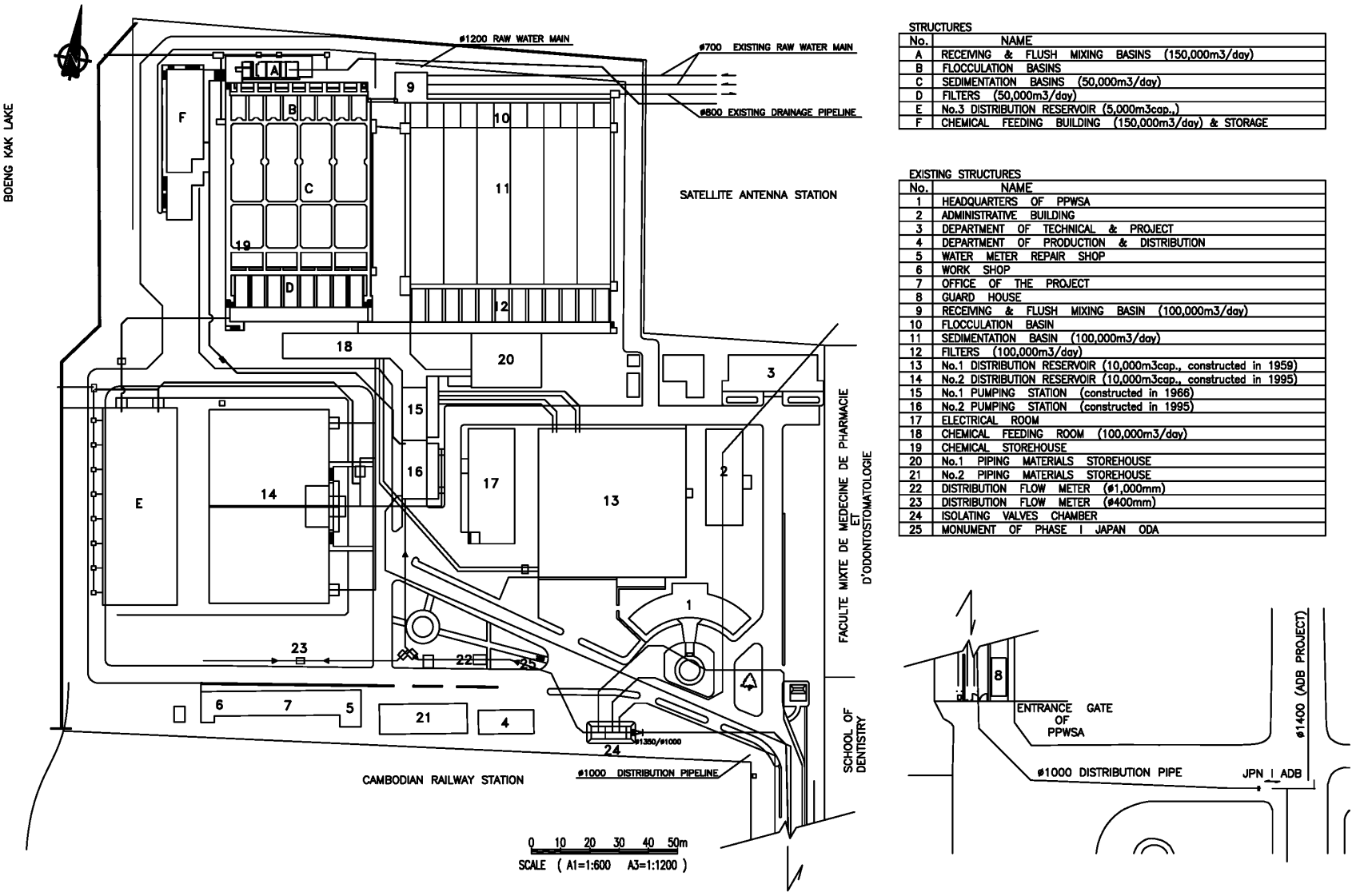
Chrouy Changva Plant which takes from the Mekong River has better raw water quality than others with respect to turbidity. Chemical consumption depends on raw water turbidity. The following table shows average chemical consumption in 2004.

Table SR2.2.4 Chemical Consumption

Plant/River		Alum (g/m3)	Lime (g/m3)	Chlorine (g/m3)
Phum Prek	Sap	22.37	6.76	3.08
Chamkar Mon	Basak	45.83	7.06	2.36
Chrouy Changva	Mekong	17.06	0.00	1.80

Chrouy Changva Plant consumes less alum and chlorine than other plants and no lime, due to better raw water quality. Chamkar Mon has biggest consumption due to higher turbidity and difficulties in operation of the chemical dosing equipment.

It is expected that deterioration of raw water quality will require more consumption of chemicals for Phum Prek and Chamkar Mon Plants in future.



STRUCTURES

No.	NAME
A	RECEIVING & FLUSH MIXING BASINS (150,000m3/day)
B	FLOCCULATION BASINS
C	SEDIMENTATION BASINS (50,000m3/day)
D	FILTERS (50,000m3/day)
E	No.3 DISTRIBUTION RESERVOIR (5,000m3cap.,)
F	CHEMICAL FEEDING BUILDING (150,000m3/day) & STORAGE

EXISTING STRUCTURES

No.	NAME
1	HEADQUARTERS OF PPWSA
2	ADMINISTRATIVE BUILDING
3	DEPARTMENT OF TECHNICAL & PROJECT
4	DEPARTMENT OF PRODUCTION & DISTRIBUTION
5	WATER METER REPAIR SHOP
6	WORK SHOP
7	OFFICE OF THE PROJECT
8	GUARD HOUSE
9	RECEIVING & FLUSH MIXING BASIN (100,000m3/day)
10	FLOCCULATION BASIN
11	SEDIMENTATION BASIN (100,000m3/day)
12	FILTERS (100,000m3/day)
13	No.1 DISTRIBUTION RESERVOIR (10,000m3cap., constructed in 1959)
14	No.2 DISTRIBUTION RESERVOIR (10,000m3cap., constructed in 1995)
15	No.1 PUMPING STATION (constructed in 1966)
16	No.2 PUMPING STATION (constructed in 1995)
17	ELECTRICAL ROOM
18	CHEMICAL FEEDING ROOM (100,000m3/day)
19	CHEMICAL STOREHOUSE
20	No.1 PIPING MATERIALS STOREHOUSE
21	No.2 PIPING MATERIALS STOREHOUSE
22	DISTRIBUTION FLOW METER (ø1,000mm)
23	DISTRIBUTION FLOW METER (ø400mm)
24	ISOLATING VALVES CHAMBER
25	MONUMENT OF PHASE I JAPAN ODA

Figure SR2.2.3 Phum Prek - Layout

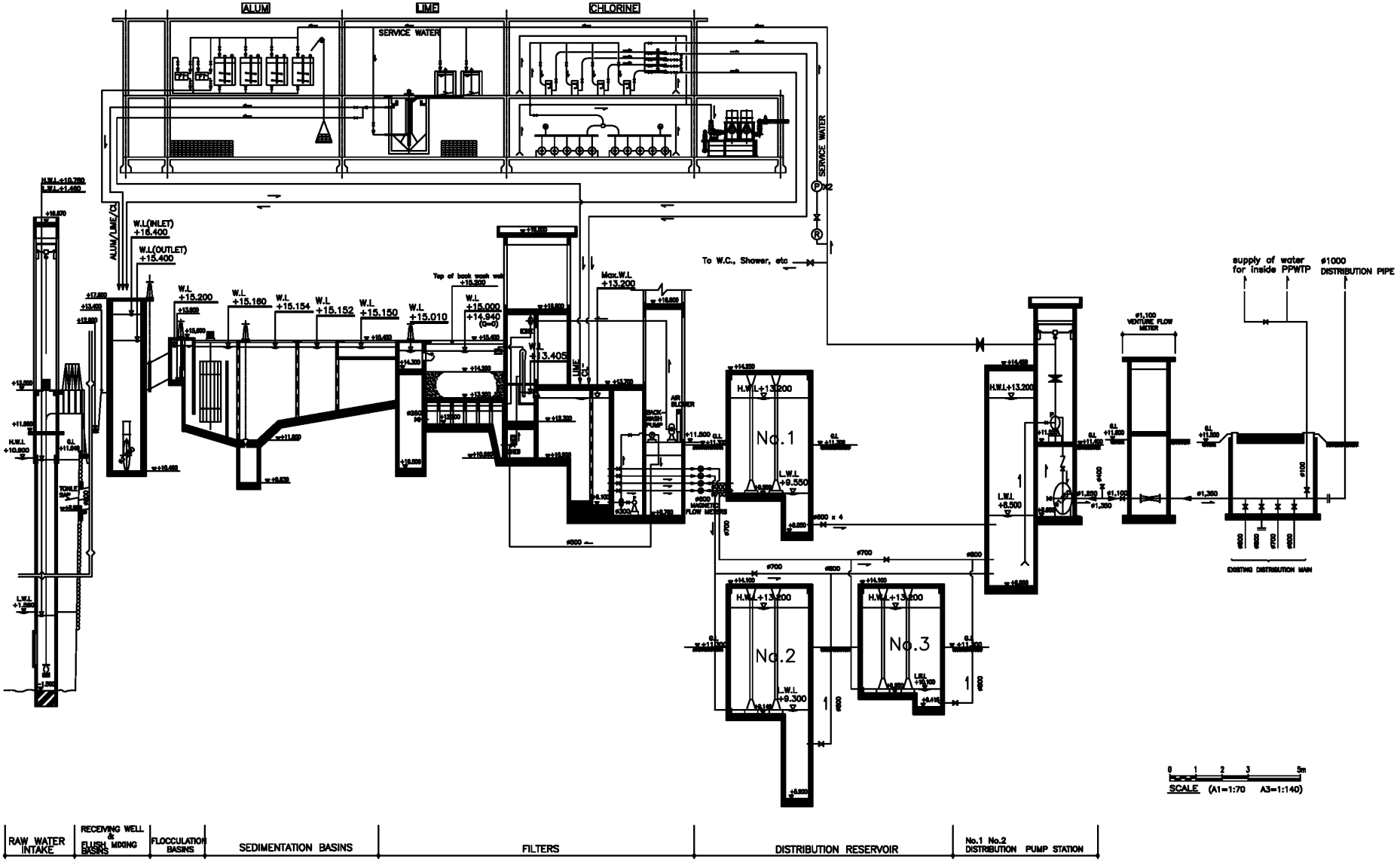


Figure SR2.2.4 Phum Prek – Hydraulic Profile

Table SR2..2.5 Phum Prek Water Treatment Plant

Name of Water Treatment Plant : Phum Prek

Capacity	100,000 m3/d (Old)	50,000 m3/d (New)
Water Source	158,400 m3/d Tonle Sap	HWL = 10.9 m, LWL = 1.5m
Construction	1965 costruction of old plant	
	1988, 1995 rehabilitation of old plant	
	2003 construc construction of new plant	
Intake Facilities	Tonle Sap HWL = 10.78 m, LWL = 1.46m	
Type	Raw Water Pumping	
Intake Pump	(existing) : 36.7 m3/min x 21 m x 3 units	
	(new) : 36.7 m3/min x 21 m x 2 units	
Receiving Well		
Type	Recutangular	
Retention Time	4.1 min	
Size & Q'ty	5.3 mW x 15 mL x 5.3 mD x 1 unit	

Name of Water Treatment Plant :	Phum Prek - Old
Capacity	100,000 m3/d (Old)
Treatment Process	
1. Rapid Mixing 2. Flocculation 3. Sedimentation 4 Filtration 5 Disinfection	
Flocculation	
Type	Horizontal Flow
Retention Time	24.8 min.
Size	8.0 mW x 11.0 mL x 3.27 mD
Q'ty	6 units
Equipment	Vertical Flocculator 6 units
Sedimentation Tank	
Type	Horizontal Flow
Retention Time	126.8 min 2.1 hr
Size	11 mL x 53 mW x 2.52 mD
Q'ty	6 units
Flow Velocity	0.52 m/min
Surface Load	119.2 mm/min
Trough/Pipe	Orifice Trough
Sludge Removal	Sludge Extraction Valve (Manual)
Equipment	Sludge Extraction Valve
Operation	Sludge Removal - Manual
Filter	
Type	Gravity, Single Media, Constant Flow, Level Control
Filtration rate	156 m/d (6.50 m/hr) 170 m/hr at washing
Filter Bed Area	53.6 m2
Size & Q'ty	4.5 mW x 11.9 mL x 12 filters
Filter Media	Sand : 0.8-1.0 mm x 1000 mm
Washing Rate	Air Scour : 0.934 m/min Wash : 0.342 m/min Rincing : 0.342 m/min
Washing System	Air Scouring (4 - 5 min), Air Scouring + Backwashing (4 - 7 min), Rincing (15 - 20 min)
Wash Trough	None
Equipment	Inlet Gate, Outlet Valve, Level Control Siphon, Siphon Regulation System
	Washwater Inlet Valve,Washwater Discharge Gate, Washwater Pump
	Scour Air Inlet Valve, Air Blower
Operation	Manual(Original-Automatic & Step-by-step)
Sludge Disposal	
	Direct Discharge to the river

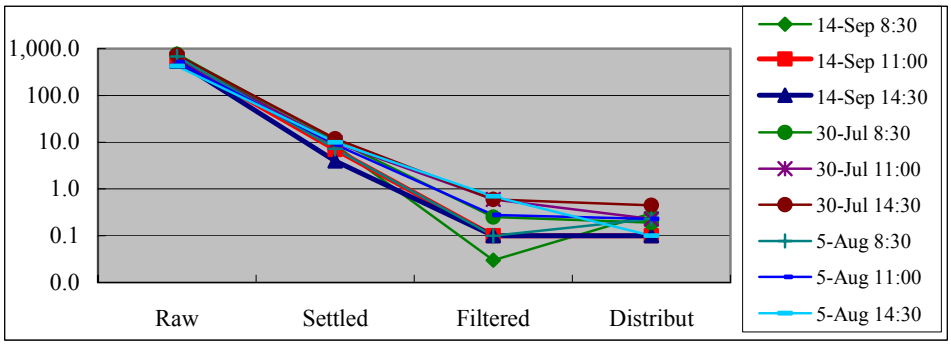
Name of Water Treatment Plant :	Phum Prek - New
Capacity	50,000 m3/d
Treatment Process	
1. Rapid Mixing 2. Flocculation 3. Sedimentation 4 Filtration 5 Disinfection	
Rapid Mixing	
Type	Weir
Retention Time	73 sec
Size & Q'ty	1.8 mW x 5.0 mL x 4.7 mD x 1 unit
Equipment	None
Flocculation	
Type	Horizontal Flow
Retention Time	26.2 min.
Size	11.3 mW x 7.0 mL x 2.9 mD
Q'ty	4 units
Equipment	Vertical Flocculator 8 units
Sedimentation Tank	
Type	Horizontal Flow
Retention Time	145.7 min 2.4 hr
Size	43.4 mL x 11.3 mW x 2.6 mD
Q'ty	4 units
Flow Velocity	1.19 m/min
Surface Load	71.4 mm/min
Trough/Pipe	Orifice Trough
Sludge Removal	Sludge Extraction Valve (Manual)
Equipment	Sludge Extraction Valve
Operation	Sludge Removal - Manual
Filter	
Type	Gravity, Single Media, Constant Flow, Level Control
Filtration rate	128 m/d (5.33 m/hr) 146 m/hr at washing
Filter Bed Area	48.8 m2
Size & Q'ty	4.5 mW x 10.85 mL x 8 filters
Filter Media	Sand : 0.8-1.0 mm x 1000 mm
Washing Rate	Air Scour : 1.024 m/min Wash : 0.375 m/min Rincing : 0.42 m/min
Washing System	Backwashing (0.5 min), Air Scouring + Backwashing (4 - 7 min), Rincing (10 - 15 min)
Wash Trough	None
Equipment	Inlet Gate, Outlet Valve, Level Control Siphon, Siphon Regulation System
	Washwater Inlet Valve,Washwater Discharge Gate, Washwater Pump
	Scour Air Inlet Valve, Air Blower
Operation	Automatic & Step-by-step
Sludge Disposal	
	Direct Discharge to the river
Chemicals	
Alum	Tank + Mixer : 4 , Dosing Tank : 2 (1)
Lime	Tank + Mixer : 2, Lime Saturator : 1, Flowmeter : 4 (2)
Chlorine	Chlorinator -Pre : 2(1), -Post : 3(1)
Clear Water Reservoir	HWL = 13.2 m, LWL = 9.3 m
No. 1	10,000 m3
No. 2	10,000 m3
No. 3	5,000 m3
Clear Water Pump	HWL = 13.2 m, LWL = 8.5 m
Transmission	(1 to 2) 17.5 m3/min x 42 m x 180 kW x 2 units
Distribution-1	(1 to 4) 35.0 m3/min x 42 m x 320 kW x 4 units
Distribution-2	(5 to 7) 17.5 m3/min x 42 m x 180 kW x 3 units

Table SR2.2.6 Phum Prek Water Treatment Plant – Process Analysis

Phum Prek - Old Plant (100,000 m3/day)

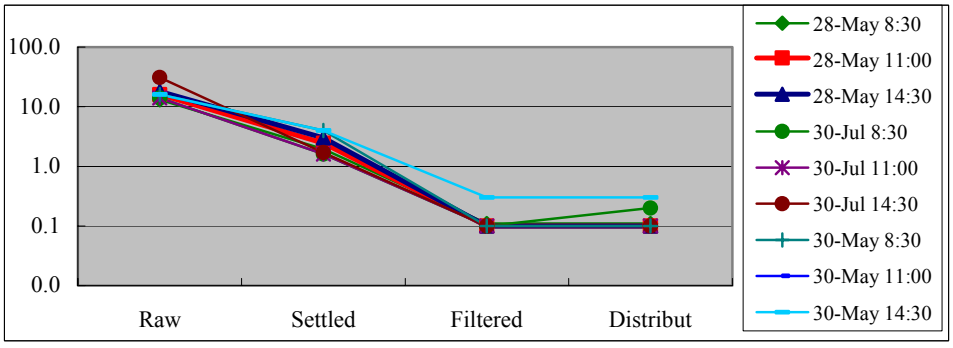
High Turbidity

	Date	Time	Item	Raw	Settled	Filtered	Distribut
1	14-Sep	8:30	Turbidity	766	8.70	0.03	0.30
		11:00	Turbidity	595	7.00	0.10	0.10
		14:30	Turbidity	545	4.00	0.10	0.10
2	30-Jul	8:30	Turbidity	756	11.00	0.25	0.19
		11:00	Turbidity	614	9.80	0.60	0.23
		14:30	Turbidity	727	12.00	0.60	0.45
1	5-Aug	8:30	Turbidity	680	7.20	0.10	0.23
		11:00	Turbidity	515	8.90	0.28	0.23
		14:30	Turbidity	423	10.00	0.70	0.10
		Average	Average	625	8.73	0.31	0.21
		Removal	Removal	100%	1.4%	0.05%	0.03%



Low Turbidity

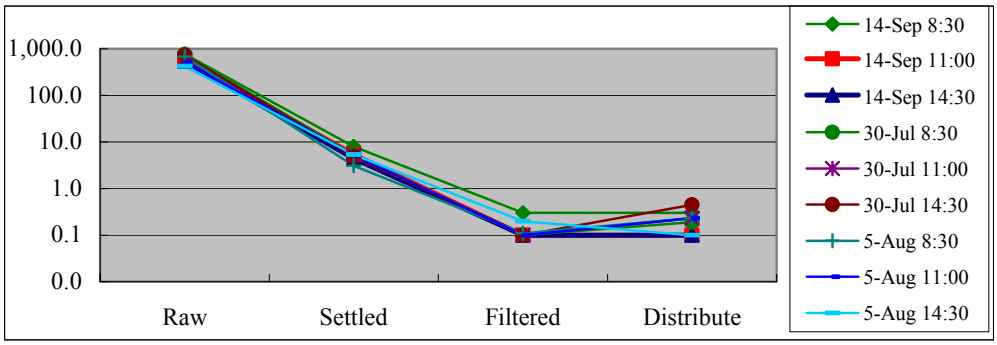
	Date	Time	Item	Raw	Settled	Filtered	Distribut
1	28-May	8:30	Turbidity	13	1.95	0.11	0.11
		11:00	Turbidity	16	2.45	0.10	0.10
		14:30	Turbidity	18	3.00	0.10	0.10
2	30-Jul	8:30	Turbidity	14	1.60	0.10	0.20
		11:00	Turbidity	14	1.60	0.10	0.10
		14:30	Turbidity	31	1.70	0.10	0.10
1	30-May	8:30	Turbidity	16	4.00	0.10	0.10
		11:00	Turbidity				
		14:30	Turbidity	16	4.00	0.30	0.30
		Average	Average	17	2.54	0.13	0.14
		Removal	Removal	100%	14.7%	0.7%	0.8%



Phum Prek - New Plant (50,000 m3/day)

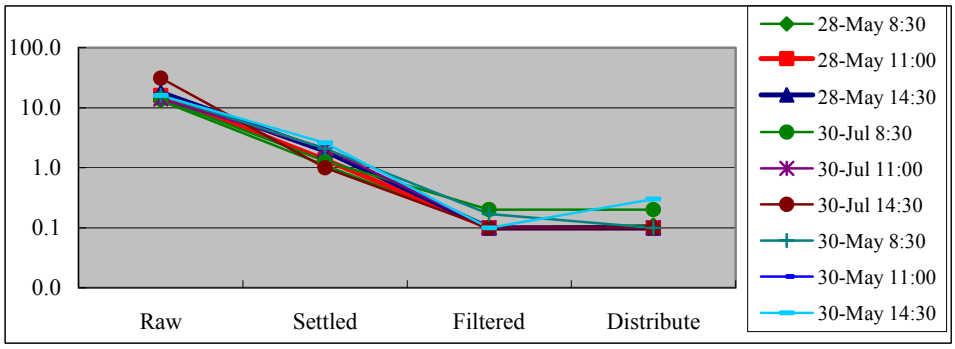
High Turbidity

	Date	Time	Item	Raw	Settled	Filtered	Distribute
1	14-Sep	8:30	Turbidity	766	8.00	0.30	0.30
		11:00	Turbidity	595	5.40	0.10	0.10
		14:30	Turbidity	545	4.40	0.10	0.10
2	30-Jul	8:30	Turbidity	756	5.30	0.10	0.19
		11:00	Turbidity	614	5.20	0.10	0.23
		14:30	Turbidity	727	4.80	0.10	0.45
1	5-Aug	8:30	Turbidity	680	3.10	0.11	0.23
		11:00	Turbidity	515	5.20	0.10	0.23
		14:30	Turbidity	423	5.40	0.20	0.10
			Average	625	5.20	0.13	0.21
			Removal	100%	0.83%	0.02%	0.03%



Low Turbidity

	Date	Time	Item	Raw	Settled	Filtered	Distribute
1	28-May	8:30	Turbidity	13	1.10	0.10	0.11
		11:00	Turbidity	16	1.37	0.10	0.10
		14:30	Turbidity	18	1.90	0.10	0.10
2	30-Jul	8:30	Turbidity	14	1.30	0.20	0.20
		11:00	Turbidity	14	2.10	0.10	0.10
		14:30	Turbidity	31	1.00	0.10	0.10
1	30-May	8:30	Turbidity	16	2.10	0.17	0.1
		11:00	Turbidity				
		14:30	Turbidity	16	2.60	0.10	0.30
			Average	17	1.68	0.12	0.14
			Removal	3%	90.2%	99.3%	99.2%



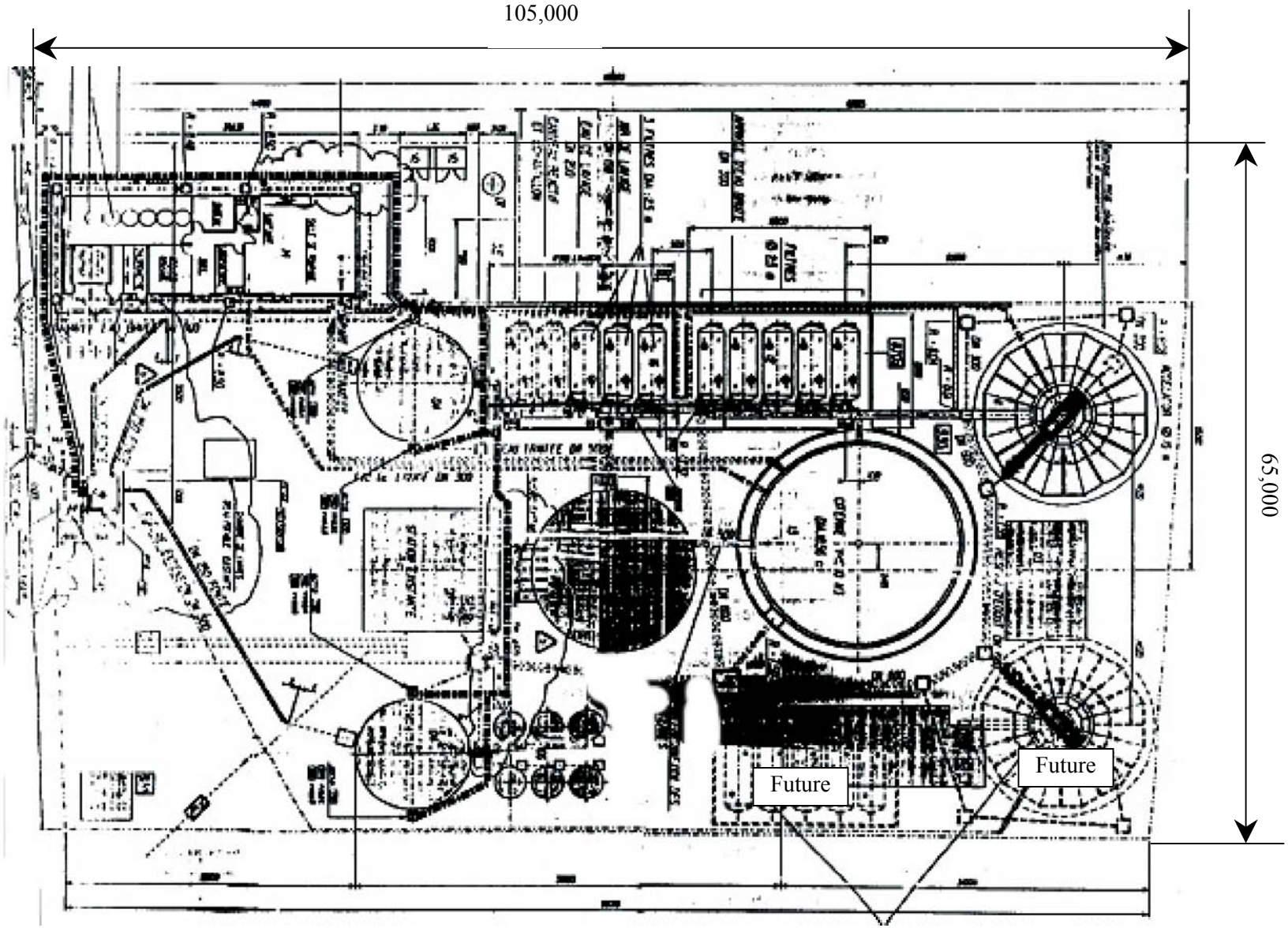


Figure SR2.2.5 Chamkar Mon – Layout

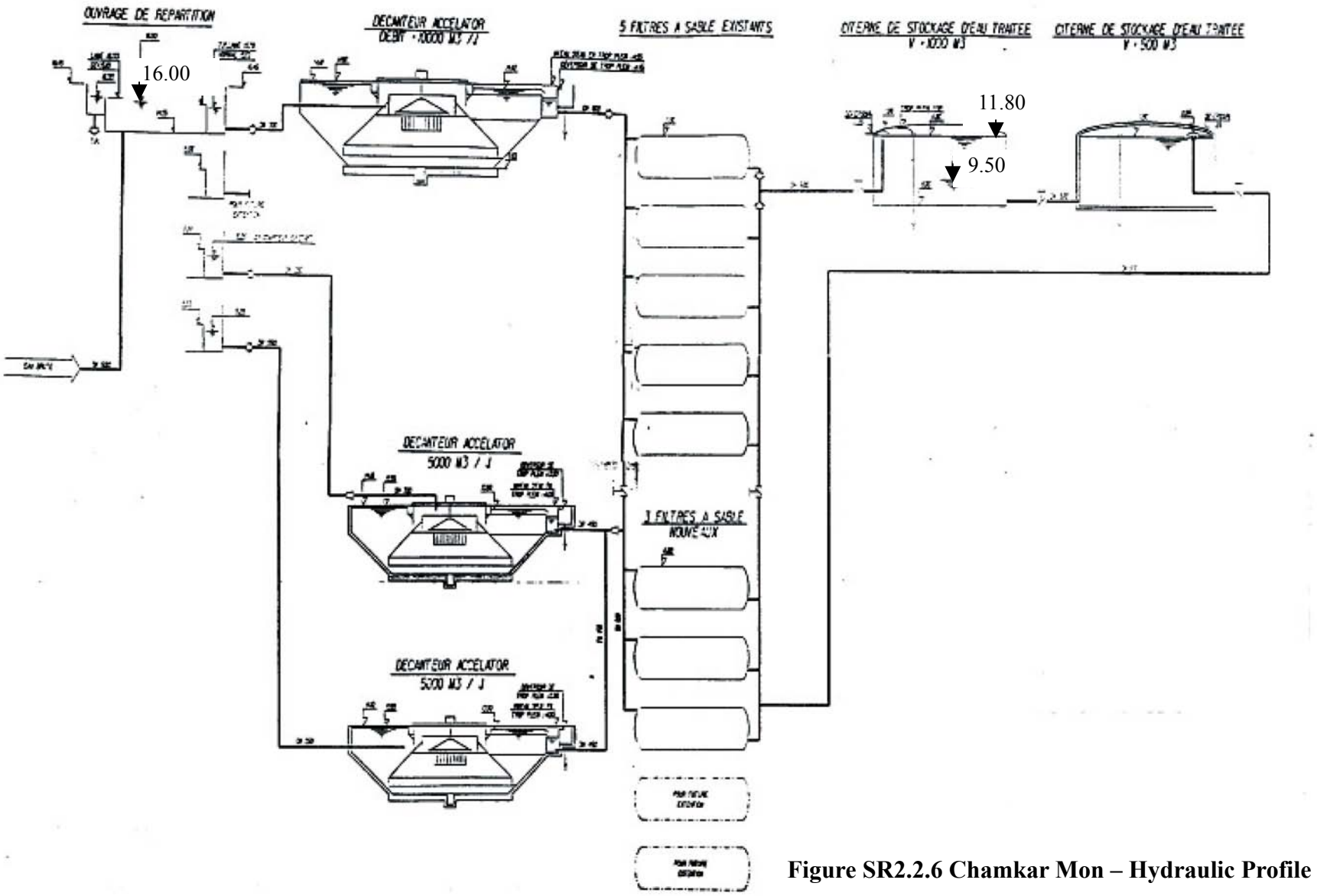


Figure SR2.2.6 Chamkar Mon – Hydraulic Profile

Table SR2.2.7 Chamkar Mon Water Treatment Plant

Name of Water Treatment Plant : Chamkar Mon

Capacity		20,000 m3/d
Water Source		Tonle Basak HWL = 10.7 m, LWL = 1.5m
Construction		1957 costruction of old plant
		1988 rehabilitation of old plant
		1995 construction of new plant
Treatment Process		
1. Rapid Mixing 2. Flocculation 3. Sedimentation 4 Filtration 5 Disinfection		
Intake Facilities		Tonle Bassac
	Type	Raw Water Pumping
	Equipment	Intake Pump : 7.65 m3/min x 28 m x 55 kW x 3 (1)
Receiving Well		
	Type	Recutangular
	Retention Time	19 sec
	Size & Q'ty	3 mW x 1 mL x 1.5 mD x 1 unit
Rapid Mixing		
	Type	Hydraulic Jamp
	Size & Q'ty	3 mW x 0.5 mD x 3 unit
	Equipment	None
Sedimentation Tank-1		Accelator (5,000 m3/d x 2 sets)
	Type	Up-flow, Sludge Blanket, Circular
	Retention Time	1.68 hr
	Capacity	350 m3
	Size & Q'ty	10 m dia(4 m dia) 4.9 mD x 2 sets
	Surface Load	0.9 mm/min
	Trough/Pipe	Radiate Orifice Trough
	Sludge Removal	Sludge Wihtdrawal Valve
	Equipment	Sludge Wihtdrawal Valve
	Operation	Sludge Removal-Mamual
Sedimentation Tank-2		Accelator (10,000 m3/d x 1 set)
	Type	Up-flow, Sludge Blanket, Circular Type with Inclined Plate
	Retention Time	1.56 hr
	Capacity	650 m3
	Size & Q'ty	15 m dia(5.5 m dia) 4.9 mD x 1 set
	Surface Load	0.8 mm/min
	Trough/Pipe	Radiate Orifice Trough
	Sludge Removal	Sludge Wihtdrawal Valve
	Equipment	Sludge Wihtdrawal Valve
	Operation	Sludge Removal-Automatic
Filter		Horizontal Cylindrical Pressured Filter
	Type	Pressured, Single Media, Declining Flow
	Filtration rate	167 m/d (6.944 m/hr) 190 m/hr at washing
	Filter Bed Area	15.00 m2 x 8 filters
	Size & Q'ty	2.5 m Dia. x 6.0 mL x 8 filters
	Filter Media	Sand : 0.95 mm x 800 mm
	Washing System	Air Scouring (5-8 min) + Backwashing (10-15 min)
	Washing Rate	Air Scour : 0.9167 m/min Backwash : 0.25 m/min
	Trough	1 no/filter
	Equipment	Inlet Valve, Outlet Valve, Washwater Valve, Washwater Drain Valve
		Washwater Pump, Air Scouring Valve, Air Blower, Flow Meter, Headloss Meter
	Operation	Manual

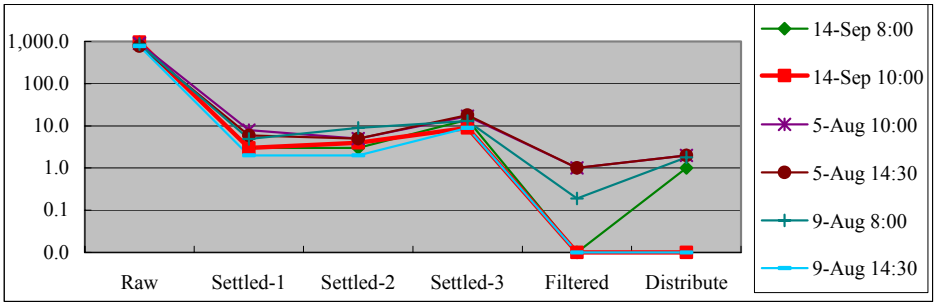
Chemicals										
	Alum	Tank + Mixer : 2 , Dosing Pump : 2 (1)								
	Lime	Tank + Mixer : 4, Dosing Pump -Pre : 2 (1), -Post : 2 (1)								
	Chlorine	Chlorinator -Pre : 2 (1), -Post : 3 (1)								
Sludge Disposal										
		Direct Discharge to the river								
Clear Water Reservoir		HWL = 9.7 m, LWL = 7.0 m								
	No. 1	1,000	m3							
	No. 2	500	m3							
Clear Water Pump										
	Transmission	7.0	m3/min	x	60	m	x	110	kW x	2 units
	Distribution	7.3	m3/min	x	30	m	x	55	kW x	2 units

Table SR2.2.8 Chamkar Mon Water Treatment Plant – Process Analysis

Chamkar Mon

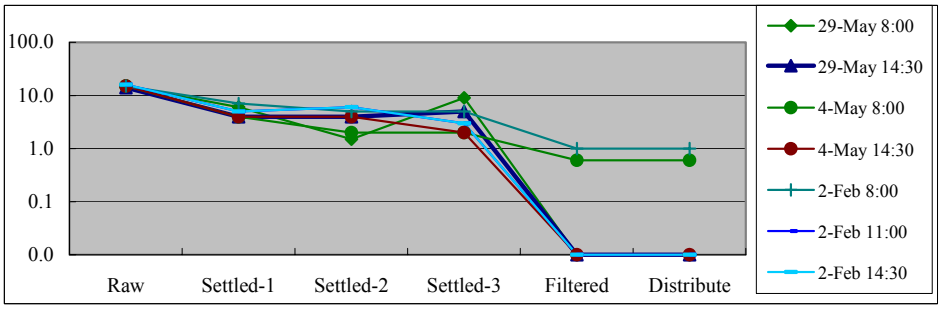
High Turbidity

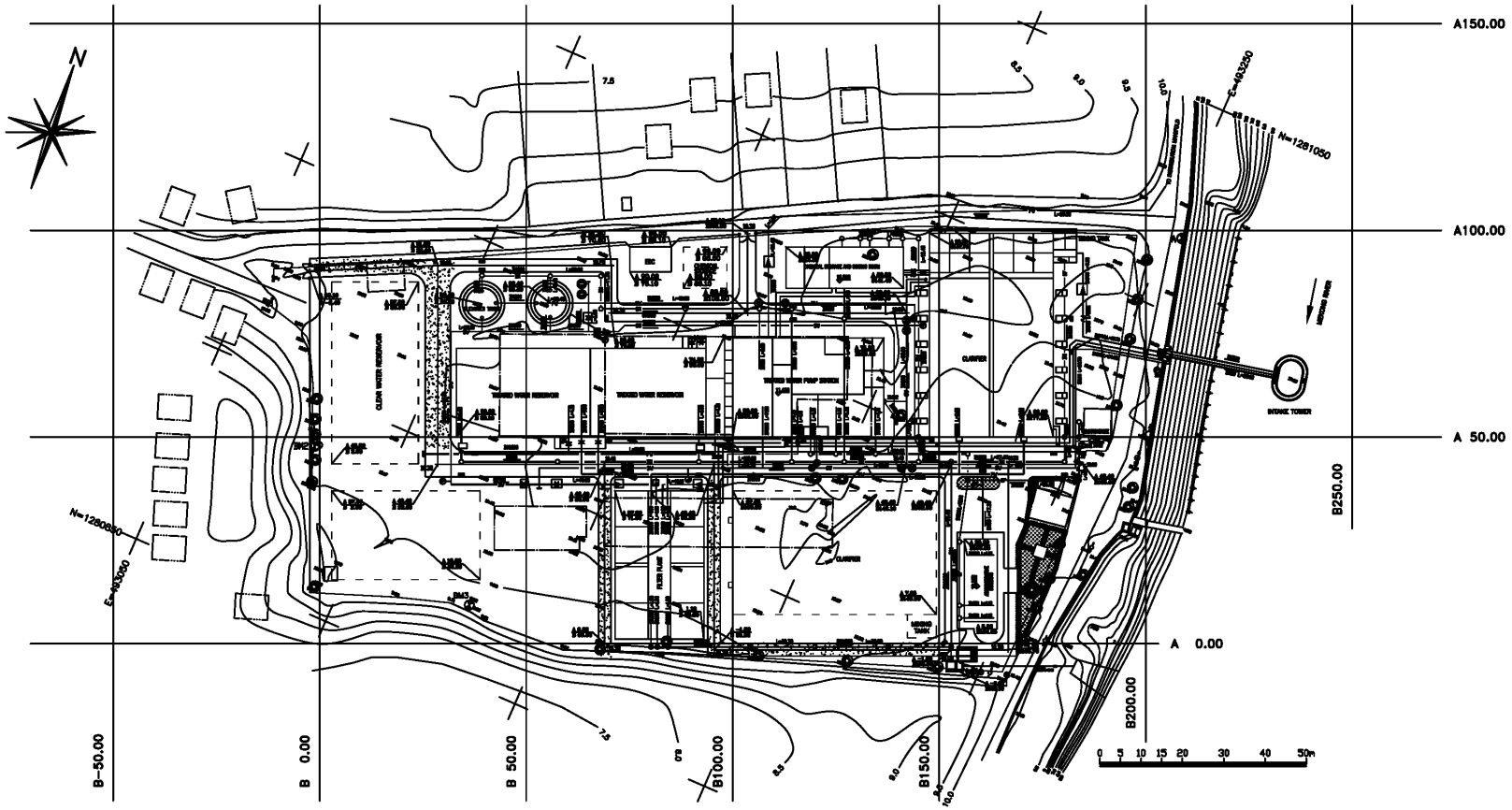
	Date	Time	Item	Raw	Settled-1	Settled-2	Settled-3	Filtered	Distribute
1	14-Sep	8:00	Turbidity	950	3.00	3.00	14.00	0.01	1.00
		10:00	Turbidity	970	3.00	4.00	9.00	0.01	0.01
		14:30	Turbidity						
2	5-Aug	8:00	Turbidity						
		10:00	Turbidity	900	8.00	5.00	17.00	1.00	2.00
		14:30	Turbidity	770	6.00	5.00	18.00	1.00	2.00
3	9-Aug	8:00	Turbidity	864	4.90	9.00	13.10	0.19	1.8
		10:00	Turbidity						
		14:30	Turbidity	771	2.00	2.00	9.00	0.01	0.01
			Average	871	4.48	4.67	13.35	0.37	1.14
			Removal	100%	0.51%	0.54%	1.53%	0.04%	0.13%



Low Turbidity

	Date	Time	Item	Raw	Settled-1	Settled-2	Settled-3	Filtered	Distribute
1	29-May	8:00	Turbidity	15.00	6.00	1.50	9.00	0.01	0.01
		11:00	Turbidity						
		14:30	Turbidity	14.00	4.00	4.00	5.00	0.01	0.01
2	4-May	8:00	Turbidity	15.00	4.00	2.00	2.00	0.60	0.60
		11:00	Turbidity						
		14:30	Turbidity	15.00	4.00	4.00	2.00	0.01	0.01
3	2-Feb	8:00	Turbidity	15.00	7.00	5.00	5.00	1.00	1.00
		11:00	Turbidity	16.00	5.00	6.00	3.00	0.01	0.01
		14:30	Turbidity	16.00	5.00	6.00	3.00	0.01	0.01
			Average	15.14	5.00	4.07	4.14	0.24	0.24
			Removal	100%	33%	27%	27.4%	1.56%	1.56%





BUILDING AND STRUCTURE SCHEDULE

No.	ITEM	DESCRIPTION	REMARK
①	INTAKE TOWER		EXISTING, RETAINED & REHABILITATED
②	MIXING TANKS	5.20m X 2.50m X 5.10m X 2	NEW WORK
③	CLARIFIERS	49.30m X 14.30m X 4.45m X 2	NEW WORK
④	FILTER PLANT	8.60m X 7.90m X 3.85m X 8	NEW WORK
⑤	TREATED WATER RESERVOIRS	32.30m X 21.50m X 4.15m X 2, 5500m ^{3}	NEW WORK
⑥	TREATED WATER PUMP STATION	36.60m X 24.00m	NEW WORK
⑦	CHEMICAL STORAGE AND DOSING BUILDING	28.50m X 10.00m	NEW WORK
⑧	ADMINISTRATIVE BUILDING	20.00m X 8.00m, 320m ^{2}	NEW WORK
⑨	ELEVATED WATER TANK	625m^3 EACH	EXISTING, RETAINED & REHABILITATED
⑩	GUARDHOUSE	6.36m X 5.50m, 70m ^{2}	EXISTING, RETAINED & REHABILITATED

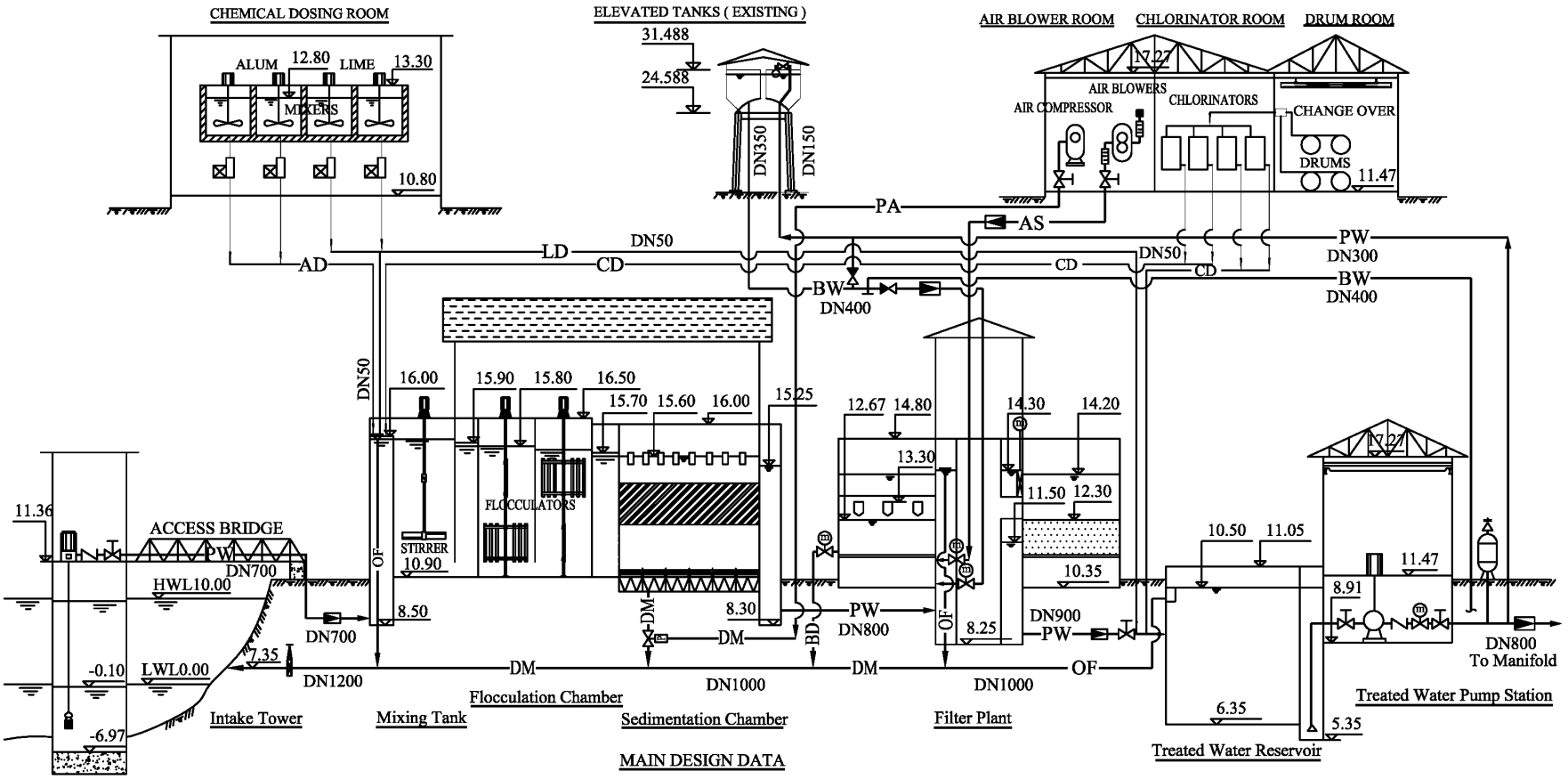
LEGENDS:

- NEW WORK
- PRIVATE HOUSING
- EXISTING – RETAINED & REHABILITATED
- EXISTING – DEMOLISHED
- FUTURE FACILITY
- PW — PROCESS WATER MAIN
- BW — BACKWASH MAIN
- AS — AIR SCOUR PIPE
- SW — SERVICE WATER PIPE
- BD — BACKWASH DRAIN
- OF — OVER FLOW PIPE
- CD — CHLORINE DOSING PIPE
- AD — ALUM DOSING PIPE
- LD — LIME DOSING PIPE
- DM — DRAIN MAIN
- SP — SEWER PIPE
- FLOW METER & CHAMBER
- VALVE & CHAMBER
- PRESSURE REDUCE VALVE & CHAMBER
- VALVE (UNDER GROUND)
- HYDRANT
- SURGE TANK
- MANHOLE
- SEPTIC CHAMBER/OUTLET PENSTOCK CHAMBER
- STORM RUNOFF INLET
- ELECTRIC CABLE, DOSING PIPE DUCT AND MANHOLE

NOTES:

1. DIMENSIONS, COORDINATES AND ELEVATIONS SHOWN IN METER.
2. THE SURVEYING COORDINATE SYSTEM (E,N) IS BASED ON POINT A, ELEVATION +10.278 WITH COORDINATE E=493253.173;N=1281017.674.
3. CONSTRUCTION COORDINATE $\frac{A\ 0.000}{B\ 0.000}$ CORRESPONDS TO SURVEYING COORDINATE N1280844.4777 E493100.8561 , AXIS–A ROTATE 23.5126' COUNTER CLOCKWISE FROM AXIS–N, $\frac{A\ 50.00}{B\ 100.00}$ CORRESPONDS TO WEST–SOUTH CORNER OF THE TREATED WATER PUMP STATION.
4. BUILDING'S COORDINATES REFER TO THE AXIS' LOCATION OF BUILDINGS, BASINS & CHAMBERS' REFER TO THE WALL INSIDE SURFACE POSITION.

Figure SR2.2.7 Chroy Chang War – Layout



MAIN DESIGN DATA

INTAKE TOWER:
Capacity: Q=3000 m³/h, H=19.50 m.
Pumps: 4 sets, submergible type.

MIXING TANK:
Mixing Chamber No. : 2.
Capacity: Q=3000 m³/h .
Stirrers: 2 sets, N=4.0 kw, n=34.20 rpm
Velocity Gradient: G= 280 S⁻¹.

FLOCCULATING CHAMBER:
Flocculating Chamber No. : 2.
Hydraulic Capacity: Q=3300 m³/h,
Velocity Gradient: G= 60 - 30 S⁻¹.
Flocculators : 6 sets, N=1.1 kw, n=3.35 rpm; 6 sets, N=0.75kw, n=2.64 rpm.

SEDIMENTATION CHAMBER:
Sedimentation chamber No. : 2.
Hydraulic Capacity: Q=3300 m³/h,
Rising Velocity: Vu=3 m/h.
Sludge Screper: 6 sets, N=0.75 kw, V=0.768 m/min..

FILTER PLANT:
Filter Cell No. : 8.
Capacity: Q=2776 m³/h, V=6.89 m/h.
Backwash Rate: 14.40 m³/h m².
Air scour rate: 54.00 m³/h m².

RESERVOIR:
Reservoir No. : 2.
Total Volume: 5760 m³.

TREATED PUMP STATION :
Capacity: Q=65000 m³/d, H=65.0m.
Pumps: 3 sets, centrifugal vertical type.
Keep space for phase II & backwash pumps.

Legend :

PW — Process Water Main	AD — Alum Dosing Pipe		Air Blower
BW — Backwash Main	LD — Lime Dosing Pipe		Air Compressor
AS — Air Scour Pipe	LD — Pressure Air Pipe		Metering Pump
BD — Backwash Drain	Raw Water Pump	Treated Water Pump	Electric Penstock
OF — Over Flow Pipe	Flow Meter	Electric Valve	Float Valve
DM — Drain Main	Manual Valve	Check Valve	Manual Pens
CD — Chlorine Dosing Pipe	Pressure Reduce Valve	Pneumatic Knife Gate Valve	Surge Tank

Note :
1. Elevation in meter, pipe in millimeter.

Figure SR2.2.8 Chroy Chang War – Hydraulic Profile

Table SR2.2.9 Chrouy Changva Water Treatment Plant

Name of Water Treatment Plant : Chrouy Changva

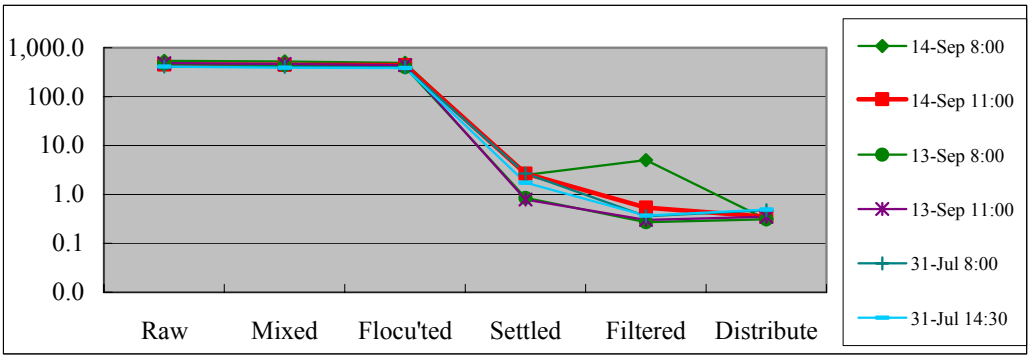
Capacity		65,000 m3/d
Water Source		72,000 m3/d Mekong River HWL = 10.0 m, LWL = 0.0m
Construction		2002 costruction of first stage
		future costruction of second stage
Treatment Process		
1. Rapid Mixing 2. Flocculation 3. Sedimentation 4 Filtration 5 Disinfection		
Intake Facilities		Pump Pit HWL = 10.0 m, LWL = -0.10m
	Type	Raw Water Pumping
	Intake Pump	16.7 m3/min x 19.5 m x 75 kW x 4 units
	Piping	Raw Water Transmission Pipe : 700 mm * DI
Rapid Mixing		
	Type	Mechnical Mixing
	Retention Time	85 sec
	Size & Q'ty	2.5 mW x 2.5 mL x 5.1 mD x 2 units
	Equipment	Vertical Mixer 2 units
Flocculation		
	Type	Horizontal Flow
	Retention Time	27.6 min.
	Size	4.6 mW x 4.6 mL x 4.9 mD
	Q'ty	12 units
	Equipment	Vertical Flocculator 6 units
Sedimentation Tank		
	Type	Up Flow with Inclined Tube
	Retention Time	104.8 min 1.7 hr
	Size	38.4 mL x 13.1 mW x 4.7 mD
	Q'ty	2 units
	Surface Load	44.9 mm/min
	Trough/Pipe	Orifice Trough
	Sludge Removal	Sludge Scraper 12 units, Sludge Extraction Valve
	Equipment	Inclined Tube, Sludge Scraper 6 units, Sludge Extraction Valve
	Operation	Sludge Collection - Automatic, Sludge Removal - Automatic
Filter		
	Type	Gravity, Single Media, Declining Flow
	Filtration rate	141 m/d (5.87 m/hr) 188 m/d at washing
	Filter Bed Area	57.67 m2 x 8 filters
	Size & Q'ty	3.65 mW x 7.9 mL x 2 beds
	Filter Media	Sand : 0.9 - 1.2 mm x 950 mm
	Washing System	Air Scouring (54 m/hr) + Backwashing (14.4 m/hr)
	Equipment	Inlet Gate, Outlet Valve, Washwater Valve, Air Scouring Valve, Washwater Drain Gate
		Washwater Pump, Air Scouring Valve, Air Blower
	Operation	Manual
Chemicals		
	Alum	Alum Tank + Mixer : 2 sets, Alum Dosing Pump : 2 (1)
	Lime	Lime Tank + Mixer : 2 sets, Lime Dosing Pump : 2 (1)
	Chlorine	Chlorinator -Pre : 2 (1) -Post : 2 (1), Pressure Pump : 4 (2)
Clear Water Reservoir		HWL = 6.35 m, LWL = 10.5 m
	Elevated No. 1	625 m3
	Elevated No. 2	625 m3
	Reservoir No. 1	2,880 m3
	Reservoir No. 2	2,880 m3
Clear Water Pump		
	Distribution	22.58 m3/min x 65 m x 315 kW x 3 units

Table SR2.2.10 Chrouy Changva Water Treatment Plant

Chrouy Changva

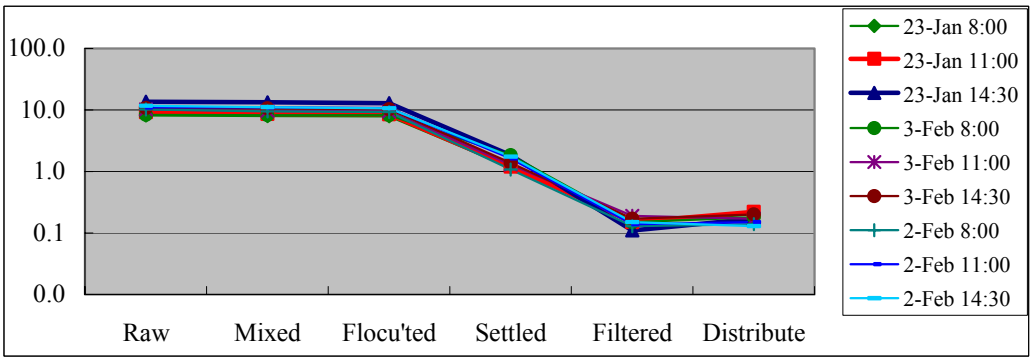
High Turbidity

	Date	Time	Item	Raw	Mixed	Flocu'ted	Settled	Filtered	Distribute
1	14-Sep	8:00	Turbidity	540	525	490	2.50	5.00	0.31
		11:00	Turbidity	451	443	441	2.66	0.54	0.35
		14:30	Turbidity						
2	13-Sep	8:00	Turbidity	468	437	398	0.85	0.27	0.31
		11:00	Turbidity	485	463	442	0.78	0.30	0.35
		14:30	Turbidity						
3	31-Jul	8:00	Turbidity	413	404	393	2.67	0.36	0.48
		11:00	Turbidity						
		14:30	Turbidity	411	392	384	1.74	0.37	0.49
			Average	461	444	425	1.87	1.14	0.38
			Removal	100%	96%	92%	0.40%	0.25%	0.08%



Low Turbidity

	Date	Time	Item	Raw	Mixed	Flocu'ted	Settled	Filtered	Distribute
1	23-Jan	8:00	Turbidity	8.20	8.02	7.94	1.18	0.15	0.20
		11:00	Turbidity	9.18	8.64	8.50	1.20	0.15	0.22
		14:30	Turbidity	13.70	13.40	12.90	1.85	0.11	0.17
2	3-Feb	8:00	Turbidity	8.30	8.25	8.24	1.85	0.15	0.18
		11:00	Turbidity	10.20	9.70	9.50	1.30	0.19	0.17
		14:30	Turbidity	10.80	10.70	10.30	1.38	0.17	0.20
3	2-Feb	8:00	Turbidity	10.20	9.50	9.30	1.08	0.13	0.14
		11:00	Turbidity	11.00	11.00	10.80	1.63	0.14	0.15
		14:30	Turbidity	11.70	11.10	10.70	1.75	0.15	0.13
			Average	10.36	10.03	9.80	1.47	0.15	0.17
			Removal	100%	97%	95%	14.2%	1.44%	1.67%



Supporting Report 2.3 Filter Operation Test

1. Filter Test Procedure

The production capacity of Chrouy Changva will be expanded from 65,000 m^3/d to 130,000 m^3/d. In this expansion project, the existing plant has limited space available so the expansion needs to minimize the usage of space. This test was undertaken to confirm if a higher filtration speed can be applied to the existing filters to increase output.

The designs of the existing and proposed filters are summarized as follows:

Item	Existing	Expansion
Production capacity	65,000 m^3/d	130,000 m^3/d
No. of filters	8	12
Area of one filter	57.67 m^2	57.67 m^2
Area of all filter	461 m^2	692 m^2
Filtration speed per day	141 m^3/m^2/d	188 m^3/m^2/d
Filtration speed per hour	5.87 m^3/m^2/hr	7.83 m^3/m^2/hr

The following procedures were applied for the test:

a. The operation was carried out on the same six (6) filters for three days (72 hrs) at full production capacity (2710 m3/hr).
b. Every hour all the following data were recorded.
   - Raw water intake flow (m^3/hr)
   - Water quality (turbidity: NTU - raw water, settled water filtered water)
   - Water levels (filter and effluent weir)
c. Water quality (NTU) of Filtered Water was measured for each filter.
d. Filter In/Out were the water levels (m) at filter and effluent channel.

2. Test Results s

Test results are described as follows:

2.1 River Water Intake Flow

Raw water intake flow can be set by the speed control system of the raw water pumps. The flow is approximately 2,900 m^3/hr (69,600 m^3/d), which is about 7 % larger than planned production capacity considering wastage for desludging of sedimentation tanks and backwashing of filters.

The intake flow is shown in Figure SR2.3.1.

2.2 Water Quality

Turbidity (NTU) is measured hourly for raw water, settled water and filtered water. Raw water is similar to annual average raw water turbidity. Filtered water of Filter No. 1 is monitored.

The water quality is shown in Figure SR2.3.1.

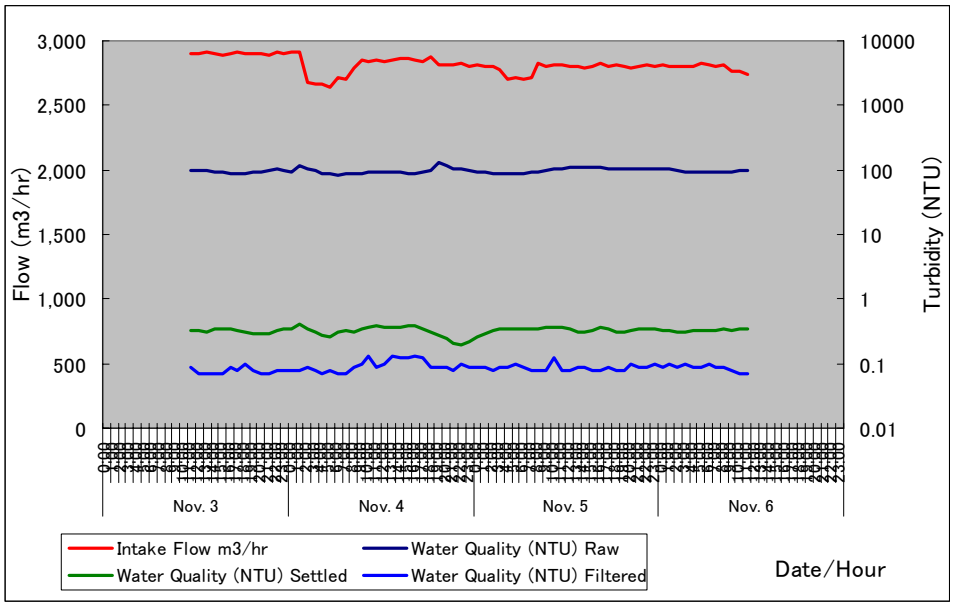


Figure SR2.3.1 Raw Water Flow and Water Quality

Turbidity of raw water is about NTU 100, settled water ranges from NTU 0.3 to 0.4, and filtered water is NTU 0.07 to 0.13. Filtered water is far below the national standard of drinking water NTU 5.

2.3 Water Level

Water level over the filter media (In) and water level at effluent weir (Out) are continuously measured by ultrasonic level sensors in each filter. In automatic filtration operation, motorized effluent valves control the opening to keep the above water level difference (In - Out) to 2.5 m, and maintain the water level over the filter media and filtration flow.

Water level over the filter media (In) varies over a range of 2.65 to 2.81 m, and water level at the effluent weir (Out) varies over a range of 0.14 to 0.28 m. The water level (Out) is altered by filtration flow of each filter and the range of 0.14 to 0.28 m translates into 259 to 751 m^3/hr, while the filters are planned to treat 677 m^3/hr or a filtration rate of 7.83 m^3/m^2/d.

Some filters show sudden reduction of the water level, which indicates backwashing at that time.

The following figure shows the fluctuation of water levels in each filter.

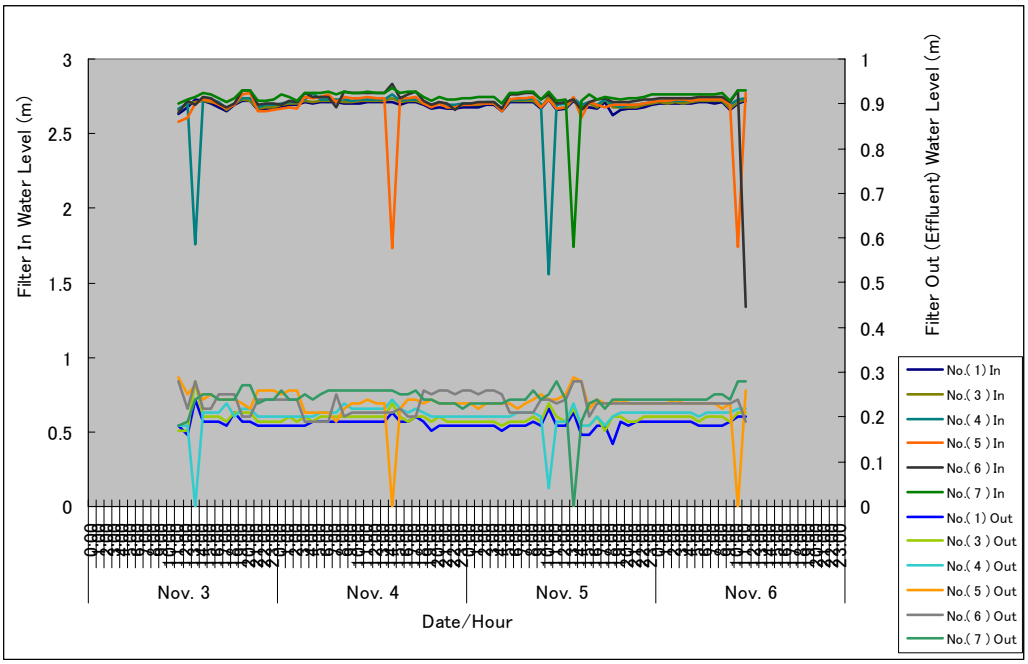


Figure SR2.3.2 Water Levels in Filters

2.4 Filtration Flow and Filtration Rate

As explained in the above section, filtration flow of each filter is calculated by water level at the effluent weir (Out). Figure SR2.3.3 shows filtration flow (m^3/hr) of each filter during 72 hours test operation.

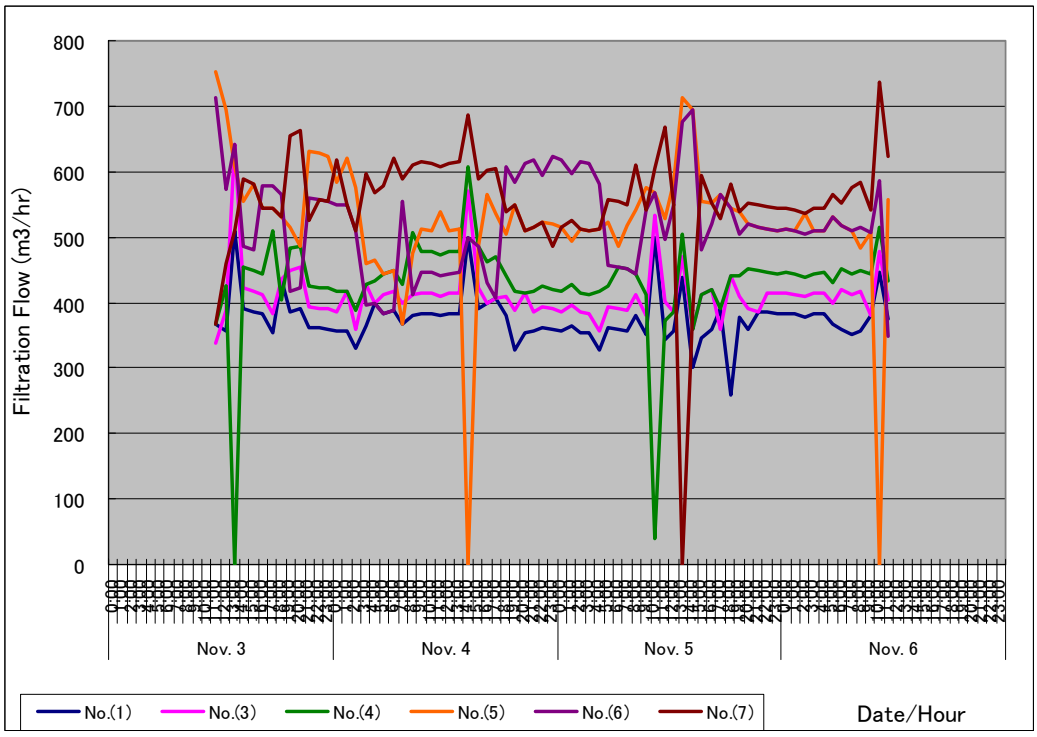


Figure SR2.3.3 Filtration Flow

The following table summarizes total filtration volume for each filter.

Table SR2.3.1 Volume of Filtration for Each Filter

Filter	No.1	No. 2	No. 4	No. 5	No. 6	No. 7
Volume (m^3)	27,035	29,628	30,929	37,630	37,682	39,831
Ratio (%)	80 %	88 %	92 %	111 %	112 %	118 %
Volume (m^3)	87,592			115,143		
Ratio (%)	43 %			57 %		

Settled water is flowed through an 800 mm pipe, then it is divided into two channels. One channel is connected to filters 1 to 4, and the other is connected to filters 5 to 8. The results clearly show that nos. 1, 2 and 4 treat less water than the others, due mainly to uneven division of the flow of settled water to the filter inflow channels.

A design change should be made to prevent the uneven flow division of the channels.

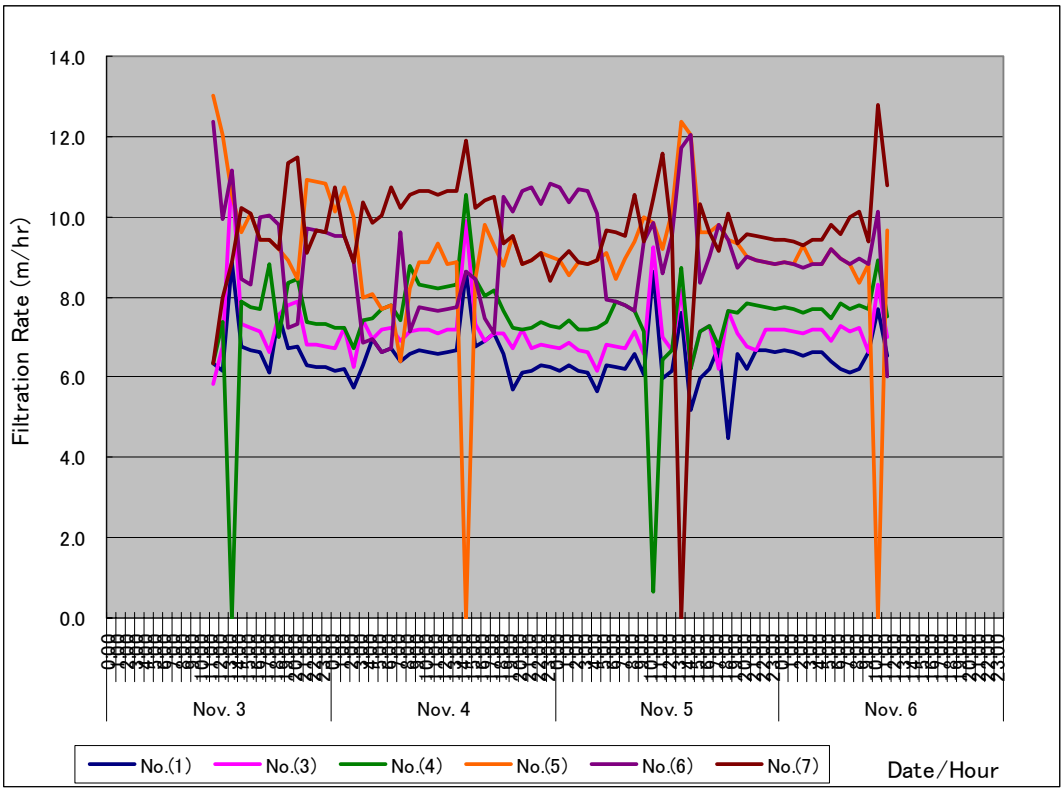


Figure SR2.3.4 Filtration Rate

Figure SR2.3.4 shows the filtration rate fluctuation of each filter. Rapid decrease of flow rate indicates filter washing in progress (e.g., No. 5 Filter at 14:00 hours on Nov. 4); while at the same hour two other filters (Nos. 6 and 7) increase their flow to accommodate the settled water diverted from filter No. 5.

Except for the above rapid and irregular fluctuations, filters are normally operated within a range

of 6 to 11 m/hr, while planned flow is 7.83 m/h. The range is 76 to 140 % of the planned rate. The original design of the filter set a filtration rate of 5.87 m/d. 11 m/hr is 1.87 times faster than the original rate.

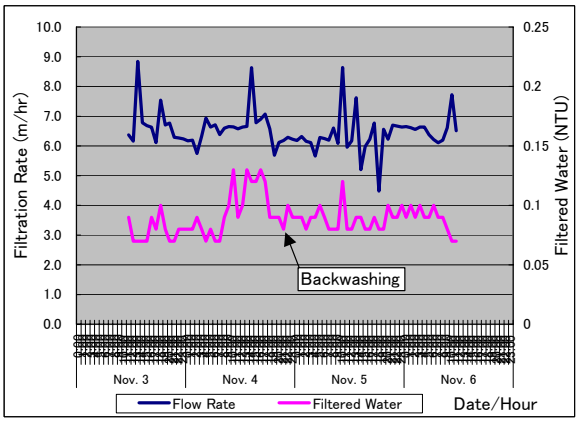


Figure SR2.3.5 Filtration Rate/Turbidity A

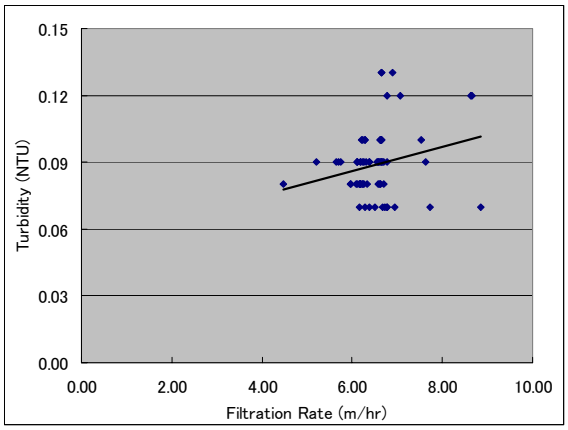


Figure SR2.3.6 Filtration Rate/Turbidity B

The above Figure SR2.3.5 indicates filtration rate and filtered water quality (NTU) during 72 hours of operation. Figure SR2.3.6 shows the correlation between filtration rate and turbidity. While it is not a strong correlation, the trend logically suggests that higher filtration rates result in higher turbidity.

Therefore, it is recommended to regulate the excessive inflow to the filters.

2.4 Backwashing

During the 72 hour test operation, Filter Nos. 4, 5 and 6 were backwashed twice. The filtration rates, filtered water volumes and durations were analyzed for the periods between the backwashings.

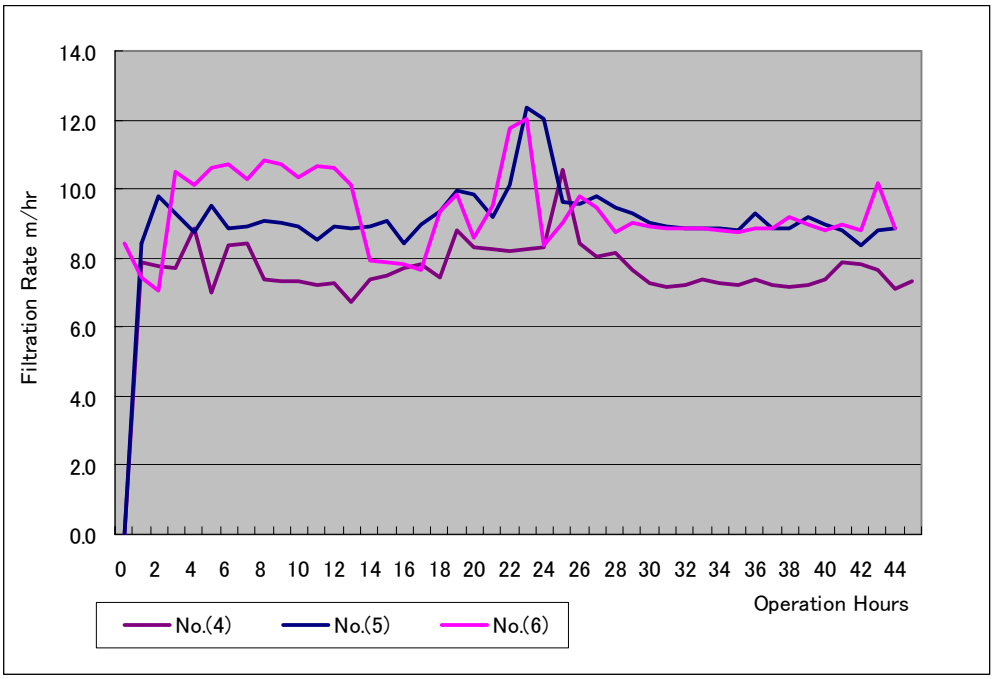


Figure SR2.3.7 Filtration Rate after Backwashing

No significant tendency was observed with respect to the variation of filtration rates before and after backwashing.

Table SR2.3.2 Filtration Period

Filter	No.4	No. 5	No. 6
Filtration Period (hrs)	45	44	44
Filtered Volume (m^3)	19,668	22,918	24,046

Table SR2.3.2 shows the filtration period and filtered volume of Filter Nos. 4, 5 and 6. In general, the filters can treat for 45 hours and approximately 20,000 m^3 after backwashing. 45 hours is considered to be a reasonable filtration period.

2.5 Hydraulic Conditions

During the filtration test operation, the hydraulic status of the existing facilities was roughly measured, with results as summarized in Table SR2.3.3.

Table SR2.3.3 Hydraulic Status

Location	Design	No.1	No. 2	No. 4	No. 5	No. 6	No. 7	No. 7	No. 8
Sedimentation Tank Effluent	15.25	14.69 – 14.73							
Filter Inflow Channel	14.30	14.30				14.34			
Operation		○	—	○	○	○	○	○	—

Filter Effluent Channel	11.50	11.20	11.45 - 11.50	11.50	11.35 – 11.40
Clear Water Tank Water Level (HWL)	10.50	10.15 – 10.19			

There is some allowance of 0.5 m between Sedimentation Tank Effluent Pits to Filter Inflow Channels. However, very small or no allowance is found within the filter facility and between the filters and Clear Water Tank.

Detailed hydraulic calculations should be carried out to solve the above problems. Improvement of the existing filters should also be considered during the detailed design stage.

3. Conclusion

For the expansion of water production from 65,000 m^3/d to 130,000 m^3/d., it is acceptable to construct four more filters connecting to the existing filters, subject to the following points:

a. Re-design and improvement of the hydraulic profile should be considered.
b. Steady operation of sedimentation tanks should be secured for high turbidity of raw water in rainy season.
c. If necessary, proper washing arrangements (washing/air scouring rate and period) and regular washing (once a day) should be considered.

Supporting Report 2.4 Reservoir Storage Simulation

1. Chrouy Changva Water Treatment Plant

1.1 Existing Plant and Clear Water Reservoir

The existing Chrouy Changva Water Treatment plant has a maximum production capacity of 65,000 m^3/d, with total clear water reservoir storage capacity of 5,800 m^3. Since current water demand does not require the full production of the plant so the record of actual operation at full production capacity is not available, the fluctuation of clear water tank storage is simulated. The result of simulation is shown in the following figure.

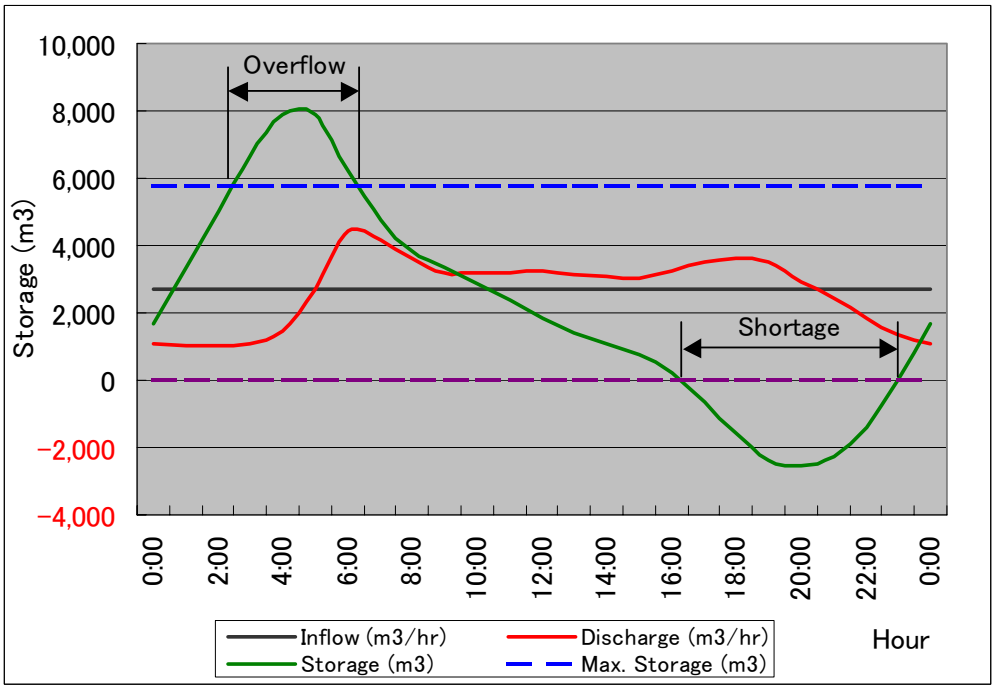


Figure SR2.4.1 Operational Simulation of Chrouy Changva Plant (65,000 m^3/d)

The figure indicates that the reservoirs will overflow early in the morning, but fall short in the evening. It is clearly demonstrated that the clear water reservoirs have far smaller capacity than needed.

1.2 Required Storage of Clear Water Reservoir for Expansion of Plant

Basically constant operation or constant production flow is one of the most important objectives for water treatment plant operation.

For the expansion of water production from 65,000 m^3/d to 130,000 m^3/d., it is necessary to examine how much storage capacity will be required using simulation. The result of simulation is shown in the following figure.

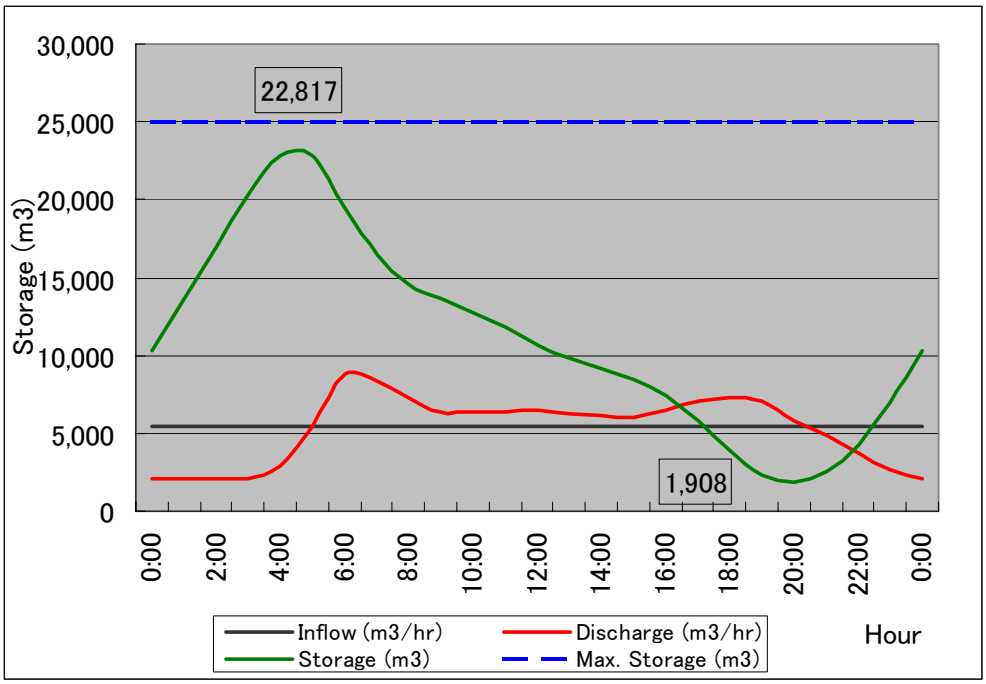


Figure SR2.4.2 Operational Simulation of Chrouy Changva Plant (130,000 m^3/d)

The figure indicates that storage will reach the maximum at 5:00 AM, and the minimum at 8:00 PM. Total storage capacity of 25,000 m^3 will support constant production of 5,420 m^3/hr or 130,000 m^3/d.

1.3 Recommendation

It is strongly recommended to construct clear water reservoirs with an additional capacity of 19,2000 m^3, increasing the total storage capacity of the plant to 25,000 m^3.

2. Phum Prek Water Treatment Plant

2.1 Current Operation

Through observation of the current operation and interviews with the operating staff of Phum Prek Water Treatment Plant, it was observed that the plant is not producing at its full capacity of 150,000 m^3/d due to overflowing of the clear water reservoirs.

Therefore, operational data for a week was collected to evaluate the storage capacity of the reservoirs.

2.2 Operation Record

The following operation record was collected:

Date	September 1 to 7, 2005
Production (m^3/hr)	3,170 to 6,900 m^3/hr (76,000 to 165,000 m^3/d)
Reservoir Water Level (m)	2.0 to 4.0 m

A flow meter is available at the main transmission/distribution header from the clear water pump station. A flow meter located on the intake pipe from the intake tower is not operational. Therefore, hourly production is assumed from the number of pumps in operation. For example, two pumps run at midnight, one pump runs at 4:00 AM, three pumps run at 06:00 AM, etc. The data is adjusted with respect to daily production, flow-head of intake pump and system loss curve of raw water transmission pipeline as follows:

1 pump operation	3,167 m^3/hr
2 pumps operation	5,542 m^3/hr
3 pumps operation	6,904 m^3/hr

2.3 Fluctuation of Water Level Clear Water Reservoir

Figure 2.4.1 shows the hourly fluctuation of clear water production, distribution and reservoir storage of Phum Prek Water Treatment Plant.

Water production varied over a range of 3,100 to 6,900 m^3/hr, which is directly related to how many raw water intake pumps were operated. Operators decide to start and stop the pumps considering water consumption and water levels in the clear water reservoirs. In general, early in the morning only one pump is operated. Then, three pumps are started around 06:00 hours continuing until 20:00 hours. In the evening, two pumps are operated until the next morning.

Although average hourly water consumption is 6,108 m^3/hr, the actual water consumption fluctuates within a range of 1,570 to 10,750 m^3/hr, which is 26 % to 176 % of the average.

Maximum daily water consumption occurs in the morning. The water level in the reservoirs is full early in the morning but decreases rapidly until 9:00 AM. It then recovers slightly but falls

again in the afternoon through the evening, reaching its lowest level around 9:00 PM. The level varies over a range of 12,000 m^3 to 25,000 m^3, and the available storage capacity is not fully utilized.

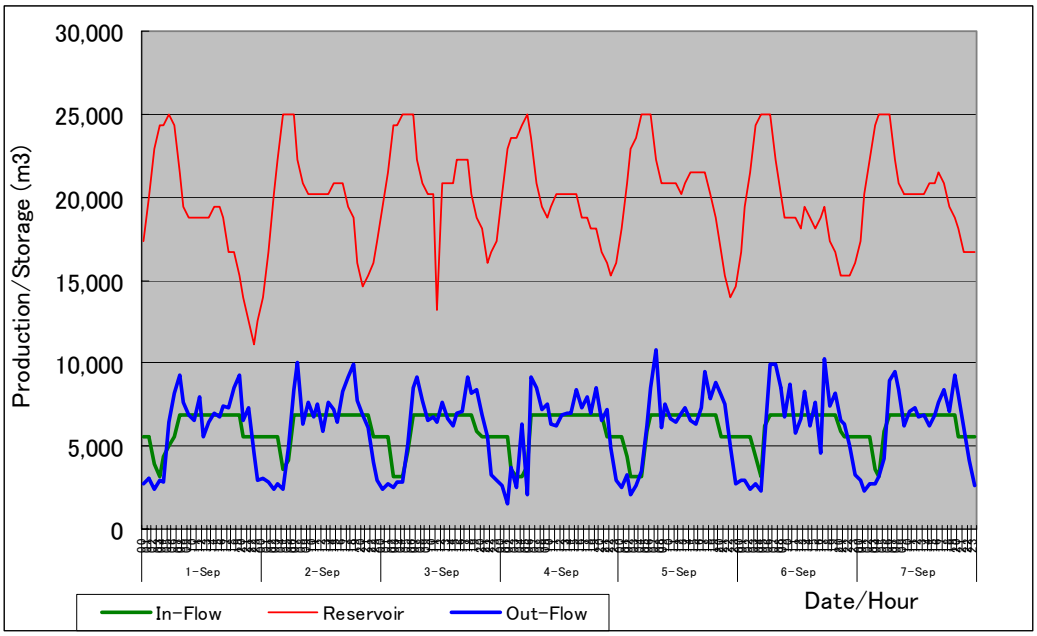


Figure SR2.4.3 Operation of Phum Prek Plant

Figure SR2.4.2 shows the water storage fluctuation in the clear water reservoirs with constant production.

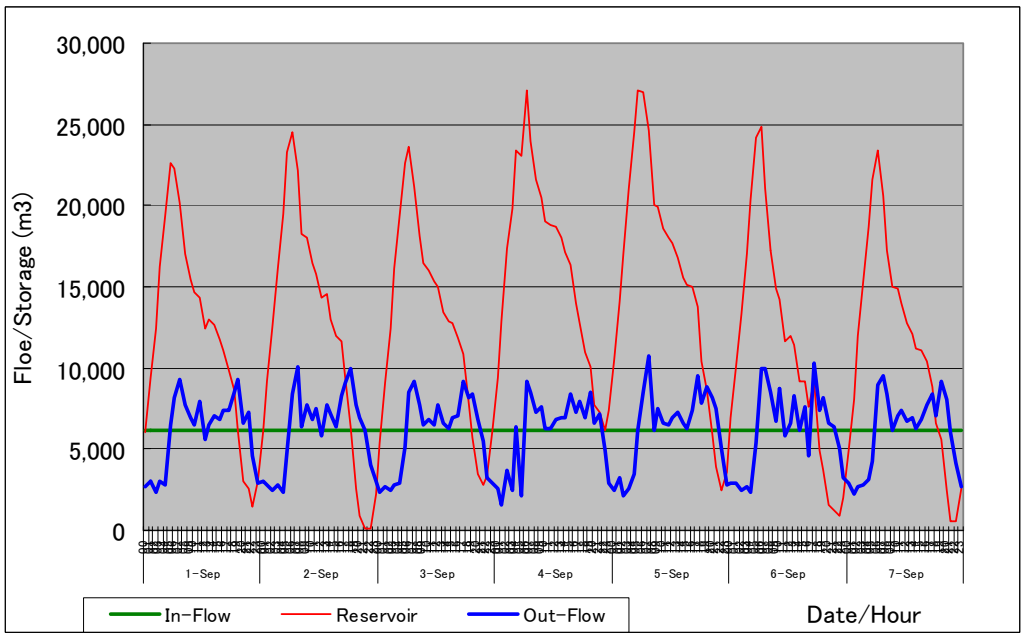


Figure SR2.4.4 Constant Production Operation of Phum Prek Plant

Clear water storage varies over a much wider range from almost no storage to more than 25,000 m^3, which means overflowing. This means that the existing three reservoirs, with total capacity

of 25,000 m^3, are not enough for constant operation at full production capacity of 150,000 m^3/d (or 6,250 m^3/hr).

2.4 Recommendation

Three water towers are being constructed under on-going projects. Also, an additional water tank is proposed at Ta Khmau as part of the Stage 1 Priority Projects. Each of the water towers has a storage capacity of 1,500 m^3, providing a total capacity of 6,000 m^3. It is expected that some clear water produced during the night will be stored in these water towers and the water will be supplied to the distribution network during periods of peak water demand.

It is therefore recommended to monitor the fluctuation of the clear water reservoirs at the plant after the construction of the water towers. Construction of an additional clear water reservoir with a storage capacity of 5,000 m^3 should be considered if the plant is unable to operate at its full production capacity due to inadequate clear water storage capacity.

Supporting Report – 3

Water Demand Projection

Supporting Report 3.1 Water Demand Projection - Scenarios

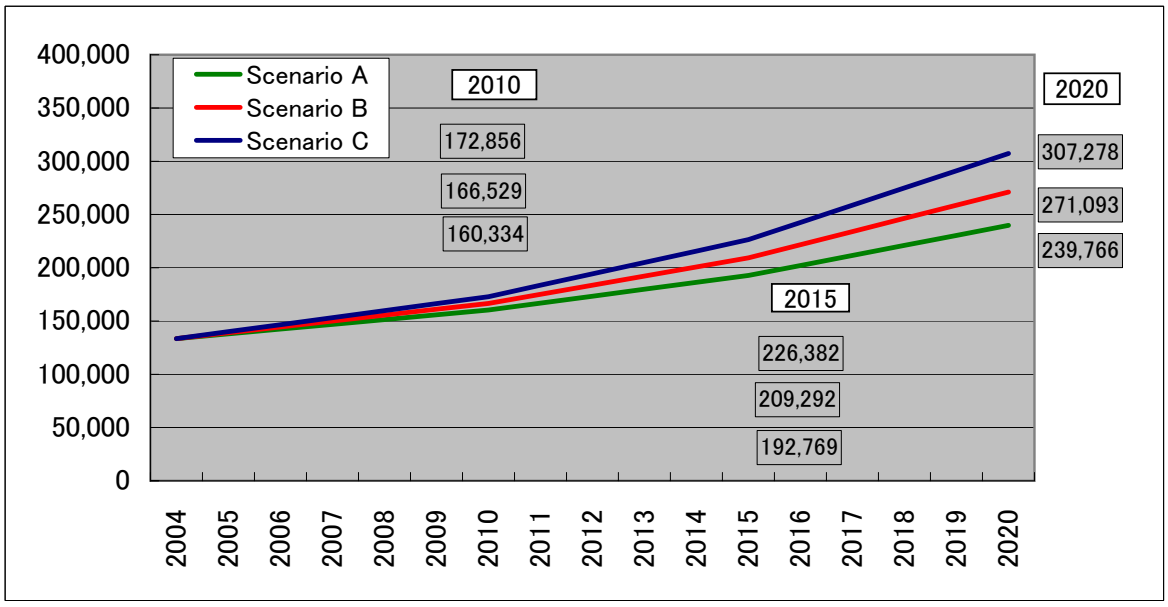
1.Applied Scenario in Unit Water Consumption Rate Increase

Districts	Planned Coverage	Domestic lpcd				Non-Domestic Incrase Ratio		
Scenario		Present	S-A	S-B	S-C	S-A	S-B	S-C
Chamcar Mon	100%	80	85	90	95	2% (ADM and Autonomy are 1%)	3% (ADM and Autonomy are 1%)	4% (ADM and Autonomy are 1%)
Doun Penh	100%	80	90	100 110	110			
7 Meakkara	100%	80	95	(2%/year)	135			
Tuol Kouk	100%	80	(1%/year)		(3%/year)			
Dangkao	40-65%	70	80	80	80			
Mean Chey	70-90%	80	85	90	95			
Ruessei Kaev	60-90%	80	90	100	110			
Kandal	20-30%	70	(1%/year)	(2%/year)	(3%/year)			

Applied Peak Factor (Max/Ave)	1.30	Applied NRW Ratio	15%

2. Ave. Day Demand by Scenario

Scenario	Served Population	Coverage	Total		Domestic			Non-Domestic		
			Demand	lpcd	Demand	lpcd	increase	Demand	lpcd	increase
Present	1,035,931	67.7%	133,402	128.8	82,676	79.8		50,726	49.0	
Scenario A										
- 2010	1,244,738	70.1%	160,334	128.8	103,103	82.8	0.6%	57,230	40.8	-3.0%
- 2015	1,491,113	73.3%	192,769	129.3	130,215	87.3	1.1%	62,554	42.0	0.6%
- 2020	1,866,102	81.0%	239,766	128.5	171,366	91.8	1.0%	68,400	36.7	-2.7%
Scenario B										
- 2010	1,244,738	70.1%	166,529	133.8	106,627	85.7	1.2%	59,901	48.1	-0.3%
- 2015	1,491,113	73.3%	209,292	140.4	141,141	94.7	2.0%	68,151	45.7	-1.0%
- 2020	1,866,102	81.0%	271,093	145.3	193,444	103.7	1.8%	77,649	41.6	-1.9%
Scenario C										
- 2010	1,244,738	70.1%	172,856	138.9	110,151	88.5	2.1%	62,705	50.4	0.6%
- 2015	1,491,113	73.3%	226,382	151.8	152,067	102.0	2.9%	74,315	49.8	-0.2%
- 2020	1,866,102	81.0%	307,278	164.7	218,938	117.3	2.8%	88,340	47.3	-1.0%

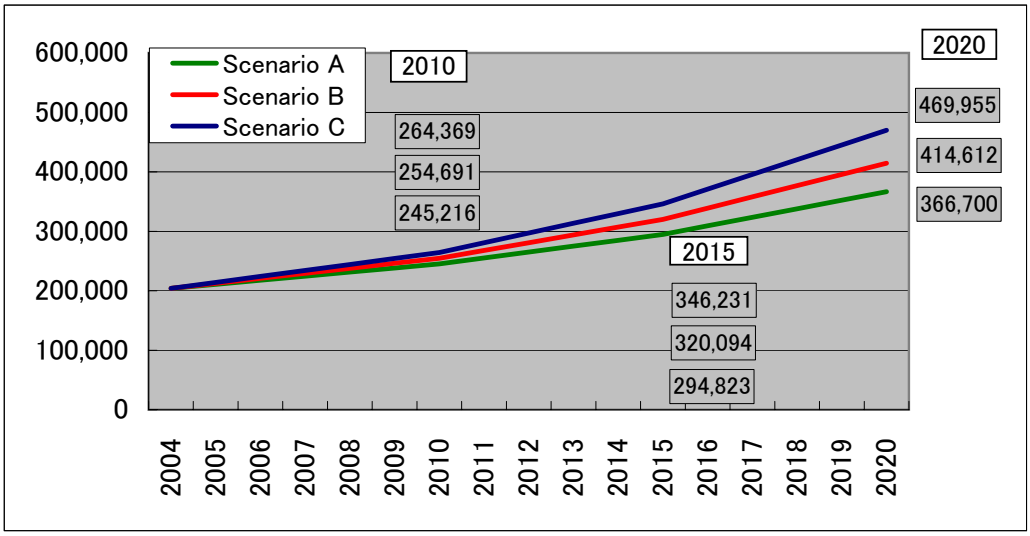


3. Peak Day Demand by Scenario (Daily Max/Daily Ave= **1.30**

Scenario	Total		Domestic			Non-Domestic		
	Demand	lpcd	Demand	lpcd	increase	Demand	lpcd	increase
Present	173,423	167.4	107,479	103.8		65,944	63.7	
Scenario A								
- 2010	208,434	160.7	134,034	107.7	0.6%	74,400	53.0	-3.0%
- 2015	250,600	168.1	169,280	113.5	1.1%	81,320	54.5	0.6%
- 2020	311,695	167.0	222,776	119.4	1.0%	88,920	47.6	-2.7%
Scenario B								
- 2010	216,487	173.9	138,615	111.4	1.2%	77,872	62.6	-0.3%
- 2015	272,080	182.5	183,483	123.1	2.0%	88,596	59.4	-1.0%
- 2020	352,420	188.9	251,477	134.8	1.8%	100,943	54.1	-1.9%
Scenario C								
- 2010	224,713	180.5	143,197	115.0	2.1%	81,517	65.5	0.6%
- 2015	294,297	197.4	197,687	132.6	2.9%	96,610	64.8	-0.2%
- 2020	399,461	214.1	284,620	152.5	2.8%	114,841	61.5	-1.0%

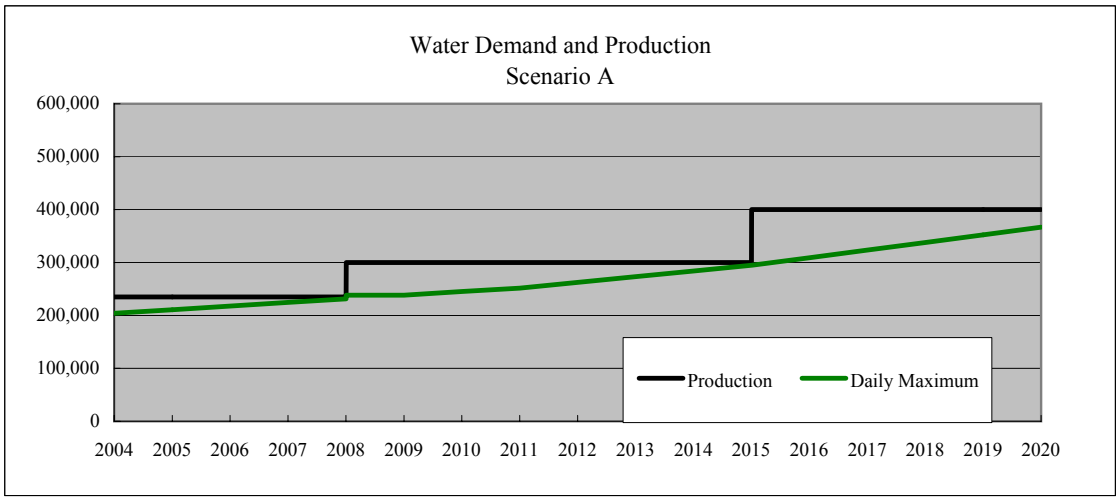
4. Max. Day Demand (Applied Peak Factor and NRW) **15%**

Scenario	Total		Domestic			Non-Domestic		
	Demand	lpcd	Demand	lpcd	increase	Demand	lpcd	increase
Present	204,027	197.0	126,446	122.1		77,581	74.9	
Scenario A								
- 2010	245,216	189.0	157,687	126.7	0.6%	87,529	62.3	-3.0%
- 2015	294,823	197.7	199,152	133.6	1.1%	95,671	64.2	0.6%
- 2020	366,700	196.5	262,089	140.4	1.0%	104,611	56.1	-2.7%
Scenario B								
- 2010	254,691	204.6	163,077	131.0	1.2%	91,614	73.6	-0.3%
- 2015	320,094	214.7	215,863	144.8	2.0%	104,231	69.9	-1.0%
- 2020	414,612	222.2	295,855	158.5	1.8%	118,757	63.6	-1.9%
Scenario C								
- 2010	264,369	212.4	168,467	135.3	2.1%	95,902	77.0	0.6%
- 2015	346,231	232.2	232,573	156.0	2.9%	113,658	76.2	-0.2%
- 2020	469,955	251.8	334,847	179.4	2.8%	135,108	72.4	-1.0%

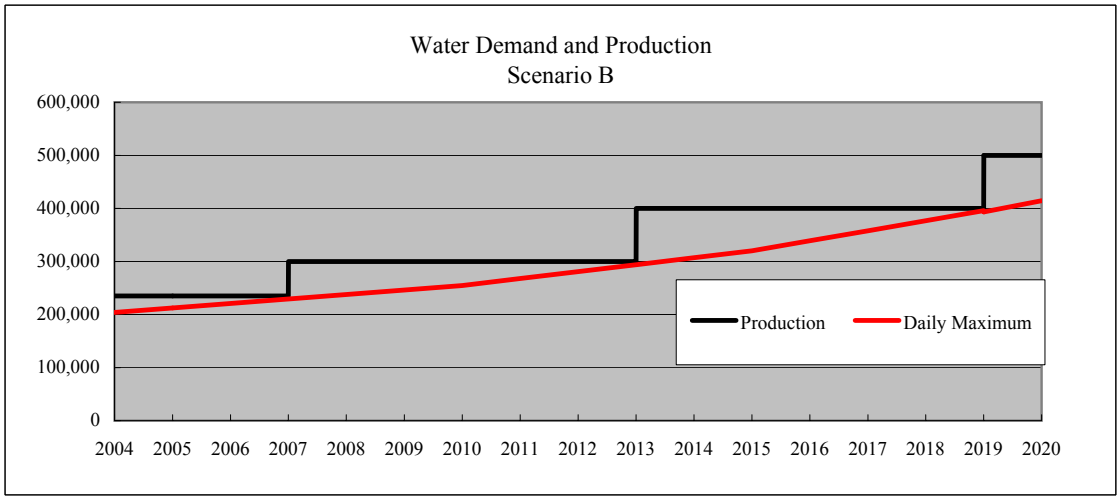


5. Comparison of Water Production Scenarios

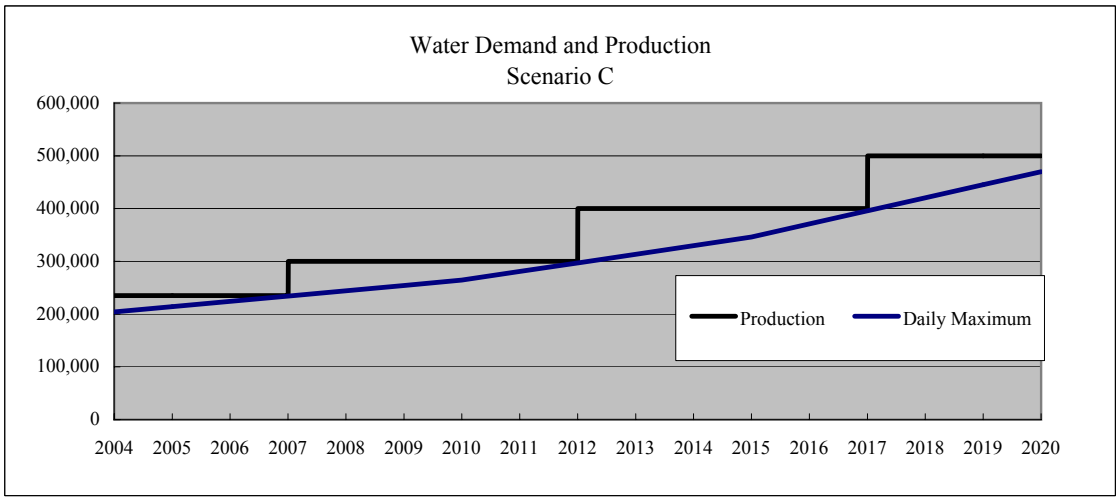
a. Scenario A



b. Scenario B



c. Scenario C



Suppoering Report 3.2 Total Water Demand Projection by Scenario

District		Present	Scenario A			Scenario B			Scenario C		
Year		2004	2010	2015	2020	2010	2015	2020	2010	2015	2020
1	Chamkar Mon										
	Domestic	19,334	20,041	21,036	22,010	21,220	23,373	25,485	22,399	25,710	30,118
	Commercial etc.	10,556	11,719	12,791	13,968	12,258	13,910	15,809	12,824	15,142	17,939
	Total	29,890	31,760	33,827	35,977	33,478	37,282	41,294	35,222	40,852	48,057
2	Doun Penh										
	Domestic	11,024	12,885	13,183	13,431	13,643	14,648	15,552	14,401	16,113	18,379
	Commercial etc.	13,128	14,451	15,665	16,990	14,992	16,788	18,839	15,561	18,026	20,979
	Total	24,152	27,336	28,848	30,421	28,635	31,436	34,391	29,961	34,139	39,358
3	7 Meakkara										
	Domestic	8,573	9,478	9,392	9,233	10,036	10,435	10,691	10,593	11,479	12,635
	Commercial etc.	5,332	5,920	6,462	7,057	6,193	7,028	7,989	6,479	7,652	9,067
	Total	13,905	15,398	15,854	16,290	16,228	17,463	18,680	17,072	19,131	21,702
4	Tuol Kouk										
	Domestic	18,530	17,505	18,857	20,245	18,535	20,953	23,442	19,564	23,048	27,704
	Commercial etc.	7,671	8,558	9,379	10,281	8,994	10,284	11,772	9,452	11,282	13,496
	Total	26,200	26,063	28,236	30,527	27,529	31,237	35,214	29,017	34,330	41,200
5	Dangkao										
	Domestic	2,135	6,607	12,605	22,695	6,607	13,347	25,217	6,607	14,088	27,738
	Commercial etc.	4,257	4,789	5,274	5,808	5,062	5,841	6,742	5,349	6,465	7,821
	Total	6,392	11,395	17,879	28,503	11,669	19,187	31,958	11,956	20,554	35,560
6	Mean Chey										
	Domestic	10,317	15,980	23,119	32,058	15,980	24,479	35,620	15,980	25,839	39,182
	Commercial etc.	4,820	5,427	5,984	6,599	5,746	6,645	7,687	6,080	7,373	8,945
	Total	15,136	21,407	29,103	38,657	21,726	31,124	43,307	22,060	33,212	48,127
7	Ruessei Kaev										
	Domestic	11,983	17,033	26,536	43,653	17,033	28,096	48,503	17,033	29,657	53,353
	Commercial etc.	4,692	5,256	5,780	6,356	5,546	6,381	7,346	5,850	7,043	8,491
	Total	16,675	22,289	32,315	50,009	22,579	34,477	55,849	22,883	36,701	61,844
8	Kandal										
	Domestic	780	3,575	5,487	8,041	3,575	5,810	8,935	3,575	6,133	9,828
	Commercial etc.	271	1,110	1,220	1,341	1,110	1,275	1,465	1,110	1,332	1,602
	Total	1,051	4,685	6,707	9,382	4,685	7,085	10,400	4,685	7,465	11,430
TOTAL											
	Domestic	82,676	103,103	130,215	171,366	106,627	141,141	193,444	110,151	152,067	218,938
	Commercial etc.	50,726	57,230	62,554	68,400	59,901	68,151	77,649	62,705	74,315	88,340
	Total	133,402	160,334	192,769	239,766	166,529	209,292	271,093	172,856	226,382	307,278
	Served Population	**1,035,931**	1,244,738	1,491,113	1,866,102	**1,244,738**	**1,491,113**	**1,866,102**	1,244,738	1,491,113	1,866,102
	Coverage	**67.7%**	70.1%	73.3%	81.0%	**70.1%**	**73.3%**	**81.0%**	70.1%	73.3%	81.0%
	lpcd	**128.8**	128.8	129.3	128.5	**133.8**	**140.4**	**145.3**	138.9	151.8	164.7
PHNOM PENH											
	Domestic	81,896	99,529	124,728	163,325	103,053	135,331	184,509	106,577	145,934	209,110
	Commercial etc.	50,455	56,120	61,334	67,059	58,791	66,876	76,183	61,595	72,983	86,738
	Total	132,351	155,649	186,062	230,384	161,844	202,207	260,693	168,172	218,917	295,848
	Served Population	**1,024,789**	1,200,056	1,426,557	1,776,757	**1,200,056**	**1,426,557**	**1,776,757**	1,200,056	1,426,557	1,776,757
	Coverage	**76.8%**	77.3%	80.3%	88.6%	**77.3%**	**80.3%**	**88.6%**	77.3%	80.3%	88.6%
	lpcd	**129.1**	129.7	130.4	129.7	**134.9**	**141.7**	**146.7**	140.1	153.5	166.5
PHNOM PENH CENTER											
	Domestic	57,461	59,909	62,468	64,919	63,433	69,409	75,170	66,957	76,350	88,837
	Commercial etc.	36,687	53,533	57,480	61,727	56,080	62,658	69,961	58,717	68,215	79,860
	Total	94,148	113,442	119,948	126,646	119,513	132,067	145,131	125,674	144,564	168,697
	Served Population	**715,532**	704,810	694,088	683,360	**704,810**	**694,088**	**683,360**	704,810	694,088	683,360
	Coverage	**100.0%**	100.0%	100.0%	100.0%	**100.0%**	**100.0%**	**100.0%**	100.0%	100.0%	100.0%
	lpcd	**131.6**	161.0	172.8	185.3	**169.6**	**190.3**	**212.4**	178.3	208.3	246.9

Suppoering Report 3.2 Domestic Water Demand Projection by Scenario

District		Present	Scenario A			Scenario B			Scenario C		
			lpcd increase/year =		1.0%	lpcd increase/year =		2.0%	lpcd increase/year =		3.0%
Year		2004	2010	2015	2020	2010	2015	2020	2010	2015	2020
1	Chamcar Mon										
	Population	237,822	235,775	233,728	231,680	235,775	233,728	231,680	235,775	233,728	231,680
	Coverage	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Served Population	237,822	235,775	233,728	231,680	235,775	233,728	231,680	235,775	233,728	231,680
	UCR (lpcd)	80.0	85.0	90.0	95.0	90.0	100.0	110.0	95.0	110.0	130.0
	Demand (m3/d)	19,334	20,041	21,036	22,010	21,220	23,373	25,485	22,399	25,710	30,118
2	Doun Penh										
	Population	156,691	151,587	146,483	141,380	151,587	146,483	141,380	151,587	146,483	141,380
	Coverage	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Served Population	156,691	151,587	146,483	141,380	151,587	146,483	141,380	151,587	146,483	141,380
	UCR (lpcd)	80.0	85.0	90.0	95.0	90.0	100.0	110.0	95.0	110.0	130.0
	Demand (m3/d)	11,024	12,885	13,183	13,431	13,643	14,648	15,552	14,401	16,113	18,379
3	7 Meakkara										
	Population	118,664	111,507	104,350	97,190	111,507	104,350	97,190	111,507	104,350	97,190
	Coverage	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Served Population	118,664	111,507	104,350	97,190	111,507	104,350	97,190	111,507	104,350	97,190
	UCR (lpcd)	80.0	85.0	90.0	95.0	90.0	100.0	110.0	95.0	110.0	130.0
	Demand (m3/d)	8,573	9,478	9,392	9,233	10,036	10,435	10,691	10,593	11,479	12,635
4	Tuol Kouk										
	Population	202,355	205,941	209,527	213,110	205,941	209,527	213,110	205,941	209,527	213,110
	Coverage	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Served Population	202,355	205,941	209,527	213,110	205,941	209,527	213,110	205,941	209,527	213,110
	UCR (lpcd)	80.0	85.0	90.0	95.0	90.0	100.0	110.0	95.0	110.0	130.0
	Demand (m3/d)	18,530	17,505	18,857	20,245	18,535	20,953	23,442	19,564	23,048	27,704
5	Dangkao										
	Population	118,466	206,458	296,599	387,948	206,458	296,599	387,948	206,458	296,599	387,948
	Coverage	25.8%	40%	50%	65%	40%	50%	65%	40%	50%	65%
	Served Population	30,506	82,583	148,300	252,166	82,583	148,300	252,166	82,583	148,300	252,166
	UCR (lpcd)	70.0	80.0	85.0	90.0	80.0	90.0	100.0	80.0	95.0	110.0
	Demand (m3/d)	2,135	6,607	12,605	22,695	6,607	13,347	25,217	6,607	14,088	27,738
6	Mean Chey										
	Population	233,348	285,361	339,983	395,779	285,361	339,983	395,779	285,361	339,983	395,779
	Coverage	55.3%	70%	80%	90%	70%	80%	90%	70%	80%	90%
	Served Population	128,957	199,753	271,986	356,201	199,753	271,986	356,201	199,753	271,986	356,201
	UCR (lpcd)	80.0	80.0	85.0	90.0	80.0	90.0	100.0	80.0	95.0	110.0
	Demand (m3/d)	10,317	15,980	23,119	32,058	15,980	24,479	35,620	15,980	25,839	39,182
7	Ruessei Kaev										
	Population	267,546	354,850	445,976	538,922	354,850	445,976	538,922	354,850	445,976	538,922
	Coverage	56.0%	60%	70%	90%	60%	70%	90%	60%	70%	90%
	Served Population	149,793	212,910	312,183	485,030	212,910	312,183	485,030	212,910	312,183	485,030
	UCR (lpcd)	80.0	80.0	85.0	90.0	80.0	90.0	100.0	80.0	95.0	110.0
	Demand (m3/d)	11,983	17,033	26,536	43,653	17,033	28,096	48,503	17,033	29,657	53,353
8	Kandal										
	Population	195,107	223,412	258,222	297,817	223,412	258,222	297,817	223,412	258,222	297,817
	Coverage	5.7%	20%	25%	30%	20%	25%	30%	20%	25%	30%
	Served Population	11,143	44,682	64,556	89,345	44,682	64,556	89,345	44,682	64,556	89,345
	UCR (lpcd)	70.0	80.0	85.0	90.0	80.0	90.0	100.0	80.0	95.0	110.0
	Demand (m3/d)	780	3,575	5,487	8,041	3,575	5,810	8,935	3,575	6,133	9,828
TTL of Study Area											
	Population	1,529,999	1,774,891	2,034,868	2,303,826	1,774,891	2,034,868	2,303,826	1,774,891	2,034,868	2,303,826
	Coverage	67.7%	70.1%	73.3%	81.0%	70.1%	73.3%	81.0%	70.1%	73.3%	81.0%
	Served Population	1,035,931	1,244,738	1,491,113	1,866,102	1,244,738	1,491,113	1,866,102	1,244,738	1,491,113	1,866,102
	UCR (lpcd)	79.8	82.8	87.3	91.8	85.7	94.7	103.7	88.5	102.0	117.3
	Demand (m3/d)	82,676	103,103	130,215	171,366	106,627	141,141	193,444	110,151	152,067	218,938
TTL of Municipality of PP											
	Population	1,334,892	1,551,479	1,776,646	2,006,009	1,551,479	1,776,646	2,006,009	1,551,479	1,776,646	2,006,009
	Coverage	76.8%	77.3%	80.3%	88.6%	77.3%	80.3%	88.6%	77.3%	80.3%	88.6%
	Served Population	1,024,789	1,200,056	1,426,557	1,776,757	1,200,056	1,426,557	1,776,757	1,200,056	1,426,557	1,776,757
	UCR (lpcd)	79.9	82.9	87.4	91.9	85.9	94.9	103.8	88.8	102.3	117.7
	Demand (m3/d)	81,896	99,529	124,728	163,325	103,053	135,331	184,509	106,577	145,934	209,110
Central 4 Districts of PP											
	Population	715,532	704,810	694,088	683,360	704,810	694,088	683,360	704,810	694,088	683,360
	Coverage	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Served Population	715,532	704,810	694,088	683,360	704,810	694,088	683,360	704,810	694,088	683,360
	UCR (lpcd)	80.3	85.0	90.0	95.0	90.0	100.0	110.0	95.0	110.0	130.0
	Demand (m3/d)	57,461	59,909	62,468	64,919	63,433	69,409	75,170	66,957	76,350	88,837

Notes:

1) Population in 2004 is based on the trend analysis of city planning.
2) Unit consumption rate in 2004 is assumed to be 70 or 80 lpcd, dependent on the area.
3) Demand (m3/d) in 2004 is based on the actual data provided by the Comercial Department of PPWSA
4) Served population in 2004 is computed based on the assumed unit consumption rate and demand recorded in 2004.
5) Coverage in 2004 is calculated based on the calculated served pops and population data in 2004.

Suppoering Report 3.2 Non-Domestic Water Demand Projection by Scenario

District		Present	Scenario A			Scenario B			Scenario C		
			commercial =		2.0%	commercial =		3.0%	commercial =		4.0%
Year		2004	2010	2015	2020	2010	2015	2020	2010	2015	2020
1	Chamkar Mon										
	Commercial	7,939	8,941	9,872	10,899	9,480	10,990	12,741	10,046	12,222	14,871
	ADM	2,562	2,719	2,858	3,004	2,719	2,858	3,004	2,719	2,858	3,004
	Autonomy	55	58	61	65	58	61	65	58	61	65
	Total	10,556	11,719	12,791	13,968	12,258	13,910	15,809	12,824	15,142	17,939
2	Doun Penh										
	Commercial	7,974	8,980	9,915	10,947	9,522	11,038	12,796	10,090	12,276	14,935
	ADM	4,883	5,183	5,448	5,726	5,183	5,448	5,726	5,183	5,448	5,726
	Autonomy	271	287	302	318	287	302	318	287	302	318
	Total	13,128	14,451	15,665	16,990	14,992	16,788	18,839	15,561	18,026	20,979
3	7 Meakkara										
	Commercial	4,019	4,526	4,997	5,517	4,799	5,563	6,449	5,085	6,187	7,528
	ADM	1,194	1,267	1,332	1,400	1,267	1,332	1,400	1,267	1,332	1,400
	Autonomy	119	127	133	140	127	133	140	127	133	140
	Total	5,332	5,920	6,462	7,057	6,193	7,028	7,989	6,479	7,652	9,067
4	Tuol Kouk										
	Commercial	6,427	7,238	7,991	8,823	7,674	8,896	10,313	8,132	9,894	12,038
	ADM	1,234	1,310	1,377	1,447	1,310	1,377	1,447	1,310	1,377	1,447
	Autonomy	10	10	11	11	10	11	11	10	11	11
	Total	7,671	8,558	9,379	10,281	8,994	10,284	11,772	9,452	11,282	13,496
5	Dangkao										
	Commercial	4,025	4,533	5,004	5,525	4,806	5,571	6,459	5,093	6,196	7,538
	ADM	232	246	259	272	246	259	272	246	259	272
	Autonomy	0	10	11	11	10	11	11	10	11	11
	Total	4,257	4,789	5,274	5,808	5,062	5,841	6,742	5,349	6,465	7,821
6	Mean Chey										
	Commercial	4,690	5,281	5,831	6,438	5,600	6,491	7,525	5,934	7,219	8,783
	ADM	128	136	143	150	136	143	150	136	143	150
	Autonomy	2	10	11	11	10	11	11	10	11	11
	Total	4,820	5,427	5,984	6,599	5,746	6,645	7,687	6,080	7,373	8,945
7	Ruessei Kaev										
	Commercial	4,268	4,806	5,306	5,859	5,096	5,908	6,849	5,400	6,570	7,994
	ADM	413	438	460	484	438	460	484	438	460	484
	Autonomy	12	12	13	14	12	13	14	12	13	14
	Total	4,692	5,256	5,780	6,356	5,546	6,381	7,346	5,850	7,043	8,491
8	Kandal										
	Commercial	216	1,000	1,104	1,219	1,000	1,159	1,344	1,000	1,217	1,480
	ADM	55	100	105	110	100	105	110	100	105	110
	Autonomy	0	10	11	11	10	11	11	10	11	11
	Total	271	1,110	1,220	1,341	1,110	1,275	1,465	1,110	1,332	1,602
TTL of Study Area											
	Commercial	39,558	45,305	50,021	55,227	47,976	55,618	64,476	50,780	61,782	75,167
	ADM	10,700	11,400	11,982	12,593	11,400	11,982	12,593	11,400	11,982	12,593
	Autonomy	468	525	552	580	525	552	580	525	552	580
	Total	50,726	57,230	62,554	68,400	59,901	68,151	77,649	62,705	74,315	88,340

Notes: In preparation of non-domestic water demand projection, the following is assumed:

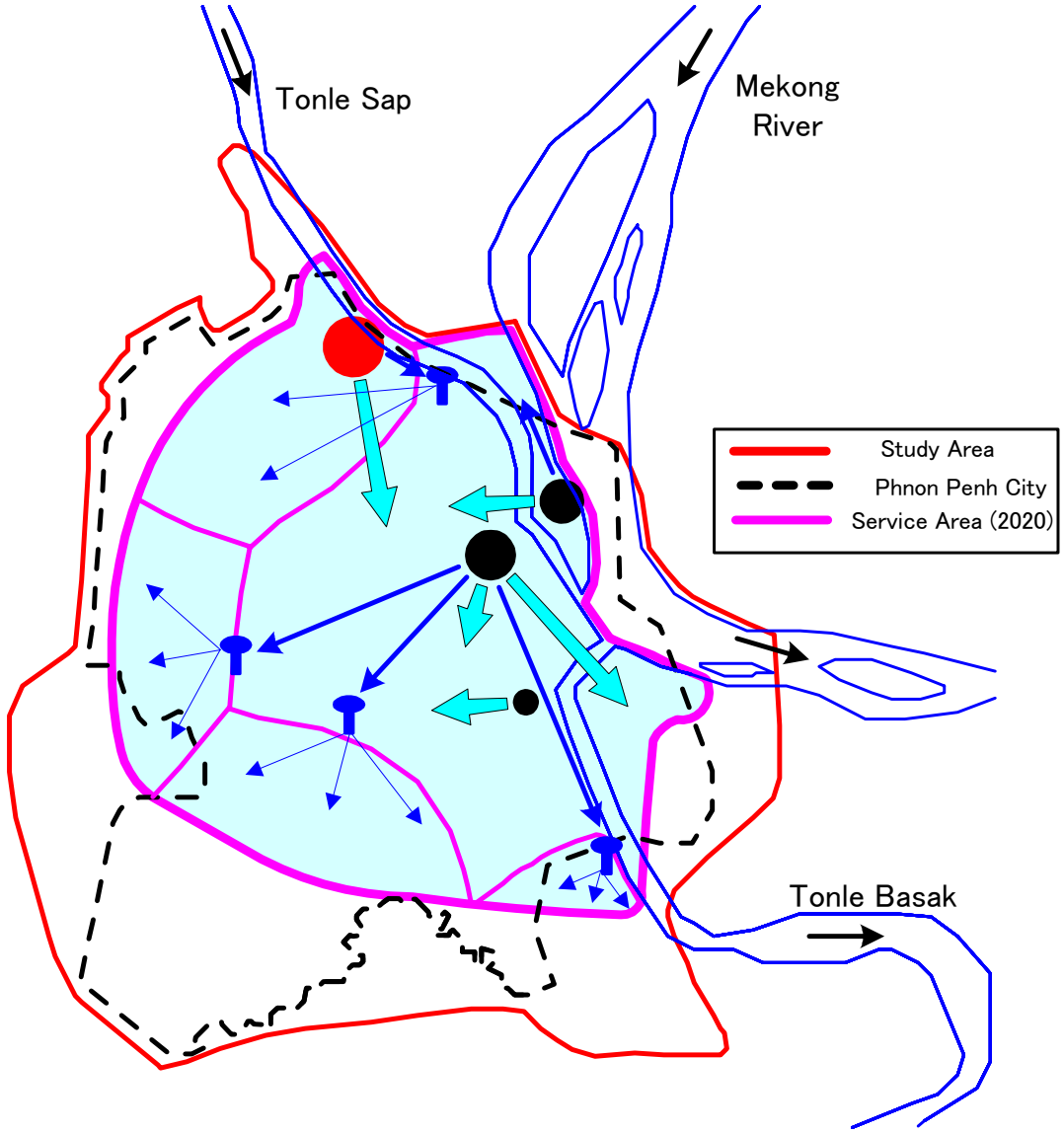
1) Commercial water demand wil be increased cnotinuously in accordance with the GDP growth scenarios, 1%, 2%, or 3%.
2) Administration and autonomy water consumptions will be increased continuously at annual rate of 1%.
3) The water demand will be continuously increased based on the present water consumption recorded in 2004.
4) The autonomy water demand in Dangkao, Mean Chey, and Kandal will be started from 10 m3/d.
5) The commercial and administration water demands of kandal will be started from 1,000m3/d and 100m3/d in 2005.

Supporting Report – 4

Proposed Water Treatment Plants - Alternative

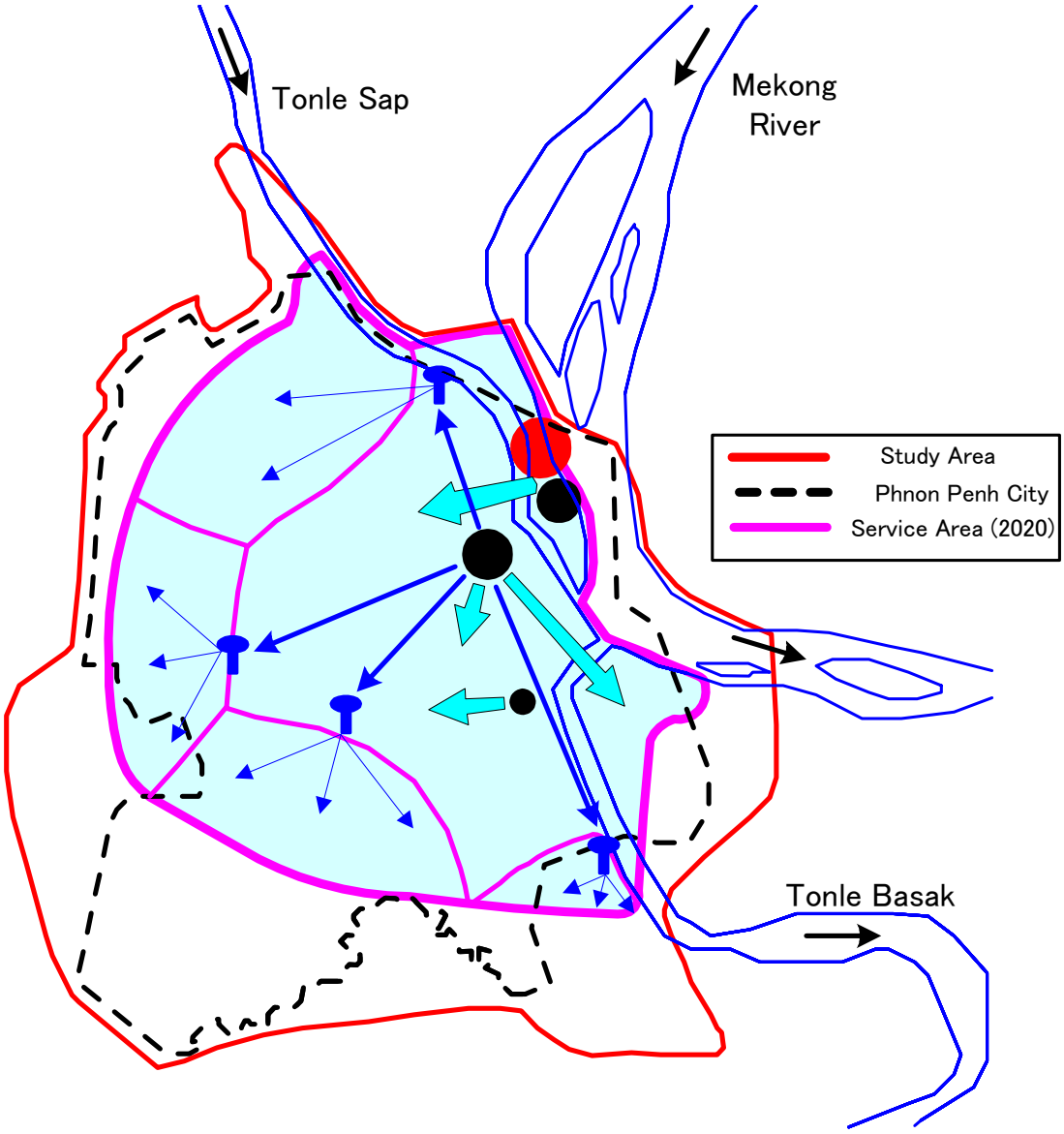
Supporting Report 4.1 Alternative Study on Water Treatment Plant

Alternative – A : Svay Pak



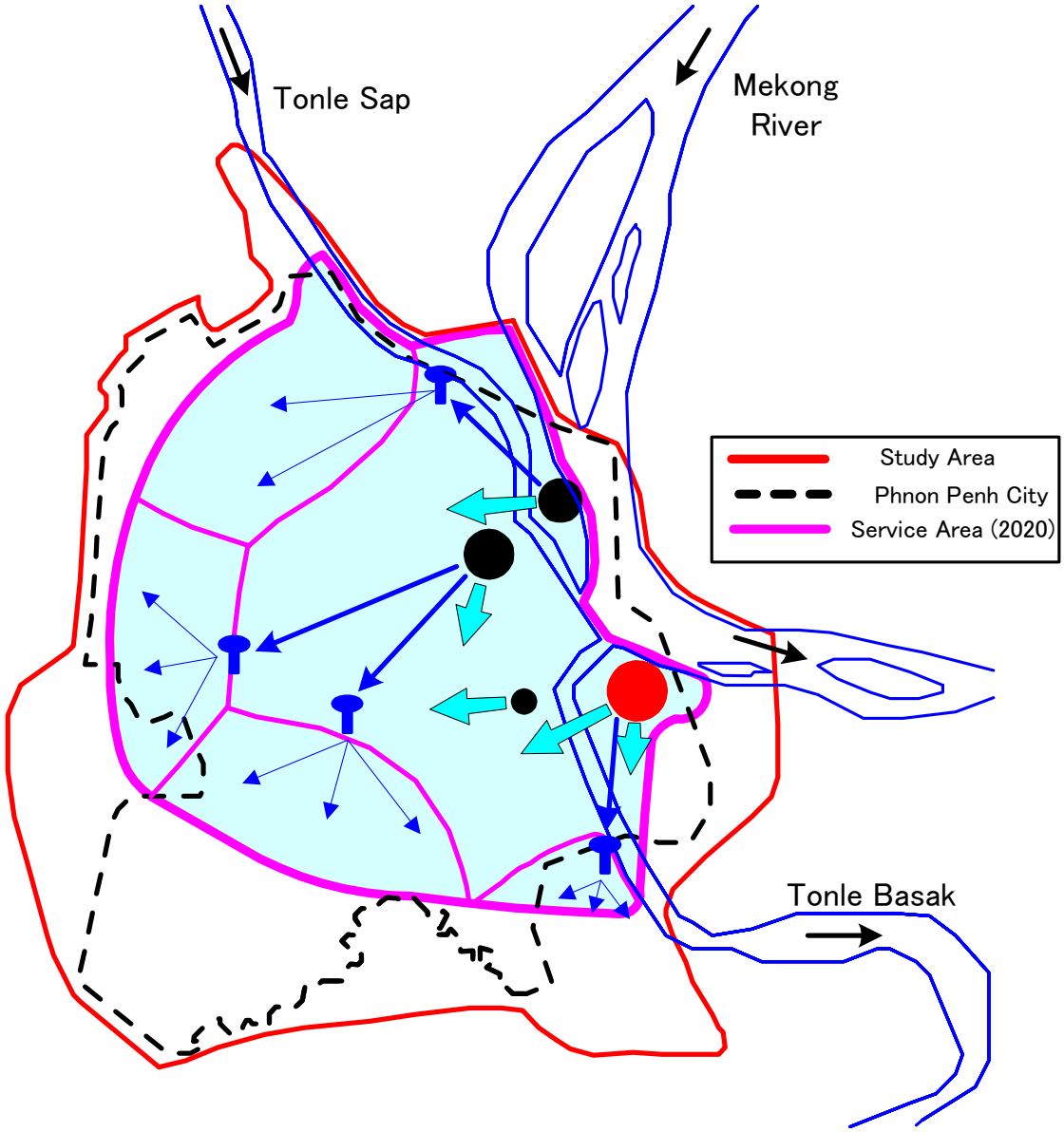
Water Source	Tonle Sap	
Raw Water Quality	Fair	
Land	12 ha (300 m x 400 m), approx. 300 m from NR No. 5	
Facility	Intake station, Water treatment plant (200,000 m^3/d) Clear water reservoir, Distribution pump station (300,000 m^3/d)	
Construction Cost	USD 103.72 million	
Operation Cost (2020)	(Power)	USD 4.78 million/year
	(Chemical)	USD 1.11 million/year
	(Total)	USD 5.89 million/year

Alternative – B : Chrouy Changva



Water Source	Mekong River - Upstream	
Raw Water Quality	Good	
Land	12 ha (300 m x 400 m), approx. 300 m from NR No. 6	
Facility	Intake station, Water treatment plant (200,000 m^3/d) Clear water reservoir, Distribution pump station (300,000 m^3/d)	
Construction Cost	USD 108.06 million	
Operation Cost (2020)	(Power)	USD 4.86 million/year
	(Chemical)	USD 0.93 million/year
	(Total)	USD 5.79 million/year

Alternative –C : Nirouth



Water Source	Mekong River - Downstream	
Raw Water Quality	Good	
Land	12 ha (300 m x 400 m), approx. 300 m from NR No. 1	
Facility	Intake station, Water treatment plant (200,000 m^3/d) Clear water reservoir, Distribution pump station (300,000 m^3/d)	
Construction Cost	USD 102.59 million	
Operation Cost (2020)	(Power)	USD 4.21 million/year
	(Chemical)	USD 0.93 million/year
	(Total)	USD 5.14 million/year

Supporting Report 4.2 Distance for Water Distribution

Census Code	Province/District/ Commune	Demand	Alternative A - Svay Pak								Alternative B - Chrouy Changva								Alternative C - Nirouth							
			Demand (Average Daily: m3/day)				Dimand x Distance (m3/day x km)				Demand (Average Daily: m3/day)				Dimand x Distance (m3/day x km)				Demand (Average Daily: m3/day)				Dimand x Distance (m3/day x km)			
		2020	271,093				1,675,848		6.18 km/m3		271,093				1,703,273		6.28 km/m3		271,093				1,472,165		5.43 km/m3	
	Study Area Total	271,093					6.18	1.00	4.54	8.47					8.04	1.00	4.89	6.40					3.17	1.00	7.26	7.08
			149,592	19,882	116,545	128,593	924,542	19,882	529,422	1,089,216	147,558	19,882	121,474	125,699	1,186,306	19,882	594,001	804,816	149,535	19,882	121,807	123,388	474,385	19,882	884,091	873,189
			150,000	20,000	130,000	200,000	150,000	20,000	130,000	200,000	150,000	20,000	130,000	200,000	150,000	20,000	130,000	200,000	150,000	20,000	130,000	200,000	150,000	20,000	130,000	200,000
			PP	**CM**	**CC-1**	**SP**	**PP**	**CM**	**CC-1**	**SP**	**PP**	**CM**	**CC-1**	**CC-2**	**PP**	**CM**	**CC-1**	**CC-2**	**PP**	**CM**	**CC-1**	**N**	**PP**	**CM**	**CC-1**	**N**
Phnom Penh Central Zone		**217,372**	97,810	13,000	76,203	84,080	604,508	13,000	346,160	712,180	96,480	13,000	79,425	82,188	775,661	13,000	388,385	526,226	97,773	13,000	79,643	80,677	310,175	13,000	578,059	570,931
120100	Chamkar Mon	41,294	28,294	13,000			84,881	13,000	0	0		13,000		28,294	0	13,000	0	212,203		13,000		28,294	0	13,000	0	198,057
120200	Doun Penh	34,391	4,500		29,891		5,400	0	125,543	0			34,391		0	0	144,443	0	16,391		18,000		19,669	0	75,600	0
120300	Prampir Meakkara	18,680				18,680	0	0	0	186,799				18,680	0	0	0	102,739	18,680				18,680	0	0	0
120400	Tuol Kouk	35,214			35,214		0	0	176,069	0				35,214	0	0	0	211,283	35,214				70,428	0	0	0
120702	Tuol Sangkae	5,223				5,223	0	0	0	31,338			5,223		0	0	15,669	0	5,223				10,446	0	0	0
120704	Kiloumaetr Lekh Prammuoy	2,647				2,647	0	0	0	11,913			2,647		0	0	11,913	0	2,647				10,589	0	0	0
120701	Khmuonh-1	2,860				2,860	0	0	0	11,441			2,860		0	0	22,882	0			2,860		0	0	22,882	0
120705	Phnom Penh Thmei	15,637				15,637	0	0	0	109,457			15,637		0	0	109,457	0			15,637		0	0	109,457	0
120706	Ruessei Kaev	3,917				3,917	0	0	0	25,462			3,917		0	0	13,710	0			3,917		0	0	13,710	0
120707	Tuek Thla	6,985				6,985	0	0	0	69,847	6,985				31,431	0	0	0	6,985				31,431	0	0	0
120711	Chrang Chamreh Muoy	1,351				1,351	0	0	0	3,378			1,351		0	0	10,809	0			1,351		0	0	10,809	0
120712	Chrang Chamreh Pir	2,301				2,301	0	0	0	6,902			2,301		0	0	14,954	0			2,301		0	0	14,954	0
120506	Kakab	7,654				7,654	0	0	0	76,535	7,654				61,228	0	0	0			7,654		0	0	84,189	0
120505	Chaom Chau-1	9,889				9,889	0	0	0	123,612	9,889				89,000	0	0	0			9,889		0	0	118,667	0
120601	Stueng Mean Chey	10,724	10,724				53,619	0	0	0	10,724				53,619	0	0	0				10,724	0	0	0	107,239
120602	Boeng Tumpun	6,631	6,631				29,839	0	0	0	6,631				29,839	0	0	0				6,631	0	0	0	49,732
120606	Chak Angrae Leu	2,728	2,728				15,006	0	0	0	2,728				15,006	0	0	0				2,728	0	0	0	13,642
120607	Chak Angrae Kraom	7,431	7,431				55,731	0	0	0	7,431				55,731	0	0	0				7,431	0	0	0	59,447
120515	Cheung Aek	1,816	1,816				16,347	0	0	0	1,816				16,347	0	0	0				1,816	0	0	0	18,163
Chrouy Changva Zone		**11,098**																								
120708	Praek Lieb	2,893			2,893		0	0	17,358	0			2,893		0	0	17,358	0			2,893		0	0	17,358	0
120709	Praek Ta Sek	2,712			2,712		0	0	21,698	0			2,712		0	0	21,698	0			2,712		0	0	21,698	0
120710	Chrouy Changva	5,492			5,492		0	0	5,492	0			5,492		0	0	5,492	0			5,492		0	0	5,492	0
Kien Svay Zone		**16,679**					0	0	0	0																
120603	Preaek Pra	2,670	2,670				21,359	0	0	0	2,670				21,359	0	0	0				2,670	0	0	0	10,680
120604	Chbar Ampov Muoy	1,570	1,570				9,421	0	0	0	1,570				9,421	0	0	0				1,570	0	0	0	6,281
120605	Chbar Ampov Pir	3,447	3,447				20,681	0	0	0	3,447				20,681	0	0	0				3,447	0	0	0	13,787
120608	Nirouth	8,106	8,106				64,848	0	0	0	8,106				64,848	0	0	0				8,106	0	0	0	24,318
080200	Kien Svay (part)	886	886				11,515	0	0	0	886				11,515	0	0	0				886	0	0	0	2,657
Chang Chamers Water Tank Zone		**6,937**																								
120703	Svay Pak	2,830				2,830				15,567	2,830				25,473	0	0	0			2,830		0	0	26,888	0
120701	Khmuonh-2	1,000				1,000				7,500	1,000				11,000	0	0	0			1,000		0	0	11,500	0
120503	Kouk Roka	2,919				2,919				30,648	2,919				40,864	0	0	0			2,919		0	0	42,323	0
080900	Ponhea Lueu	188				188				1,781	188				2,438	0	0	0			188		0	0	2,532	0
Airport Water Tank Zone		**6,379**																								
120511	Krang Thnong	1,004	1,004				13,550				1,004				13,550	0	0	0	1,004				13,550	0	0	0
120509	Samraong Kraom	1,390	1,390				17,380				1,390				17,380	0	0	0	1,390				17,380	0	0	0
120502	Trapeang Krasang	1,032	1,032				12,387				1,032				12,387	0	0	0	1,032				12,387	0	0	0
080800	Angk Snuol (part)	2,952	2,952				39,857				2,952				39,857	0	0	0	2,952				39,857	0	0	0
Pochentong Water Tower Zone		**6,254**																								
120505	Chaom Chau-2	3,000	3,000				27,000				3,000				27,000	0	0	0	3,000				27,000	0	0	0
120504	Phleung Chheh Roteh	122	122				1,705				122				1,705	0	0	0	122				1,705	0	0	0
120507	Pong Tuek	212	212				2,753				212				2,753	0	0	0	212				2,753	0	0	0
120501	Dangkao	2,421	2,421				29,049				2,421				29,049	0	0	0	2,421				29,049	0	0	0
120510	Prey Sa	500	500				5,250				500				5,250	0	0	0	500				5,250	0	0	0
120508	Prey Veaeng	0	0				0				0				0	0	0	0	0				0	0	0	0
120513	Prateah Lang	0	0				0				0				0	0	0	0	0				0	0	0	0
120514	Sak Sampov	0	0				0				0				0	0	0	0	0				0	0	0	0
120512	Krang Pongro	0	0				0				0				0	0	0	0	0				0	0	0	0
Ta Khmau Zone		**6,374**																								
080100	Kandal Stueng (part)	0	0				0				0				0	0	0	0				0	0	0	0	0
081100	Ta Khmau	6,374	6,374				66,930				6,374				66,930	0	0	0				6,374	0	0	0	66,930

Supporting Report 4.3 Capacity Calculation

Capacity Calculation for Chrouy Changva Water Treatment Plant - Stage II (65,000 cu m/day)

Item	Stage I + II	Stage I (Existing)
Plant Capacity	Q= 130,000 cu m/day	Q= 65,000 cu m/day
Plant Capacity (Daily Max)	Q= 136,500 cu m/day = 5,688 cu m/hour = 94.8 cu m/min = 1.580 cu m/sec	Q= 68,250 cu m/day = 2,844 cu m/hour = 47.4 cu m/min = 0.790 cu m/sec
(1) Receiving Well Criteria	Retention Time T = 1.0 min	
Dimension	Rectangular 1 units L m x W m x D m x units 13.0 x 5.0 x 4.0 x 1	
	V= 260.0 cu m T= 2.6 min	
(2) Mixing Chamber Criteria	Retention Time T= 1 - 5 min	Retention Time T= 1 - 5 min
Dimension	Rectangular 4 units L m x W m x D m x units 3.7 x 2.5 x 5.1 x 4	Rectangular 2 units L m x W m x D m x units 3.7 x 2.5 x 5.1 x 2
Unit Volume	UV = 47.2 cu m/unit	UV = 47.2 cu m/unit
Total Volume	V = 188.7 cu m	V = 94.35 cu m
Retention Time	T= 2.0 min	T= 2.0 min
Mixing	Hydraulic Mixing	Mechanical Mixing
(3) Flocculation Basin Criteria	Retention Time T = 20 - 40 min Required Volume V = 1,896 cu.m to 3,792 cu.m	Retention Time T = 20 - 40 min Required Volume V = 948 cu.m to 1,896 cu.m
Unit Flow	q = 23.7 cu m/min/basin	q = 23.7 cu m/min/basin
Dimension	4 units	2 units
Step 1	W m x L m x D m x No.of Chambers 4.6 x 4.6 x 4.7 x 1	W m x L m x D m x No.of Chambers 4.6 x 4.6 x 4.7 x 1
Step 2	W m x L m x D m x No.of Chambers 4.6 x 4.6 x 4.7 x 2	W m x L m x D m x No.of Chambers 4.6 x 4.6 x 4.7 x 2
Step 3	W m x L m x D m x No.of Chambers 4.6 x 4.6 x 4.7 x 2	W m x L m x D m x No.of Chambers 4.6 x 4.6 x 4.7 x 2
Step 4	W m x L m x D m x No.of Chambers 4.6 x 4.6 x 4.7 x 1	W m x L m x D m x No.of Chambers 4.6 x 4.6 x 4.7 x 1
Volume	Step 1 99.5 cu m/unit Step 2 198.9 cu m/unit Step 3 198.9 cu m/unit Step 4 99.5 cu m/unit Volume / Unit 596.7 cu m/unit	Step 1 99.5 cu m/unit Step 2 198.9 cu m/unit Step 3 198.9 cu m/unit Step 4 99.5 cu m/unit Volume / Unit 596.7 cu m/unit
Total Volume	V = 2,387 cu m	V = 1,193 cu m
Retention Time	25.2 minutes	25.2 minutes
(4) Sedimentation Basin Type	Rectangular, Up-flow with Inclined Tube	Rectangular, Up-flow with Inclined Tube
Unit Flow	q = 1,422 cu m/hr/basin	q = 1,422 cu m/hr/basin
Criteria	Tank Retention Time T = 1.0 hours Plate Retention Time T = 15.0 min Tank Surface Load a = 80 mm/min Plate Surface Load a = 7 - 14 mm/min Depth D = 3 - 4 m Depth of 30 cm or more is provided for sludge settlemen	Tank Retention Time T = 1.0 hours Plate Retention Time T = 15.0 min Tank Surface Load a = 80 mm/min Plate Surface Load a = 7 - 14 mm/min Depth D = 3 - 4 m Depth of 30 cm or more is provided for sludge settlemen

Item	Stage I + II	Stage I (Existing)
Dimension	No. 4 basins W m x L m x D m x N 14.3 38.4 4.5 4	No. 2 basins W m x L m x D m x N 14.3 38.4 4.5 2
Inclined Tube	60 degree, Height = 0.75 m Clearance = 25 mm	60 degree, Height = 0.75 m Clearance = 25 mm
Volume	V = 2,444 cu m/basin	V = 2,444 cu m/basin
Tank Retention Time	T = 1.7 hours	T = 1.7 hours
Plate Retention Time	T = 10.1 min	T = 10.1 min
Tank Surface Load	a = 43.2 mm/min	a = 43.2 mm/min
Plate Surface Load	a = 2.9 mm/min	a = 2.9 mm/min
Hor. Flow Velocity	v = 0.372 m/min	v = 0.372 m/min
Overflow Weir	Load = 500 m3/m/day	Load = 500 m3/m/day
Trough Length	L = 68.25 m or longer	L = 68.25 m or longer
	No. 40 troughs L m x N 5.75 40	No. 40 troughs L m x N 5.75 40
	L = 230.0 m	L = 230.0 m
Sludge Removal	Cable-operated underwater bogie sludge collector or Travelling bridge sludge collector	Cable-operated underwater bogie sludge collector or Travelling bridge sludge collector
Sludge Amount Solid Amount (ton-DS)	So = Q * (K*(T1-T2)+B*C*156/102)*10^-6 where So:Sludge dry weight(ton) Q :Treated water amount(m3/d) K :Coefficient converting turbidity to SS (0.8-1.5 ->>1.0) T1 :Turbidity in raw water (rainy ave= 300) T2 :Turbidity after Sedimentation (ave = 5) B :Alum dosage rate (rainy ave.= 35) C :Concentration of AL2O 17%	
	So = 41.51 ton-DS/day	So = 24.78 ton-DS/day
	Water Contents of Drained Sludge (with wash-out water) w = 98.0 %	Water Contents of Drained Sludge (with wash-out water) w = 98.0 %
	Frequency of Cleaning : Continuous	Frequency of Cleaning : Continuous
Sludge Volume	Total v = 2,075 cu.m/day So = 41.51 ton-DS/day	Total v = 1,239 cu.m/day So = 24.78 ton-DS/day
(5) Rapid Sand Filter Type	Down Flow, Single Media	Down Flow, Single Media
No.	12 units (wasl 1 units)	8 units (wasl 1 unit)
Unit Flow	q = 11,375 cu m/day/unit	q = 8,531 cu m/day/unit
Criteria	Filtration Rate Fr = 150 - 200 m/day =6.25 - 8.33 m/hour Filter Area per Unit A < 150 sq m	Filtration Rate Fr = 150 - 200 m/day =6.25 - 8.33 m/hour Filter Area per Unit A < 150 sq m
Dimension	W m x L m x N units 7.3 7.9 12 (12 filters/group)	W m x L m x N units 7.3 7.9 8 (8 filters/group)
	A = 57.67 sq m/unit	A = 57.67 sq m/unit
Filtration Rate	Fr = 197.2 m/day	Fr = 147.9 m/day
Filtration Rate during washing	Fr'= 215.2 m/day 1 unit out of 12 are washing	Fr'= 169.1 m/day 1 unit out of 8 is washing

Item	Stage I + II	Stage I (Existing)
Filter Washing Frequency	Once a day for each filter	Once a day for each filter
Rate	Air Scouring (Step 1) rate = 0.90 m3/m2/min Backwashing (Step 1) rate = 0.24 m3/m2/min duration = 4.5 min Backwashing (Step 2) rate = 0.36 m3/m2/min duration = 4.5 min	Air Scouring (Step 1) rate = 0.90 m3/m2/min Backwashing (Step 1) rate = 0.24 m3/m2/min duration = 4.5 min Backwashing (Step 2) rate = 0.36 m3/m2/min duration = 4.5 min
Water Amount for washing	Backwashing (Step 1) Vs = 62.3 cu m/unit Backwashing (Step 2) Vb = 93.4 cu m/unit Vs + Vb = 155.7 cu m/unit	Backwashing (Step 1) Vs = 62.3 cu m/unit Backwashing (Step 2) Vb = 93.4 cu m/unit Vs + Vb = 155.7 cu m/unit
for Total Units	Total Amount for Washing 1,868.5 cu m/day Percentage for Planned Flow 1.4 %	Total Amount for Washing 1,245.7 cu m/day Percentage for Planned Flow 1.8 %
Solid Amount in Wastewater (ton-DS)	So = Q*K*(T1-T2)*10^-6 where So:Sludge dry weight(ton) Q :Treated water amount(m3/d) K :Coefficient converting turbidity to SS (0.8-1.5 ->>1.0) T1 :Turbidity before filter(a 5) T2 :Turbidity after filter(ave 0)	
	So = 0.82 ton-DS/day	So = 0.41 ton-DS/day
SS Contents	s = 438 mg/l	s = 329 mg/l
(6) Clear Water Reservoir Criteria	Retention Time T > 6.0 hours	Retention Time T > 6.0 hours
Required Volume	V = 32,500 cu m	V = 16,300 cu m
Reservoir-1 Dimension	No. 2 units L m x W m x D m m x N units 32.0 21.5 4.2 2 V1 = 5,710 cu m	No. 2 units L m x W m x D m m x N units 32.0 21.5 4.2 2 V1 = 5,710 cu m
Reservoir-A Dimension	No. 2 units L m x W m x D m m x N units 45.0 20.0 5.0 1 VA = 4,500 cu m	
Reservoir-B Dimension	No. 1 units L m x W m x D m m x N units 50.0 30.0 5.0 2 VB = 15,000 cu m	
Total Volume	V = 25,210 cu m	V = 5,710 cu m
Retention Time	T = 4.65 hours	T = 2.11 hours

Supporting Report 4.3 Capacity Calculation

Chemical Capacity Calculation - Chrouy Chamgva Water Treatment Plant - Stage II (65,000 cu m/day)

Item	Stage I + II	Stage I (Existing)
Plant Capacity (Daily Max)	Q= 130,000 cu m/day	Q= 65,000 cu m/day
Planned Flow	Q= 136,500 cu m/day	Q= 68,250 cu m/day
	= 5,688 cu m/hour	= 2,844 cu m/hour
	= 94.8 cu m/min	= 47.4 cu m/min
	= 1.580 cu m/sec	= 0.790 cu m/sec
(1) Alum Dissolving Tank		
Coagulant	Solid Aluminum Sulphate (Al2(SO4)3) containing 15 % Al2-O3	Solid Aluminum Sulphate (Al2(SO4)3) containing 15 % Al2-O3
Criteria	Dosage Rate : 10-50 mg-solid alum/l	Dosage Rate : 10-50 mg-solid alum/l
	- Maximum 50 mg/l	- Maximum 50 mg/l
	- Average 30 mg/l (monthly max.)	- Average 30 mg/l (monthly max.)
	- Minimum 10 mg/l	- Minimum 10 mg/l
	Coagulant Solution : 3 % sg = 1.0152	Coagulant Solution : 3 % sg = 1.0152
	Retention Time 24 hours	Retention Time 24 hours
	Dissolving Time 2 hours	Dissolving Time 2 hours
Dosage Amount	Wt = 4,095 kg-Alum/day (Ave dosage)	Wt = 2,048 kg-Alum/day (Ave dosage)
Coagulant Solution	Vmax = 224.1 cu m/day (Max dosage)	Vmax = 112.0 cu m/day (Max dosage)
	Vave = 80.7 cu m/day (Ave dosage)	Vave = 40.3 cu m/day (Ave dosage)
Solution Tank	Square 4 units	Square 2 units
Dimension	L m x W m x D m x units	L m x W m x D m x units
	3.5 3.5 2.5 4	3.5 3.5 2.5 2
Total Volume	V = 122.5 cu m	V = 61.3 cu m
Retention Time	T = 13.1 hours for maximum dosing	T = 13.1 hours for maximum dosing
Alum Pump	1 units each (excl. 1 unit stand-by)	1 units (excl. 1 unit stand-by)
Capacity	Qmax = 155.6 liter/min 9.34 cu m/hr	Qmax = 77.8 liter/min 4.67 cu m/hr
	Qmin = 31.1 liter/min 1.87 cu m/hr	Qmin = 15.6 liter/min 0.93 cu m/hr
(Existing)	Qmax = 2.30 cu m/hr (excl. 1 unit stand-by)	Qmax = 2.30 cu m/hr (excl. 1 unit stand-by)
Storage	Period 30 days	Period 30 days
	Bulk s. g. 0.60	Bulk s. g. 0.60
Storage Area	A = 102 m2 at 2.0 m height	A = 51 m2 at 2.0 m height
(2) Chlorination Equipment		
Injection Point	Pre-Chlorine at the Inlet of Distribution Chamber	Pre-Chlorine at the Inlet of Distribution Chamber
	Post-Chlorine and outlet of Filter	Post-Chlorine and outlet of Filter
Type	Liquid Chlorine (900 kg-cylinder)	Liquid Chlorine (900 kg-cylinder)
Dosage Rate	Maximum Average Minimum	Maximum Average Minimum
	Pre (1.0-3.0 mg/ 3.0 2.0 1.0	Pre (1.0-3.0 mg/ 3.0 2.0 1.0
	Post (0.5-1.0 mg/ 2.0 1.0 0.5	Post (0.5-1.0 mg/ 2.0 1.0 0.5
Dosage Amount	Wt = 410 kg- Cl gas/day (Average)	Wt = 205 kg- Cl gas/day (Average)
	or 17.1 kg- Cl gas/hour (Average)	or 8.5 kg- Cl gas/hour (Average)
Chlorinator	Vacuum Type	Vacuum Type
Capacity	Pre- 1 units each (excl. 1 unit stand-by)	Pre- 1 units each (excl. 1 unit stand-by)
	Qmax = 17.1 kg/hr 409.50 kg/day	Qmax = 8.5 kg/hr 204.75 kg/day
	Qmin = 5.7 kg/hr 136.50 kg/day	Qmin = 2.8 kg/hr 68.25 kg/day
	Post- 2 units each (excl. 1 unit stand-by)	Post- 1 units each (excl. 1 unit stand-by)
	Qmax = 5.7 kg/hr 136.50 kg/day	Qmax = 5.7 kg/hr 136.50 kg/day
	Qmin = 1.4 kg/hr 34.13 kg/day	Qmin = 1.4 kg/hr 34.13 kg/day
(Existing Pre)	Qmax = 20.0 kg/hr (excl. 1 unit stand-by)	Qmax = 20.0 kg/hr (excl. 1 unit stand-by)
(Existing Post)	Qmax = 20.0 kg/hr (excl. 1 unit stand-by)	Qmax = 20.0 kg/hr (excl. 1 unit stand-by)
Storage	Period 30 days	Period 30 days
No. of Container	16 units	9 units
Storage Area	A = 32 m2 as 2.0 m2/container	A = 18 m2 as 2.0 m2/container

Supporting Report 4.4 Hydraulic Calculation

Cambodia - Chrouy Chamgva Water Treatment Plant - Stage II

Hydraulic Calculation for Cambodia - Chrouy Chamgva Water Treatment Plant - Stage II (65,000 cu m/day)

No.	Descriptions				
1	Production rate	Total Q =	130,000	m^3/day	**Note: Receiving well for 130,000 m3/d will be constructed in Stage II.**
2	Production loss	(	5	%)	
3	Planned Flow Rate	=	136,500		
		=	5,688	m^3/hour	
		=	94.8	m^3/min	
		=	1.580	m^3/s	

No.	Descriptions				
1	Production rate	Total Q =	65,000	m^3/day	**Note: Stage II**
2	Production loss	(	5	%)	
3	Planned Flow Rate	=	68,250		
		=	2,844	m^3/hour	
		=	47.4	m^3/min	
		=	0.790	m^3/s	

Summary of Designed Water Level

00	Design Raw Water Receiving Level	WL0 = +	17.000	m	
01	Receiving Well	SL10 = +	17.500	m	(structure top)
	Receiving Chamber	WL11 = +	16.670	m	
	Weir	WL12 = +	16.610	m	
	Chamber to Mixing Tank	WL13 = +	16.160	m	
	Distribution Weir Crest	Hw11 = +	16.300	m	(structure)
02	Mixing Tank	SL20 = +	0.060	m	(structure top)
	Inflow Chamber	WL21 = +	15.900	m	
	Mixing Chamber	WL22 = +	15.840	m	
	Effluent Chamber	WL23 = +	15.820	m	
	Inflow Conduit	WL24 = +	15.800	m	
	Overflow Level	H2over = +	16.050	m	(overflow weir at Mixing Tank)
03	Flocculation/Sedimentation Tank	SL30 = +	16.500	m	(Flocculation Tank - structure top)
		SL31 = +	16.000	m	(Sedimentation Tank - structure top)
	Inflow Conduit	WL31 = +	15.750	m	
	Flocculation Channel				
	Start	WL32 = +	15.730	m	
	End	WL33 = +	15.550	m	
	Sedimentation Tank Inflow Chamber	WL34 = +	15.550	m	
	Sedimentation Basin	WL34 = +	15.550	m	
	Outlet Channel to Filter	WL35 = +	15.310	m	(ordinal operation)
			15.310	m	(during backwashing)
	Flloculation Tank Weir-1 Crest	Hw31 = +	15.500	m	(structure)
	Flloculation Tank Weir-2 Crest	Hw32 = +	15.090	m	(structure)
	Trough Orifice Center	Hw33 = +	15.500	m	(structure)
	Trough Top	Hw34 = +	15.700	m	(structure)
	Trough bottom	Hw35 = +	15.300	m	(structure)
04	Sand Filter	SL40 = +	14.800	m	(structure top)
	Inflow Conduit	WL41 = +	14.450	m	(ordinal operation)
			14.470	m	(during backwashing)
	Inflow Gate to Filter	WL42 = +	14.360	m	(ordinal operation)
			14.370	m	(during backwashing)
	Inflow Weir to Filter	WL43 = +	14.200	m	(ordinal operation)
			14.000	m	(during backwashing)
	Filter : HWL	WL44 = +	14.200	m	
	Filter : LWL	WL45 = +	14.000	m	
	Effluent Conduit	WL46 = +	11.750	m	ordinal operation
			11.760	m	during backwashing
	Effluent Water Level to Resevoir	WL47 = +	11.210	m	
	Filter Inflow Weir Crest	Hw41 = +	14.250	m	(structure)
	Filter Effluent Weir Crest	Hw42 = +	11.550	m	(structure)
04	Clear Water Reservoir			m	
	Reservoir : HWL	WL41 = +	10.500	m	
	Reservoir : LWL	WL42 = +	5.500	m	
	Overflow Crest Level	H5over = +	10.660	m	(overflow weir at clearwater tanks)

00	Initial Water Level in Receiving Well		WL0 = + 17.000 m AMSL
01	Inlet Facilities	**(Stage I + II)**	
	Receiving Well	No. of Unit = 1	SL10 = + 17.500 m (structure)
		Flow rate Q = original +5%) 136,500 m^3/day	Water Level in the Receiving Well Chamber
		1.580 m^3/s	WL11 = + 16.670 m < 17.000
1)	Perfolated Buffle	Wall Width = 5.30 m	
		Depth = 5.70 m	(1) Head Loss through baffle wall
		Area = 30.21 m^2	$h = (1/c^2)*(v^2/(2*g))$
		Holes Diameter = 0.10 m	where, c = 0.600
		No. = 336 No.	= 0.051 m
		Area = 2.64 m^2	say = 0.060 m
		Pitch = 0.30 m	
		Open Ratio 8.73 %	
		Velocity in Hole: v = 0.60 m/s	
2)	Distribution Weir	Weir Crest Level	Hw11 = + 16.300 m
		No. = 2 trains	(1) Weir Loss
		Unit q = 0.790 m^3/s	$hw = (q/(C*b))^{2/3}$ say
		Width of weir b = 2.500 m	= 0.307 m 0.310
		Hight of crest W = 4.600 m	where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e)
		W<=1 m e= 0	= 1.861
		W>1m e=0.55*(W-1) 1.980	
		hw = 0.307 m (trial)	WL12 = + 16.610 m
3)	Weceiving Well to Mixing Tank	No. = 2 lines	WL13 = + 16.160 m
		Unit Q = 0.790 m^3/s	(1) Friction Loss (pipe)
		Dia : D = 1.00 m	$hf = f*(L/D)*(v^2/(2*g))$
		Length: L = 100.0 m	= 0.159 m
		Area : A = 0.79 m^2	where, f = (20+(1/(2*D)))*1.5/1000
		Velocity in Pipe : v = 1.01 m/sec	= 0.031 m
		(3) In-Out Loss assumption	(2) Bend Loss (bend)
		$hio = f*(v^2/(2*g))$	$hb = f*(v^2/(2*g))$
		where, f = 1.5 = (0.5 + 1)	90 deg. Bend = 2 (f = 0.17)
		= 0.077 m	= 0.018 m
			Total Loss : hf + hb + hio
			= 0.254 m
			say 0.260 m
02	Mixing Tank	**(Stage II)**	
		No. of Unit = 2	SL20 = + 16.500 m
		Flow rate Q = original +5%) 68,250 m^3/day	Water Level in the Mixing Tank
		0.790 m^3/s	WL21 = + 15.900 m
	Mixing Tank		
1)	Mixing Tank Inflow Gate	No. = 2 trains	(1) Gate Orifice Loss
		Unit q = 0.395 m^3/s/train	$ht = v^2/(2*9.8*C^2)$
		Inflow gate W = 800 mm	C = 0.60 say
	Inflow gate velocity;	H = 800 mm	hw(7)= 0.054 m 0.060
	1.0 m/sec>	Inflow velocity v= 0.617 m/s	
2)	Downflow	No. = 2 outlets	WL22 = + 15.840 m
		Unit q = 0.395 m^3/s	(1) Orifice Loss
		Openning Width = 2.50 m	$ht = v^2/(2*9.8*C^2)$
	Inflow gate velocity;	Depth = 0.45 m	C = 0.60 say
	1.0 m/sec>	Inflow velocity v = 0.351 m/s	hw = 0.017 m 0.020
3)	Mixing Tank Effluent Gate	No. = 2 trains	WL23 = + 15.820 m
		Unit q = 0.395 m^3/s/train	(1) Gate Orifice Loss
		Inflow gate W = 1200 mm	$ht = v^2/(2*9.8*C^2)$
	Inflow gate velocity;	H = 1000 mm	C = 0.60 say
	1.0 m/sec>	Inflow velocity v = 0.329 m/s	hw(7)= 0.015 m 0.020
4)	Inflow Conduit	No. Channels = 1	Water level at the distribution channel of filter
		Unit q = 0.790 (m^3/s/channel)	WL24 = + 15.800 m
		Width of inflow channel W= 0.70 m	(1) Friction Loss (open channel)
		D = 1.20 m	$hf = n^2*v^2*L/R^{4/3}$
		L = 36 m	where, n = 0.015
	1.0 m/sec>	Velocity in Channel : v = 0.94 m/s	R = W*D/(2*D+W)
			= 0.271 m
			= 0.0409 m 0.050
5)	Overflow Weir	Overflow Weir Crest Level	H2over = + 16.050 m
		No. = 1 trains	(1) Weir Loss
		Unit q = 0.790 m^3/s	$hw(14) = (q/(C*b))^{2/3}$ say
		Width of weir b = 2.500 m	= 0.302 m 0.310
		Hight of crest W = 4.600 m	where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e)
		W<=1 m e= 0	= 1.908
		W>1m e=0.55*(W-1) 1.980	
		hw = 0.079 m (trial)	WL25 = + 16.360 m
03	Flocculation/Sedimentation Tank		
		No. of Unit = 2	SL30 = + 16.500 m
		Flow rate Q = original +5%) 34,125 m^3/day	Water Level in the Inflow Conduit
		0.395 m^3/s	WL31 = + 15.750 m
	Flocculation/Sedimentation Tank		
1)	Flocculation Tank Inflow Gate	No. = 2 trains	(1) Gate Orifice Loss
		Unit q = 0.395 m^3/s/train	$ht = v^2/(2*9.8*C^2)$

		Inflow gate	W =	1200	mm			C =	0.60	say
	Inflow gate velocity;		H =	1000	mm		hw(7)=	0.015	m	0.020
	1.0 m/sec>	Inflow velocity v=		0.329	m/s					
2)	Flocculation Tank Weir/Downflow	Weir Crest Level of Effluent					WL32 = +	15.730	m	
		No. =		4	trains		Hw31 = +	15.500	m	
		Unit q =		0.197	m^3/s		(1) Weir Loss			
		Width of weir b =		4.625	m		hw1 = $(q/(C*b))^{2/3}$			say
		Hight of crest W =		4.600	m		=	0.079	m	0.080
		W<=1 m	e= 0				where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e)			
		W>1m	e=0.55*(W-1)	1.980			=	1.908		
			hw =	0.079	m (trial)		(2) Orifice Loss			
	Downflow	No. =		4	outlet		ht = $v^2/(2*9.8*C^2)$			
	Inflow gate velocity;	Unit q =		0.197	m^3/s		C =	0.60	say	
	1.0 m/sec>	Openning	Width =	4.60	m		hw =	0.013	m	0.020
			Depth =	0.20	m					
		Inflow velocity v =		0.215	m/s		Hw32 = +	15.090	m	
		No. of Openings =		2			(3) Weir Loss			
							hw2 = $(q/(C*b))^{2/3}$			say
							=	0.080	m	0.080
							where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e)			
							=	1.908		
							Total Loss:	0.180	m	
3)	Flocculation Channel Effluent Baffle Wa	No. =		2	trains		Flocculation level before buffle wall			
		Unit q =		0.395	m^3/sec/train		WL33 = +	15.550	m	
	Inlet Baffle wall	Wall	Width =	14.30	m		(1) Head Loss at the Inlet difuser wall before			
	to Sedimentation Basin		Depth =	5.60	m(approx)		sedimentation basin			
			Area =	80.08	m^2		h = $(1/c^2)*(v^2/(2*g))$			
		Holes	Width =	0.20	m		where, c =	0.600		
			Height =	0.20	m		=	0.0013	m	negregible
			No. =	102	Nos.					
			Area =	4.08	m^2					
	approx. 6%	Open Ratio =		5.1	%					
	0.23m/sec >	Velocity in Hole: v =		0.10	m/s					
	Loss of head	for floc protection		<10	mm					
4)	Sedimentation Tank Trough	No. =		2	trains		Sedimentation Structure Level			
		Unit q =		0.414	m^3/s/train		SL31 = +	16.000	m	
						Trough orifice level :	Water Level in Sedimentation Tank			
		No. : n =		40	No./train		WL34 = +	15.550	m	Orifice level
		Length : L =		6.6	m		Hw33 = +	15.500	m	0.3
		Width : B =		150	mm		(1) Trough Loss			
		Depth : h =		400	mm		ht = $v^2/(2*9.8*C^2)$			say
		Orifice size d=		25	mm		=	0.044	m	0.050
		Pitch of orifice		345	mm		C =	0.60		
		Clearance from WL		0.15	m		Trough Top Level			
		Nos of orrifice		38	per trough		Hw34 =	15.700	m	
		TTL Nos of orifice		1520	per basin		Critical Depth at the Trough End: hc			
		TTL area of orifice		0.746	m^2		hc = $(1.1*q^2/(g*B^2))^{1/3}$			say
	Trough Flow	Passing velocity of orifice		0.555	m/s		=	0.081	m	0.090
		Unit Flow : per trough q =		0.010	m^3/s		Depth at the Beggining of Trough: ho			
		Total Trough Length: L=		524	m/train		ho = $\sqrt{3}$*hc			say
		Overflow Load : FL =		68.2	m^3/m/day		=	0.117	m	0.120
		(Trough Bottom -		0.160	m below)		Trough Bottom Level : Htb			
		(baffle wall loss will be absorbed with this allowances.)					Hw35 =	15.300	m	
5)	Outflow Channel	No. =		2	trains		Channel Top Level			
		Unit q =		0.395	m^3/sec/train		Hw32 =	16.000	m	
							Critical Depth at the Channel End: hc			
		Width of inflow channel W=		0.80	m		hc = $(1.1*q^2/(g*B^2))^{1/3}$			say
			D =	2.14	m		=	0.301	m	0.310
			L =	38.4	m		Depth at the Beggining of Channel: ho			
		Channl Area =	approx.	0.84	m^2		ho = $\sqrt{3}$*hc			say
		Discharge q =		0.395	m^3/s		=	0.435	m	0.440
	1.0 m/sec>	Velocity in Channel : v =		0.47	m/s		Channel Bottom Level : Htb			
							Hw34 =	13.860	m	

6) Sedmentation Basin Outlet to Filter Inflow Channel	No. = 2 lines Unit Q = 0.790 m^3/s Dia : D = 0.80 m Length: L = 100.0 m Area : A = 0.50 m^2 Velocity in Pipe : v = 1.57 m/sec (4) Bend Loss (branch) hb = $f*(v^2/(2*g))$ where, f = 0.9 0.113 m (4) In-Out Loss assumption hio = $f*(v^2/(2*g))$ where, f = 1.5 = (0.5 + 1) = 0.189 m	WL 35 = + 15.290 m (ordinal operation) 15.310 m (during washing) (1) Friction Loss (pipe) hf = $f*(L/D)*(v^2/(2*g))$ = 0.487 m where, f = (20+(1/(2*D)))*1.5/1000 = 0.031 m (2) Bend Loss (confluence) hc = $f*(v^2/(2*g))$ where, f = 0.35 = 0.044 m Total Loss : hf + hb + hc + hio = 0.834 m say 0.840 m	
04 Filter Units	**(Stage I + II)** No. of Unit = 12 Flow rate Q = original +5% 136,500 m^3/day 1.580 m^3/s	SL40 = + 14.800 m	
Filter Units			
1) Inflow Channel	No. Channels = 2 Unit q = 0.790 (m^3/s/channel) Width of inflow channel W= 0.80 m D = 1.20 m L = 55 m Velocity in Channel : v = 0.82 m/s	Water level at the distribution channel of filter WL41= + 14.450 m (ordinal operation) 14.470 m (during washing) (1) Friction Loss (open channel) hf = $n^2*v^2*L/R^{4/3}$ where, n = 0.015 R = W*D/(2*D+W) = 0.300 m = 0.0417 m 0.050	
2) Inflow gate Inflow gate velocity; 1.0 m/sec>	Inflow gate W = 500 mm H = 500 mm Inflow velocity v (12) = 0.527 m/s Inflow velocity v (11) = 0.574 m/s	WL42 = + 14.400 m (during ordinal opertioin) 14.420 m (during backwashing) (1) Gate Orifice Loss ht = $v^2/(2*9.8*C^2)$ C = 0.60 say hw (12)= 0.039 m 0.040 hw (11)= 0.047 m 0.050	
3) Inflow Weir	Weir Crest Level of Each Filter Effluent During Filtration 12 filters Flow rate Q = 130,000 m^3/day per basin q= 0.125 m^3/sec Width of weir b = 2.000 m Hight of crest W = 1.000 m W<=1 m e= 0 W>1m e=0.55*(W-1) 0.000 hw(12) = 0.105 m (trial) During Washing 11 filters per basin q= 0.137 m^3/sec hw (11)= 0.111 m (trial)	Hw41= 14.250 m (1) Weir Loss durinf ordinal filtration hw(12) = $(q/(C*b))^{2/3}$ say = 0.105 m 0.110 where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e) = 1.838 (2) Weir loss during washing hw (11)= $(q/(C*b))^{2/3}$ say = 0.111 m 0.120 where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e) = 1.838 WL43 = + 14.360 m (during ordinal opertioin) 14.370 m (during backwashing)	
4) Filter Bed (a) Loss of head between filter and Effluent Pipe 1.5 to 0.6 m/sec Effluent Pipe Size 1.5 to 0.6 m/sec	12 filters q (per filter) = 0.125 m^3/s d= 350 mm actual v= 1.303 m/s 11 filters q (per filter) = 0.137 m^3/s d= 350 mm actual v= 1.422 m/s pipe length L= 2.500 m (5) Fair Hatch Formula: Re= p_F*D*v/m = 2.275 >1 C_d= 24/Re+3/√Re+0.34 = 12.9 h(12) = $0.178*C_d*L*v^2/g/e^4/D*a/b$ = 0.117 m h(11) = 0.140 m	HW 44 = + 14.200 m (HWL) HW 45 = + 14.000 m (LWL) (1) Friction loss of effluent pipe hf (12)= $f*(L/D)*(v^2/(2*g))$ where, f = (20+(1/(2*D)))*1.5/1000 = 0.032 = 0.020 m hf (11)= $f*(L/D)*(v^2/(2*g))$ = 0.024 m (2) In-Out Loss ho = $f*(v^2/(2*g))$ where, f = 1.5 (=0.5+1) ho (12)= 0.130 m ho (11)= 0.155 m (3) Valve Loss(butterfly valve) hv = $f*(v^2/(2*g))$ where, f = 0.1 hv (12)= 0.009 m hv (11)= 0.010 m	

	(b) Initial Loss of Head through Filter	Media size D= 1.2 mm Thickness of media L= 950 mm Void ratio e= 0.45 Filtration rate v (12) = 187.9 m/d 2.174E-03 m/sec v (11) = 204.9 m/d 2.372E-03 m/sec Viscosity m= at 15 ℃ 1.146E-03 kg/m/s Density of water at 15 ℃.= 999.1 kg/m^3 Coefficient of figure a/b= 5.5	(4) Bend Loss (blanch) hb = f*(v^2/(2*g)) where, f = 1.5 h(12)= 0.130 m h(11)= 0.155 m TTL head loss h =(1)+(2)+(3)+(4)+(5) say h (12)= 0.406 m 0.410 h (11)= 0.483 m 0.490
5)	Effluent Weir	Weir Crest Level of Each Filter Effluent During Filtration 12 filters Flow rate Q = 130,000 m^3/day per basin q= 0.125 m^3/sec Width of weir b = 0.800 m Hight of crest W = 3.300 m W<=1 m e= 0 W>1m e=0.55*(W-1) 1.265 hw(12) = 0.193 m (trial) During Washing 11 filters per basin q= 0.137 m^3/sec hw (11)= 0.204 m (trial)	Hw42= 11.550 m (1) Weir Loss durinf ordinal filtration hw(12) = (q/(C*b))$^{2/3}$ say = 0.193 m 0.200 where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e) = 1.851 (2) Weir loss during washing hw (11)= (q/(C*b))$^{2/3}$ say = 0.204 m 0.210 where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e) = 1.851 WL46 = + 11.750 m (during ordinal opertioin) 11.760 m (during backwashing)
6)	Filtered Water Effluent Channel to Clear Water Reservoir	No. = 2 lines Unit Q = 0.790 m^3/s Dia : D = 0.90 m Length: L = 50.0 m Area : A = 0.64 m^2 Velocity in Pipe : v = 1.24 m/sec 90 deg. Bend = 2 (f = 0.17) 45 deg. Bend = 2 (f = 0.12) (4) In-Out Loss assumption hio = f*(v^2/(2*g)) where, f = 1.5 = (0.5 + 1) = 0.118 m (5) Valves hv= f*(v^2/(2*g)) where, fv= 0.200 0.016 m	(1) Friction Loss (pipe) hf = f*(L/D)*(v^2/(2*g)) = 0.135 m where, f = (20+(1/(2*D)))*1.5/1000 = 0.031 m (2) Bend Loss hb = f*(v^2/(2*g)) where, f = 0.17 *2 + 0.12 *2 = 0.580 = 0.046 m (3) Bend Loss (confluence) hc = f*(v^2/(2*g)) where, f = 5.0 = 0.393 m Total Loss : hf + hb + hc + hio +hv say = 0.707 m 0.710 WL47 = + 11.210 m
05	Clear Water Reservoir		
		Overflow pipe will not be applicable but orifice.	WL 51 = + 10.500 m (HWL) WL 52 = + 5.500 m (LWL)
1)	Overflow Weir	Weir Crest Level No. = 5 trains Unit q = 0.316 m^3/s Dia. of pipe mouth D = 0.900 m Width of weir b = 2.827 m Hight of crest W = 5.000 m W<=1 m e= 0 W>1m e=0.55*(W-1) 2.200 hw = 0.153 m (trial)	Hw5over 10.660 m (1) Weir Loss hw(14) = (q/(C*b))$^{2/3}$ say = 0.153 m 0.160 where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e) = 1.870 WL12 = + 10.660 m