MINISTRY OF INDUSTRY, MINES AND ENERGY
SIEM REAP WATER SUPPLY AUTHORITY
THE KINGDOM OF CAMBODIA

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

FINAL REPORT 1

VOLUME III

SUPPORTING REPORT

JANUARY 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

NJS CONSULTANTS CO., LTD.
KOKUSAI KOGYO CO., LTD.

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11-006

Supporting Report

Supporting Report

Report No. **Title of Supporting Report**

Supporting Report

Chapter 2
Project Framework

SR 2.1 Number of Hotels and Guest Houses in Siem Reap City

Area	14 Commune (2008)					
Discript	Hotel (No.)	Max Tourist (No.)	Guest House (No.)	Max Tourist (No.)	Hotel+Guest H (No.)	Max Tourist (No.)
Total	**113**	**14,700**	**208**	**4,315**	**321**	**19,015**

Commune / Village		Hotel	Tourist	Guest House	Tourist	Hotel+Guest H	Max Tourist
1	**Sla Kram**	**32**	**2,909**	**47**	**998**	**79**	**3,907**
1- 1	Slor Kram	6	276	7	120	13	396
1- 2	Boeng dunpa	5	323	0	0	5	323
1- 3	Chong Kavsu	7	618	15	340	22	958
1- 4	Dork pou	0	0	0	0	0	0
1- 5	Bantay chas	10	1,063	16	386	26	1,449
1- 6	Trang	1	60	1	19	2	79
1- 7	Mondol 3	3	569	8	133	11	702
2	**Svay Dangkum**	**58**	**8,859**	**111**	**2,327**	**169**	**11,186**
2- 1	Pngea Chei	0	0	1	25	1	25
2- 2	Kantrork	0	0	0	0	0	0
2- 3	Kouk Krasang	2	238	0	0	2	238
2- 4	Svay Chrei	0	0	1	12	1	12
2- 5	Pou Bos	0	0	0	0	0	0
2- 6	Tmei	0	0	0	0	0	0
2- 7	Svay Dangkum	0	0	2	42	2	42
2- 8	Salakanseng	14	3,016	8	172	22	3,188
2- 9	Krous	11	1,664	4	70	15	1,734
2- 10	Vihear Chin	2	112	13	282	15	394
2- 11	Steng Tmei	1	57	18	422	19	479
2- 12	Mondol 1	10	1,642	14	247	24	1,889
2- 13	Mondol 2	8	1,405	2	36	10	1,441
2- 14	Ta phoul	10	725	48	1,019	58	1,744
3	**Sala Kamraeuk**	**17**	**1,140**	**41**	**787**	**58**	**1,927**
3- 1	Vat Bo	16	1,068	30	571	46	1,639
3- 2	Vat Svay	0	0	2	37	2	37
3- 3	Vat Damnak	1	72	9	179	10	251
3- 4	Sala Kamreak	0	0	0	0	0	0
3- 5	Chun long	0	0	0	0	0	0
3- 6	Ta Vean	0	0	0	0	0	0
3- 7	Trapang Treng	0	0	0	0	0	0
4	**Kouk Chak**	**1**	**378**	**4**	**75**	**5**	**453**
4- 1	Trapang Ses	1	378	4	75	5	453
4- 2	Veal	0	0	0	0	0	0
4- 3	Kasin tabong	0	0	0	0	0	0
4- 4	Kouk Chan	0	0	0	0	0	0
4- 5	Khatean	0	0	0	0	0	0
4- 6	Kouk Beng	0	0	0	0	0	0
4- 7	Kouk Tanot	0	0	0	0	0	0
4- 8	Nokor krav	0	0	0	0	0	0
5	**Siem Reap**	**0**	**0**	**1**	**16**	**1**	**16**
5- 1	Pou	0	0	0	0	0	0
5- 2	Phnom krom	0	0	0	0	0	0
5- 3	Pror Lay	0	0	0	0	0	0
5- 4	Korkragn	0	0	0	0	0	0
5- 5	Kra Sangroleung	0	0	0	0	0	0
5- 6	Spean Chreav	0	0	0	0	0	0
5- 7	Arragn	0	0	0	0	0	0
5- 8	Treak	0	0	1	16	1	16
6	**Teuk Vil**	**0**	**0**	**0**	**0**	**0**	**0**
6- 1	Kouk doung	0	0	0	0	0	0
6- 2	Sandan	0	0	0	0	0	0
6- 3	Chrei	0	0	0	0	0	0
6- 4	Prayut	0	0	0	0	0	0
6- 5	Bantay Cheu	0	0	0	0	0	0
6- 6	Teuk Vil	0	0	0	0	0	0
6- 7	Pri Chas	0	0	0	0	0	0
6- 8	Tuek Tla	0	0	0	0	0	0
6- 9	Pri Tmei	0	0	0	0	0	0
6- 10	Chei	0	0	0	0	0	0
7	**Chreav**	**0**	**0**	**3**	**99**	**3**	**99**
7- 1	Chreav	0	0	0	0	0	0
7- 2	Knar	0	0	3	99	3	99
7- 3	Bos Kralang	0	0	0	0	0	0
7- 4	Ta Chek	0	0	0	0	0	0
7- 5	Veal	0	0	0	0	0	0
7- 6	Kra sang	0	0	0	0	0	0
7- 7	Boeng	0	0	0	0	0	0

Commune / Village		Hotel	Tourist	Guest House	Tourist	Hotel+Guest H	Max Tourist
8	**Krabei Riel**	**0**	**0**	**0**	**0**	**0**	**0**
8- 1	Ta Ros	0	0	0	0	0	0
8- 2	RoKa	0	0	0	0	0	0
8- 3	Prei Pou	0	0	0	0	0	0
8- 4	To tear	0	0	0	0	0	0
8- 5	Krasang	0	0	0	0	0	0
8- 6	Popil	0	0	0	0	0	0
8- 7	Trapang veng	0	0	0	0	0	0
8- 8	Kouk doung	0	0	0	0	0	0
8- 9	Boeng	0	0	0	0	0	0
8- 10	Prorma	0	0	0	0	0	0
8- 11	Khnar	0	0	0	0	0	0
8- 12	Prei kroch	0	0	0	0	0	0
9	**Ampil**	**0**	**0**	**0**	**0**	**0**	**0**
9- 1	Kouk Chan	0	0	0	0	0	0
9- 2	Thnal Chak	0	0	0	0	0	0
9- 3	Tanot	0	0	0	0	0	0
9- 4	Trapang Run	0	0	0	0	0	0
9- 5	Ta pang	0	0	0	0	0	0
9- 6	Prei kuy	0	0	0	0	0	0
9- 7	Bang Koung	0	0	0	0	0	0
9- 8	Kiri manon	0	0	0	0	0	0
9- 9	Bos tom	0	0	0	0	0	0
9- 10	Trach chrom	0	0	0	0	0	0
10	**Norkor Thum**	**0**	**0**	**0**	**0**	**0**	**0**
10- 1	Rohal	0	0	0	0	0	0
10- 2	Sras srang	0	0	0	0	0	0
10- 3	Sras srang	0	0	0	0	0	0
10- 4	Kravan	0	0	0	0	0	0
10- 5	Arak svay	0	0	0	0	0	0
10- 6	Ang Chang	0	0	0	0	0	0
11	**Srangae**	**5**	**1,414**	**1**	**13**	**6**	**1,427**
11- 1	Kasikam	5	1,414	1	13	6	1,427
11- 2	Tnal	0	0	0	0	0	0
11- 3	Roka Thom	0	0	0	0	0	0
11- 4	Prei Thom	0	0	0	0	0	0
11- 5	Srangie	0	0	0	0	0	0
11- 6	Chanlong	0	0	0	0	0	0
11- 7	Ta Chouk	0	0	0	0	0	0
12	**Sambour**	**0**	**0**	**0**	**0**	**0**	**0**
12- 1	Pnouv	0	0	0	0	0	0
12- 2	Sambour	0	0	0	0	0	0
12- 3	Veal	0	0	0	0	0	0
12- 4	Chrei	0	0	0	0	0	0
12- 5	Ta kong	0	0	0	0	0	0
13	**Kandaek**	**0**	**0**	**0**	**0**	**0**	**0**
13- 1	Kouk Tlouk	0	0	0	0	0	0
13- 2	Trapang Tem	0	0	0	0	0	0
13- 3	Khun Mouk	0	0	0	0	0	0
13- 4	Chras	0	0	0	0	0	0
13- 5	Ou	0	0	0	0	0	0
13- 6	Spean Ka ek	0	0	0	0	0	0
13- 7	Trang	0	0	0	0	0	0
13- 8	Chrei	0	0	0	0	0	0
13- 9	Kouk Tanot	0	0	0	0	0	0
13- 10	Lo ork	0	0	0	0	0	0
14	**Chong Khneas**	**0**	**0**	**0**	**0**	**0**	**0**
14- 1	Phum Pir	0	0	0	0	0	0
14- 2	Phum Muoy	0	0	0	0	0	0
14- 3	Phum Bei	0	0	0	0	0	0
14- 4	Phum Buon	0	0	0	0	0	0
14- 5	Phum Pram	0	0	0	0	0	0
14- 6	Phum Prammuoy	0	0	0	0	0	0
14- 7	Phum Prampir	0	0	0	0	0	0

1/19 SRWSA

KINGDOM OF CAMBODIA
NATION RELIGION KING

MINISTRY OF TOURISM
SIEM REAP TOURISM DEPARTMENT
Tel: 063964925 Fax : 063963996

HOTELS IN SIEM REAP PROVINCE
AS OF DECEMBER 2008

Commune No. - Village No.

Nº	NAME OF HOTEL	OWNER OR MANAGER & Nationality	TYPE OF Bus	TEL/FAX	NUMBER OF ROOMS		ROOM RATES (US$)		STAFF		ADDRESS	LICENSE EXPIRATION DATE	HOTEL CAPITAL INVESTMENT(US$) & CLASSIFICATION
					SGL Suite	TWIN Trip	SGL Suite	TWIN Trip	M	F			
1	Angkor Century	Mr. Som Sanung (Cambodian)	H+R +M	063963777 063963123	20 S 2	168	220$ 560$	235$ 580$	145	75	PhumSalakansengKhum Svaydang kum Srok Siem Reap	174/08Mot 03-10-09	12.800.000$ 2-8
2	Allson Angkor	Mrs. Kham Plally (Cambodian)	H+R	063964301 063964302	120 S 4	64 trip5	100$ 190$	125$ 145$	60	45	N.Road6PhumSalakanseng Khum Svaydangkum Srok Siem Reap	042/08Mot 03-02-09	3.000.000$ ☆☆☆☆ 2-8
3	Angkor Saphir	Mrs. Ly Mouly Mr.Kao KimHoth (Cambodian)	H	063965339 092932619	7	29	15$	20$	11	15	N.Road 6 Phum Slorkram Khum Slorkram Srok Siem Reap	204/08Mot 09-10-09	250.000$ 1-1
4	Angkor Villa Resort & Spa	Mr. Olivier Piot (Franch)	H+R	063963361 063963363	20	20	70$	80$	7	38	Phum Traing Khum Slokrum Srok Siem Reap	014/08Mot 09-11-08	250.000$ 1-6
5	Angkor Thom	Mr.Jonn Jang kilchol (Korean)	H+R	063964862 012295144	5	25	10$	12$	2	5	Phum Watbo Khum Salakamreok Srok Siem Reap	172/08Mot 17-09-09	150.000$ 3-1
6	Angkor Village	Mr.Olivier Piot Mrs.Tap Vuthor (Franch)	H+R	063963561 063380104		42		50$ 80$	6	41	Phum Watbo Khum Salakamreok Srok Siem Reap	128/07Mot 05-10-08	1.973.500$ 3-1
7	Angkoriana	Mrs..Moung Vouch Lim (Cambodian)	H +R	063760274 063964349	10 S 2	31 trip 1	50$ 120$	60$ 70$	5	5	Nº297Group8 St.Charle de Gaulle Phum Boengdoupa Khum Slorkram Srok Siem Reap	139/08Mot 18-06-09	450.000$ 1-2
8	Apsara Angkor	Mrs.Keo Leakhena Mr. Noun Tevithen (Cambodian)	H+R	063964999 063964567	15 S10	91 trip2	70$ 170-220	80-90 110$	85	25	N.Road6 Phum Salakanseng Khum Svaydangkum Srok Siem Reap	119/08Mot 24-07-09	4.100.000$ 2-8
9	Apsara Palace	Mrs. Ry Vor (Cambodian)	H+R	063766667 063766666	5	15	10$	15$	1	5	N. Road 6 Phum Watbo Khum Salakamreok Srok Siem Reap	007/08srtd 09-10-08	150.000$ 3-1
10	Apsara Holiday	Mss. Reth Chan Rattana(Cambodian)	H+R	063390006 063760342	6	38	15$	15$	4	6	Phum Boengdounpa khum slorkam Sork Siem Reap	151/08Mot 06-07-09	250.000$ 1-2

11	**Angkor Riverside**	Mrs. Yos Envanda (Cambodian)	H+R	063390006 063760342	3	47	15$	15$	13	6	Phum Boengdounpa khum slorkam Sork Siem Reap	080/08Mot 15-10-08	250.000$ 1-2
12	**Angkor Star**	Mr. Wee Chee Keong (Malaisia)	H+R	063766999 063768999	26 S 2	32	45$ 90$	60$	23	22	N.Road 6 St.Sivatha Mondol 2 Khum Svaydangkum Srok Siem Reap	012/08Mot 01-01-09	500.000$ 2-13
13	**Angkor Palace resort & Spa**	Mrs. Lao Kimnay (Cambodian)	H+R +Ma	063760511 063760512	18 S11	48 V 5	300$ 550$	325 $ 1550	117	65	N° 55 Road 6 Phum Krous Khum Svaydangkum Srok Siem Reap	015/08Mot 18-01-09	☆☆☆☆☆ 2-9
14	**Amansara princiere Resort**	Mr. Siddharth Mehra (Indian)	H+R +Ma	063760333 063760335	24		650$ 850$		47	38	Road Angkorwat Phum Beng-donpa Khum Slorkram Srok S. R	កំពុងរត់ការ	1-2
15	**Allson Angkor Paradise**	Mrs. Kham Plally (Cambodian)	H+R	063760690 063760691	57 S 4	101 trip7	150$ 200$	170$ 190$	61	45	N.Road6 Phum Salakanseng Khum Svaydangkum Srok Siem Reap	043/08Mot 03-02-09	☆☆☆☆ 2-8
16	**Angkor Howard**	Mr. Chiang Ching Huo (Cambodian)	H+R	063965000 063965111	184 S 36	50 trip 6	50$ 180$ - 600$	50$ 70$	73	37	N.Road 6 Phum Kaksikam Khum Sronge Srok Siem Reap	100/08Mot 08-06-09	☆☆☆☆☆ (proposal) 11-1
17	**Angkorland**	Mr. Sao Maley (Cambodian)	H+R	063760544 063760547	16 S 5	49	35$ 60$	40-50	47	23	Phum Ta Phul Khum Svaydang-kum Srok Siem Reap	កំពុងរត់ការ	2-14
18	**Angkor View**	Mr.Chea Chanrasmey (Cambodian)	H	011672290	9	21	10-15	10-15	09	10	N° Road6 Phom Bangtheaychhas Khum Slorkram Srok Siem Reap	133/08Mot 17-05-09	85.000$ 1-5
19	**Angle Angkor**	Mr. Heng Chheang (Cambodian)	H	063761777 063761444	03	19	20$	25$	08	12	St.CharledeGaulle Phum Boengdoun- pa Khum Slorkram Srok Siem Reap	146/08Mot 01-08-09	1-2
20	**Auberge Mon't Royal D'Angkor**	Mr.Prim Phloeun (Cambodian)	H+R	063964044 063964528	5 S 2	21	25$ 50$	30$	4	11	N° 49 7 Phum Taphul Khum Svay dangkum Srok Siem Reap	132/08Mot 14-06-09	170.591$ 2-14
21	**Angkor Diamond**	Mrs. Yer Chunfei (Chiness)	H+R	063380038 063964449	5	32 trip1	20$	25$ 30$	10	20	St.Acharsva Phum Watbo Khum Salakamreok Srok Siem Reap	021/08 Mot 20-12-08	359.183$ 3-1
22	**Angkor AOS Condominium**	Mrs.Chhun Phallin (Cambodian)	H	012693355	16	750$ - 900$ 1Mont			7	10	Phum Salakanseng Khum Svaydang Kum Srok Siem Reap	011/08 srtd 12-12-08	1.200.000$ 2-8
23	**Angkor Way**	Mrs. Neang Soeur (Cambodian)	H+R	063963866 063963867	18	52	30$	30$	23	23	St.Charle de Gaulle Mondol 3 khum Slorkram Srok Siem Reap	060/08Mot 06-03-09	350.000$ 1-7
24	**Angkor Highway**	Mr. Huh Jae Ho (Korean)	H		10	6	20-25$	20-25$	23	23	N.Road6 Phum Salakanseng Khum SvaydangkumSrok Siem Reap	013/08 srtd 25-04-09	2-8
25	**Angkor Riviera**	Mr. Sok Thytha (Cambodian)	H+R +Ma	063969333 063969666	53 S 7	131	80$ 120$	80 - 100$	68	32	Phum Mondol 1Khum Svaydang-kum Srok Siem Reap	123/08Mot 16-07-09	2-12

26	Angkor Holiday	Mr. Voek Chuor (Cambodian)	H+R	063966777 063966800	46 S 12	94 trip 6	100$ 140$	120$1 30$			Phum Mondol 2Khum Svaydang-kum Srok Siem Reap	182/08Mot 04-10-09	☆☆☆☆ 2-13
27	Angkor Twon	Mrs. Ren chanthach (Cambodian)	H	063761130 063761130	5	18	10- 12$	10- 12$	3	6	Phum Mondol 1 Khum Svaydeng kum Srok Siem Reap	138/08Mot 21-06-09	2-12
28	Angkor Watanakpheap	Mrs. Y Sotheary (Cambodian)	H	063969222	3	39 trip 1	10- 15$	10- 15$	9	6	N. Road 6 Phum Banteay Chas Khum Svay dangkum Srok S. R	កំពុងរង់ការ	1-5
29	Banteay Srey	Mr. Mik Saphanaret (Cambodian)	H+R	012830666 016830666		54		55$	24	12	N.Road 6 Phum Taphul Khum Svaydangkum Srok Siem Reap	មិនទាន់បង្គ	270.915$ 2-14
30	Bequest Angkor	Mr. Ich Try (Cambodian)	H	012898668 016833480	4	26	15$	20$	4	7	N° 012 St. Phsakrom Phum Vihearchen Khum Svaydangkum Srok Siem Reap	192/08Mot 11-11-09	150.450$ 2-10
31	Bopha Angkor	Mrs. Chhang Soam (Cambodian)	H+R	063964928 012819302	8	14	20$	25$	15	17	St.Acharsva Phum Watbo Khum Salakamreuk Srok Siem Reap	193/08Mot 15-11-09	270.000$ 3-1
32	Borann l'auberge des teample	Mr.BenoitDuchateauF ranch & (Cambodian)	H+R	012800003 063964740		20		30$	11	12	Phum Slorkram Khum Slorkram SrokSiem Reap	002/08 srtd 04-02-09	350.000$ 1-1
33	Borei Angkor Resort & spa	Mrs. Kuoy Naline (Cambodian)	H+R	063964406 063963436	54 S 11	119 Trip4	135$ 600$ - 1600$	185$ 210$	108	62	N.Road6 Phum Bangtheay chhas Khum Slorkram Srok S.R	198/08Mot 20-12-09	950.350$ 1-5
34	Battambang Angkor	Mr. Chom Runthen (Cambodian)	H	063399333 012956135	10	19	15$- 25$	15$- 25$	3	5	Phum Chong Koasou Khum Slorkram Srok Siem Reap	116/08Mot 15-06-09	1-3
35	CASA Angkor	Mrs.Lim Chhiv Ho (Cambodian)	H+R	063963658 063963657	53 S 3	40	30$ 45$	35$	14	12	St.Oum Chhay Mondol 1 Khum Svaydangkum Srok Siem Reap	131/08Mot 09-07-09	213.000$ 2-12
36	City Angkor	Mr. Seang Nom Mr. Sathirana Weera (Cambodian)	H+R	063760336 063760340	23 S 8	165 trip8	85$ 100$	95$ 120$	95	33	N.Road 6 Phum Salakanseng Khum Svaydangkum Srok Siem Reap	140/08Mot 10-08-09	1.200.000$ 2-8
37	City Royal	Mr. Fak Hemming-sen (Danamac)	H+R	063760636 063964278	35 S 3	67 trip8	70$ 150$	70$ 80$	60	26	N. Road 6 Phum Salakanseng Khum Svaydangkum Srok Siem Reap	003/08Mot 04-12-08	2.790.000$ 2-8
38	City River	Mr. Leam Monin (Cambodian)	H+R	063763000 063963963	11 S 1	38	30$ 70$	30$ 35$	10	24	PhumWatbo Khum Salakam-reok Srok Siem Reap	199/08Mot 04-12-09	1. 000250 $ 3-1
39	Cozyna Angkor	Mr. Yim Sivanna (Cambodian)	H+R	063966569 063966569	23 S 2	30	20$ 35$	30	15	26	N. Road 6 Phum Kraus Khum Svaydangkum Srok Siem Reap	121/08Mot 05-06-09	2-9
40	Claremont Angkor	Mr. Craig Murray (Australia)	H	063966898 063966998	11	33	30$ - 40$	30$ - 40$	48	12	# 0017 Phum Watbo Khum Salakamroeuk Srok Siem Reap	094/08Mot 09-04-09	3-1
41	Day Inn Angkor Resort	Mr. Ly Heap (Cambodian)	H+R	063760500 063760503	22 S 2	36	35$ 70$	40$	30	15	St.Oum Chhay Phun Mondol I Khum Svaydangkum Srok Siem Reap	147/08Mot 02-09-09	2.500 000$ 2-12

42	**Dragon Royal**	Mrs. Cha Chanthy (Cambodian)	H+R +Ma	063966666 063965999	16 S 4	133	80$ 110$	90$	41	28	N. Road 6 Phum Krous Khum Svay dangkum Srok Siem Reap	053/08Mot 06-03-09	☆☆☆☆ 2-9
43	**De La Paix**	Mr. Lo Sokoun (Cambodian)	H+R +Ma	063966000 063966002	52 S23	32	195$ 400$	275$	122	58	St.Sivatha Mondol II Khum Svaydangkum Srok Siem Reap	108/08 Mot 02-05-09	2-13
44	**Damnak Angkor Spa & Resort**	Mrs. Lee Kyungmi (Korean)	H+R	063966000 063966002	8	10 trip2	40$	40$ 50$	8	5	N.Road 6 Phum Krous Khum Svaydangkum Srok Siem Reap	005/08 srtd 04-05-09	2-9
45	**Empress Angkor**	Mr. Yin Ngech (Cambodian)	H+R +Ma	063963999 063964333	54 S 4	69	120$ 500$	140$- 160$	112	52	N.Road 6 Phum Kaksikam Khum Sronge Srok Siem Reap	149/08Mot 05-04-09	5.000.000$ ☆☆☆☆ 11-1
46	**Eng Ty Angkor**	Mrs. Ly Um Eng (Cambodian)	H	063966700 063966701	5	25	15$	15$	6	9	N.Road 6 Phum Khna Khum Slorkram Srok Siem Reap	071/08 Mot 08-02-09	1-1
47	**Emerald City**	Mrs. Sieng Eng (Cambodian)	H	012707979		35		15$- 15$	8	8	N.Road 6 Phum Chong Koasou Khum Slorkram Srok Siem Reap	117/08 Mot 16-06-09	1-3
48	**FCC Angkor**	Mr. Anthony John Alderson (England)	H+R +Ma	063760280 063760281	21 S 2	7	90$ 330$	140$	85	55	St.Oum Khun Mondol 2 Khum Svaydangkum Srok Siem Reap	157/08Mot 22-09-09	2-13
49	**Goldiana Angkor**	Mr. Meas Sary (Cambodian)	H+R	063760805 063760809	11 S 2	131 trip6	100$ 240$	120$ 140$	30	20	N.Road 6 Phum Salakanseng Khum Svaydangkum Srok Siem Reap	173/08Mot 12-07-09	5.000.000$ 2-8
50	**Golden Orange**	Mrs.Ream Jenny (Cambodian)	H	063965389 063965389	15	15	15$	15$	6	5	Phum Slorkram Khum Slorkram Srok Siem Reap	200/08Mot 20-10-09	1-1
51	**Heritage II " Angkor "**	Mr. Ing Somath (Cambodian)	H+R	063969100 063969103	17 S 3		120$ 160$		12	14	Phum Slorkram Khum Slor-kram Srok Siem Reap	004/08 srtd 02-04-09	1-1
52	**Koh Ker**	Mr. Eam So (Cambodian)	H+R	016633436 063963234	6	36	20$	25$	6	13	N° 8 Group 4 Phum Watbo Khum Salakamreok Srok Siem Reap	កំពុងតែការ	350.000$ 3-1
53	**Khemara Angkor**	Mrs. Lim Chheng (Cambodian)	H+R +Ma	063760999 063760777	17 S 6	77 trip4	100$ 120$	100$ 120$	41	26	Road 6 Phum Salakanseng Khum Svay dangkum Srok Siem Reap	114/08 Mot 24-03-09	2.400.000$ 2-8
54	**Kingdom Angkor**	Ms. Chhor Siek Houy (Cambodian)	H+R	063760526 063760527	9 S 6	75	65$ 80$	$65	14	26	N.Road 6 Phum Krous Khum Svay dangkum Srok Siem Reap	052/08Mot 28-12-09	2.500.000$ ☆☆☆☆ 2-9
55	**Krung Meas**	Mr. Seng Try (Cambodian)	H+R	063964888 063963372	13	62	10$- 15$	10$- 15$	20	25	Road 6 Phum Salakanseng Khum Svay dangkum Srok Siem Reap	069/08 Mot 04-04-09	2-8

56	Linratanak Angkor	Mrs. Chhim Heav (Cambodian)	H+R	063969888 063969884	50 S 2	45	35$	45$	49	28	N.Road6 Phum Banteay Chas Khum Slorkram Srok Siem Reap	កំពុងរត់ការ		1-5
57	La Noria	Mr.Chhoun Sok Mrs.Heng Chantha (Cambodian)	H+R	063964242 063964243	8	20	29$ 39$	29$ 39$	16	26	Phum Slorkram Khum Slorkram Srok Siem Reap	144/08Mot 13-09-09	470.970$	1-1
58	Lotus Angkor	Mrs. Srang Leng (Cambodian)	H+R	063965555 063965556	15 S 7	38 trip12	60$ 110$	70$ 85$	33	32	N. Road 6 Phum Krous Khum Svay dangkum Srok Siem Reap	065/08 Mot 15-10-08		2-9
59	Le Meridien Angkor	Mr . Prakit China-mourpong (Thai)	H+R +Ma	063963900 063963901	70 S 8	144 V 1	290$ 430$	310$ 540$	153	72	St. CharledeGualle Phum Trapeangses Khum Kokchark Srok Siem Reap	127/08Mot 25-08-09	20.000.000$ ☆☆☆☆☆	4-1
60	La Maison Angkor	Mr. Jean - Claude Garen (Franch)	H+R	063965045 063964966	24		50$		7	21	N.Road 6 Phum Kaksekam Khum Sronger Srok Siem Reap	019/07 srtd 24-06-09	800.000$	11-1
61	La Résidence Angkor	Mr. Charles Mortimer Coleman (England)	H+R	063963390 063963391	S 1	54	440$	280$- 340$	70	38	St.Acharsva Phum Watbo Khum Salakamreok Srok Siem Reap	020/08 Mot 17-02-09	5.500.000$	3-1
62	Lucky Chane	Mrs. So Chanthou (Cambodian)	H			7		15$ - 25$	4	3	N.Road 6 Phum Chong Koasou Khum Slorkram Srok Siem Reap	008/08 srtd 09-06-09		1-3
63	Moon Asian Angkor	Mr. Heng Srun (Cambodian)	H	063969798 063969798	5	25	12- 25$	12- 25$	2	8	St.LorkTaNeoy PhumWatbo Khum Salakamreok Srok Siem Reap	169/08 Mot 20-08-09		3-1
64	Mekong Angkor	Mr. Nil Sopheap (Cambodian)	H	063963636	10	12 trip1	25$- 30$	25$- 30$	5	10	St.Sivatha Mondul 2 Khum Svaydangkum Srok Siem Reap	178/08 Mot 01-09-09		2-13
65	Majestic Angkor	Mrs.Mao Chanthou (Cambodian)	H+R	063969682 063963681	5 S 7	86 trip2	120$ 180$	120$ 120$	32	22	N. Road 6 Phum Krous Khum Svaydangkum Srok Siem Reap	203/08 Mot 22-11-09	☆☆☆☆	2-9
66	Molina	Mrs.Tan Sithan (Cambodian)	H	012982082 063963351	8	11	15$	15$	4	7	Phum Taphul Khum Svaydang-kum Srok Siem Reap	015/07 srtd 11-06-09	350.000$	2-14
67	Monika Angkor	Mr. Nhep Penghak (Cambodian)	H+R	063764444 063963587		30		35$ 45$	4	10	N° 245 St.Charle de Gaulle Mondol 3 Khum Slorkram Srok Siem Reap	066/08 Mot 01-04-09	450.000$	1-7
68	Medusa Socheata	Mr.Lee Hyukgeun (Korean)	H+M	012308302	8	8	10$	15$	9	16	N° 36 Group 9 Phum Ta Phul Khum Svaydangkum Srok Siem Reap	012/08 srtd 13-06-09	270.000$	2-14
69	Monoreach Angkor	Mrs. Sony Mr. Soun Narin (Cambodian)	H+R	063760182 063963861	18 S 3	77	50$ 70$	50$	16	19	N. Road 6 Phum Salakenseng Khum Svaydangkum Srok Siem Reap	045/08 Mot 04-12-08	1.500.000$	2-8
70	Menbora	Mrs. Sar Boravy (Cambodian)	H+R	063963796 063963896	8 S1	20 trip1	10$ 20$	15$ 20$	16	8	N. Road 6 Phum Banteaychas Khum Svay dangkum Srok S. R	061/08 Mot 16-12-08		1-5

71	Monarch Angkor	Mr. Doung Teoh (Cambodian)	H+R	063964778 063964877		81		20$ 30$	20	10	St. LorkTaNeoy Phum Watbo Khum Salakamreok Srok Siem Reap	001/08Mot 28-01-09	1.500.000$ 3-1
72	Neak Pean	Mrs. Meas Samon (Cambodian)	H+R	063965429 063964429	27	73	30$ 40$	40$ - 60$	21	27	N°053 St.SivathaMondul 2 Khum Svaydangkum Srok Siem Reap	013/08 Mot 27-01-09	550.000$ 2-13
73	Nokor Phnom	Mr. Sam Heang (Cambodian)	H+R	063963855 063963727	9 S 1	77 trip 8	20$ 80$	30$ 50$	40	20	N.Road 6 Phum Kaksekam Khum Svaydangkum Srok Siem Reap	141/08Mot 02-08-09	1.500.000$ 2-3
74	Orien d'Angkor	Mrs .Oung Kim Houn (Cambodian)	H+R	053966456 063965276		28		30$	10	20	Phum Salakanseng Khum Svay-dangkum Srok Siem Reap	184/08Mot 24-11-09	2-8
75	Paris Angkor	Mrs. Tep Sothea (Cambodian)	H	012951707	6	17	15$	20$	3	4	N° 517 Phum Ta Phul Khum Svaydangkum Srok Siem Reap	012/07srtd 10-06-08	100.000$ 2-14
76	Passaggio	Mr. Peter Liez (Swiss)	H	063964732 063760163		17		15$ 20$		8	N° 0432 Phum Watbo Khum Salakamreok Srok Siem Reap	006/08srtd 23-06-09	100.000$ 3-1
77	Princess Angkor	Mr. Othsman Has-san . Imran Hassan (Cambodian)	H+R +Ma	063760056 063963688	20 S 4	92 trip 5	80$ 150$	100$ 120$	48	35	N.Road 6 Phum Krous Khum Svaydangkum Srok Siem Reap	113/08Mot 12-05-09	3.200.000$ ☆☆☆☆ (proposal) 2-9
78	Pruhm Bayon	Mrs. Keo Charya (Cambodian)	H+R	063963568 063963519	14	48	40-70	40-70	15	15	N.Road 6 Phum Ta Phul Khum Svaydangkum Srok Siem Reap	148/08Mot 05-08-09	450.000$ 2-14
79	Ree Hotel	Mr. Chan Vunnak (Cambodian)	H+R +Ma	063766888 063766889	26 S 8	108	$110 $160	$120	98	59	N. Road 6 Phum Krous Khum Svaydangkum Srok Siem Reap	175/08Mot 11-02-10	6.700.000$ ☆☆☆☆ 2-9
80	Phnom Bok	Mrs.Keo Sophcavy (Cambodian)	H	063964845 063963845	2	22	$10	$12	3	4	Road6Group 3 Phum Chong-KaoSou Khum Slokram Srok Siem Reap	070/08 Mot 01-03-09	375.250$ 1-3
81	Prince d'Angkor	Mr.Ly Hongkim (Cambodian)	H+R +Ma	063963333 063763888 063963334	51 S 16	107 trip 16	120$ 320$	140$ 190$	90	68	St.Sivatha Phum Mondol 2 Khum Svaydangkum Srok Siem Reap	081/08 Mot 12-03-09	2-13
82	Pacific	Mr. Sun Hour (Cambodian)	H+R	063761818 063761020	27 S 3	144 trip 62	100$ 350$	120$ 140$	114	52	N.Road 6 Phum Kaksikam Khum Sronge Srok Siem Reap	097/08 Mot 20-05-09	11-1
83	Parklane	Mr. Loem Sophy (Cambodian)	H	063967676 063967680	1	35	25$- 35$	30$- 40$	24	15	Phum Ta Phul Khum Svaydang-kum Srok Siem Reap	134/08 Mot 30-07-09	2-14
84	Preah Vihea	Mr. Ea Kim Eng (Cambodian)	H	063966233 063966233	8	16 trip2	15$	15$ 25$	4	4	N.Road 6 Phum Chong Koasou Khum Slorkram Srok Siem Reap	135/08 Mot 30-07-09	150.000$ 1-3

85	Raksmei Chanrash	Mr. Pov Chhang (Cambodian)	H+R	012849967 063963557	4	25 trip1	10$ 15$	15$ 20$	1	2	N°330 St. Sivatha Phum Stung Thmei Khum Svaydangkum S.R	022/08Mot 13-01-09	2-11
86	Reaksmey Crystal Hotel Aparment	Mr. Meng Sivutthy (Cambodian)	H. Apar	063761607 063761804	25		600$ - 650$ 1Mont		2	2	N:Road 6 Phum Krous Khum Svaydangkum Srok Siem Reap	032/08Mot 25-02-09	2-9
87	Raffles Grand Hotel d'Angkor	Mr. Jean Philippe Beghin (Australia)	H+R	063963888 063963168	52 S 12	67 V 2	310$ 460$	360$ 1900$	198	71	N° 1 St.Charle de Gaulle Mondol I KhumSvaydangkum Srok S.R	047/08Mot 21-04-09	40.000.000$ 2-12
88	Song Lama	Mr. Song Jong sik (Korean)	H	063965733 092404369		27		15 $ - 35$	11		N° 0088 N.Road 6 Phum Banteay Chas Khum Slorkram Siem Reap	167/08Mot 01-03-09	410.000$ 1-5
89	Royal Angkor Resort	Mrs. Kou Kimlong (Cambodian)	H+R +M	063965577 063965511	85 S 8	104	250$ 280$	270$	94	36	N.Road 6 Phum Kaksikam Khum Sronge Srok Siem Reap	051/08 Mot 11-01-09	250.000$ 11-1
90	Royal Crown	Mr. Tuy Hor Mr. Mom Pearith (Cambodian)	H	063760316 063760317	8	32	25$	25$	13	12	St.7 january Phum Watdamnak Khum Salakamreok Siem Reap	143/08Mot 02-08-09	250.000$ 3-3
91	Shinta Mani	Mr. Lo Sokoun (Cambodian)	H+R +Ma	063761998 063761999	2	16	160$	144$	26	24	St.Oum Phun Mondol 1 Khum Svaydangkum Srok Siem Reap	002/08 srtd 05-02-09	170.650$ 2-12
92	Salina	Mrs. Koy Salina Mr. Khhan Someth (Cambodian)	H+R	063760487 063380035	18 S 2	44 trip6	45$ 100$	55$ 65$	22	28	Phum Taphul Khum Svaydang-kum Srok Siem Reap	176/08Mot 15-09-09	800.000$ 2-14
93	Somadevi Angkor	Mr. Khek Leang (Cambodian)	H+R +Ma	063967666 063967660	21 S 3	105 trip 14	120$ 180$	120$ 140$	81	49	St.Sivatha Phum Mondol 2 Khum Svaydangkum Srok Siem Reap	កំពុងរត់ការ	☆☆☆☆ 2-13
94	Sokha Angkor	Mr. Sok Kong (Cambodian)	H+R +Ma	063969999 063969995	169 S 36	71	259$ 2000	500$ 700$	265	95	NRoad6 PhumSalakenseng KhumSvaydangkum Srok S.R	168/08 Mot 25-10-09	☆☆☆☆☆ 2-8
95	Sky way	Mr. Sok Meng (Cambodian)	H	063760658	5	25	6-10$	6-10$	2	8	N.Road 6 Phum Banteaychas Khum Slorkram Srok Siem Reap	115/08 Mot 01-09-09	1-5
96	Sovan Angkor	Mrs.Hout Neardey (Cambodian)	H	012838042 063964039	5	17	5-10$	7-15$	2	6	N° 063 N.Road 6 Phum Ta Phul Khum Svaydangkum Srok Siem Reap	101/08 Mot 02-01-09	250.000$ 2-14
97	Sydney Angkor	Mrs. Chea Sony (Cambodian)	H	012835998 063965064	10	31	5-10$	5-10$	7	10	# 152 Phum Watbo Khum Salakamroeuk Srok Siem Reap	095/08 Mot 09-02-09	1.250.000$ 3-1
98	Sovann Angkor II	Mrs.Hout Neardrey (Cambodian)	H	063964991 063964992	3	24 trip3	15$	20$ 35$	4	8	N.Road 6 Phum Banteaychas Khum Slorkram Srok Siem Reap	130/08 Mot 06-06-09	1.000.000$ 1-5
99	SO HO	Mrs.Linda Chong Laylin (Malaisia)	H+R +Ma	012333933	7	8	10$ 15$	10$ 15$	8	17	Phun Mondol 1 Khum Svaydang- kum Srok Siem Reap	014/08 srtd 13-12-09	2-12

100	Serey Pheap	Mrs.Eam Samnang (Cambodian)	H+R	063963473 063964274	37	70 trip3	15$ 30$	45$ 55$	16	20	N.Road 6 Phum Banteay Chas Khum Slorkram Srok Siem Reap	កំពុងសាង	600.000$ 1-5
101	Soria Moria LTD (Angkor Lion)	Mrs. Kristin Hold Hansen (Norway)	H	063964768 063964769	12	11	10-15$	10-15$	8	24	Phum Watbo Khum Salakamreok Srok Siem Reap	138/07 Mot 28-12-08	3-1
102	SiemReap Town	Mrs. Chan Lay Mr. Lek Yen (Cambodian)	H+R	063963591 063963431	10	20	40$	40$	12	16	N.Road 6 Phum Banteay Chas Khum Slorkram srok Siem Reap	092/08 Mot 16-01-09	420.000$ 1-5
103	Smyling	Mr. Ea Kais (Cambodian)	H+R	063763838 063766868	14 S 11	125	50-60$ 150$	50-60$			N.Road 6 Phum Chong Koasou Khum Slorkram Srok Siem Reap	145/08Mot 20-08-09	1-3
104	Sofitel Angkor Phokeethra Golf & Spa resort	Mr. Supachai Virapuchong (Thai)	H+R +Ma	063964600 063964610	76 S 21	141 V 1	380$ 400$	350$ 1500$	157	117	Mondol 1 Khum Svaydangkum Srok Siem Reap	183/08Mot 20-09-09	8.000.000$ ☆☆☆☆☆ 2-12
105	The Sothea Boutique Resort	Mrs. Ki Sothea (Cambodian)	H+R +Ma	063761181 023215962	S 39		100-150		43	96	N. Road 6 Phum Krous Khum Svay dangkum Srok Siem Reap	កំពុងសាង	2-9
106	Thunborey	Mrs. Kim Eng (Cambodian)	H	063761990 063761725	4	26	10$ 15$	10-15	5	5	St.Phsakrom Phum Vihearchen Khum Svaydangkum Srok Siem Reap	177/08Mot 21-09-09	2-10
107	Tmor Meas	Mrs. Chon Sokhom (Cambodian)	H	063969898 063969898	4	26	15$	15$	5	5	Phum Watbo Khum Salakam-reuk Srok Siem Reap	158/08Mot 11-07-09	3-1
108	Ta Prohm	Mrs. Mom Rady Mr. Yin Reatuna (Cambodian)	H+R	063380117 063380116	6 S 2	61 trip1	28 55	32 45	30	15	St. Pokambor Mondol 1 Khum Svaydangkum Srok Siem Reap	109/08 Mot 29-04-09	450.000$ ☆☆☆ 2-12
109	Tara Angkor	Mr. Say Ching (Cambodian)	H+R	063966661 063964444	46 S7	153 Trip 7	120$ 180$	130$ 160$	41	54	St.Charle de Gaulle Mondol 3 khum Slorkram Srok Siem Reap	186/07 Mot 26-11-09	☆☆☆☆ 1-7
110	T. S . P Lucky Angkor	Mrs. Hor Sayon (Cambodian)	H+R	063767666 063963131	6	51	25$	25$	17	9	Road 6 Phum ChongKaoSou Khum Slokram Srok Siem Reap	102/08 Mot 01-03-09	1.300.000$ 1-3
111	Victoria Angkor Resort & Spa	Mr.Raphael Gullin (Franch)	H+R +Ma	063760428 063760350	39 S10	81	240$ 400$	360$	145	68	Phum Mondol I Khum Svaydang- kum Srok SiemReap	035/08Mot 23-12-08	470.000$ ☆☆☆☆☆ 2-12
112	Whit Lotus	Mr. Sophanna Sadath (Cambodian)	H	063966299 063966298	11	19	15$ 25$	15-25	4	1	Phum Taksenthong Khum Svaydangkum Srok Siem Reap	185/07 Mot 28-09-09	2-3
113	Xclusive	Mrs. Chan sophy (Cambodian)	H+R	063760088 063760099	19		15-20		15	55	St. Lorktaneoy Phum Watbo Khum Salakamreok Srok Siem Reap	003/08 srtd 01-01-09	3-1

TOTAL	:	HOTELS	113	ROOMS	8405	SINGLE	2316	TWIN	5487	TRIPLE	204	SUITE	389	VILLA	9
IN OPERATION	:	HOTELS	113	ROOMS	8405	SINGLE	2316	TWIN	5487	TRIPLE	204	SUITE	389	VILLA	9
LICENSE	:	HOTELS	112	ROOMS	8351	SINGLE	2316	TWIN	5433	TRIPLE	204	SUITE	389	VILLA	9
UN VALIDITIES LICENSE	:	HOTELS	01	ROOMS	54	SINGLE	0	TWIN	54	TRIPLE	0	SUITE	0		

TOTAL STAFF : 6 792 PAX M : 4 040PAX F : 2 802 PAX

TOTAL : CAPITAL INVESTMENT : USD$ 151. 670. 959

LOCAL INVESTMENT : 94 HOTELS USD$ 117. 848. 276

FOREIGN INVESTMENT : 19 HOTELS USD$ 33. 822. 683

Note : H : Hotel , R : Restaurant , Ma : Massage , SGL : Single , TWIN : Twin , Trip : Triple , S : suite , V : villa , Mot : Ministry of Tourism , Srtd : Siem Reap Tourism Department , M : Male , F : Female , ☆(one Star), ☆☆(Two Stars), ☆☆☆(Three Stars), ☆☆☆☆(Four Stars), ☆☆☆☆☆(Five Stars)

Siem Reap , Date 30 December 2008
SEEN AND AGREED
DIRECTOR OF TOURISM DEPARTMENT

NGOUV SENGKAK
Deputy Director

Chief of Tourism Industry Office

THIM SEREYVUDH

Siem Reap , Date 27 December 2008
REPORTED BY

LY SARETH

1/19 SRWSA

KINGDOM OF CAMBODIA

NATION RELIGION KING

MINISTRY OF TOURISM

SIEM REAP TOURISM DEPARTMENT

TOURISM INDUSTRY OFFICE

Tel : (855-63) 964 925/012 545405

Fax :(855-63) 963 996

LIST OF GUEST HOUSE IN SIEM REAP (HAVE A LICENSED)

AS OF December 2008

Commune No - Village No

N°	Guest House's Name	Owner Of Manager	TEL & FAX	Total Room	Number		Room Rates		Staff		Address	Licensed Expiration	Remark
					SGL	DBL	SGL	DBL	M	F			
01	A LITTLE WORLD	Mr. Cho Choo Hyun	092256062	15	3	12	5-10$	5-10$	3	3	#208 Phum Taphul Khum Svaydangkum S.R	101/08 TO 01 - 08 - 09	2-14
02	ANCIENT ANGKOR	Mr. Vin Hoksang	012772862	20	14	6	8-25$	8-25$	2	4	Phum StungThmei Khum Svaydangkum S.R	032/08 M T 12 - 07 - 09	2-11
03	ANGKOR SINA BRIGHT	Mrs Chau Sina	012935895	14	5	9	5-12	5-12	0	4	Phum Taphul Khum Svaydangkum S.R	132/08 TO 18 - 10 - 09	2-14
04	ANGKOR SPIRIT PALACE	Mr.Khim Chamroeun	012404622	15	5	10	15-20$	15-20$	2	3	Phum Pjiechey Khum Svaydangkum S.R	128/08 TO 01 - 11 - 09	2-1
05	ANGKOR SEILA PICH	Mrs. Sar Nakon	012582129	13	8	5	5-15$	5-15$	0	2	Phum Taphul Khum Svaydangkum S.R	127/08 TO 19 - 09 - 09	2-14
06	ANGKOR PARK	Mr. Lim Heng	012658492	15	7	8	5-15$	5-15$	2	2	# Phum Vichearchen Khum Svaydangkum S.R	111/08 TO 01 - 10 - 09	2-10
07	AMATAO	Mr. Basler Stephene	121878480	8	4	4	15-20$	15-20$	1	1	P.Svayprey Khum Svaydangkum S.R	005/08 TO 24 - 01 - 09	2-4
08	ANGKOR BEAUTY VILLA	Mrs. Phin Radý	012599054	10	6	4	10-15$	10-15$	2	3	# Phum Watdomnak Khum Salakamreok S.R	034/08 TO 21 - 02 - 09	3-3
09	ANGKOR MARVEL	Mrs. Chea Sopheak	012686980	13	3	10	6-10$	6-10$	3	4	# Phum Watdomnak Khum Salakamreok S.R	035/08 TO 27 - 02 - 09	3-3
10	ANTANOU ANGKOR VILLA	Mr.Kawahara Yoshifumi	012777879	14	4	10	15-30$	15-30$	4	8	# Phum Watdomnak Khum Salakamreok S.R	033/08 TO 10 - 02 - 09	3-3
11	ANGKOR DAISY	Mr. Moch Sophon	092842806	10	2	8	$4	$5	1	2	#0271Phum Banteaychas Khum Slorkram S.R	064/08 TO 20 - 04 - 09	1-5
12	ANGKOR DAVY	Mr. Kong Song	012935015	15	4	11	5-15$	5-15$	2	2	#119 Phum Banteay Chas khumSlorkram S.R	072/08 TO 11 - 05 - 09	1-5
13	ANGKOR DISCOVER INN	Mr.Ty Sophath	012952727	10	5	5	$15	$30	1	3	Phum Slorkram Khum Slorkram S.R	063/08 TO 23 - 03 - 09	1-1
14	ANGKOR GRAND	Mr. Sòr Tong	012992230	13	0	13		5-8	1	3	#335 Road N° 6 Phùm Dorkpo Khum Svaydangkum S.R	028/08 TO 01 - 02 - 09	2-14

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15	ANGKOR GREEN	Mrs.Morn Sokvany	012630006 016630467	6	2	4	$10	$12	3	2	#20 Gr.7.Mondul III Khum Svaydangkum S.R	190/07 TO 24 - 10 - 08	1-7
16	ANGKOR INDRADEVI	Mrs.Ros Chenda	017272262	14	2	12	5-10$	6-15$	2	2	#468 Group 22 Phum Krous Khum Svaydangkum S.R	095/08 TO 19 - 06 - 09	2-9
17	ANGKOR LUCK PARADISE	Mr. Tan Bunhoung	012537758	15	5	10	5-10$	5-10$	1	1	Road Nº 6 Phum Dorkpo Khum Svaydangkum S.R	098/08 TO 15 - 07 - 09	2-14
18	ANGKOR SOKSAN	Mr.Sor Heng	012944669	10	5	5	$5	$5	0	1	#539 Group2 Phum Taphul Khum Svaydangkum S.R	024/08 TO 13 - 01 - 09	2-14
19	ANGKOR TANCITY	Mr. Koy Ponnaka	12898692 016222259	10	5	5	5-10$	20-39$	4	4	# Phum Watbo Khum Salakamreok S.R	079/08 TO 12 - 06 - 09	3-1
20	ANGKOR TIP	Mr.Plan Viruth	012866119	10	3	7	$5	$5	1	2	#0052 Phum Slorkram Khum Slorkram S.R	177/07 TO 31 - 12 - 08	1-1
21	ANGKOR TODAY	Mr.Huot kheang	012479999	15	2	13	10$	10$	3	4	# P.Salakonseng Khum vaydangkum S.R	102/08 TO 15 - 08 - 09	2-8
22	ANGKOR WAT 286	Mrs.Seur Siam	012890143	30	14	16	$5	$6-$10	3	3	#286 Phum Taphul Khum Svaydangkum S.R	031/08 M T 18 - 05 - 09	2-14
23	APSARA ANGKOR	Mr.Jeung Ik hoon	092381908 063761910	14	3	11	$5	$10	2	2	#279 Phum TaphulKhum Svaydangkum S.R	077/08 TO 04 - 06 - 09	2-14
24	APSARA STEUNG STMEY	Mr.Chea bunpheng	012351321	15	14	1	5-15$	5-15$	2	2	Phum StungThmei Khum Svaydangkum S.R	062/08 TO 05 - 04 - 09	2-11
25	AUSTRALIA	Mr.Keo Tola	012442285 012661414	30	11	19	5-10$	5-10$	2	4	P.BanteayChas Khum Slorkram S.R	028/08 M T 22 - 05 - 09	1-5
26	BACA VILLA	Mr.Kao Chamreoun	012260440	15	3	12	7-12$	7-12$	2	3	Phum Taphul Khum Svaydangkum S.R	076/08 TO 14 - 06 - 09	2-14
27	BABEL SIEM REAP	Mrs.Arnod prin maryane	012 626406	20	13	7	5-12$	5-12$	1	4	Phum Watbo Khum Salakamreok S.R	017/08 M T 22 - 04 - 09	3-1
28	BAPUON 2	Mr.Van Chhay	012629284	6	6	0	$3		0	1	#0336 group5 Phum Watbo Khum Salakamreok S.R	078/08 TO 16 - 06 - 09	3-1
29	BAPUON I (117)	Mr.Thhong Sevey Vong	012897339	10	2	8	$4	$5	1	2	#017 Phum Slorkram Khum Slorkram S.R	176/07 TO 23 - 12 - 08	1-1
30	BIG LINA 659	Mr.Som Dararith	012832297 063963047	10	3	7	5-10$	5-10$	4	2	#659 st.Acharsva Phum WatboKhum Salakamreok S.R	148/08 TO 12 - 11 - 09	3-1
31	BOU SAVY	Mrs.Chhour Vannak Hon Bovuth	012898627	10	4	6	4-10$	6-12$	1	3	#261Phum Taphul Khum Svaydangkum S.R	043/08 TO 20-02-09	2-14
32	BUN NATH	Tith Kimlin	012652121	30	20	10	$5	$10	1	7	#446 N.Road 6 P.Taphul Khum SvaydangkumS.R	159/07 TO 26 - 11 - 08	2-14
33	BUN SEDA ANGKOR	Mrs. Bun Seda	012917294	20	10	10	5-15$	5-15$	2	4	#169 P. StungThmei Khum Svaydangkum S.R	002/08 M O 14-01-09	2-11
34	BUN HAN CHAKRIY INN	Mr. Chhoeung Bunhan	012849951 012907096	15	0	15	5-15$	5-15$	1	4	#0271Phum Banteaychas Khum Slorkram S.R	032/08 TO 05 - 02 - 09	1-5
35	CHAMRONG CHAMROEUN JAY	Mr.Chhoeum chamroeun	012563594	10	5	5	5$	6$	1	1	Phum Taphul Khum Svaydangkum S.R	152/08 TO 04 - 12 - 09	2-14
36	CHAMNAP HOLYDAY	Mr.Srèng Somoeun	017430043	9	4	5	4-5$	5-6$	2	2	#621 Mondul 1Khum Svaydangkum S.R	1140/08 TO 01 - 11 - 09	2-12
37	CHEA PHALLY	Chea Phally	012206153	10	5	5	2-3$	2-3$	0	2	# Phum Chongcaosou Khum Slorkram S.R	114/08 TO 13 - 06 - 09	1-3

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38	CHEN LA 260	Mr. Prohm Yean	012910794	15	5	10	$15	$15	1	6	#260 Phum TaphulKhum Svaydangkum S.R	160/08 TO 12 - 11 - 09	2-14
39	CHETH LHOOR	Mrs.Tann Prachnhary	012960879	10	4	6	5$	$7	1	2	#0072 Phum Watbo Khum Svaydangkum S.R	027/08 TO 05 - 02 - 09	3-1
40	CHHORVY VORN ANGKOR	Mrs. Ung Channara	012282333	15	4	11	5-10$	6-12$	3	5	#105 Phum Mundul 1,Khum Slorkram S.R	141/08 TO 29 - 11 - 09	2-12
41	CHOEUN LOEUN	Mrs.Liu Junhong	012512868	10	0	10	$5		1	2	#0618 Phum Banteay Chas khum Slorkam S.R	007/08 TO 22 - 01 - 09	1-5
42	CHHOUK TEP	MrS.Kroch Lorn	012894827	10	5	5	$5	$15	1	2	#035 Phum Vichearchen Khum Svaydangkum S.R	060/08 TO 05 - 02 - 09	2-10
43	COCONUT (Lavilla Loti)	Mrs.Horm Siphanna	012653019	8	5	3	$15	$15	1	6	#697 Phum Mundul 3,Khum Slorkram S.R	164/07 TO 31 - 12 - 08	1-7
44	DO DO	Mr. Bun Saram	012312829	10	6	4	5-10$	5-10$	0	3	# Phum Vichearchen Khum Svaydangkum S.R	117/08 TO 17 - 09 - 09	2-10
45	DARA	Mr.Muy Moeun	012630448	14	3	11	$4-$5	$8-$10	1	1	#010 st. Sivatha Mondul 2 Khum Svaydangkum S.R	130/08 TO 10 - 10 - 09	2-13
46	EARTH WALKER	Ms.thipnet Sulaiphorn	089590284 063760107	20	3	17	$8	$15	3	3	Phum Salakanseng Khum Svaydangkum S.R	047/07 M .T 27 - 09 - 09	2-8
47	ECORE ANGKOR	Mrs. Ul Soma	012263567	28	13	15	8-35$	8-35$	3	3	# P. StungThmei Khum Svaydangkum S.R	035/08 TO 01 - 09 - 09	2-11
48	EISHT ROOM	Mr. Lim Kim Swee	012843833	12	7	5	10-15$	10-15$	5	1	# P. StungThmei Khum Svaydangkum S.R	094/08 TO 03 - 07 - 09	2-11
49	EUROPEAN	Mrs.Sao Srey Pov	012582237	11	2	9	$5	$5	1	2	#0566 Phum Beaychas KhumSlorkram S.R	145/07 TO 01 - 03 - 08	1-5
50	ELIZA ONE	Mr.Niet Kimny	012397273	14	7	7	5-15$	5-15$	2	3	#Phum Chongcaosou Khum Slorkram S.R	068/08 TO 01 - 05 - 09	1-3
51	FAMILY	Mrs.Mom Lun	012841864	15	6	9	$3	$5	1	2	#019 Group 1 Phum Taphul Khum Svaydangkum S.R	142/08 TO 18 - 11 - 09	2-14
52	FRESH	Mrs. Suk Thea Vy	092765627	10	5	5	8-12$	8-12$	2	5	#005 St.Sivatha Mundul 1 Khum Svaydangkum S.R	093/08 TO 11 - 07 - 09	2-12
53	GARDEN HOUSE	Mr. Ith Kimphan	063963523	15	5	10	$8-10$	6-15$	2	4	#129 Phum Watbo Kum Salakamreok S.R	125/08 TO 03 - 10 - 09	3-1
54	GARDEN VILLAGE	Mr.Van Sithavuth	012858647	15	10	5	$4		2	3	#434PhumStungThmeiKhum Svaydangkum S.R	133/08 TO 04 - 11 - 09	2-11
55	GLOBAL	Mr Song Kwon Soo	012781983	13	8	5	$3	5-15$	2	14	#018 Phum Salakanseng KhumSvaydangkum S.R	053/08 TO 19 - 03 - 09	2-8
56	GOLDEN BANANA	Mrs. Peung cheng	092875269	15	10	5	8-20$		4	2	# Phum Watdomnak Khum Salakamreok S.R	149/08 TO 12 - 11 - 09	3-3
57	GOLDEN SAND	Mrs. Tan Yolin	012866149 012786688	7	0	7		$4	0	2	#0729 PhumBateay Chas Khum Slorkram S.R	121/08 TO 28 - 08 - 09	1-5
58	GOLDEN TAKEO VILLA	Mrs.Kim Leang	012785424	8	6	2	5-8$	5-10$	1	2	#123Phum Watbo Kum Salakamreok S.R	050/08 TO 03 - 03 - 09	3-1
59	GOLDEN TEMPLE VILLA	Mr.Ly Kongsren	012943459 012999918	30	15	15	8-10$	10-15$	4	8	#Phum Stung Thmei Khum Svaydangkum S.R	029/08 M T 18 - 07 - 09	2-11
60	GOLDEN WEEK	Mr.Touch San	012726984	10	5	5	$4	$8	0	2	#154P.Chongcaosou Khum Slorkram S.R	136/08 TO 15 - 10 - 09	1-3

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61	GOLDEN MANGO	Mr.Chiep Cheung	092630252	18	8	10	$5-$15	$5-$15	2	5	#.Chongcaosou Khum Slorkram S.R	026/08 M T 26 - 06 - 09	1-3
62	GOLDEN VILLAGE	Mr. Ros Chanthou	012817616	25	13	12	$5-$10	$7-$12	2	4	Phum Watbo Kum Salakamreok S.R	003/08 M T 08 - 0 1- 09	3-1
63	GREEN PARK	Mr. Kong Bunhay	012890358	14	2	12	6-8$	6-8$	2	2	#304 Phum DorkpoKhum Svaydangkum S.R	120/08 TO 27 - 09 - 09	2-14
64	GREEN GARDEN HOME	Long Chanthy	063963342 012890363	14	1	13	$8	$7	1	5	#051 St.Sivatha Phum Taphul Khum Svaydangkum S.R	070/08 TO 23 - 05 - 09	2-14
65	GREEN TOWN	Mr. Chhun Reth	012943181	27	5	22	$3	$5	2	5	#182 Group 3 Phum Watbo Khum Salakamreok S.R	165/07 TO 31 - 12 - 08	3-1
66	GREEN VILLAGE	Mrs.Seung Sam Ath	012659590	14	4	10	5-10$	8-12$	1	3	#0147 Phum Watdamnak Kum Salakamreok S.R	016/08 TO 15 - 01 - 09	3-3
67	GREEN FLOWER APARTEL	Mr.Eun Ho Ji	092218852	20	4	16	15-20$	15-20$	7	8	Phum.Salakanseng Khum Svaydangkum SR	006/08 M T 08 - 02 - 09	2-8
68	HANUMANALAYA	Tan Sotho	012936469	10	1	9	15-25$	15-25$	5	5	#005 Phum trang Khum Slorkram S.R	008/08 TO 14 - 01 - 09	1-6
69	HEART OF ANGKOR	Mr. Chhiv yong	012888816	15	5	10	$5	$6	4	6	# st Sivatha P. StungThmei Khum Svaydangkum S.R	022/08 TO 16 - 01 - 09	2-11
70	HAPPY	Mrs.Thao Sophy	012968879	15	6	9	5-10$	5-10$	1	3	#0134 Group 2 Phum Watbo Khum Salakamreok S.R	089/08 TO 11 - 07 - 09	3-1
71	HILTION ANGKOR	Mrs.Do Vanna	016388338	20	8	12	5-10$	5-10$	2	3	#Phum Chongcaosou Khum Slorkram S.R	005/08 M T 01 - 02 - 09	1-3
72	HENG KHIM	Mr.Chea Hak	012971979	10	3	7	5$	6$	2	2	#Phum Chongcaosou Khum Slorkram S.R	002/08 TO 01 - 01 - 09	1-3
73	HENG AN	Mr. Fang nung	012990556	15	9	6	5-10$	5-10$	5	5	Phum Watbo Khum Salakamreok S.R	001/08 TO 01 - 01 - 09	3-1
74	HOK LAY NY	Mr. Tiv lay	012514344	15	7	8	5-10$	5-10$	2	2	Phum Mondol3 Khum Svaydangkum S. R	014/08 TO 11 - 01 - 09	1-7
75	HOME SWEET HOME	Mrs.Sao Sreypov	012693393 012961377	27	7	20	5-10$	5-10$	2	6	Phum Watbo Khum Salakamreok S.R	146/07 TO 01 - 12 - 08	3-1
76	HELLO PARADISE	Mr. Preck Sarith	012970433	9	4	5	5-10$	5-10$	1	2	Phum Taphul Khum Svaydangkum S. R	083/08 TO 08 - 06 - 09	2-14
77	HUOR SAN	Mrs. Kit Nay Sim	012307080	8	5	3	5-10$	5-10$	1	3	Phum Taphul Khum Svaydangkum S. R	040/08 TO 14 - 02 - 09	2-14
78	I Vy I	Mr.Karl Balch	012800860	6	0	6		15$	1	11	#423Mondul 1Khum svaydangkum Srok S.R	179/07 TO 31 - 12 - 08	2-12
79	INDR KOSA	Mr. Nuch Wudhika	011704554	9	9	0	5-8$		2	2	# Phum Mundul 3,Khum Slorkram S.R	188/07 TO 30 - 12 - 08	1-7
80	IMAGINE D'ANGKOR	Ms.Leng Theary	012306078	15	6	9	15-25$	15-25$	4	6	# Phum Trapiengsies Khum Kauk Chark S.R	038/08 TO 17 - 02 - 09	4-1
81	JASMINE LODGE	Mr.Nourn seth	012934998	10	4	6	$3	$4	2	2	#307 Root N6Phum Taphul Khum Svaydangkum S. R	012/08 TO 07 - 01 - 09	2-14
82	JOURNEY WITHIN	Mr.Ross Brandon	012997442	6	2	4	15-30$	35$	1	3	Phum Krous Khum Svaydangkum S.R	178/07 TO 06 - 12 - 08	2-9
83	KHMER ANGKOR	Mr.Man Kry	012630809	6	3	3	$3	$4	0	2	#639 PhumSalakanseng Khum Svaydangkum S.R	183/07 TO 27 - 12 - 08	2-8

84	KIM TEUNG	Mr. Tiv KimTeung	012910784 012581358	10	5	5	$3	$3	0	1	#129 Phum Banteay Chas Khum Slorkram S.R	113/08 TO 03 - 09 - 09	1-5
85	KOLAB KROHOM	Mrs.Sor Kimthea	012820059	15	5	10	$5	$5	1	2	#522 Phum Taphul Khum Svaydangkum S.R	042/08 TO 13 - 01 - 09	2-14
86	K.SUN LIGHT VILLAGE	Mrs. Cheng Pisith	012668847	15	5	10	$5-15	$5-15	2	2	# Phum Taphul Khum Svaydangkum S.R	048/08 TO 25 - 02 - 09	2-14
87	KHMER INN ANGKOR	Mr.Keo Bunsang	012682576	10	2	8	$5-15	$5-15		2	# Phum Taphul Khum Svaydangkum S.R	057/08 TO 18 - 03 - 09	2-14
88	KHUT DOEUN	Mr. Khut Doeun	012233766	10	5	5	$5-15	$5-15	1	2	# Phum Taphul Khum Svaydangkum S.R	159/08 TO 28 - 08 - 09	2-14
89	LAVILA MONA D'Angkor	Mrs.Oum Phat	012307902	10	4	6	10-15$	10-20$	1	2	# Phum tropangsiesi Khum Kauk Chark S.R	066/07 TO 10 - 04 - 09	4-1
90	LAY LAY	Mrs.Hean KimSean	011214134	9	3	6	$4	$5	0	1	#033 Group 4 Phum Taphul Khum Svaydangkum S.R	122/08 TO 29 - 08 - 09	2-14
91	LEANG CHHAY HONG	Mr. Som Leang	012963441	15	3	12	6 -12	6-12	1	2	#0767 Phum Chongcaosou Khum Slorkram S.R	143/08 TO 17 - 09 - 09	1-3
92	LES ORIENTALES	Mr.Jean francois	012440627	6	6	0	10-15$		2	8	#613 Phum Watbo Khum Salakamreok S.R	158/08 TO 06 - 12 - 09	3-1
93	LE TIGER DE PAPIER	Mr.Gaune Jean Lucdenis	012674611	12	6	6	15-25$	15-25$	0	4	# Phum Svaydangkum Khum Svaydangkum S.R	097/08 TO 23 - 07 - 09	2-7
94	LÉURA SIANE	Mrs.Thy Chantha	012677622	6	3	3	15-25$	15-25$	0	1	Phum Watbo Khum Salakamreok S.R	147/08 TO 13 - 11 - 09	3-1
95	LONG LIVE ANGKOR	Mrs.Po Pheaktry	012843462	15	6	9	5$	5$	2	2	Phum Taphul Khum Svaydangkum S.R	009/08 TO 15 - 01 - 09	2-14
96	LUY LAY	Mrs. Chai Lay	012965206	10	10	0	5-10$		0	2	#Phum Chongcaosou Khum Slorkram S.R	004/08 TO 01 - 01 - 09	1-3
97	LOVE INN	Mrs. Vong Sarath	000001271	13	13	0	5-15$		1	2	Phum Kaksekam Khum Sronge S.R	019/08 TO 15 - 01 - 09	11-1
98	LY PHALLEAN ANGKOR	Mrs.Som Phallean	012941784	14	7	7	5-15$	5-15$	1	2	# Phum Stungthmei Khum Svaydangkum S.R	110/08 TO 01 - 10 - 09	2-11
99	MONI ROTHANA	Mr. Yin Fou	012656616	15	10	5	5-15$	5-15$	2	2	Borei Sieng nam Phum kna Khum Chriev S.R	112/08 TO 26 - 09 - 09	7-2
100	MAHOGANY	Mr. Phav Proeun	012630142 063963417	10	3	7	$3	$5	0	2	#593 Phum Watbo Khum Salakamreok S.R	164/08 TO 20 - 09 - 09	3-1
101	MANDALAY INN	Mrs.Sim Sokhun	012865356	10	5	5	5-15$	5-15$	1	4	#034 Phum Vichear Chen Khum Svaydangkum S.R	031/08 TO 04 - 02 - 09	2-10
102	MARINA VILLA	Mrs.Chhen Savat	012910756 012910759	10	0	10		5-10	1	1	#659 Phum Watbo Khum Salakamreok S.R	067/08 TO 15 - 03 - 09	3-1
103	MALYLY	Mr.Hok Reaksmey	012705959	10	5	5	5-10	5-10	1	1	Phum Taphul Khum Svaydangkum S.R	044/08 TO 24 - 02 - 09	2-14
104	MEN RADY	Mrs. Suy Rady	012867617	25	0	25	5-10	5-10	1	2	#428Phum Tapul Khum Svaydangkum S.R	001/08 M T 17 - 01 - 09	2-14
105	MEAS THOEUN VILLA	Mr. Meas Thoeun	092332649	6	1	5	5-10	5-10	1	1	Phum Vichear Chen Khum Svaydangkum S.R	084/08 TO 01 - 06 - 09	2-10
106	MINI	Mrs.Sory Lai	092134250	10	10	0	4-10	4-10	1	2	#011 Phum Vichear Chen Khum Svaydangkum S.R	010/08 TO 02 - 01 - 09	2-10

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107	MAX MART	Mrs. Dean Thida	012828008	6	3	3	5-15$	5-15$	1	2	# Mondul 1Khum Svaydangkum S.R	174/07 TO 10 - 12 - 08	2-12
108	MITH LAOR	Mr.Kong Chamroeun	012630393	10	6	4	3-5$	4-6$	1	1	#263 Phum Taphul Khum Svaydangkum S.R	161/08 TO 06 - 12 - 09	2-14
109	MITRI	Mr. Luon Sokvan	012447406	15	5	10	5-10$	5-15$			# Phum Stungthmei Khum Svaydangkum S.R	054/08 TO 18 - 03 - 09	2-11
110	MOM'S	Mrs.Un Leaphiny	012630170 063963037	15	5	10	$8	$8-$13	1	2	#099 St.Achar Hemcheav P. Watbo Khum SalakamreokS.R	124/08 TO 12 - 09 - 09	3-1
111	MONO MEAS	Mr.Khut Khunchakrey	012922135	15	5	10	5-12$	6-15$	2	4	# Phum Trapiengsies Khum Kauk Chark S.R	163/08 TO 20 - 11 - 09	4-1
112	MOLLY MALONE'S	Mr. Yombll Thierry	012784175	7	3	4	10-20$	10-20$	4	6	# Mondul 1Khum Svaydangkum S.R	106/08 TO 01 - 09 - 09	2-12
113	MONOROM	Mrs.Sous sinath	012645324	7	3	4	$3	$3	0	1	#018 St.Sivatha Mondul 2 KhumSvaydangkum S.R	109/08 TO 11 - 07 - 09	2-13
114	MOLYNA II	Mrs.Tan Sithan	012864204	20	10	10	10$	15$	2	4	#253Phum Taphul Khum Svaydangkum S.R	022/08 M T 23 - 04 - 09	2-14
115	MON PAPA	Mrs. Long Neary	092929449	8	3	5	5-10$	5-10$	1	2	#Phum Taphul Khum Svaydangkum S.R	115/08 M T 26 - 09 - 09	2-14
116	MYSTERES D'ANGKOR	Bridot Pascal	012636103	15	9	6	30$	30$	2	7	#235 Phum Slorkram Khum Slorkram S.R	185/07 TO 30 - 12 - 08	1-1
117	MY HOME	Mrs. Ou Charya	012971016	15	7	8	5-15$	5-15$	1	2	# Phum Vichear Chen Khum Svaydangkum S.R	105/08 TO 20 - 08 - 09	2-10
118	MAI DO	Mr.Yakov Ben Simon	092882040	6	2	4	15-40$	15-40$	2	4	#Phum Taphul Khum Svaydangkum S.R	165/08 TO 07 - 12 - 09	2-14
119	NAGA	Mr.John Jangkil	012912005	10	5	5	$3	$5	1	4	#243 Phum Stungthmei Khum Svaydangkum S.R	119/08 TO 30 - 09 - 09	2-11
120	NEW MILLENNIUM .	Mr.Chan Vannak	012823583	9	0	9		$5	1	2	#041 Phum Vichear Chen Khum Svaydangkum S.R	085/08 TO 16 - 07 - 09	2-10
121	NIDA	Mr.Khunn Thony	015630247 012945545	6	2	4	$15	$20	2	0	#0263 Mondol 3 Khum Slorkram S.R	129/08 TO 03 - 10 - 09	1-7
122	OLD MARKET HOSTEL	Mrs.Oeng MuyChheng	012924622	8	2	6	10-20$	10-20$	3	2	# Mondul 1Khum Svaydangkum S.R	074/08 TO 03 - 06 - 09	2-12
123	ORCHIDAE 239	Mr.Sok Meng Huor	012939964	10	4	6	$4	$6-$12	2	3	#239 Phum Stung Thmei Khum Svaydangkum S.R	162/08 TO 02 - 12 - 09	2-11
124	ORAL D'ANGKOR	Mr. Choup Samat	012973811	10	5	5	5-10$	5-10$	1	2	# Phum Stung Thmei Khum Svaydangkum S.R	039/08 TO 14 - 02 - 09	2-11
125	OEUN NARIN	Mrs.Oeun Narin	012209317	10	8	2	5-10$	5-10$	1	2	Phum Watbo Khum Salakamreok S.R	135/08 TO 01 - 11 - 09	3-1
126	OR MOEURN HOI	Mrs.Thim Hoy	012280050 012280052	20	0	20	5-10$	5-10$	1	2	#577Phum Chongcaosou Khum Slorkram S.R	020/08 M T 25 -04 -09	1-3
127	OUN PISITH ANGKOR	Mrs. Dy Moy	011820253	13	1	12	5-15$	5-15$	2	3	# Phum Banteaychas Khum Slorkram S.R	089/08 TO 19 - 03 - 09	1-5
128	OMBRELLE & KIMONO	Mrs.Bouan cheau Evelyne	012965192 016240866	6	6	0	40-90$		1	1	Phum Watbo Khum Salakamreok S.R	154/08 TO 05 - 12 - 09	3-1
129	PAVILLON INDOCHING	Mrs:Men Thavy	012849681	8	6	2	$10-$20		3	5	#054 Phum Trapiengsies Khum Kauk Chark S.R	107/08 TO 08 -08- 09	4-1

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130	PAVILLION D'ORIENT RESORT	Mr. Kang Sothea	012849681	15	5	10	5-15$	5-15$	2	4	#Phum Chongcaosou Khum Slorkram S.R	037/08 TO 01 - 02 -09	1-3
131	POV MEAN CHEY	Mrs. Cheum Samut	012437254	6	6	0	5$		0	2	# Phum Taphul Khum Svaydangkum S.R	056/08 TO 17 - 03 -09	2-14
132	PALM GARDEN LODGE	Mr. Leng Dein	012793896	15	6	9	5-10$	5-10$	1	2	#Phum Svaydangkum Khum Svaydangkum S.R	103/08 TO 11 - 08 - 09	2-7
[illegible]	PEACE OF [illegible]	Mr. [illegible]	[illegible]	10	2	8	10-15$	10-[illegible]	4	4	#0133 Phum Slorkram Khum Slorkram S.R	090/08 TO 14 - 07 - 09	1-1
[illegible]	[illegible] CHHOUN ANGKOR	Mr. [illegible] Keng Kheang	092812860	10	3	7	$10 $12	$10 $15	4	5	#0229 Phum Banteaychas Khum Slorkram S.R	156/08 TO 05 - 12 - 09	1-5
135	[illegible] LOEU ANGKOR SIEM REAP	Mrs.Sok Sarorun	063380126 063963419	20	4	16	$20	$25	2	3	#003Phum Vichearchen Khum Svaydangkum S.R	034/08 M T 23 - 07 - 09	2-10
136	POPULAR 033	Mrs. Vien Kimhun	012916165	30	10	20	$4-$5	$6-$7	2	3	#033Phum Vihearchen Khum Svaydangkum S.R	048/08 M T 24 - 09 - 09	2-10
137	PRAH RIEM	Mr.Thim Ang	015630039 063380025	6	2	4	$6-$10	$8-$10	0	1	#0027 Phum Watbo Khum Salakamreok S.R	151/08 TO 18 - 10 - 09	3-1
138	PRASATKEOMOON RISE	Mr.Sor BonKheng	012920568	10	3	7	$5	$5-$10	2	1	#055 Phum Taphul Khum Svaydangkum S.R	081/08 TO 23 - 05 - 09	2-14
139	PROHM MEAS	Mr. Sy Chiv	012351352	15	0	15	5-10$	5-10$	1	4	#Phum Chongcaosou Khum Slorkram S.R	023/08 TO 01 - 02 - 09	1-3
140	PHOUM KHMER	Mrs. Phou Sopha	012933219	15	5	10	5-10$	5-10$	2	3	# Phum Salakanseng Khum Svaydangkum S.R	116/08 TO 17 - 09 - 09	2-8
141	PRASAT PICH	Mrs.Kouv Yekly	011897730	27	0	27		5-15$	2	3	Borei Sieng nam Phum kna Khum Chriev S.R	021/08 M T 23 - 04 - 09	7-2
142	PICH NEAS MEAS	Mr. Cheum Pich	092487616	10	5	5	5$	5$	1	1	Phum Taphul Khum Svaydangkum S.R	153/08 TO 04 - 12 - 09	2-14
143	QUEEN VILLA ANGKOR	Mr. Gutmeyr Michael	011221838	8	2	6	5-15$	5-15$	1	2	# Phum Watdomnak Khum Salakamreok S.R	158/08 TO 20 -11 - 09	3-3
144	RAKSMEI ANGKOR	Mrs.Ros Seang hour	012968881	7	2	5	4$	5$	0	2	#353 St.Porkamber Group 10 Khum Svaydangkum S.R	096/08 TO 18 - 07 - 09	2-14
145	RAKSMEY MONOROM	Mr. OUM ROM	012962368	10	1	9	$5	$7	0	1	#045Phum Tapul Khum Svaydangkum S.R	030/08 TO 01 - 02 - 09	2-14
146	RAKSMEY SAKSITH ANGKOR	Mr.Lim Heng	012858492	10	5	5	$5-$10	$5-$11	0	3	#447Phum Vihearchen Khum Svaydangkum S.R	011/08 TO 03 - 01 - 09	2-10
147	RAKSMEY PHNOM LEAP	Mrs. Ly Um Aeng	012563676 012856578	10	3	7	$4	$5	1	2	#0182Phum Chongcaosou Khum SlorkramS.R	052/08 TO 01 - 03 - 09	1-3
148	RAKSMEYCHANPENHVONG	Mr. Khuon Chanly	012824786	20	7	13	5-10$	5-10$	2	1	# 065Phum Dorkpo Khum Slorkram S.R	033/08 M T 01 - 08 - 09	1-7
149	RADETH ANGKOR	Mr. Em Marithara	012942720	12	4	8	6-10$	6-10$	3	4	# 065Phum Dorkpo Khum Slorkram S.R	051/08 TO 01 - 03 - 09	1-7
150	RED LODGE	Mr.Tanporn Pimtong	012963795	10	5	5	5-10$	6-15$	2	2	#0116 Phum Stung Thmei Khum Svaydangkum S.R	134/08 TO 01 - 11 - 09	2-11
151	RELAX&RESORT ANGKOR	Mr.Kawahara Yoshifumi	012901216	15	7	8	6-12$	6-12$	1	4	#00245 Phum Banteaychas Khum Slorkram S.R	118/08 TO 14 - 09 - 09	1-5
152	RIBO ANGKOR	Mrs. Mao Ry	012818178	7	0	7		5$	0	2	#098 Phum Watbo Khum Salakamreok S.R	126/08 TO 19 - 09 - 09	3-1

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153	RYDA ANGKOR	Mrs. Hieb Pich chenda	012589271	14	5	9	$5-$15	$5-$15	1	2	# Phum Taphul Khum Svaydangkum S.R	087/08 TO 01 - 07 - 09	2-14
154	ROYAL	Mr.Nuon Mny	012894594	14	0	14		$5-$15	2	2	# Sivatha Mondul 1Khum Svaydangkum S.R	036/08 TO 05 - 02 - 09	2-12
155	REATH BUNTHA	Mrs. Chhoeum Seda	012289928	10	5	5	5$	5$	1	1	# Phum Taphul Khum Svaydangkum S.R	049/08 TO 27 - 02 - 09	2-14
156	RIVER STAR	Mr.Prum Socheat	011767691	10	5	5	$10-$15	$10-$1	1	2	#560Road Sivatha Mondul 1Khum Svaydangkum S.R	025/08 TO 29 - 01 - 09	2-12
157	RITTHY RIN ANGKOR	Mr.Sin Ritthy	012396722	28	9	19	$6	$12	4	6	Phum Watbo Khum Salakamreok Srok Siem Reap	009/08 M T 24 -03 - 09	3-1
158	RITHY ANGKOR	Mr.Tan Rithy	012888583	15	5	10	5-15$	5-15$	1	2	Borei Sieng nam Phum kna Khum Chriev S.R	144/08 TO 20 - 11 - 09	7-2
159	ROSY	Mr.Simon Henry	012315852	10	2	8	$5	$5	2	1	#0074 Phum Slorkram Khum Slorkram S.R	013/08 TO 17 - 01 - 09	1-1
160	REGA	Mrs.Vann touch	012897205	6	3	3	5-15$	5-15$	2	2	Phum Salakanseng Khum Svaydangkum S.R	145/08 TO 21 - 11 - 09	2-8
161	RAIN VILLA	Mrs. In Saren	012831176	15	5	10	12-25$	12-25$	2	2	Phum Banteaychas Khum Slorkram S.R	155/08 TO 05 - 12 - 09	1-5
162	SING HOUR	Mrs.Top Sokha	012323719	10	0	10	$0	5-15$	0	1	# Phum Watbo Khum Salakamreok S.R	138/08 TO 07 - 11 - 09	3-1
163	SAKURA	Ly Le Ny	012963404 012878100	10	3	7	8-25$	8-25$	1	5	#0455 Group 15 Phum Watbo Khum Salakamreok S.R	123/08 TO 10 - 09 - 09	3-1
164	SAMARA ANGKOR	Mrs.Ung Sovanna	012320492	6	5	1	5-15$	5-15$	1	1	Phum Watsvay Khum Salakamreok Srok Siem Reap	075/08 TO 04 - 06 - 09	3-2
165	SECRET OF ELEPHEANT	Mr.Urich Kurt	63964328 012637478	7	4	3	10-15$	10-15$	1	5	#069 Phum Salakanseng Khum Svaydangkum S.R	082/08 TO 22 - 05 - 09	2-8
166	SEOUL GARDEN	Mr. Jahn Jangkil Choi	012912005	10	2	8	$5	$7	2	3	#063 Phum Krous Khum Svaydangkum S.R	029/08 TO 24 - 02 - 09	2-9
167	SEVEN IN	Mr.Jonasson Svend Erik	092926966	14	7	7	5-15$	5-15$	1	2	Phum Watdamnak Khum Salakamreok Srok Siem Reap	104/08 TO 18 - 08 - 09	3-3
168	SO JOURN	Mrs.Kidston Fiona Michlle	092608694	10	4	6	10-20$	10-20$	2	2	Phum Triek Khum Siem reap Srok Siem Reap	100/08 TO 03 - 08 - 09	5-8
169	SIEM REAP RIVERSIDE	Mrs.Hor Sona	012936566	15	1	14	5-12	6-15$	2	3	Phum Vichear Chen Khum Svaydangkum S.R	026/08 TO 25 - 01 - 09	2-10
170	SIM PO GOLDEN STAR	Mr. Kou Po	012702223	15	5	10	5-10$	5-10$	1	6	#0432 Phum Banteaychas Khum Slorkram S.R	146/08 TO 16 - 11 - 09	1-5
171	SAM NANG VATHANA	Mrs. Choeum Khut	012654069	10	5	5	5-10$	5-10$	1	2	Phum Taphul Khum Svaydangkum S.R	061/08 TO 25 - 03 - 09	2-14
172	SAWADEE ANGKOR INN	Mr. Oeung Song Thai	012313164	20	10	10	5-15$	5-15$	4	5	Phum Stung Thmei Khum Svaydangkum S.R	030/08 M T 25 - 03 - 09	2-11
173	SMILEY'S	Mr.Touch Nara	012852955	30	20	10	$2-$3	$4-$5	3	5	Phum Taphul Khum Svaydangkum S.R	184/07 TO 26 - 12 - 08	2-14
174	SOR PHOUN	Mr.Von Roatha	012893647	20	9	11	$6-$12	$7-$13	1	2	#0275 Phum Banteay Chas Khum Slorkram S.R	025/08 M T 29 - 06 - 09	1-5
175	SOCHEA	Ms. Un Polen	012362240	15	3	12	$5-$11	$5-$12	1	4	#Phum Chongcaosou Khum Slorkram S.R	003/08 T O 01 - 01 - 09	1-3

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176	STAR D'ANGKOR	Mrs.Kream Dareap	012910176	6	4	2	$6-$7	$7-$10	0	1	#0106 Group 1Phum Watbo Khum Svaydangkum S.R	041/08 TO 08 - 01 - 09	3-1
177	STAR MOHANOKOR	Mr. Ly Kun	012828834	10	5	5	5-10$	5-10$	1	1	#Phum Watbo Khum Svaydangkum S.R	180/07 TO 13 - 12 - 08	3-1
178	SAM SO	Mr. Nauo Savy	012630590	10	5	5	5-10$	5-10$	1	1	#Phum Watbo Khum Svaydangkum S.R	166/08 TO 13 - 12 - 09	3-1
179	SUN RISE 592	Mr.Kim Hong	012983483	6	2	4	$3	$4	0	1	#592 Group 2 Phum Watbo Khum Salakamreok S.R	150/08 TO 10 - 09 - 09	3-1
180	SUN SENGKY	Mr.Sung Sengky	012634943	15	1	14		$7-$15	4	4	#015Sivatha Mondul 1Khum Svaydangkum S.R	015/08 TO 26 - 01 - 09	2-12
181	TA KEO	Mrs.Prum Navy	012922674	18	8	10	5-15$	5-15$	2	2	#258 N.Road 6 Phum Taphul Khum Svaydangkum S.R	027/08 M T 27 - 06 - 09	2-14
182	TA KEO II	Mrs.Prum Navy	012922674	10	4	6	5-15$	5-15$	0	2	#258 N.Road 6 Phum Krous Khum Svaydangkum S.R	080/08 T O 22 - 06 - 09	2-9
183	TA SOM	Lim Nang	012830170	10	4	6	$5	$6	1	2	#268 Road6 P.Taphul Khum Svaydangkum S.R	091/08 TO 05 - 07 - 09	2-14
184	TANEY	Mr. Say Kim Eang	092865150	8	3	5	7-13$	7-13$	2	3	Phum Stung Thmei Khum Svaydangkum. S.R	088/08 TO 15 - 07 - 09	2-11
185	TAN KANG	Mrs.Tan Kang	12852622 012287900	13	5	8	$4	$5	1	3	#022 Mondul 1 Khum Svaydangkum S.R	092/08 TO 23 - 06 - 09	2-12
186	THE DEAD FISH TOWER	Mr. Ma boon	012630377	10	3	7	$5	$5	1	2	Road Sivatha Mondul 1Khum Svaydangkum S.R	172/07 TO 14 - 12 - 08	2-12
187	THE IVY TWO	Mr.Steven Andrew Fab	012380516	10	5	5	6$	8$	1	4	#312 Mondul 1Khum Svaydangkum S.R	187/07 TO 30 - 12 - 08	2-12
188	THE REVER GARDEND	Mrs. Saunder Deborch Joy	092883293	9	1	8	20-30	20-30	4	6	Mondol 3 Khum Slorkram S.R	071/08 TO 18 - 5 - 09	1-7
189	THE PRINCE MEKONG VILLA	MrBader Erich	012437972	8	0	8	$3	$5	2	2	#415 Phum Taphul Khum Svaydangkum S.R	069/08 TO 30-05-09	2-14
190	THE RED PIANO II	Mr. Geert Caboor	012854150	15	5	10	8-15$	8-15$	2	4	#427 StuengtmeyKhum Svaydangkum S.R	086/08 TO 18 - 07 - 09	2-11
191	THE VILLA SIEM REAP I	Mr. Jeansch Anthony Peter	092256691 063761036	14	7	7	5-10$	5-10$	2	4	# 153Phum Taphul Khum Svaydangkum Srok S.R	099/08 TO 03 - 08 - 09	2-14
192	THE SIEM REAP HOSTEL	Mr.David Andrew	012701104	15	6	9	5-10$	5-10$	6	5	# Phum Watdamnak Kum Salakamreok S.R	175/07 TO 10 - 12 - 08	3-3
193	THE KING VILLA ANGKOR	Mrs. Nheb Sophy	012930011	15	5	10	5-15$	5-15$	2	3	# Stuengtmey Khum Svaydangkum S.R	055/08 TO 10 - 03 - 09	2-11
194	THERINYA	Mr. Nuon Ya	012851364	10	7	3	$4	$5-$6	1	3	#0019 Phum Slorkram Khum Slorkram S.R	186/07 TO 23 - 12 - 08	1-1
195	TOP EYE ANGKOR	Mr.Sim Soda	012759475	10	5	5	5-10$	5-10$	2	2	# Phum Taphul Khum Svaydangkum S.R	020/08 TO 01 - 01 - 09	2-14
196	TRANG YIV	Mr.Tran Yi	012910786	15	2	13	$4	$4	0	2	#0126 Phum Banteaychas Khum Slorkram S.R	108/08 TO 08 - 09 - 09	1-5
197	TWO DRAGONS	Mr.Gordon shearpless	012868551	13	7	6	6-12$	7-18$	0	3	#0110 Phum Watbo Khum Salakamreok S.R	131/08 TO 01 - 11 - 09	3-1
198	U.DARA INN	Mr.Lim Han	12958824 121802246	15	9	6	5-10$	6-12$	2	3	#642 Mondul 1 Khum Svaydangkum S.R	139/08 TO 28 - 11 - 09	2-12

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199	VICTORY VILLA ANGKOR	Mrs. Am Vannary	012452492	14	4	10	5-15$	5-15$	1	3	#322 Phum Taphul Khum Svaydangkum S.R	046/08 TO 09 - 01 - 09	2-14
200	VILLA COCONUT LODGE	Mr.Peung Vutha	012856562	15	7	8	6-10$	6-10$	1	3	#033 Phum Vihearchen Khum Svaydangkum S.R	006/08 TO 01 - 01 - 09	2-10
201	VUO SOKHOM ANGKOR	Mr.Sin Vuo	012512898	10	10	0	5-10$		1	3	#200Phum Chongchaosou Khum Slorkram S.R	017/08 TO 14 - 01 - 09	1-3
202	VIROTH'S	Mr.Koi Virath	016715349	7	7	0	15-30$		3	2	#Phum Watbo Khum Svaydangkum S.R	021/08 TO 15 - 01 - 09	3-1
203	WINTER	Mr. Oum Sophin	012940659	14	2	12	$3	$4	1	4	#200Phum Chongchaosou Khum Slorkram S.R	018/08 TO 08 - 01 - 09	1-3
204	WAT SUP	Mr'. Moun Rontoeur	012675881	10	5	5	5-12$	5-12$	1	1	# Phum Watdomnak Khum Salakamreok S.R.	047/08 TO 01 - 03 - 09	3-3
205	WHITE ELEPHANT	Mr.Sarge Billot	121947002	15	0	15	$0	5-15$	2	2	# Phum Watsvay Khum Salakamreok S.R	065/08 TO 20 - 03 - 09	3-2
206	YAMATO	Mr.Nishimura	012517905	10	2	8	5$	6$	1	4	#311 Phum Taphul Khum Svaydangkum S.R	073/08 TO 19 - 05 - 09	2-14
207	YELLOW	Mr. Bou Sarin	017568007	12	5	7	5-15$	5-15$	6	4	# Phum Taphul Khum Svaydangkum S.R	045/08 TO 24 - 02 - 09	2-14
208	YARK LOM ANGKOR LODGE	Hang Rayana	012854149	10	0	10	15$	15$	2	2	#025 Phum Banteaychas Khum Slorkram S.R	137/08 TO 01 - 10 - 09	1-5
	Total			2671	1027	1644			337	609			

Total : Guset house 208 , Rooms : 2671 , Single : 1027 , Double: 1644

In operation= **Guset house 208 =2671, Room** **Close =**

License : **Guest houses 200** **Expiry 8** :

Total Staff : 946 , **Male :** 337 , **Female :** 609

Siem Reap, the 16 Dec 2008

SEEN AND AGREED

DIRECTOR OF TOURISM DEPARTMENT

KOY_SANG

Chief of Tourism Industry Office

THIM SEREYVUDH

REPORT BY

Chou Na

Supporting Report

Chapter 3

Water Demand Projection and Proposed Long-Term Water Supply Development Scheme

JICA/NJS CONSULTANTS CO., LTD

SOCIAL SURVEY REPORT

FOR

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT

PREPARED BY

KEY CONSULTANTS (CAMBODIA)

SIEM REAP, AUGUST 2009

ABSTRACT

The study provides preliminary information of water consumption patterns of low, medium, and high water consumers within the service area and of poor, medium, and better off households within the non service area. People's willingness to connect to the new water supply system and affordable fees for water consumption in the non service area were observed. To fulfill the study objectives, two main components were used: background information source and household interviews. In the service area, sample selection was classified into three categories: low, medium and high water consumers. In the non service area, the samples were divided into three types: poor, medium, and better off households and were selected around and very close to the service area. One third of the total selected samples for each village was applied either the service or the non service areas.

As a result, in the service area the water consumption quantities were 60.1, 100.3, and 168.2 liters per day per person for low, medium, and high water consumers, respectively. In the non service area, the quantities were different amongst the seasons. In the rainy season, the quantities of water consumption were 83, 100, and 110 liters per person per day for poor, medium, and better off households. In the dry season, the quantities were 100, 128, and 143 liters per person per day for poor, medium, and better of households, respectively. In the non service area, respondents' willingness to connect to the new water supply system were provided. 70% of the respondents will connect to the system whenever its construction is finished without considering of the connection costs. 11% of them replied No idea. Meanwhile, they seem to feel hesitate to provide the answer, some of whom mentioned that if their neighbors connect to the system, they will also do. In contrast, 19% of the respondents say No for the system. This is due to the fact that they already had open ring wells or tube wells and can not be affordable for the connection fees. These respondents are known as the poor households. Many respondents are willing to pay for water supply to a certain extent. The WTP is related to obtaining adequate service for their essential needs. Asking the respondents about the maximum amounts to pay, their payments were 32.4%, 25.7%, 25.7%, 12.9%, and 4,3% for From 2 to less than 5 US$, From 1 to less than US$ 2, Depend on water tariff , From 5 to 7 US$, and More than 7 US$, respectively. Generally it is also found that common factors for WTP is responsive to consumption, affordability and the nature of the service provided. On determining affordability, it is found that affordability of the poor households is 4.5% of their incomes.

The study concluded that in the service area water consumptions are different, depending mainly on family economic, family size, occupations, and seasons. In the non service area, the differences were also found. Poor households consume water less than the medium and better off households due to the fact that medium and better off households always use pumps, while the poor were normally found to be lack of it. The respondents are willing to connect to the system whenever its construction is finished without considering of the connection costs. On the other hand, the affordability rate of the poor households should be considered for the water supply expansion purpose. The study can be used as a source and as one of the reference tools for the city water supply planning.

Keywords: water consumption, willing to connect, willing to pay, affordability

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1. Objective

The main aims of the social survey were to know about and to find out:

- The actual amounts of low, medium, and high water consumers for the service area and of poor, medium, and high income water consumers for the non service area;
- People's willingness to connect to the new water supply system in the non service area; and
- Affordable fees for water consumption.

Collection of information for the study including occupation, household income, satisfactory with the water supply service, water borne diseases, sanitary facilities was also conducted for the service and non-service areas.

Of the objectives, it creates an extensive and realistic picture and other associated aspects within the service and non service areas which help development actors understand and determine the city's needs and find out proper solutions to manage the demand and expand from service area to non service area in a proper and substantable manner.

2. Scope of work and limitations

Due to the fact that time was limited, the study was conducted for one month period during July 2009. It is administered only in 200 household samples: 100 samples from the service area and 100 samples from the non service area. The study covered aspects related to water consumption quantities within the service and non service areas, willingness to connect to and to find out affordable fees for the new water supply system. Of the selected samples and the covered aspects, they can be generated the needed information for the study.

3. Methodology

3.1 Description

In order to fulfill the defined objectives, household interviews by the KCC study team was conducted. Prior to the interviews started, the discussions between JICA and KCC study teams on questionnaire improvement were made. The questionnaires were administered to households within service and non-service areas. Translation the questionnaire into Khmer version was done prior to training interviewers. During the training, the interviewers practiced administering the questionnaire until they could administer the survey correctly on their own. This is the most important point to obtain confidential and realistic data. Pilot testing and final revision were then conducted respectively. Once in the field, the interviewers were again supervised by a field supervisor to assure their consistency and competence. The field supervisor accompanied the interviewers on a daily basis to ensure that interviews were handled professionally and was also responsible for quality control.

Regarding to sample selection in the service area, they were classified into three categories: low (from 0 – 10m^3), medium (from 11 – 25m^3) and high water consumers (Over 25m^3) based on the actual data pointed out by SRWSA staff. In order to get balance between these different consumers, one third of the total selected samples in each village was applied for these categories (Table 1).

Table 1 Population and samples of the current service area

Commune	Village	Number of Family in 2008*	Number of Population in 2008	Samples of Residents	Water Consumption			Total Connection as of June 2009**
					Low 0 - 10m^3	Medium 11 - 25m^3	High 25m^3	
Svay Dangkum SRWSA Zone 1, South-West of NR No.6 West of SR River	Salakom seng	767	10,977	3	1	1	1	204
	Kruse	559	3,072	3	1	1	1	39
	Vihea Chin	935	4,874	3	1	1	1	199
	Stung Thmey	402	2,272	3	1	1	1	251
	Mondoul-1	397	2,197	6	2	2	2	614
	Mondoul-2	200	1,250	3	1	1	1	259
	Ta poul	447	2,541	6	2	2	2	296
	Subtotal samples and number of water connection as of June 2009			27	9	9	9	1,862
Sla Kram SRWSA Zone 3, North-East of NR No.6	Sla Kram	316	2,740	3	1	1	1	159
	Boeng Doun Pa	825	5,951	3	1	1	1	32
	Chong Kausu	2,311	12,683	3	1	1	1	248
	Dak Pou	585	3,514	6	2	2	2	305
	Banteay Chas	957	6,334	6	2	2	2	501
	Treang	612	3,473	3	1	1	1	56
	Mondol Bel	1,078	5,778	3	1	1	1	206
	Subtotal samples and number of water connection as of June 2009			27	9	9	9	1,507
Sala Kamraeuk SRWSA Zone 4, South-East of NR No.6	Voat Bour	1,114	5,686	12	4	4	4	460
	Voat Svay	841	4,659	-	-	-	-	2
	Voat Damnak	749	3,939	6	2	2	2	187
	Sala Kamraeuk	290	1,790	-	-	-	-	9
	Ta Vien	638	3585	6	2	2	2	90
	Subtotal samples and number of water connection as of June 2009			24	8	8	8	748
Kouk Chak SRWSA Zone 2	Tror pang sese	1,212	3,545	18	6	6	6	305
	Tlek sene Tbong	604	3,213	4	2	1	1	33
	Subtotal samples and number of water connection as of June 2009			22	8	7	7	338
Srangae	Kark sel karne	334	1,698	-	-	-	-	1
	Thnori	281	1,468	-	-	-	-	4
	Number of water connection as of June 2009			0	-	-	-	5
GRAND TOTAL				100	34	33	33	4,460

Source: * Planning Department, Siem Reap, as of March 2009
** Siem Reap Water Supply Authority, June 2009

In the non service area, samples were selected around and very close to the service area. One third of the total selected samples in each village was also used for low, medium, and high income households[1]. In order to find out such different wealth groups, village chiefs were asked to point out people's name within their villages for the interviews. This provides preferred meaningful information for the study. The village name of the non service area is shown as in table 2 and its location is pointed out as shown in appendix 1.

Table 2 Population and samples of the non service area

Commune	Village	Number of Family in 2008*	Number of Population in 2008	Samples of Residents	Household Income		
					Low	Medium	High
Srangae	Kark sei karme	334	1,698	15	5	5	5
Siem Reap	Kor Kragne	425	2,426	9	3	3	3
	Triek	242	1,412	9	3	3	3
Chreav	Chreav	141	771	9	3	3	3
	Khnar	633	3,616	9	3	3	3
Sambuor	Veale	115	649	7	3	2	2
	Ta kong	134	686	9	3	3	3
Krabei Riel	Krasang	84	556	9	3	3	3
	Boeng	186	961	6	2	2	2
Tuek Vil	Kouk Doung	388	1,648	18	6	6	6
GRAND TOTAL				100	34	33	33

Source: * Planning Department, Siem Reap, as of March 2009

3.2 Data analysis

Data analysis was set to comply with the objectives. Since there is no an in depth analysis tool was used in this study, the data were analyzed descriptively using the SPSS statistical package software version 16.0. Prior to analysis, those data were rechecked, arranged, and classified into groups. Finally, the output from analysis was used as the result of the study.

[1] **Better off households** refer to those having Car, Pedestrian tractor, Rice field more than 2 hectares, Rice thresher, Motorbike more than one, Cattle, Big house, Regular daily income sources, Telephone more than one, Color television, Daily income more than 71000 Riel. **Medium households** are for those having Semi regular daily income, Two cattle, Rice field for 1 hectares, New brand motorbike, Poultry more than 3, House size more than 30m^2, One telephone, and Daily income 12000 to 70000 Riel. **Poor households** are defined as those having One bike-cycle, Two cattle, One second hand of motorbike, House size <25m^2, Black and white television, No rice field, One telephone, Have residential land, and Daily income less than 12000 Riel. Such wealth group categories were classified by GTZ, March 2004.

4. Results and Discussion

4.1 Introduction

This section provides and analyzes information of allied aspects regarding to the study objectives. Only the data obtained from the interviewed households was analyzed for the study.

4.2 The Current service area aspects

Prior to understanding allied aspects in the service area, some of the main points from respondents were asked such as position in the family and education. These introductory questions are a basic reference to their response. For instance, if the respondent is not a household head or spouse of household head or parent of household head, then he/she may not clearly know about the general conditions. As a result, the answers provided would have some trouble to make general analysis. Similarly, if the respondent is uneducated, he/she might also provide misinformation. This is why these two main questions were asked in an introductory section. In view of this, the respondents are 73%, 25%, and 2% for household heads, spouses of household heads, and parents for household heads, respectively. Their educations are mostly in the secondary level. Of these, it may provide a good start from the respondents.

4.2.1 House ownership and occupations

Prior to providing description of this subsection, it is noted that some low water consumers were not available during the studied period. This means that they were away from their houses for income-generating purposes, keeping the houses closed. Since it was hard to conduct the interviews with them, the numbers of medium and high water consumers were increased. As a result, 27, 38, and 35 were selected as low, medium, and high water consumers, respectively.

Mostly, the respondents have their own houses for either living or conducting businesses in the city. Occupations of low water consumers are different. Small scale business owner, government employee, and workers for private companies were commonly found. The other occupations are car repairer, chef, tailor, and tour guide. The detailed information regarding to the occupations of low water consumers is shown as in table 3.

Table 3 The occupation of low water consumer

Occupation	Number of respondent	Percentage
Small scale business owner	11	40.7
Government Employee	6	22.3
Worker at private company/Factory	2	7.4
Others	8	29.6

For medium water consumers, their occupations are mainly small scale business owner, government employee, transportation service provider either motor or car. The other occupations are part-time teacher, electrician, T.V and radio repairer. The detailed information regarding to the occupations of medium water consumers is shown as in table 4.

Table 4 The occupation of medium water consumer

Occupation	Number of respondent	Percentage
Small scale business owner	16	42.1
Government Employee	6	15.8
Transportation service provider	4	10.5
Motor taxi driver	2	5.3
Worker at private company/Factory	1	2.6
Construction worker	1	2.6
Others	8	21.1

High water consumers' occupations dominated by small scale business owner and government employee. The other occupations are dentist, motorbike repairer, tourist guide, and car repairer. The information regarding to the occupations of high water consumers is shown as in table 5.

Table 5 The occupation of high water consumer

Occupation	Number of respondent	Percentage
Small scale business owner	13	37.1
Government Employee	9	25.7
Worker at private company/Factory	2	5.7
Transportation service provider	2	5.7
Motor taxi driver	1	2.9
Others	8	22.9

4.2.2 Household income

This section presents information on family income and expenditures. The income and expenditure here were classified into three categories: low, medium and high water consumers. It is found that total monthly incomes are 325, 462.5, and US$ 600, while total monthly expenditures are 275, 300, and US$ 375 for low, medium, and high water consumers, respectively (Table 6, 7, and 8). The monthly incomes and expenditures of the categories can also be summarized as in figure 1.

Table 6 Monthly income and expenditure of low water consumer

No	Respondent name	Low water consumer			
		Monthly income (Riel)	Monthly income (US$)	Monthly expenditure (Riel)	Monthly income (US$)
1	Koe Samnang	205,000.00	51.25	200,000.00	50
2	Kro Him	1,000,000.00	250	928,000.00	232
3	Heak Kim Cheang	1,600,000.00	400	1,200,000.00	300
4	Chin Ouleang	400,000.00	100	380,000.00	95
5	Lov Samoeun	600,000.00	150	450,000.00	112.5
6	Ly Kunthea	4,000,000.00	1000	3,200,000.00	800
7	Pia Pouly	1,600,000.00	400	115,000.00	28.75
8	Eang Phall	3,000,000.00	750	9,200,000.00	2300
9	Sav Virak	1,500,000.00	375	1,200,000.00	300
10	Soun Srey Vorn	1,200,000.00	300	900,000.00	225
11	Leng Bang	4,500,000.00	1125	3,130,000.00	782.5
12	Thun Sokhun	900,000.00	225	859,000.00	214.75

No	Respondent name	Low water consumer			
		Monthly income (Riel)	Monthly income (US$)	Monthly expenditure (Riel)	Monthly income (US$)
13	Pan Heu	1,500,000.00	375	1,300,000.00	325
14	Chhou Sreng	1,200,000.00	300	900,000.00	225
15	Ong Tea Sia	750,000.00	187.5	600,000.00	150
16	Nia Sim	590,000.00	147.5	420,000.00	105
17	Bun Leng	3,000,000.00	750	2,000,000.00	500
18	Than Na	1,300,000.00	325	1,100,000.00	275
19	Peach Kari Raoth	3,000,000.00	750	2,000,000.00	500
20	Por Moa	3,200,000.00	800	1,600,000.00	400
21	Long Sora Ny	450,000.00	112.5	2,000,000.00	500
22	Chan Sokunthea	180,000.00	45	150,000.00	37.5
23	Sun Kong	1,500,000.00	375	1,200,000.00	300
24	Hear Lay	1,500,000.00	375	1,318,000.00	329.5
25	Ol Phalla	800,000.00	200	600,000.00	150
26	Touch Savonn	600,000.00	150	400,000.00	100
27	Yo Ying	2,500,000.00	625	1,800,000.00	450
Average		**1,576,851.85**	**394.21**	**1,450,000.00**	**362.50**
Median		**1,300,000.00**	**325.00**	**1,100,000.00**	**275.00**

Table 7 Monthly income and expenditure of medium water consumer

No	Respondent name	Medium water consumer			
		Monthly income (Riel)	Monthly income (US$)	Monthly expenditure (Riel)	Monthly income (US$)
1	Chea Pov	1,800,000.00	450	1,200,000.00	300
2	Chea Vanna	2,000,000.00	500	1,500,000.00	375
3	Seang Kim Thav	1,500,000.00	375	1,200,000.00	300
4	Sok Rin	15,000,000.00	3750	1,230,000.00	307.5
5	Chhor Visak	9,000,000.00	2250	850,000.00	212.5
6	Prak Kunthy	2,000,000.00	500	1,000,000.00	250
7	Chhong Hout	900,000.00	225	900,000.00	225
8	Sok Kim Chhoun	750,000.00	187.5	510,000.00	127.5
9	Meas Phalkea	600,000.00	150	450,000.00	112.5
10	Kim Yeang	1,435,000.00	358.75	1,230,000.00	307.5
11	Korina	1,900,000.00	475	1,845,000.00	461.25
12	E Romdol	1,200,000.00	300	1,200,000.00	300
13	Kim Iv	1,200,000.00	300	900,000.00	225
14	Keang Vign	4,305,000.00	1076.25	3,690,000.00	922.5
15	Suth Thyda	1,500,000.00	375	1,200,000.00	300
16	Samrith Chanrathana	1,222,000.00	305.5	400,000.00	100
17	Sithi Mony	1,200,000.00	300	800,000.00	200
18	Khoeum Bunthai	3,200,000.00	800	2,000,000.00	500
19	Hun Houn	1,350,000.00	337.5	1,000,000.00	250
20	Oeun Kim Hun	2,400,000.00	600	2,000,000.00	500
21	Ly Chai Heang	2,350,000.00	587.5	2,000,000.00	500
22	Som Sophal	3,000,000.00	750	1,785,000.00	446.25
23	Peang Vannak	1,000,000.00	250	1,000,000.00	250
24	Top KimHav	8,000,000.00	2000	600,000.00	150
25	Sav Yuk Kunthor	12,000,000.00	3000	12,000,000.00	3000
26	Koe Bun Heang	600,000.00	150	400,000.00	100
27	Seng Khay	2,000,000.00	500	800,000.00	200
28	Sum Puy	2,000,000.00	500	750,000.00	187.5
29	Ton Vanna	400,000.00	100	1,200,000.00	300

No	Respondent name	Medium water consumer			
		Monthly income (Riel)	Monthly income (US$)	Monthly expenditure (Riel)	Monthly income (US$)
30	Chan Rom	2,000,000.00	500	2,000,000.00	500
31	Ngem Sokhum	900,000.00	225	586,000.00	146.5
32	Lim Peach	1,480,000.00	370	1,400,000.00	350
33	Leng Siv Tav	3,000,000.00	750	1,600,000.00	400
34	Tan Bo Song	3,000,000.00	750	2,000,000.00	500
35	Dab SoBory	1,000,000.00	250	600,000.00	150
36	Chhoeun Lay	500,000.00	125	400,000.00	100
37	Koe Sothea	3,000,000.00	750	2,500,000.00	625
38	Van Yung Eak	3,000,000.00	750	2,000,000.00	500
Average		**2,728,736.84**	**682.18**	**1,545,421.05**	**386.36**
Median		**1,850,000.00**	**462.50**	**1,200,000.00**	**300.00**

Table 8 Monthly income and expenditure of high water consumer

No	Respondent name	high water consumer			
		Monthly income (Riel)	Monthly income (US$)	Monthly expenditure (Riel)	Monthly income (US$)
1	Ly Sounly	4,500,000.00	1125	3,500,000.00	875
2	Si Na	1,000,000.00	250	1,000,000.00	250
3	Kim Meang Ry	1,350,000.00	337.5	1,050,000.00	262.5
4	Phally Vanndath	2,800,000.00	700	600,000.00	150
5	Chhiv Yong	1,800,000.00	450	1,400,000.00	350
6	Chrik Pov	1,435,000.00	358.75	1,230,000.00	307.5
7	Chhong Chamroeun	2,000,000.00	500	2,000,000.00	500
8	Ouk Sam Art	2,500,000.00	625	2,000,000.00	500
9	Ouk Savoeun	2,400,000.00	600	2,000,000.00	500
10	Kov Hai	1,500,000.00	375	1,250,000.00	312.5
11	Soun Vuthy	1,600,000.00	400	1,200,000.00	300
12	Hong Bunthy	4,000,000.00	1000	3,200,000.00	800
13	Tap Bun Chhoy	1,800,000.00	450	1,500,000.00	375
14	Siv Bunrith	2,500,000.00	625	1,345,000.00	336.25
15	Pik Pak	2,500,000.00	625	1,318,000.00	329.5
16	Ek Khin	2,000,000.00	500	1,600,000.00	400
17	Thyda	3,200,000.00	800	2,400,000.00	600
18	Porn Phearak	2,400,000.00	600	2,400,000.00	600
19	Bun Chi Na	1,260,000.00	315	1,050,000.00	262.5
20	Lim Meng Kang	2,000,000.00	500	1,500,000.00	375
21	Lim Kang	2,500,000.00	625	2,000,000.00	500
22	Bun Raoth	2,400,000.00	600	1,400,000.00	350
23	Doung Sarim	2,000,000.00	500	1,800,000.00	450
24	Lim Tang	1,600,000.00	400	900,000.00	225
25	Ngoy Malay	3,000,000.00	750	2,870,000.00	717.5
26	Noun Chhun	3,500,000.00	875	3,200,000.00	800
27	Kheng Ta	1,600,000.00	400	1,360,000.00	340
28	Loeung Visith	2,000,000.00	500	1,800,000.00	450
29	Noun Nal	3,000,000.00	750	600,000.00	150
30	Ming Cheng	3,500,000.00	875	2,000,000.00	500
31	Ros Srey	800,000.00	200	400,000.00	100
32	Ly NaRon	3,000,000.00	750	2,400,000.00	600
33	Thong Sokha	15,000,000.00	3750	11,000,000.00	2750
34	Top Sokha	3,600,000.00	900	1,500,000.00	375

No	Respondent name	high water consumer			
		Monthly income (Riel)	Monthly income (US$)	Monthly expenditure (Riel)	Monthly income (US$)
35	Keam Vannak	400,000.00	100	2,100,000.00	525
Average		**2,641,285.71**	**660.32**	**1,967,800.00**	**491.95**
Median		**2,400,000.00**	**600.00**	**1,500,000.00**	**375.00**

Note: 1 US$ = 4000 Riel was calculated in this study

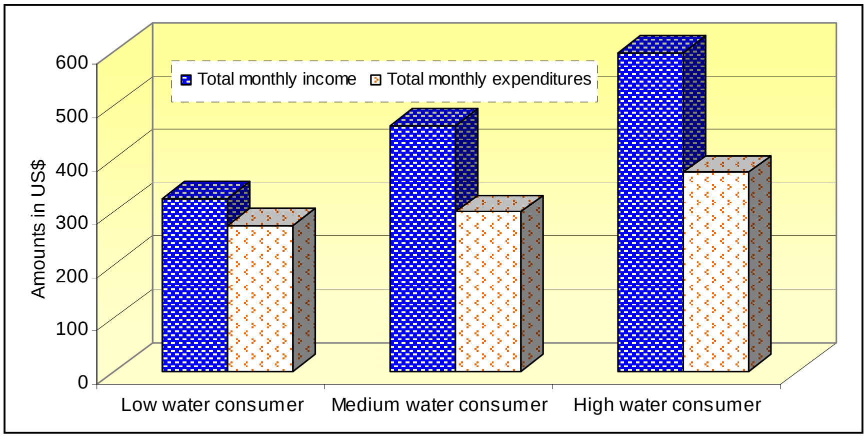

Figure 1 Household's income and expenditures in the service area

Furthermore, water consumption cost contributes to the total monthly expenditures was calculated. As a result, it is revealed that the percentages of the cost contributing to total monthly expenditures are 0.94%, 1.53%, and 3.12% for low, medium, and high water consumers. If combined the water cost with the electricity cost and the telephone cost, they contributed 13.7%, 16.5%, and 18.5% for low, medium, and high water consumers, respectively (Table 9, 10, and 11).

Table 9 Contribution of water cost, electricity cost, and telephone cost to monthly expenditure

For low water consumer

No	Respondent Name	Expenditure	Water cost	Electricity cost	Telephone cost
1	Koe Samnang	200,000	8,400	80,000.00	41,000.00
2	Kro Him	928,000	7,600	80,000.00	41,000.00
3	Heak Kim Cheang	1,200,000	33,600	150,000.00	20,000.00
4	Chin Ouleang	380,000	8,400	44,280.00	80,000.00
5	Lov Samoeun	450,000	12,000	80,000.00	20,000.00
6	Ly Kunthea	3,200,000	7,200	90,000.00	160,000.00
7	Pia Pouly	115,000	12,750	123,500.00	80,000.00
8	Eang Phall	9,200,000	7,200	240,000.00	160,000.00
9	Sav Virak	1,200,000	27,600	90,000.00	60,000.00
10	Soun Srey Vorn	900,000	10,800	100,000.00	60,000.00
11	Leng Bang	3,130,000	12,750	61,500.00	60,000.00
12	Thun Sokhun	859,000	12,000	49,200.00	60,000.00
13	Pan Heu	1,300,000	7,200	70,000.00	60,000.00
14	Chhou Sreng	900,000	10,800	100,000.00	40,000.00
15	Ong Tea Sia	600,000	5,550	50,000.00	20,000.00
16	Nia Sim	420,000	3,600	17,200.00	20,000.00
17	Bun Leng	2,000,000	10,800	61,500.00	120,000.00

No	Respondent Name	Expenditure	Water cost	Electricity cost	Telephone cost
18	Than Na	1,100,000	4,350	122,000.00	80,000.00
19	Peach Kari Raoth	2,000,000	28,000	400,000.00	80,000.00
20	Por Moa	1,600,000	3,150	200,000.00	40,000.00
21	Long Sora Ny	2,000,000	12,750	90,000.00	20,000.00
22	Chan Sokunthea	150,000	6,000	30,000.00	20,000.00
23	Sun Kong	1,200,000	10,350	150,000.00	20,000.00
24	Hear Lay	1,318,000	9,600	32,000.00	60,000.00
25	Ol Phalla	600,000	8,400	45,000.00	20,500.00
26	Touch Savonn	400,000	10,800	80,000.00	60,000.00
27	Yo Ying	1,800,000	13,200	271,420.00	200,000.00
Median		**1,100,000.00**	**10,350.00**	**80,000**	**60,000**
			0.94%		**13.7%**

Table 10 Contribution of water cost, electricity cost, and telephone cost to monthly expenditure For medium water consumer

No	Respondent Name	Expenditure	Water cost	Electricity cost	Telephone cost
1	Chea Pov	1,200,000	21,600	80,000	40,000
2	Chea Vanna	1,500,000	18,000	287,000	120,000
3	Seang Kim Thav	1,200,000	18,750	63,000	80,000
4	Sok Rin	1,230,000	28,800	82,000	82,000
5	Chhor Visak	850,000	21,600	27,880	40,000
6	Prak Kunthy	1,000,000	8,400	79,540	20,000
7	Chhong Hout	900,000	12,000	13,500	150,000
8	Sok Kim Chhoun	510,000	30,000	110,000	150,000
9	Meas Phalkea	450,000	12,000	60,000	20,000
10	Kim Yeang	1,230,000	18,000	25,000	41,000
11	Korina	1,845,000	20,400	130,000	123,000
12	E Romdol	1,200,000	23,400	290,000	40,000
13	Kim Iv	900,000	12,000	140,000	60,000
14	Keang Vign	3,690,000	42,000	250,000	12,000
15	Suth Thyda	1,200,000	16,800	120,000	120,000
16	Samrith Chanrathana	400,000	27,600	72,160	80,000
17	Sithi Mony	800,000	24,750	120,000	40,000
18	Khoeum Bunthai	2,000,000	7,200	100,000	80,000
19	Hun Houn	1,000,000	16,350	152,000	40,000
20	Oeun Kim Hun	2,000,000	12,000	200,000	60,000
21	Ly Chai Heang	2,000,000	19,950	400,000	150,000
22	Som Sophal	1,785,000	25,950	160,000	100,000
23	Peang Vannak	1,000,000	30,000	120,000	20,000
24	Top KimHav	600,000	12,000	80,000	120,000
25	Sav Yuk Kunthor	12,000,000	6,000	280,000	200,000
26	Koe Bun Heang	400,000	13,950	28,700	40,000
27	Seng Khay	800,000	20,400	119,700	80,000
28	Sum Puy	750,000	20,000	99,000	60,000
29	Ton Vanna	1,200,000	25,950	90,000	60,000
30	Chan Rom	2,000,000	19,950	90,000	20,000
31	Ngem Sokhum	586,000	14,400	80,000	41,000
32	Lim Peach	1,400,000	18,000	100,000	200,000
33	Leng Siv Tav	1,600,000	15,150	60,000	80,000

34	Tan Bo Song	2,000,000	17,550	100,000	20,000
35	Dab SoBory	600,000	27,600	110,000	80,000
36	Chhoeun Lay	400,000	14,400	65,000	80,000
37	Koe Sothea	2,500,000	18,000	125,000	120,000
38	Van Yung Eak	2,000,000	27,600	85,000	80,000
Median		**1200000**	**18375**	**100000**	**80000**
			1.53%		**16.5%**

Table 11 Contribution of water cost, electricity cost, and telephone cost to monthly expenditure
For high water consumer

No	Respondent Name	Expenditure	Water cost	Electricity cost	Telephone cost
1	Ly Sounly	3,500,000	84,000	500,000	120,000
2	Si Na	1,000,000	40,000	50,000	20,000
3	Kim Meang Ry	1,050,000	34,800	55,760	15,000
4	Phally Vanndath	600,000	55,950	123,540	200,000
5	Chhiv Yong	1,400,000	36,750	9,000	40,000
6	Chrik Pov	1,230,000	42,000	52,800	41,000
7	Chhong Chamroeun	2,000,000	63,600	140,000	80,000
8	Ouk Sam Art	2,000,000	80,000	200,000	120,000
9	Ouk Savoeun	2,000,000	63,600	150,000	200,000
10	Kov Hai	1,250,000	46,800	200,000	40,000
11	Soun Vuthy	1,200,000	34,350	120,000	240,000
12	Hong Bunthy	3,200,000	135,150	120,000	40,000
13	Tap Bun Chhoy	1,500,000	48,000	130,000	60,000
14	Siv Bunrith	1,345,000	50,000	287,000	80,000
15	Pik Pak	1,318,000	38,400	400,000	40,000
16	Ek Khin	1,600,000	51,600	320,000	80,000
17	Thyda	2,400,000	36,000	200,000	120,000
18	Porn Phearak	2,400,000	42,000	80,000	120,000
19	Bun Chi Na	1,050,000	37,950	100,000	20,000
20	Lim Meng Kang	1,500,000	37,200	76,260	80,000
21	Lim Kang	2,000,000	45,600	54,900	120,000
22	Bun Raoth	1,400,000	48,750	150,000	80,000
23	Doung Sarim	1,800,000	75,000	300,000	40,000
24	Lim Tang	900,000	40,000	485,000	20,000
25	Ngoy Malay	2,870,000	44,400	250,000	120,000
26	Noun Chhun	3,200,000	91,950	50,000	60,000
27	Kheng Ta	1,360,000	33,150	140,000	60,000
28	Loeung Visith	1,800,000	49,200	200,000	120,000
29	Noun Nal	600,000	35,600	139,400	12,000
30	Ming Cheng	2,000,000	50,000	200,000	60,000
31	Ros Srey	400,000	27,000	300,000	100,000
32	Ly NaRon	2,400,000	50,400	287,000	120,000
33	Thong Sokha	11,000,000	40,800	164,000	60,000
34	Top Sokha	1,500,000	72,000	328,000	162,000
35	Keam Vannak	2,100,000	79,200	400,000	80,000
Median		**1,500,000**	**46,800**	**150,000**	**80,000**
			3.12%		**18.5%**

Of the respondents in the service area consumed SRWSA supplied water for daily consumption. Some of them also use deep wells to meet their excessive needs due to the fact that they need more water for their business and could not afford for monthly water expenditure.

4.2.3 Water consumption

A number of questions arise for water consumption in an attempt to study consumption patterns of households. For example, where do households obtain their water? How much water do different types of household consume? how many person in family? do you share water consumption with other household? Therefore, water consumption can be answered through such essential questions. As a result, it is found that the water consumption quantities vary amongst consumers. The quantities of water consumed are 60.1, 100.3, and 168.2 liters per day per person for low, medium, and high water consumers, respectively (Table 12, 13, and 14). They are also summarized as in figure 2. Such consumptions were found to be for general purposes such as cooking, washing, bathing, and drinking. On the other hand, the major water consumptions are different from household to household. The respondents' major consumptions are 51%, 35%, and 14% for cooking, drinking, and bathing, respectively.

Table 12 Water quantity consumed by low water consumer

No	Respondent name	Low water consumer					
		Family member	Relatives	Monthly water consumption (m^3)	People sharing	Total People Use Water	Liters per day
1	Koe Samnang	5		7.00		5	46.7
2	Kro Him	2		6.00		2	100.0
3	Heak Kim Cheang	4	2	10.00		6	55.6
4	Chin Ouleang	3	1	7.00		4	58.3
5	Lov Samoeun	3	3	10.00	3	9	37.0
6	Ly Kunthea	1	1	6.00		2	100.0
7	Pia Pouly	2		10.00		2	166.7
8	Eang Phall	5	2	6.00		7	28.6
9	Sav Virak	6		10.00		6	55.6
10	Soun Srey Vorn	6		9.00		6	50.0
11	Leng Bang	6		10.00		6	55.6
12	Thun Sokhun	3		10.00		3	111.1
13	Pan Heu	4	1	6.00		5	40.0
14	Chhou Sreng	4		9.00		4	75.0
15	Ong Tea Sia	4		4.00		4	33.3
16	Nia Sim	2		3.00		2	50.0
17	Bun Leng	4		9.00		4	75.0
18	Than Na	6		3.00		6	16.7
19	Peach Kari Raoth	5	1	2.00		6	11.1
20	Por Moa	2	1	2.00		3	22.2
21	Long Sora Ny	6		10.00		6	55.6
22	Chan Sokunthea	3		5.00		3	55.6
23	Sun Kong	5		8.00		5	53.3
24	Hear Lay	2		8.00		2	133.3
25	Ol Phalla	5		7.00		5	46.7
26	Touch Savonn	4	3	9.00		7	42.9
27	Yo Ying	5	2	10.00		7	47.6
						Average	**60.1**

Table 13 Water quantity consumed by medium water consumer

No	Respondent name	Medium water consumer					
		Family member	Relatives	Monthly water consumption (m^3)	People sharing	Total People Use Water	Liters per day
1	Chea Pov	5		18.00		5	120.0
2	Chea Vanna	5		15.00		5	100.0
3	Seang Kim Thav	6		15.00		6	83.3
4	Sok Rin	5		24.00	1	6	133.3
5	Chhor Visak	5		18.00		5	120.0
6	Prak Kunthy	5		17.00		5	113.3
7	Chhong Hout	5		11.00		5	73.3
8	Sok Kim Chhoun	5	1	11.00		6	61.1
9	Meas Phalkea	4		11.00		4	91.7
10	Kim Yeang	4	2	15.00		6	83.3
11	Korina	4	1	17.00		5	113.3
12	E Romdol	4	1	19.00	1	6	105.6
13	Kim Iv	4	2	11.00	2	8	45.8
14	Keang Vign	5	1	25.00	1	7	119.0
15	Suth Thyda	2	3	14.00	3	8	58.3
16	Samrith Chanrathana	7		23.00		7	109.5
17	Sithi Mony	5		20.00		5	133.3
18	Khoeum Bunthai	2		11.00		2	183.3
19	Hun Houn	4		12.00		4	100.0
20	Oeun Kim Hun	5		11.00		5	73.3
21	Ly Chai Heang	2	1	19.00		3	211.1
22	Som Sophal	9		21.00		9	77.8
23	Peang Vannak	4		25.00	6	10	83.3
24	Top KimHav	6		11.00		6	61.1
25	Sav Yuk Kunthor	4	1	15.00		5	100.0
26	Koe Bun Heang	2	1	11.00		3	122.2
27	Seng Khay	4		17.00		4	141.7
28	Sum Puy	5		17.00		5	113.3
29	Ton Vanna	5		20.00		5	133.3
30	Chan Rom	12		16.00		12	44.4
31	Ngem Sokhum	3		12.00		3	133.3
32	Lim Peach	6		15.00		6	83.3
33	Leng Siv Tav	7		12.00		7	57.1

No	Respondent name	Medium water consumer					
		Family member	Relatives	Monthly water consumption (m^3)	People sharing	Total People Use Water	Liters per day
34	Tan Bo Song	6		14.00		6	77.8
35	Dab SoBory	3	1	23.00	9	13	59.0
36	Chhoeun Lay	4	1	12.00		5	80.0
37	Koe Sothea	5	1	15.00		6	83.3
38	Van Yung Eak	5	1	23.00		6	127.8
						Average	**100.3**

Table 14 Water quantity consumed by high water consumer

No	Respondent name	High water consumer					
		Family member	Relatives	Monthly water consumption (m^3)	People sharing	Total People Use Water	Liters per day
1	Ly Sounly	6		70.00		6	388.9
2	Si Na	5		50.00	8	13	128.2
3	Kim Meang Ry	6	1	29.00		7	138.1
4	Phally Vanndath	7		40.00		7	190.5
5	Chhiv Yong	7		30.00		7	142.9
6	Chrik Pov	7	3	35.00		10	116.7
7	Chhong Chamroeun	11		53.00		11	160.6
8	Ouk Sam Art	4		97.00	10	14	231.0
9	Ouk Savoeun	6		53.00	12	18	98.1
10	Kov Hai	6	4	39.00		10	130.0
11	Soun Vuthy	7		28.00		7	133.3
12	Hong Bunthy	12		112.00	15	27	138.3
13	Tap Bun Chhoy	7	3	40.00	3	13	102.6
14	Siv Bunrith	5	7	65.00	7	19	114.0
15	Pik Pak	5	10	32.00		15	71.1
16	Ek Khin	7		43.00		7	204.8
17	Thyda	6		30.00		6	166.7
18	Porn Phearak	4		35.00		4	291.7
19	Bun Chi Na	4		30.00	5	9	111.1
20	Lim Meng Kang	7		31.00		7	147.6
21	Lim Kang	10		38.00		10	126.7
22	Bun Raoth	5		45.00		5	300.0
23	Doung Sarim	7	1	100.00	6	14	238.1

No	Respondent name	High water consumer					
		Family member	Relatives	Monthly water consumption (m^3)	People sharing	Total People Use Water	Liters per day
24	Lim Tang	4	16	98.00	16	36	90.7
25	Ngoy Malay	5	3	37.00		8	154.2
26	Noun Chhun	8	15	76.00		23	110.1
27	Kheng Ta	6	1	27.00		7	128.6
28	Loeung Visith	8	1	41.00		9	151.9
29	Noun Nal	6		43.00		6	238.9
30	Ming Cheng	7	1	40.00		8	166.7
31	Ros Srey	8		30.00		8	125.0
32	Ly NaRon	8		42.00		8	175.0
33	Thong Sokha	7		34.00		7	161.9
34	Top Sokha	10		60.00		10	200.0
35	Keam Vannak	7		66.00		7	314.3
						Average	**168.2**

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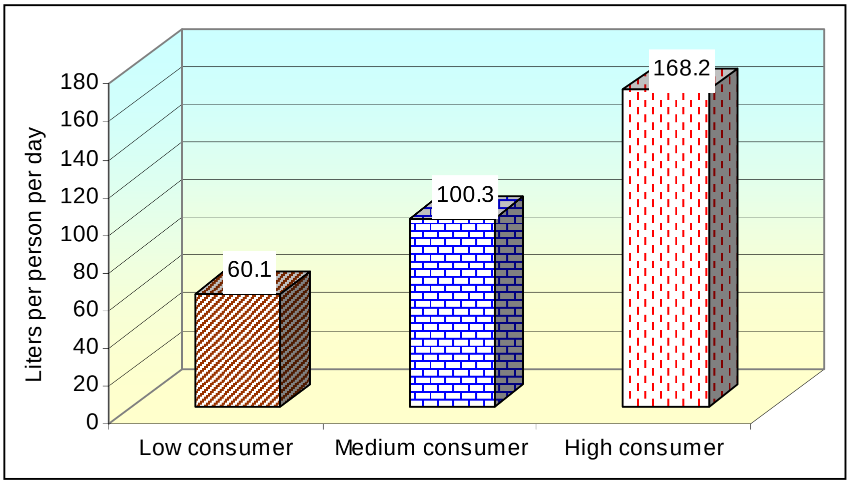

Figure 2 Water quantity consumed by different consumers

4.2.4 Satisfactory with the water supply service

All of the interviewed households enjoyed 24-hour water supply service. 95% of the households satisfied with the current service (figure 3). This is due to the fact that the service provides enough and safe water for consumption purposes and reduces time consuming.

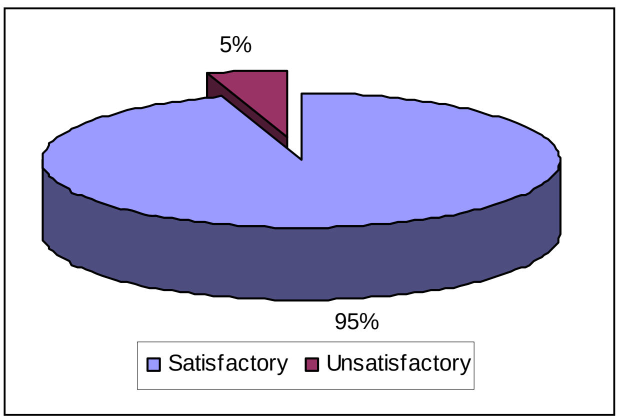

Figure 3 Percentage of satisfactory to the water supply service

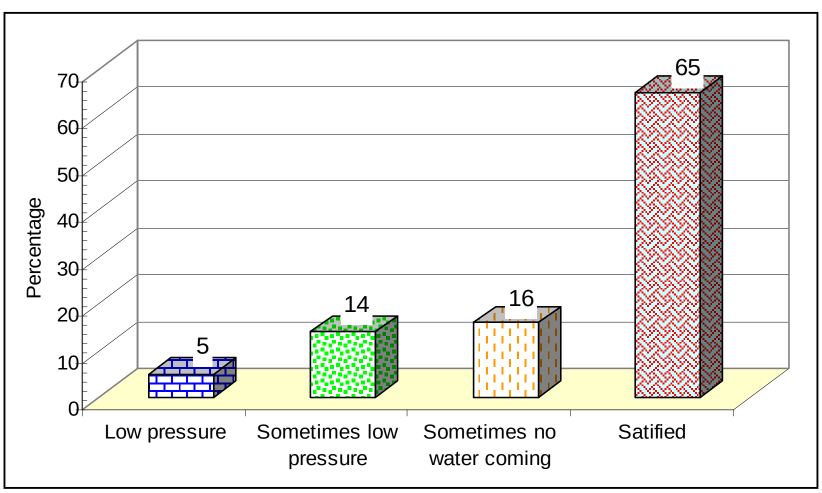

Figure 4 Satisfactory with the current water pressure

Although they have satisfied with such service, some of those think that water tariff seems to be high and should be reduced as low as possible. However, very few respondents still did not satisfy with the service due to sometimes there was no water coming and not enough water for their general consumptions. In term of water pressure, 65% of the respondents satisfied with the currently provided pressure, while 16%, 14%, and 5% reported that there were sometimes no water coming, sometimes low pressure, and completely low pressure, respectively (Figure 4).

Providing access to water services and sanitation is an integral part of the Government's efforts to improve health and living conditions in Cambodia and to meet the related Cambodia Millennium Development Goals. Regarding to drinking water, in the Siem Reap city at the present time, the SRWSA supplied water is considered to be clean. However, no any household drank water directly. This means that the city water supply is still used for drinking purpose, but prior to drinking, water is boiled to minimize diseases. In this regard, 57% of the respondents drank the supplied water by boiling, while the other 43% drank pure water instead. In terms of water quality, it seems to be not a significant problem. Yet, 17% and 3% of the consumers also complain about chlorine smell and color (high turbidity), respectively.

4.2.5 Waterborne diseases

Waterborne diseases are dirty-water diseases caused by water that has been contaminated. The lack of sanitary waste disposal and of clean water for drinking, cooking, and washing is one of the critical problems for such diseases. Of the respondents, only 3% were found to be infected by the diseases such as Typhoid, Dengue fever, and Skin infection. Those also reported that there was no a clear evidence to define if such diseases are from water. It might be from any other source. The costs of medical treatment were reported to be lesser than that of other diseases which were usually occurred in their families. Yet, the costs were mostly not reported. The costs of only two families (US$ 25 and US$ 100) were reported.

4.2.6 Request to SRWSA

In an attempt to improve the current service, only 10 % of the respondents used to request to SRWSA for service improvement such quantity and quality. Apart from these, to reduce water tariff and discount connection charge as much as possible are the most important needs.

4.2.7 Sanitary facilities

Sanitary facility in particular sanitary latrine is one of several factors to understand people health condition. Without it, it is likely to have serious problems to health. In the service area, of the interviewed households use sanitary latrine (73% use latrine with septic tank and 27% use latrine connected to the city drainage system). Thus, sanitation facilities are quite good. Asking about willingness to connect to the system, 85% of the respondents said that they will be glad to connect to the city sewerage system if the system is constructed, while 9% of those reported that they will disconnect to the system (figure 5). On the other hand, respondents 6% acknowledged they will connect to the system, but it depends mainly on charge. It seems to be hard for them to decide at the present time not knowing if to connect or not. If the connection cost is not so high, they will be very pleased to do as well.

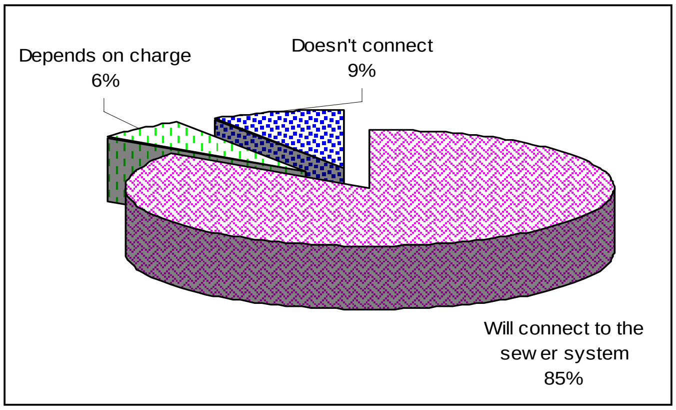

Figure 5 Willingness to connect to the sewerage system

4.2.8 Public works need to be improved

All of the respondents were asked to show their opinions regarding to the improvements of the public works. The core objective is to know if water supply and sewerage system are generally in their priorities or not? As a result, it is revealed that the major priorities of the public works, that should be improved, are illustrated in descending percentage as in figure 9. It is found that sewerage system is the first priority, followed by Road network, Water supply, Education system, Medical system, and Preservation for the heritage, respectively.

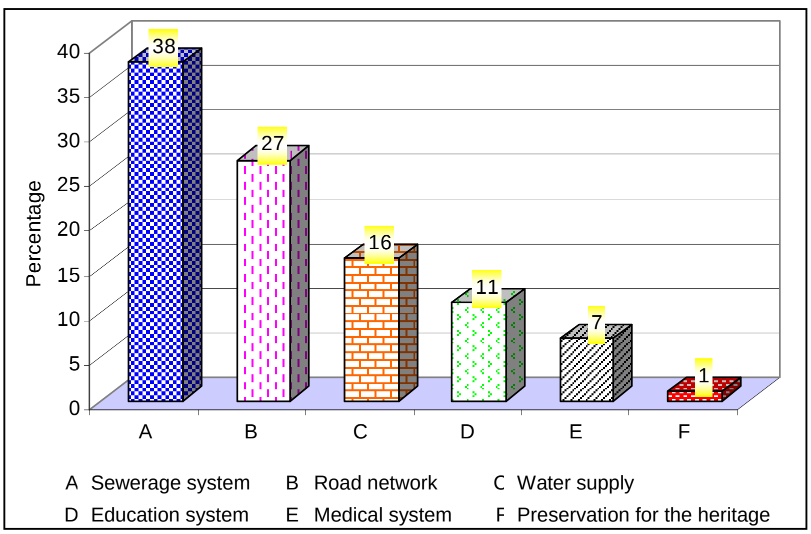

Figure 6 Public works should be improved

4.3 The Non service area settings

Similar to the service area, prior to understanding relevant aspects, respondents were asked to identify their positions in the family, education, and so on. This provided data consistency and a basic reference for their response. Of this, the respondents are 72% and 28% for household heads and spouses of household heads, respectively. Although their educations were mostly found within primary and secondary schools, they also provided good response to the interviewers.

4.3.1 House ownership and occupations

All of the respondents such as poor, medium, and better off households have their own houses for either living or conducting businesses. The occupations of the poor household are mainly farmers, small scale business owner, NGOs staff, motorbike taxi driver, government employee, and construction worker. The other occupations are small round basket/sieve producer, tailor, and laundry service provider. The information regarding to the poor household occupations is shown as in table 15.

Table 15 The occupation of poor household

Occupation	Number of respondent	Percentage
Farmer	16	46
Small scale business owner	6	18
NGOs/IOs staff	3	9
Motor taxi driver	2	6
Government Employee	1	3
Construction worker	1	3
Others	5	15

For medium households, their occupations are farmer, small scale business owner, construction worker, government employee, private company/factory worker, and transportation service provider. The other occupations are car repairer, tailor, fisherman, and tour guide. The information regarding to the medium household occupations is shown as in table 16.

Table 16 The occupation of medium household

Occupation	Number of respondent	Percentage
Farmer	14	43
Small scale business owner	8	24
Construction worker	3	9
Government Employee	3	9
Worker at private company/Factory	1	3
Others	4	12

For better off households, their occupations are farmer, small scale business owner, government employee, transportation service provider, and private company/factory worker. The other occupations are fish businessman, tailor, basket producer, and airport staff. The information regarding to the better off household occupations is shown as in table 17.

Table 17 The occupation of better off household

Occupation	Number of respondent	Percentage
Farmer	12	37
Small scale business owner	7	21
Government Employee	5	15
Transportation service provider	2	6
Worker at private company/Factory	1	3
Others	6	18

4.3.2 Household or family income

The information on monthly household income and expenditure were presented. The income and expenditure here were classified into three categories: poor, medium and better off households. It is found that total monthly expenditures are 57.5, 127.5, and US$ 187.5, while total monthly incomes are 75, 187.5, and US$ 250 for poor, medium, and better off, respectively (Table 18, 19, and 20). They are summarized as in figure 7.

Table 18 Monthly income and expenditure of poor household

No	Respondent name	Poor household			
		Monthly income (Riel)	Monthly income (US$)	Monthly expenditure (Riel)	Monthly income (US$)
1	Mia Heng	354000	88.5	360000	90
2	Proch Boeuy	500000	125	350000	87.5
3	Pech Youn	450000	112.5	600000	150
4	San Nan	220000	55	220000	55
5	Sam Sa Morn	360000	90	300000	75
6	Han Sun	120000	30	90000	22.5
7	Soeun So Von	300000	75	150000	37.5
8	Hoeun Leam	160000	40	120000	30
9	Lam Samai	150000	37.5	90000	22.5
10	Sorng Som	400000	100	302000	75.5
11	Vann Bich	400000	100	300000	75
12	Man Mean	600000	150	240000	60
13	Huy Phan	450000	112.5	300000	75
14	Koe Kong	300000	75	300000	75
15	Lom Moeun	100000	25	100000	25
16	Voeun Veth	300000	75	240000	60
17	Yea Kon	200000	50	200000	50
18	Thean Much	200000	50	150000	37.5
19	Moeu Ya	200000	50	200000	50
20	Hing Loeuy	200000	50	150000	37.5
21	Hib Yan	300000	75	150000	37.5
22	Chun Chhisa	300000	75	210000	52.5
23	Proeun Pream	360000	90	310000	77.5
24	Chan Sa Eam	750000	187.5	670000	167.5
25	Lot Vanny	900000	225	750000	187.5
26	Chin Chindaroath	900000	225	600000	150
27	Chrek Phanh	189000	47.25	150000	37.5
28	Makh Silang	150000	37.5	125000	31.25
29	Vai Sor	200000	50	150000	37.5
30	Krong Rithy	1000000	250	1600000	400

No	Respondent name	Poor household			
		Monthly income (Riel)	Monthly income (US$)	Monthly expenditure (Riel)	Monthly income (US$)
31	Peach Houn	660000	165	600000	150
32	Makh Savy	100000	25	80000	20
33	Chhork Va	100000	25	80000	20
34	Sun Samnag	480000	120	300000	75
	Average	363323.5	90.8	309911.8	77.47794
	Median	**300000**	**75**	**230000**	**57.5**

Table 19 Monthly income and expenditure of medium household

No	Respondent name	Medium household			
		Monthly income (Riel)	Monthly income (US$)	Monthly expenditure (Riel)	Monthly income (US$)
1	Doung Kim Korng	660000	165	600000	150
2	Norng Polan	650000	162.5	600000	150
3	Ly Raksmey	900000	225	400000	100
4	Porn Pot	500000	125	400000	100
5	Som Soeun	1000000	250	600000	150
6	Som Si Nang	900000	225	750000	187.5
7	Chhoun Kim	900000	225	600000	150
8	Seng Norm	1250000	312.5	1050000	262.5
9	Soeun Lun	820000	205	660000	165
10	Sam Thyda	1170000	292.5	535000	133.75
11	Ros Prem	300000	75	270000	67.5
12	Chhem Mom	540000	135	510000	127.5
13	Soeun Rorn	210000	52.5	150000	37.5
14	Chhoung Chhoun	300000	75	300000	75
15	Thoeum Phat	700000	175	600000	150
16	Chlang Von	750000	187.5	323000	80.75
17	Chhen Voeun	375000	93.75	330000	82.5
18	Seng Houk	200000	50	200000	50
19	Kong Chong	300000	75	300000	75
20	Ngem Sothai	950000	237.5	750000	187.5
21	Hub Pheap	900000	225	400000	100
22	Thoun Sophov	400000	100	310000	77.5
23	Chea Soeum	570000	142.5	395000	98.75
24	Chan Sok	1250000	312.5	1000000	250
25	Plong Dany	1600000	400	600000	150
26	Chrik Kea	180000	45	150000	37.5
27	Chhav Thai	900000	225	450000	112.5
28	Vin Vai	450000	112.5	360000	90
29	Chhieb Ngab	1000000	250	600000	150
30	Kat Sary	900000	225	490000	122.5
31	Math Lop	4200000	1050	600000	150
32	Chhoeun Thy	600000	150	600000	150
33	Som Sophan	880000	220	600000	150
	Average	824394	206	499485	125
	Median	**750000**	**187.5**	**510000**	**127.5**

Table 20 Monthly income and expenditure of better off household

No	Respondent name	Better off household			
		Monthly income (Riel)	Monthly income (US$)	Monthly expenditure (Riel)	Monthly income (US$)
1	Kroy Thou Lyda	900000	225	900000	225
2	Kok Khorn	1200000	300	600000	150
3	Unn Bunthy	2400000	600	1200000	300
4	Eang Chenda	920000	230	500000	125
5	Chhoeun Moeut	750000	187.5	640000	160
6	Som Chhoeu	1500000	375	1390000	347.5
7	Dary Pesith	1800000	450	1660000	415
8	Som Noeum	1200000	300	1.20E+07	3000
9	Seng Saran	1200000	300	1050000	262.5
10	Chay Horm	1500000	375	1000000	250
11	Sorn Sum	800000	200	356000	89
12	Hoar Hour	3000000	750	2000000	500
13	Prok Prorn	750000	187.5	600000	150
14	Loa Sara	900000	225	300000	75
15	Soy Chay	1000000	250	300000	75
16	Uon Cham	480000	120	450000	112.5
17	Sor Saroeun	600000	150	450000	112.5
18	Un Hay Nam	600000	150	210000	52.5
19	Nuon Neu	600000	150	300000	75
20	Morn Bun Mey	1200000	300	400000	100
21	Ly Lay	900000	225	800000	200
22	Chan Sokha	1200000	300	900000	225
23	Liam Sambath	2400000	600	1290000	322.5
24	Chan Phorn	2000000	500	900000	225
25	Kun Votthorn	1550000	387.5	1200000	300
26	Sin Proeung	300000	75	210000	52.5
27	Seng Ngim	1200000	300	750000	187.5
28	Ly Hap	1600000	400	1200000	300
29	Mom Pok	900000	225	644000	161
30	Hong Sambo	850000	212.5	510000	127.5
31	Chhoeun Mao	850000	212.5	660000	165
32	Chhoeun Yanh	1000000	250	1000000	250
33	Lan Sothearak	2500000	625	1200000	300
Average		1228788	307	1138485	285
Median		**1000000**	**250**	**750000**	**187.5**

Note: 1 US$ = 4000 Riel was calculated in this study

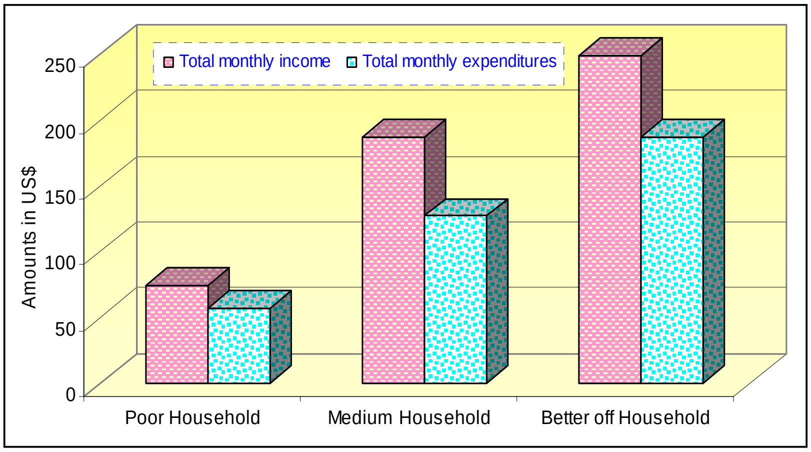

Figure 7 Household's monthly income and expenditure

Table 21 Relationship wealth group, well type, use pump, and Operation and Maintenance cost

Wealth group			Well type		Use pump		Operation and maintenance cost (US$)	
Poor	Medium	Better off	Open ring well	Tube well				
Yes			Yes		Yes		No case was found	
Yes			Yes			No	No case was found	
Yes				Yes	Yes		5 to 25	5
								18
								25
								25
							Average=18.3	
Yes				Yes		No	1.25 to 12.5	5
								5
								5
								5
								5
								5
								5
								5
								7.5
								12.5
							Average=6	
	Yes		Yes		Yes		No case was found	
	Yes		Yes			No	No case was found	
	Yes			Yes	Yes		5 to 25	5
								6.25
								25
								25
								25
								25
								25
								25
								25
								25
							Average=21.1	
	Yes			Yes		No	5 to 17.5	5
								5
								5
								5
								5

Wealth group			Well type		Use pump		Operation and maintenance cost (US$)	
Poor	Medium	Better off	Open ring well	Tube well				
								5.5
								6.25
								7.5
								7.5
								15
								17.5
								Average=7.66
		Yes	Yes		Yes		1.25 to 3.7	1.25
								3.7
								Average=2.5
		Yes	Yes			No	No case was found	
		Yes		Yes	Yes		5 to 25	5
								9.75
								10
								10
								11
								11
								12.5
								17.5
								20
								20
								25
								25
								25
								25
								25
								25
								25
								25
								25
								Average=18.5
		Yes		Yes		No	6 to 7.5	6
								7.5
								Average=6.8

Moreover, the total monthly pumping costs are relatively different. It is found that the costs ranged from 1.5 to US$ 2.75, from 2.5 to US$ 7.5 and 2.5 to US$ 25 for poor, medium, and better off households, respectively.

Regarding to well operation and maintenance costs (O&M costs), for the poor households using only open ring wells, there is no cost. If they use tube wells with and without pump, the costs ranged from 1.25 to US$ 12.5 and 5 to US$ 25 per year, respectively. Similarly, for medium households, if they use only open ring wells, there is no cost. Yet, if they use tube wells with and without pump, the costs ranged from 5 to US$ 25 and 5 to US$ 17.5 per year, respectively. For better off households, if they use open ring wells with pump, the cost ranged from 1.25 to US$ 3.5. No any case was found regarding to using open ring well without pump within this household category. However, if these households use tube wells with and without pump, the costs ranged from 5 to US$ 25 and 6 to US$ 7.5 per year, respectively. Such explanation can be summarized as in table 21.

4.3.3 Water sources

All of the households in the Siem Reap city, which is located outside the water supply service area, still depends on self-provision through groundwater abstraction such as tube wells and open ring ones (figure 8a & b) as well as from family systems (rainwater collected in small jars).

Currently, it is found that around 82% use open ring wells, 14% use tube wells, and 4% use communal wells. Apart from this, rain water collection is still used to supplement their daily needs. On the other hand, the distance from their homes to open ring well water source is mostly less than 20 meters (about 93%), while the the distance of tube well is also less than 20 meters (about 94%). Identically, the distance from home to communal wells was also found to be less than 20 meters. Generally, the location of tap of houses were found mostly outside their houses. It is found that 76% and 86% of the tap locations are outside their houses for deep wells and open ring ones. In term of communal well, the tap location is found to be completely outside users' houses.

Figure 8 a) Deep/tube wells   b) Open ring well

4.3.4 Water consumption

Water consumption in the non service area seem to be hard to estimate consumption amounts (liters per person per day). However, in the attempt to generate realistic data many detailed questions were used in parallel with observations via consumption patterns of households. For instance, how many times do you and your family members collect water from your well per day? What are the means for the water collection? What are the means for keeping the collected water? Do all of your family members consume the collected water? if no, how many members do they consume water directly from well? The respondents were also asked to count their family members including children. Of the questions, they were calculated and applied for the dry and rainy seasons. This is helpful to get an accurate figure regarding to the actual comsumption per day per household either in the dry season or the rainy one. As a result, it is found that the water consumption quantities vary amongst three different households: Poor, Medium, and Better off households. Also, the consumption amounts were different between the seasons.

Table 22 Water quantity consumed in the dry season

The Dry Season								
Poor household			**Medium household**			**Better off household**		
No.	**Interviewee name**	**Lrs/Person/Day**	**No.**	**Interviewee name**	**Lrs/Person/Day**	**No.**	**Interviewee name**	**Lrs/Person/Day**
1	Mia Heng	75	1	Doung Kim Korng	91	1	Kroy Thou Lyda	187
2	Proch Boeuy	200	2	Norng Polan	128	2	Kok Khorn	111
3	Pech Youn	125	3	Ly Raksmey	80	3	Unn Bunthy	111
4	San Nan	40	4	Porn Pot	67	4	Eang Chenda	91
5	Sam Sa Morn	120	5	Som Soeun	83	5	Chhoeun Moeut	150
6	Han Sun	120	6	Som Si Nang	166	6	Som Chhoeut	187
7	Soeun So Von	75	7	Chhoun Kim	150	7	Dary Pesith	170
8	Hoeun Leam	200	8	Seng Norm	145	8	Som Noeum	142
9	Lam Samai	120	9	Soeun Lun	180	9	Seng Saran	143
10	Sorng Som	140	10	Sam Thyda	170	10	Chay Horm	340
11	Vann Bich	85	11	Ros Prem	140	11	Sorn Sum	130
12	Man Mean	62	12	Chhem Mom	150	12	Hoar Hour	70
13	Huy Phan	104	13	Soeun Rorn	138	13	Prok Prorn	125
14	Koe Kong	100	14	Chhoung Chhoun	86	14	Loa Sara	80
15	Lom Moeun	75	15	Thoeum Phat	120	15	Soy Chay	150
16	Voeun Veth	150	16	Chlang Von	150	16	Uon Cham	140
17	Yea Kon	100	17	Chhen Voeun	150	17	Sor Saroeun	180
18	Thean Much	100	18	Seng Houk	36	18	Un Hay Nam	100
19	Moeu Ya	90	19	Kong Chong	62	19	Nuon Neu	93
20	Hing Loeuy	30	20	Ngem Sothai	160	20	Morn Bun Mey	100
21	Hib Yan	150	21	Hub Pheap	36	21	Ly Lay	150
22	Chun Chhisa	150	22	Thoun Sophov	160	22	Chan Sokha	200
23	Proeun Pream	160	23	Chea Soeum	80	23	Liam Sambath	100
24	Chan Sa Eam	120	24	Chan Sok	165	24	Chan Phorn	100
25	Lot Vanny	175	25	Plong Dany	120	25	Kun Votthorn	190
26	Chin Chindaroath	60	26	Chrik Kea	110	26	Sin Proeung	150
27	Chrek Phanh	100	27	Chhav Thai	80	27	Seng Ngim	70
28	Makh Silang	75	28	Vin Vai	180	28	Ly Hap	185
29	Vai Sor	150	29	Chhieb Ngab	170	29	Mom Pok	166
30	Krong Rithy	100	30	Kat Sary	110	30	Hong Sambo	185
31	Peach Houn	75	31	Math Lop	83	31	Chhoeun Mao	160
32	Makh Savy	40	32	Chhoeun Thy	50	32	Chhoeun Yanh	333
33	Chhork Va	100	33	Som Sophan	150	33	Lan Sothearak	43
34	Sun Samnag	120						
	Average	**108**		**Average**	**120**		**Average**	**146**
	Median	**100**		**Median**	**128**		**Median**	**143**

Note: Lrs/Person/Day = Liters per person per day

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Table 23 Water quantity consumed in the rainy season

The Rainy Season								
Poor household			**Medium household**			**Better off household**		
No.	**Interviewee name**	**Lrs/Person/Day**	**No.**	**Interviewee name**	**Lrs/Person/Day**	**No.**	**Interviewee name**	**Lrs/Person/Day**
1	Mia Heng	62	1	Doung Kim Korng	91	1	Kroy Thou Lyda	150
2	Proch Boeuy	200	2	Norng Polan	85	2	Kok Khorn	83
3	Pech Youn	83	3	Ly Raksmey	80	3	Unn Bunthy	111
4	San Nan	40	4	Porn Pot	67	4	Eang Chenda	91
5	Sam Sa Morn	80	5	Som Soeun	83	5	Chhoeun Moeut	100
6	Han Sun	100	6	Som Si Nang	111	6	Som Chhoeut	160
7	Soeun So Von	50	7	Chhoun Kim	120	7	Dary Pesith	130
8	Hoeun Leam	160	8	Seng Norm	110	8	Som Noeum	71
9	Lam Samai	120	9	Soeun Lun	120	9	Seng Saran	143
10	Sorng Som	140	10	Sam Thyda	100	10	Chay Horm	340
11	Vann Bich	62	11	Ros Prem	100	11	Sorn Sum	110
12	Man Mean	50	12	Chhem Mom	110	12	Hoar Hour	70
13	Huy Phan	83	13	Soeun Rorn	123	13	Prok Prorn	100
14	Koe Kong	100	14	Chhoung Chhoun	57	14	Loa Sara	40
15	Lom Moeun	38	15	Thoeum Phat	110	15	Soy Chay	70
16	Voeun Veth	100	16	Chlang Von	120	16	Uon Cham	140
17	Yea Kon	100	17	Chhen Voeun	100	17	Sor Saroeun	125
18	Thean Much	100	18	Seng Houk	36	18	Un Hay Nam	75
19	Moeu Ya	60	19	Kong Chong	50	19	Nuon Neu	62
20	Hing Loeuy	15	20	Ngem Sothai	110	20	Morn Bun Mey	100
21	Hib Yan	100	21	Hub Pheap	36	21	Ly Lay	52
22	Chun Chhisa	150	22	Thoun Sophov	120	22	Chan Sokha	150
23	Proeun Pream	130	23	Chea Soeum	60	23	Liam Sambath	100
24	Chan Sa Eam	100	24	Chan Sok	120	24	Chan Phorn	100
25	Lot Vanny	120	25	Plong Dany	100	25	Kun Votthorn	125
26	Chin Chindaroath	60	26	Chrik Kea	75	26	Sin Proeung	140
27	Chrek Phanh	70	27	Chhav Thai	80	27	Seng Ngim	50
28	Makh Silang	50	28	Vin Vai	120	28	Ly Hap	120
29	Vai Sor	110	29	Chhieb Ngab	120	29	Mom Pok	140
30	Krong Rithy	100	30	Kat Sary	100	30	Hong Sambo	130
31	Peach Houn	50	31	Math Lop	83	31	Chhoeun Mao	120
32	Makh Savy	40	32	Chhoeun Thy	38	32	Chhoeun Yanh	333
33	Chhork Va	80	33	Som Sophan	100	33	Lan Sothearak	43
34	Sun Samnag	80						
	Average	**89**		**Average**	**92**		**Average**	**117**
	Median	**83**		**Median**	**100**		**Median**	**110**

Note: Lrs/Person/Day = Liters per person per day

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In the rainy season, the quantities of water consumption were found to be 83, 100, and 110 liters per person per day for poor, medium, and better off households. In the dry season, the quantities were 100, 128, and 143 liters per person per day for poor, medium, and better of households, respectively (Table 22 and 23). They are also summarized as in figure 9.

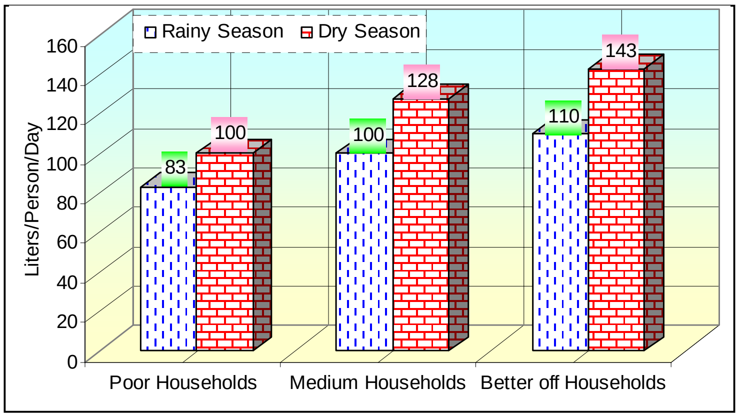

Figure 9 Water consumption in dry and in rainy seasons

Similar to the service area, such consumptions were found to be for general purposes such as cooking, washing, bathing, and drinking. Besides, well water source is used for home gardening and also for animal raisings.

Table 24 Yearly well's operation and maintenance cost

yearly operation and maintenance cost by well type			
Tube well (Riel)	Frequency	Open ring well (Riel)	Frequency
20000	17	5000	3
22000	1	14700	1
24000	1	15000	1
25000	2	20000	1
30000	4	- Only 6 of the 13 cases were reported for the open ring well.	
39000	1		
40000	2		
44000	2	-57 of the 79 cases were reported for the tube well.	
50000	2		
60000	1		
70000	2	Apart from these, people in the non service area use communal well	
72000	1		
80000	2		
100000	19		
Min= 5 US$, Max= 25 US$ Median = 11 US$		Min = 1.25 US$, Max= 5 US$ Median = 2.25 US$	

The quantities of water consumed are usually higher than that of households in the service area because of water sources is free of charge. Also, carelessness of water without saving sense is found. On the other hand, 45% of the respondents use pumps to ease their livings. Regarding to water quality, based on the surveyed findings indicate that colour (high turbidity) is a major problem, followed by odour, and taste. 40% of the respondents were reported to these problems. To minimize such problems, only 5% treat their wells using filters. Furthermore, most of the respondents have no quantitative problems. Only 4% of them were lack of water from march to may. The uses of open ring wells and tube ones are always faced with manternaince costs.

It was found that people using open ring wells, the costs ranged from 1.25 to 5 US$, on the median basis, the cost is 2.25 US$ per year. On the other hand, people using tube wells, the costs ranged from 5 to 25 US$. On the median basis, the cost was 11 US$ (Table 24).

4.3.5 Willingness to connect to and to pay for the new water supply

Respondents' opinions in association with their willingness to connect to the new water supply system was surveyed. As a result, 70% of the respondents will connect to the system whenever its construction is finished without considering of the connection costs. 11% of the respondents replied No idea (figure 10). This means that they seem to hesitate to provide the answer at the present time, some of whom mentioned that if their neighbors connect to the system, they will also do. However, 19% of the respondents say No to the new system. They reported that they already had open ring wells or tube wells and can not be affordable for the connection fees. However, these respondents are known as the poor households.

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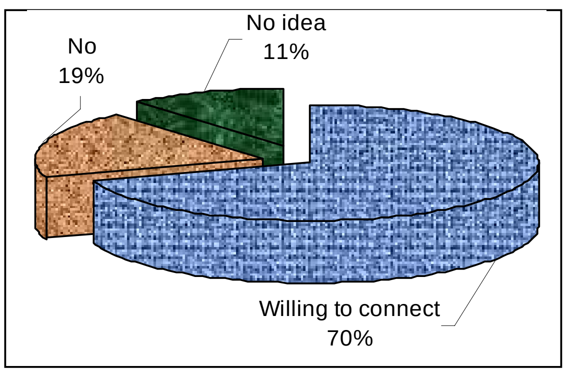


Figure 10 Opinions for the new water supply

Many residents are willing to pay (WTP) for water supply to a certain extent. The WTP is generally related to obtaining adequate service for their essential needs. Asking about the maximum amounts, the respondents would be able to pay are 32.4%, 25.7%, 25.7%, 12.9%, and 4,3% for From 2 to less than 5 US$, From 1 to less than US$ 2, Depend on water tariff , From 5 to 7 US$, and More than 7 US$, respectively (figure 11). Generally, common factors are that willingness to pay is responsive to consumption, affordability and the nature of the service provided.

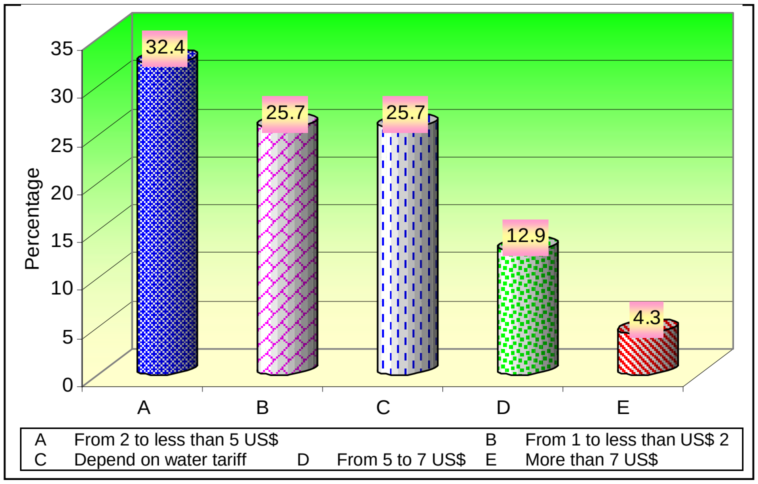


Figure 11 Willingness to pay for water consumption

4.3.6 Affordability Analysis

The objective of affordability analysis is to ensure that water tariff level should be affordable to low-income households. Also, the water tariff can be calculated based on the average monthly incomes and expenditures[2], average water consumption per month and household size of the low-income households that are calculated by using the processed raw data of social survey conducted by KCC study team in August 2009 for the preparatory study on the Siem Reap Water Supply Expansion Project. Likewise, the results of the affordability analysis from Exhibit 2 to Exhibit 5 are summarized in the following Exhibit 1.

The affordability analysis result quoted from Exhibit 5 is based on the basis information of the social survey. In addition, the average water consumption is 91.50 liters per person day or 15.56m^3 per month for the poor households (The household size of 5.67 is applied for the calculation of the water consumption per month of the poor households). Using this water consumption level, the water tariff should be charged at rate 700KHR/m^3. However, water supply expenses per month is calculated by multiplying of water tariff and water consumption level which is equaled to 14,892KHR (Sewerage user fees for 4,000KHR per month[3] is included) or 4.4% comparing to the average monthly income that can be affordable by the low income households.

Moreover, if we assumed that water consumption is 88.21 liters per person day or 15 m^3 per month for the poor households, the water tariff should be charged at rate 700KHR/m^3. Using these both water consumption and water tariff levels the water supply expenses & sewerage user fees per month is calculated and equaled to 14,500KHR or 4.3% comparing to the average monthly income that can be affordable by the low income households.

Similarly, if we assumed that water consumption is 58.80 liters per person day or 10 m^3 per month for the poor households, the water tariff should be charged at rate 1,100KHR/m^3. Using these both

[2] The average monthly incomes and expenditures herein referred to as "the average monthly household income", because the behaviors of respondent are not telling the true and fair view of their monthly household incomes and expenditures.

[3] The sewerage user fees is approved by ministerial PRAKAS No.132, Signed by Minister of MEF and MPWT, Dated 02 March 2009, for the new Siem Reap Sewerage Wastewater Treatment Plant Unit (SSWTPU).

water consumption and water tariff levels the water supply expenses & sewerage user fees per month is calculated and equaled to 15,000KHR or 4.5% comparing to the average monthly income that can affordable by the low income households.

In addition, if we assumed that water consumption is 41.16 liters per person day or 7 m^3 per month for the poor households, water tariff should be charged at rate 1,600KHR /m^3. Using these both water consumption and water tariff levels the water supply expenses & sewerage user fees per month is calculated and equaled to 15,200KHR or 4.5% comparing to the average monthly income that can be affordable by the low income households.

4.3.7 Expectation if the new water supply project is completed

Respondent expectations from the new water supply project are different. For instance 82% and 18% of them expected to get *less drawing time for water* and l*ess diseases and less medical expenditure*, respectively. Less drawing time for water means that they would be able to have a water supply with good sanitation within or very close to their houses. Their health will also be better whenever the new water supply project comes. Based on such benefits, 75% of the respondents will cooperate the project if the construction work starts, while the other 25% said no idea. Apart from the above-provided choices, they also gave a lot of views about the project. If the project is completed, it will help the Siem Reap city and its new development zones to have safe and reliable water supply and to achieve long term sustainable economic development. On the other hand, this project will sustain water resource and strengthen integrated environmental planning and protection for water resources management and water supply service. Further, the project's institutional development component will strengthen the capacity of the executing agency and the implementing agency on project implementation and environmental monitoring regarding to water quality.

4.3.8 Waterborne diseases

Few waterborne diseases were found. The respondents 86% reported that they don't get infected such diseases while the rest 14% reported they infected with the diseases (figure 12).

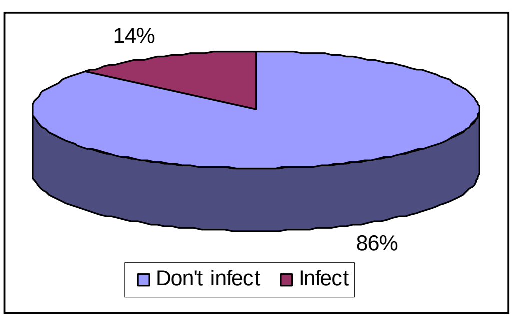
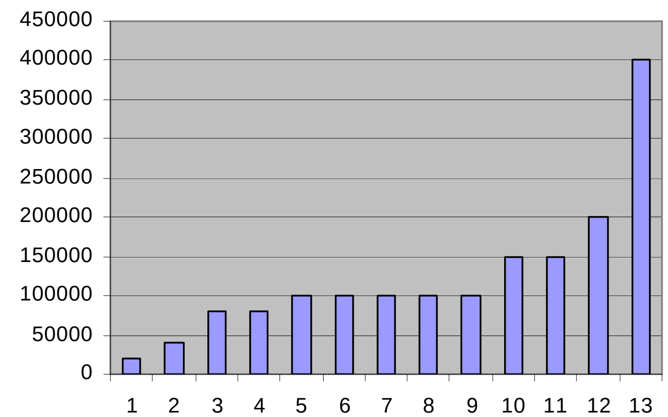


Figure 12 percentage of waterborne infection of the respondents

Of the 14% reported, 8%, 4%, and 2% were found to be infected by Diarrhea, Typhoid, and Skin infection, respectively. It is thus higher than that of what were found in the service area. However, it is also tough for them to define sources of the diseases, but water may be one of the root sources contributing to such diseases. The costs of medical treatment ranged from 5 to US$ 100. On the median basis, the cost was US$ 25 (Table 25) which was generally less than that of other diseases generally occurred in their families.

Table 25 The yearly costs of medical treatment

Medical treatment cost (Riel)		**Graphical presentation**
	20000	
	40000	
	80000	
	80000	
	100000	
	100000	
	100000	
	100000	
	100000	
	150000	
	150000	
	200000	
	400000	
Min	**20000 or US$ 5**	
Max	**400000 or US$ 100**	
Median	**100000 or US$ 25**	



4.3.9 Sanitary facilities

Sanitary facility here is focused only on sanitary latrine and is one of several factors to know of well beings. In the non service area, not all of the interviewed households use sanitary latrine: 68% use latrine with septic tank and 1% use pit latrine. Besides, 31% of the respondents defecate around their house compounds by digging and burying those wastes. High percentage of latrine indicates better living standards and knowledge about health care in their community. In view of this, sanitation facilities are poor and in need of development. On the other hand, currently no sewerage system was found. Asking about willingness to connect to the system, 48% of the respondents said that they will connect to the city sewerage system, while 9% of those will also do in the condition of proper charges (figure 13). The reason of willingness to connect to the system is due to the fact that they prefer getting sanitary facilities as a part of improving sanitary within their own households as well as in the city. 43% of the respondents reported that it is impossible or very difficult for them to connect to the system, because they are poor or low income households. The connection to the system is thus not a serious concern at the present time.

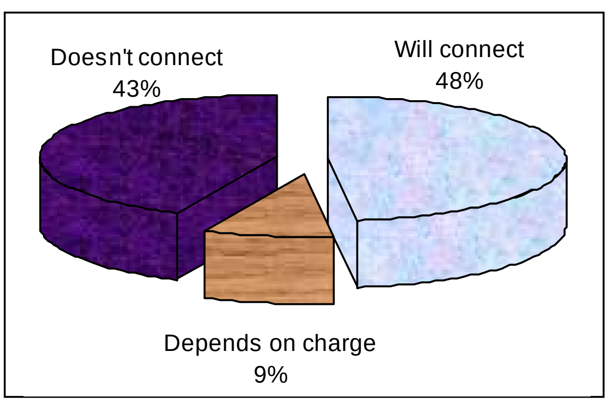


Figure 13 Willingness to connect to the system

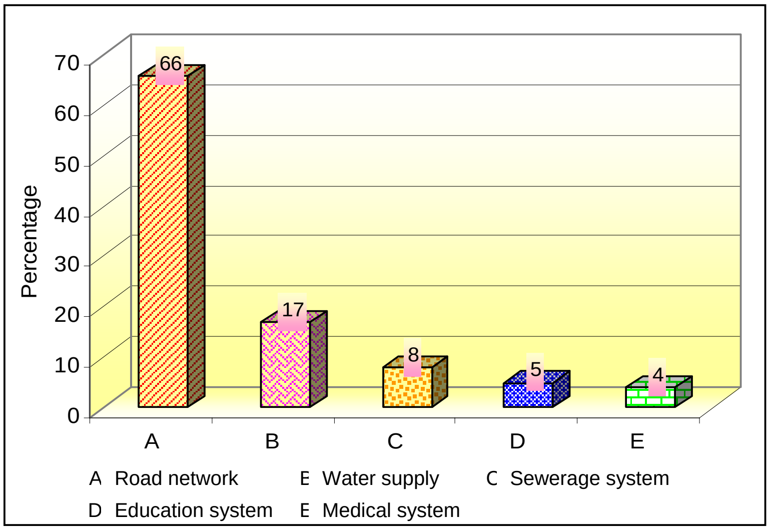


Figure 14 Public works should be improved

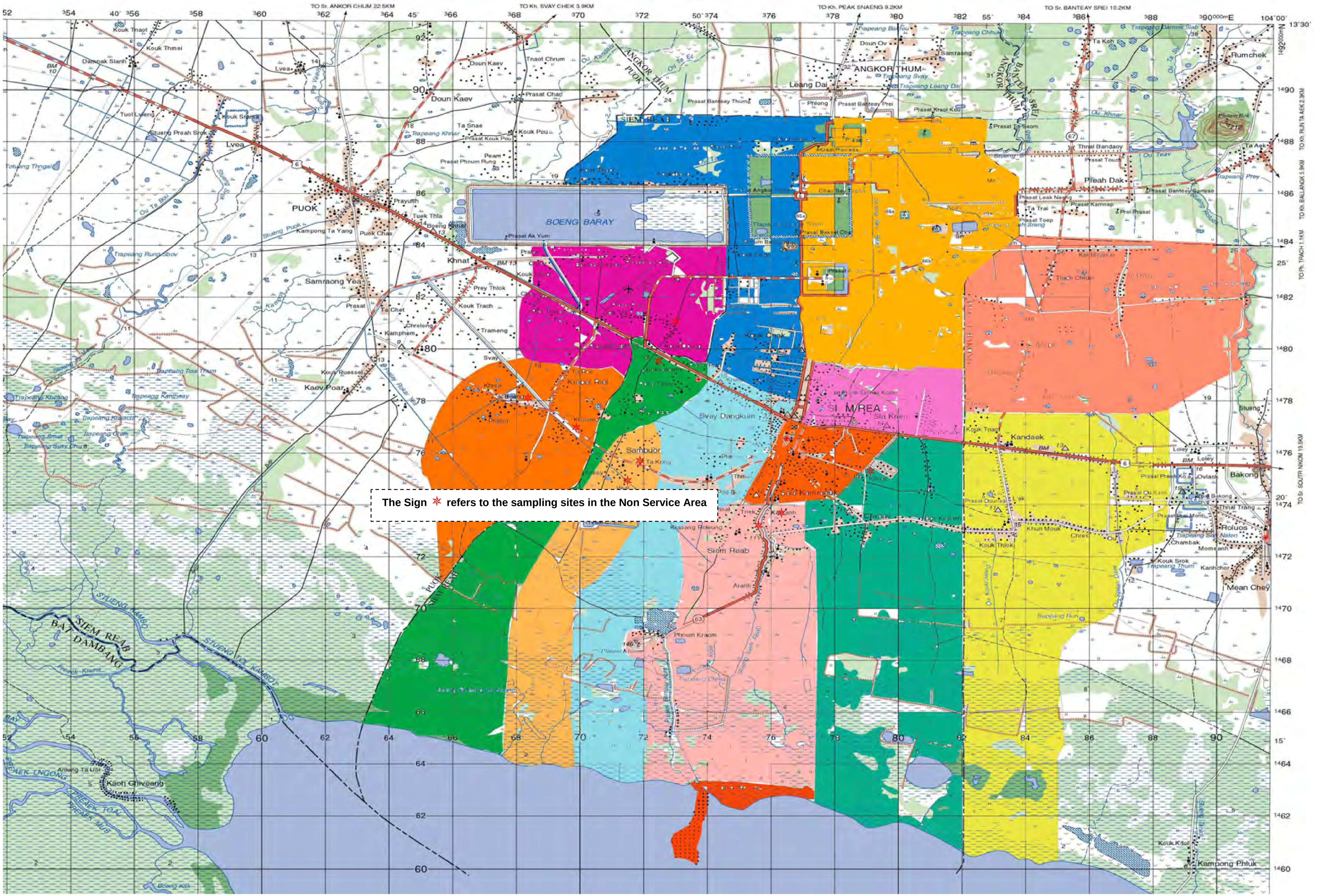
4.3.10 Public works need to be improved

Respondents' opinions regarding to the improvements of the public works were provided. It is revealed that the major priorities of the public works, that should be improved, are illustrated in descending percentage as in figure 14. It is found that road network is the first priority, followed by water supply, sewerage system, education system, and medical system, respectively. In the non service area, the improvement infrastructure in particular road network is regarded as one of the most important factors to indicate development progress. Since the road network is still hard for local traveling, it is one of the major priorities for development actors to take into considerations.

5. Conclusion

The study concluded that in the service area water consumptions are different from household to household, depending mainly on family economic, family size, occupations, and seasons. In the non service area, the differences of water consumptions by household categories were also found. The poor households consume water less than the medium and better off households. This is due to the fact that medium and better off households always use pumps, which is an easy facility, for their general purposes, while the poor were normally found to be lack of it. The respondents are willing to connect to the system whenever its construction is finished without considering of the connection costs. The affordability rate of the poor households should be considered for the water supply purpose. The study can be used as a source and as one of the reference tools for the city water supply planning.

APPENDIX



Appendix 1 Map of Sampling Sites in the Non Service Area

QID:

Appendix 2

Questionnaire for Household Survey
សំនួរសំរាប់អង្កេតជាលក្ខណៈគ្រួសារ

❒1- **Service Area តំបន់ផ្គត់ផ្គង់ទឹកបច្ចុប្បន្ន** ❒2- **Non-Service Area តំបន់មិនទាន់មានការផ្គត់ផ្គង់ទឹក**

Wealth Group កំរិតជីវភាព: ❒1 Poor ក្រ ❒2 Average មធ្យម ❒3 Better Off ធូរធារ

1 Geographical Location ទីតាំងភូមិសាស្ត្រ

Address អាស័យដ្ឋាន: ________________ Village ភូមិ: ____________________

Sangkat ឃុំ: ______________________ City ក្រុង: ______________________

2 Information of Respondent ព័ត៌មានពីអ្នកផ្តល់ចំលើយ

2.1 Name ឈ្មោះ___________________

2.2 Position in Family ឋានៈក្នុងគ្រួសារ: ❒1- Household head មេគ្រួសារ

❒2- Spouse of household head ប្តី ឬប្រពន្ធមេគ្រួសារ ❒3- Parents of household head ឪពុកម្តាយមេគ្រួសារ

2.3 Sex: ភេទ ❒1- Male ប្រុស ❒2- Female ស្រី

2.4 Age: អាយុ: ________ ឆ្នាំ

2.5 Education of the respondent ការសិក្សាអ្នកផ្តល់ចំលើយ

❒1- Non Education មិនបានរៀន

❒2- Primary School បឋមសិក្សា (ថ្នាក់ទី១ - ថ្នាក់ទី៦ថ្មី) / (ថ្នាក់ទី១២ - ទី៧ជំនាន់ដើម)

❒3- Secondary School អនុវិទ្យាល័យ (ថ្នាក់ទី៧ - ទី៩ថ្មី) / (ថ្នាក់ទី៦ - ទី៣ជំនាន់ដើម)

❒4- High School វិទ្យាល័យ (ថ្នាក់ទី១០ - ទី១២ថ្មី) / (ថ្នាក់ទី២ - ទី១ជំនាន់ដើម)

❒5- Bachelor Degree and above បរិញ្ញាបត្រឡើងទៅ

2.6 Occupation មុខរបរ: Main ចំបង[1]: _________ Secondary បន្ទាប់បន្សំ: _________

1- Government employee មន្ត្រីរាជការ 2- NGOs/IOs staff បុគ្គលិកអង្គការ

3- Worker at private companies/Factories កម្មករក្រុមហ៊ុនឯកជន/កម្មកររោងចក្រ

4- Small-scale business owner អ្នកប្រកបរបរលក់ដូរតិចតួច 5- Motor taxi driver អ្នករត់ម៉ូតូឌុប

6- Transportation service provider អ្នកស៊ីឈ្នួលដឹកទំនិញ 7- Construction worker កម្មករសំណង់

8- Other (Please specify) ផ្សេងៗ (សូមបញ្ជាក់): _________________

2.7 If the respondent is not household head, what is the household head occupation?
ប្រសិនបើអ្នកផ្តល់ចំលើយមិនមែនជាមេគ្រួសារ តើមេគ្រួសារមានមុខរបរធ្វើអ្វី? _________ *សូមប្រើកូដខាងលើ*

2.8 How many members are there in your family? ចំនួនមនុស្សក្នុងបន្ទុកគ្រួសារ: _________ នាក់

2.9 Do you have relative(s) staying with តើអ្នកមានបងប្អូនស្នាក់នៅជាមួយដែរឬទេ? ❒1- Yes បាទ ❒2- No ទេ

2.9.1 If yes, how many ប្រសិនបើមាន តើមានប៉ុន្មាននាក់_________ នាក់

2.10 Is this house yours តើផ្ទះនេះជារបស់អ្នក? ❒1- Yes បាទ ❒2- No ទេ

[1] មុខរបរចំបង សំដៅលើមុខរបរជាគោលសំរាប់គ្រួសារ ពោលគឺមិនសំដៅលើមុខរបរណាដែលមានប្រាក់ចំណូលច្រើនជាងគេឡើយ ឧ. កសិករ មន្ត្រីរាជការ ជាដើម។

2.10.1 If no, do you rent the house ប្រសិនបើទេ តើផ្ទះនេះអ្នកជួលគេ? ❒1- Yes បាទ ❒2- No ទេ

2.10.1.1 If no, who does the house belong to ប្រសិនបើទេ តើផ្ទះនេះជារបស់អ្នកណា?____________________

2.10.2 How size it is តើផ្ទះនេះមានទំហំប៉ុន្មាន?___________ m^2 ម៉ែត្រការ៉េ

3 Total Income/expenditures of your household (family total) សរុបចំនូល/ចំណាយជាមធ្យមក្នុងគ្រួសារ

3.1 Monthly income ចំនូលជាមធ្យមប្រចាំខែ:____________________________ Riel/month រៀល/ខែ

3.2 Monthly total expenditure ចំណាយជាមធ្យមប្រចាំខែ:____________________ Riel/month រៀល/ខែ

3.3 Monthly expenditure for water supply ចំណាយលើថ្លៃប្រើប្រាស់ទឹកប្រចាំខែ:_________________ Riel/month រៀល/ខែ

4 Accessibility to water supply ភាពងាយស្រួលពីការផ្គត់ផ្គង់ទឹក

4.1 Water source ប្រភពទឹក: ❒1- Siem Reap Water Supply Authority រដ្ឋាករទឹកសៀមរាប

❒2- Own well water ទឹកអណ្តូងផ្ទាល់ខ្លួន ❒3- Others ដ៏ទៃទៀត:_________________

If you are supplied by the Siem Reap Waterworks, proceed to item 8
ប្រសិនបើប្រើប្រាស់បណ្តាញរដ្ឋាករទឹកសៀមរាប សូមរំលងទៅសំនួរទី៨

4.2 If you use **own well water** system, please describe the well type
ប្រសិនបើអ្នកប្រើប្រាស់**ទឹកអណ្តូងផ្ទាល់ខ្លួន** ចូររៀបរាប់ពីប្រភេទអណ្តូង: ❒1- Open ring well អណ្តូងដៃ ❒2- Deep well អណ្តូងស្នប់

❒3- Communal well អណ្តូងរួម ❒4- Others ផ្សេងៗទៀត:__________________

4.3 Distance from home to your well water source ចំងាយពីផ្ទះ ទៅកាន់ប្រភពទឹកអណ្តូងរបស់អ្នក

❒1- < 20 m តិចជាង២០ម៉ែត្រ ❒2- 20< < 50 m ពី២០ ទៅតិចជាង ៥០ម៉ែត្រ ❒3- > 50 m លើសពី ៥០ម៉ែត្រ

4.4 Location of your tap តើកន្លែងបិទបើកទឹករបស់អ្នកនៅកន្លែងណា?

❒1- Inside the house ក្នុងផ្ទះ ❒2- Outside the house ក្រៅផ្ទះ ❒3- Others ផ្សេងៗ:_________________

4.5 Frequency of access to your well water ភាពញឹកញាប់ក្នុងការប្រើប្រាស់អណ្តូង

4.5.1 During the dry season period, how many times per day that you collected water from your well?
នៅរដូវប្រាំង ជាទូទៅតើអ្នកដងទឹកប៉ុន្មានដងចេញពីអណ្តូងរបស់អ្នក?________ Times ដង

4.5.1.1 On the average basis, how many liters per person used per day during the dry season?
ជាមធ្យម តើសមាជិកក្នុងគ្រួសាររបស់អ្នកប្រើប្រាស់ទឹកអស់ប៉ុន្មានលីត្រ សំរាប់ម្នាក់ ក្នុងមួយថ្ងៃ?

___________Liters/person/day លីត្រ/ម្នាក់/ថ្ងៃ

4.5.2 During the rainy season, how many times per day that you collected water from your well?
នៅរដូវវស្សា ជាទូទៅតើអ្នកដងទឹកប៉ុន្មានដងចេញពីអណ្តូងរបស់អ្នក?________ Times ដង

4.5.2.1 On the average basis, how many liters per person used per day during the rainy season?
ជាមធ្យម តើសមាជិកក្នុងគ្រួសាររបស់អ្នកប្រើប្រាស់ទឹកអស់ប៉ុន្មានលីត្រ សំរាប់ម្នាក់ ក្នុងមួយថ្ងៃ?

___________Liters/person/day លីត្រ/ម្នាក់/ថ្ងៃ

4.6 Do you use your pump តើអ្នកប្រើប្រាស់ម៉ាស៊ីនបូមទឹក? ❒1- Yes បាទ ❒2- No ទេ

4.7 Any problems on your well water quality តើមានបញ្ហាពីគុណភាពទឹកអណ្តូងរបស់អ្នកទេ? ❒1- Yes បាទ ❒2- No ទេ

4.7.1 If yes, what are your problems ប្រសិនបើមាន អ្វីជាបញ្ហារបស់អ្នក?

❒1- Taste រសជាតិ ❒2- odour ក្លិន ❒3- colour ពណ៌ ❒4- others ផ្សេងៗ:___________________

4.8 Do you have any quantitative problems on your well water?
តើអណ្តូងអ្នក មានបញ្ហាខ្វះខាតទឹកប្រើប្រាស់ដែរ ឬទេ? ❐1- Yes បាទ ❐2- No ទេ

4.8.1 If Yes in the above question, when the problems happen?
ប្រសិនបើមាន តើបញ្ហានេះកើតឡើងពីខែណា?_______________

4.9 Do you treat your well water តើអ្នកសំអាតទឹកអណ្តូងរបស់អ្នកទេ? ❐1- Yes បាទ ❐2- No ទេ

4.9.1 If Yes, how do you treat your well water ប្រសិនបើបាទ តើអ្នកសំអាតទឹកអណ្តូងរបស់អ្នកយ៉ាងដូចម្តេច?

❐1- Disinfection by bleaching powder សំលាប់មេរោគដោយដាក់ថ្នាំធ្វើអោយទឹកថ្លា

❐2- Others (specify) ផ្សេងៗសូមបញ្ជាក់:_______________________________

4.10 How much do you spent for operation/treatment and maintenance for your well yearly?
តើអ្នកចំណាយប៉ុន្មានសំរាប់ការបូម សំអាត និង ថែទាំអណ្តូងប្រចាំឆ្នាំរបស់អ្នក?_________________Riel/year រៀល/ឆ្នាំ

5 Willingness to connect to new water supply បំណងក្នុងការតភ្ជាប់បណ្តាញទឹកថ្មី

5.1 Will you connect to new water supply តើអ្នកនឹងភ្ជាប់បណ្តាញផ្គត់ផ្គង់ទឹកថ្មីដែរទេ?

❐1- Yes បាទ ❐2- No ទេ ❐3- No idea គ្មានយោបល់

5.1.1 If no, why ប្រសិនបើទេ ហេតុអ្វី? ____

5.1.2 If yes, how much will you pay for new water supply at maximum per month?
ប្រសិនបើបាទ តើអ្នកអាចនឹងចំណាយយ៉ាងច្រើនបំផុតប៉ុន្មានក្នុងមួយខែ សំរាប់ការប្រើប្រាស់ទឹករបស់គំរោងថ្មី?

❐1- From 1 to less than US$ 2 ពី 1 ទៅតិចជាង 2 US$ ❐2- From 2 to less than 5 US$ ពី 2 ទៅតិចជាង 5 US$

❐3- From 5 to 7 US$ ពី 5 ទៅ 7 US$ ❐4- More than 7 US$ ច្រើនជាង 7 US$

❐5- Depend on water tariff អាស្រ័យលើតារាងតំលៃទឹក

5.1.3. If yes, how much are you willing to pay for the new water connection fee?
ប្រសិនបើបាទ តើអ្នកអាចនឹងចំណាយប៉ុន្មានសំរាប់ការភ្ជាប់បណ្តាញទឹកថ្មីនេះ?______________________ រៀល

6 What is your expectation if new water supply augmentation project be completed?
អ្វីជាការសង្ឃឹមរបស់អ្នក ប្រសិនបើគំរោងផ្គត់ផ្គង់ទឹកថ្មីមួយ ត្រូវបានគេសាងសង់រួច?

❐1- Less drawing time for water ចំណាយពេលតិចក្នុងការយកទឹក

❐2- Less diseases and less medical expenditure កាត់បន្ថយ ជំងឺដោយសារទឹក និង ចំណាយលើថ្នាំពេទ្យ

❐3- Increase of working chance បង្កើនឱកាសការងារ

❐4- Increase of education chance បង្កើនឱកាសរៀនសូត្រ

7 Will you cooperate/support the new Project if the construction work starts?
តើអ្នកនឹងធ្វើការគាំទ្រទេ ប្រសិនបើគំរោងនេះដំណើការសាងសង់? ❐1- Yes បាទ ❐2- No ទេ ❐3- No idea គ្មានយោបល់

7.1 If yes, why ប្រសិនបើបាទ ហេតុអ្វី?____

7.2 If no, why ប្រសិនបើទេ ហេតុអ្វី?____

8 Siem Reap Waterworks water supply conditions លក្ខខណ្ឌនៃការផ្គត់ផ្គង់ទឹកខេត្តសៀមរាប

The following questions are for those households who receive water supply from Siem Reap Water Supply Authority

សំនួរខាងក្រោមនេះ គឺសំរាប់គ្រួសារទាំងឡាយណាដែលផ្គត់ផ្គង់ទឹកដោយរដ្ឋាករទឹកសៀមរាប

8.1 Average monthly water consumption ការប្រើប្រាស់ទឹកជាមធ្យមប្រចាំខែ:______ m^3 ម៣

8.2 Average monthly water charge ចំណាយលើការប្រើប្រាស់ទឹកជាមធ្យមប្រចាំខែ:_______________ Riel/month រៀល/ខែ

8.3 Do you share your water with the other households?
តើអ្នកចែកចាយការប្រើប្រាស់ទឹកជាមួយគ្រួសារដ៏ទៃៗទៀត? ❐1- Yes បាទ ❐2- No ទេ

8.3.1 If yes, how many people in the other households?
ប្រសិនបើបាទ តើគ្រួសារនោះមានសមាជិកប៉ុន្មាននាក់:______ Persons នាក់

8.4 Availability and satisfaction of water supply ការពេញចិត្តចំពោះការផ្គត់ផ្គង់ទឹក

8.4.1 How many hours per day for water supply that satify your mind?
តើការផ្គត់ផ្គង់ទឹកប៉ុន្មានម៉ោងក្នុងមួយថ្ងៃទើបអ្នកពេញចិត្ត? ______ hours/day ម៉ោង/ថ្ងៃ

8.4.2 Do you currently satisfy with water supply?
តើអ្នកពេញចិត្តចំពោះការផ្គត់ផ្គង់ទឹកដោយរដ្ឋាករទឹកបច្ចុប្បន្នទេ? ❐1- Yes បាទ ❐2- No ទេ

8.4.2.1 If yes, why ប្រសិនបើបាទ ហេតុអ្វី? ____

8.4.2.2 If no, why ប្រសិនបើទេ ហេតុអ្វី? ____

8.5 Do you drink the city water supply directly តើអ្នកទទួលទានទឹក ពីប្រព័ន្ធផ្គត់ផ្គង់ដោយផ្ទាល់? ❐1- Yes បាទ ❐2- No ទេ

8.6 What are the major consumption in your family? Show your priority in order
តើការប្រើប្រាស់ទឹកសំខាន់ៗរបស់អ្នកមានអ្វីខ្លះ? ចូរបង្ហាញតាមលំដាប់អាទិភាព

▢- Drinking ផឹក ▢- Cooking ចំអិនអាហារ ▢- Shower ងូត

▢- Planting ដាំដំណាំ ▢- Others ផ្សេងៗទៀតៗ:___________________________

8.7 Any problems on water quality តើមានបញ្ហាណាមួយពីគុណភាពទឹកដែរឬទេ?

❐1- Taste រសជាតិ ❐2- Odour ក្លិន ❐3- Colour ពណ៌

❐4- others, if any ដ៏ទៃទៀត ប្រសិនបើមាន ❐5- No problems គ្មានបញ្ហា

8.8 Any problems on water pressure មានបញ្ហាណាមួយពីសំពាធទឹកដែលប្រើប្រាស់បច្ចុប្បន្ន

❐1- Always low pressure ជានិច្ចកាលតែងមានកំលាំងសំពាធខ្សោយ

❐2- Sometimes low pressure ពេលខ្លះសំពាធទាប

❐3- Sometimes no water coming ពេលខ្លះដាច់ទឹក

❐4- Satisfied សមស្របហើយអាចទទួលយកបាន

8.9 Do you have any request to the Siem Reap Wate Supply Authority?
តើអ្នកធ្លាប់បានធ្វើការស្នើរណាមួយទៅរដ្ឋាករទឹកសៀមរាបដែរទេ ក្នុងន័យកែលំអរ? ❐1- Yes បាទ ❐2- No ទេ

8.9.1 If yes, what is/are the request(s) ប្រសិនបើមាន អ្វីជាសំណើររបស់អ្នក

❐1- Water quality improvement កែលំអរគុណភាពទឹកអោយកាន់តែប្រសើរឡើង

❐2- Water quantity improvement បង្កើនបរិមាណទឹក

❐3- Discount tariff បញ្ចុះតំលៃលើការប្រើប្រាស់ទឹក

❐4- Discount connection charge បញ្ចុះតំលៃលើការភ្ជាប់បណ្តាញទឹក

❐5- Improvement of services ការកែលំអរសេវាកម្មអោយកាន់តែប្រសើរឡើង

❐6- Others (specify) ផ្សេងៗសូមបញ្ជាក់:__________________________

9 Sanitary facilities ផ្នែកអនាម័យ

9.1 What type of toilet do you have ប្រភេទបង្គន់អ្វីដែលអ្នកប្រើប្រាស់សព្វថ្ងៃ?

❒1- Connected to city sewer បង្ហូរទៅប្រព័ន្ធលូទឹកស្អុយក្រុង ❒2- Toilet with septic tank បង្គន់ដែលមានអាងស្តុក

❒3- Pit latrine បង្គន់ចាក់ផេះ ❒4- Others ផ្សេងៗ

9.2 Provided that the city sewer system is prepared for your street, are you wiling to be connected to the system?
ប្រសិនបើប្រព័ន្ធលូទឹកស្អុយក្នុងក្រុងត្រូវបានរៀបចំតាមផ្លូវក្បែរៗផ្ទះរបស់អ្នក តើអ្នកនឹងភ្ជាប់បណ្តាញនោះទេ?

❒1- Yes បាទ ❒2- It depends on charge អាស្រ័យនឹងតំលៃ ❒3- No ទេ

10 Waterborne diseases suffered ជំងឺដែលកើតឡើងដោយសារទឹក

10.1 Did you get waterborne diseases during the last 12 months during the year 2008?
តើអ្នកបានកើតជំងឺដែលកើតឡើងដោយសារការប្រើប្រាស់ទឹកដែរទេ កាលពីឆ្នាំ២០០៨កន្លងទៅ? ❒1- Yes បាទ ❒2- No ទេ

10.1.1 If yes, what kind of diseases are you suffered ប្រសិនបើបាទ តើប្រភេទជំងឺអ្វីដែលអ្នកជួបប្រទះ?

❒1- Cholera អាសន្នរោគ ❒2- Diarrhea រាគរូស ❒3- Typhoid គ្រុនពោះវៀន ❒4- Malaria គ្រុនចាញ់

❒5- Dengue fever គ្រុនក្តៅ ❒6- Skin infection រោគសើស្បែក ❒7- Others ផ្សេងៗ:_________________

10.1.2 How did you get such diseases តើអ្នកឆ្លងជំងឺនេះយ៉ាងដូចម្តេច?

❒1- Through water consumption តាមរយៈការប្រើប្រាស់ទឹក

❒2- Through infection from someone តាមរយៈឆ្លងពីអ្នកដទៃ

❒3- Others ផ្សេងៗ:________________________________

10.1.3 If yes, how much for the cost of medical treatment, including medicines
ចំណាយទៅលើការព្យាបាលជំងឺ រួមបញ្ចូលទាំងថ្នាំពេទ្យ:_________________ Riel/year រៀល/ឆ្នាំ

11 What is your average monthly electric bill?
តើអ្នកចំណាយលើអគ្គិសនីជាមធ្យមប៉ុន្មាន ក្នុងមួយខែ?_________________ Riel/month រៀល/ខែ

12 What is your average monthly telephone bill?
តើអ្នកចំណាយលើទូរស័ព្ទជាមធ្យមប៉ុន្មាន ក្នុងមួយខែ?_________________ Riel/month រៀល/ខែ

13 Which fields of public works do you want to improve? Show your priority in order
តើកិច្ចការសាធារណៈណាខ្លះ ដែលអ្នកចង់អោយមានការកែលំអរ? ចូរបង្ហាញតាមលំដាប់អាទិភាព

☐- Water supply ការផ្គត់ផ្គង់ទឹកស្អាត ☐- Sewerage system ការកែលំអរប្រព័ន្ធលូទឹកស្អុយ

☐- Road network ការកែលំអរបណ្តាញផ្លូវថ្នល់ ☐- Education system ការកែលំអរប្រព័ន្ធអប់រំ

☐- Irrigation system ការកែលំអរប្រព័ន្ធធារាសាស្ត្រ ☐- Medical system ការកែលំអរប្រព័ន្ធសុខាភិបាល

☐- Telecommunication system ប្រព័ន្ធទូរគមនាគមន៍ _ ☐- Preservation for the heritage ការអភិរក្សបេតិកភ័ណ្ឌ

Surveyed by ធ្វើអង្កេតដោយ:________________________ Date កាលបរិច្ឆេទ: ____________________________

Starting Time ពេលចាប់ផ្តើម:________________________ Completion Time ពេលបញ្ចប់:____________________

Checked by ត្រួតពិនិត្យដោយ:________________________ Date កាលបរិច្ឆេទ:____________________________

សូមអរគុណ!

Appendix 3 List of Interviewers

No	Name	Background	Phone Number
1	Mr. May Simorn	M.Sc., Environmental Science	012 933 354
2	Mr. Chan Vannak	Master Degree of Business Administration (MBA), and BSc. of Economic	012 856 727
3	Mr. Yim Borey	Master Degree of Business Administration	012 655 265
4	Mr. Lim Piseth	Bachelor Degree of Management and Accounting	012 784 584
5	Mr. Srey Viseth	Bachelor Degree of Law	012 499 078
6	Mr. Klot Chheang Y	Bachelor Degree of Business Administration	092 836 114

Exhibit 1: Results of Affordability Analysis for Low income household for year 2009

Household size	5.67	Person/per household
Average monthly expenditure per month	309,912	Khmer Riel (KHR)
Average monthly income per month	363,324	Khmer Riel (KHR)
Average monthly income & expenditures per month	336,618	Khmer Riel (KHR)

Water tariff/ m^3 (KHR)	Water consumption	Average water consumption per person day (Liter)	Total Water supply expenses & Sewerage user fees (KHR)	(%) Compare to AVR monthly expenditures	(%) Compare to AVR monthly income	(%) Compare to AVR monthly income & expenditures	Result Analysis
1,600	If 07m^3/per month	41.16	15,200	4.9%	4.2%	4.5%	Affordable
1,100	If 10m^3/per month	58.80	15,000	4.8%	4.1%	4.5%	Affordable
700	If 15m^3/per month	88.21	14,500	4.7%	4.0%	4.3%	Affordable
700	15.56m^3/per month	91.50	14,892	4.8%	4.1%	4.4%	Affordable

Exhibit 2: Affordability Analysis for Low income household year 2009 " If average water consumption 7m^3/per month"

Household size	5.67	Person/per household
Average water consumption	41.16	Liter/person day
Average monthly expenditure per month	309,912	Khmer Riel (KHR)
Average monthly income per month	363,324	Khmer Riel (KHR)
Average monthly income & expenditures per month	336,618	Khmer Riel (KHR)
Average water consumption per month	7.00	m3/per month

Water tariff/ m^3 (KHR)	Water supply expenses (KHR)	Sewerage user fees (KHR)	Total Water supply expenses & Sewerage user fees (KHR)	(%) Compare to AVR monthly expenditures	(%) Compare to AVR monthly income	(%) Compare to AVR monthly income & expenditures
100	700	4,000	4,700	1.5%	1.3%	1.4%
200	1,400	4,000	5,400	1.7%	1.5%	1.6%
300	2,100	4,000	6,100	2.0%	1.7%	1.8%
400	2,800	4,000	6,800	2.2%	1.9%	2.0%
500	3,500	4,000	7,500	2.4%	2.1%	2.2%
600	4,200	4,000	8,200	2.6%	2.3%	2.4%
700	4,900	4,000	8,900	2.9%	2.4%	2.6%
800	5,600	4,000	9,600	3.1%	2.6%	2.9%
900	6,300	4,000	10,300	3.3%	2.8%	3.1%
1,000	7,000	4,000	11,000	3.5%	3.0%	3.3%
1,100	7,700	4,000	11,700	3.8%	3.2%	3.5%
1,200	8,400	4,000	12,400	4.0%	3.4%	3.7%
1,300	9,100	4,000	13,100	4.2%	3.6%	3.9%
1,400	9,800	4,000	13,800	4.5%	3.8%	4.1%
1,500	10,500	4,000	14,500	4.7%	4.0%	4.3%
1,600	**11,200**	**4,000**	**15,200**	**4.9%**	**4.2%**	**4.5%**
1,700	11,900	4,000	15,900	5.1%	4.4%	4.7%
1,800	12,600	4,000	16,600	5.4%	4.6%	4.9%
1,900	13,300	4,000	17,300	5.6%	4.8%	5.1%
2,000	14,000	4,000	18,000	5.8%	5.0%	5.3%

Exhibit 3: Affordability Analysis for Low income household year 2009 " If average water consumption 10m^3/per month"

Household size	5.67	Person/per household
Average water consumption	58.80	Liter/person day
Average monthly expenditure per month	309,912	Khmer Riel (KHR)
Average monthly income per month	363,324	Khmer Riel (KHR)
Average monthly income & expenditures per month	336,618	Khmer Riel (KHR)
Average water consumption per month	10.00	m3/per month

Water tariff/ m^3 (KHR)	Water supply expenses (KHR)	Sewerage user fees (KHR)	Total Water supply expenses & Sewerage user fees (KHR)	(%) Compare to AVR monthly expenditures	(%) Compare to AVR monthly income	(%) Compare to AVR monthly income & expenditures
100	1,000	4,000	5,000	1.6%	1.4%	1.5%
200	2,000	4,000	6,000	1.9%	1.7%	1.8%
300	3,000	4,000	7,000	2.3%	1.9%	2.1%
400	4,000	4,000	8,000	2.6%	2.2%	2.4%
500	5,000	4,000	9,000	2.9%	2.5%	2.7%
600	6,000	4,000	10,000	3.2%	2.8%	3.0%
700	7,000	4,000	11,000	3.5%	3.0%	3.3%
800	8,000	4,000	12,000	3.9%	3.3%	3.6%
900	9,000	4,000	13,000	4.2%	3.6%	3.9%
1,000	10,000	4,000	14,000	4.5%	3.9%	4.2%
1,100	**11,000**	**4,000**	**15,000**	**4.8%**	**4.1%**	**4.5%**
1,200	12,000	4,000	16,000	5.2%	4.4%	4.8%
1,300	13,000	4,000	17,000	5.5%	4.7%	5.1%
1,400	14,000	4,000	18,000	5.8%	5.0%	5.3%
1,500	15,000	4,000	19,000	6.1%	5.2%	5.6%
1,600	16,000	4,000	20,000	6.5%	5.5%	5.9%
1,700	17,000	4,000	21,000	6.8%	5.8%	6.2%
1,800	18,000	4,000	22,000	7.1%	6.1%	6.5%
1,900	19,000	4,000	23,000	7.4%	6.3%	6.8%
2,000	20,000	4,000	24,000	7.7%	6.6%	7.1%

Exhibit 4: Affordability Analysis for Low income household year 2009 " If average water consumption 15m^3/per month"

Household size	5.67	Person/per household
Average water consumption	88.21	Liter/person day
Average monthly expenditure per month	309,912	Khmer Riel (KHR)
Average monthly income per month	363,324	Khmer Riel (KHR)
Average monthly income & expenditures per month	336,618	Khmer Riel (KHR)
Average water consumption per month	15.00	m3/per month

Water tariff/ m^3 (KHR)	Water supply expenses (KHR)	Sewerage user fees (KHR)	Total Water supply expenses & Sewerage user fees (KHR)	(%) Compare to AVR monthly expenditures	(%) Compare to AVR monthly income	(%) Compare to AVR monthly income & expenditures
100	1,500	4,000	5,500	1.8%	1.5%	1.6%
200	3,000	4,000	7,000	2.3%	1.9%	2.1%
300	4,500	4,000	8,500	2.7%	2.3%	2.5%
400	6,000	4,000	10,000	3.2%	2.8%	3.0%
500	7,500	4,000	11,500	3.7%	3.2%	3.4%
600	9,000	4,000	13,000	4.2%	3.6%	3.9%
700	**10,500**	**4,000**	**14,500**	**4.7%**	**4.0%**	**4.3%**
800	12,000	4,000	16,000	5.2%	4.4%	4.8%
900	13,500	4,000	17,500	5.6%	4.8%	5.2%
1,000	15,000	4,000	19,000	6.1%	5.2%	5.6%
1,100	16,500	4,000	20,500	6.6%	5.6%	6.1%
1,200	18,000	4,000	22,000	7.1%	6.1%	6.5%
1,300	19,500	4,000	23,500	7.6%	6.5%	7.0%
1,400	21,000	4,000	25,000	8.1%	6.9%	7.4%
1,500	22,500	4,000	26,500	8.6%	7.3%	7.9%
1,600	24,000	4,000	28,000	9.0%	7.7%	8.3%
1,700	25,500	4,000	29,500	9.5%	8.1%	8.8%
1,800	27,000	4,000	31,000	10.0%	8.5%	9.2%
1,900	28,500	4,000	32,500	10.5%	8.9%	9.7%
2,000	30,000	4,000	34,000	11.0%	9.4%	10.1%

Exhibit 5: Affordability Analysis for Low income household "Based on Survey Data conducted in August 2009, 15.56m^3/per month"

Household size	5.67	Person/per household
Average water consumption	91.50	Liter/person day
Average monthly expenditure per month	309,912	Khmer Riel (KHR)
Average monthly income per month	363,324	Khmer Riel (KHR)
Average monthly income & expenditures per month	336,618	Khmer Riel (KHR)
Average water consumption per month	15.56	m3/per month

Water tariff/ m^3 (KHR)	Water supply expenses (KHR)	Sewerage user fees (KHR)	Total Water supply expenses & Sewerage user fees (KHR)	(%) Compare to AVR monthly expenditures	(%) Compare to AVR monthly income	(%) Compare to AVR monthly income & expenditures
100	1,556	4,000	5,556	1.8%	1.5%	1.7%
200	3,112	4,000	7,112	2.3%	2.0%	2.1%
300	4,668	4,000	8,668	2.8%	2.4%	2.6%
400	6,224	4,000	10,224	3.3%	2.8%	3.0%
500	7,780	4,000	11,780	3.8%	3.2%	3.5%
600	9,336	4,000	13,336	4.3%	3.7%	4.0%
700	**10,892**	**4,000**	**14,892**	**4.8%**	**4.1%**	**4.4%**
800	12,448	4,000	16,448	5.3%	4.5%	4.9%
900	14,004	4,000	18,004	5.8%	5.0%	5.3%
1,000	15,560	4,000	19,560	6.3%	5.4%	5.8%
1,100	17,116	4,000	21,116	6.8%	5.8%	6.3%
1,200	18,672	4,000	22,672	7.3%	6.2%	6.7%
1,300	20,228	4,000	24,228	7.8%	6.7%	7.2%
1,400	21,784	4,000	25,784	8.3%	7.1%	7.7%
1,500	23,340	4,000	27,340	8.8%	7.5%	8.1%
1,600	24,896	4,000	28,896	9.3%	8.0%	8.6%
1,700	26,452	4,000	30,452	9.8%	8.4%	9.0%
1,800	28,008	4,000	32,008	10.3%	8.8%	9.5%
1,900	29,565	4,000	33,565	10.8%	9.2%	10.0%
2,000	31,121	4,000	35,121	11.3%	9.7%	10.4%

Water Supply Development Plan (Scenario 1)

Item	Year		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	**Population**		166230	171450	177820	186080	194460	202950	211560	220250	229030	237890	246840
2	Pops growth rate	%	N/A	3.14%	3.72%	4.65%	4.50%	4.37%	4.24%	4.11%	3.99%	3.87%	3.76%
3	**Coverage**	%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%
4	Population served		33,246	42,863	53,346	65,128	77,784	91,328	105,780	121,138	137,418	154,629	172,788
5	Unit consumption rate	lpcd	100		110	111	112	113	114	115	116	117	118
6	Constant growth rate	1	-	-	1	1	1	1	1	1	1	1	1
7	Total domestic water demand	m^3/d	16,623	0	19,560	20,655	21,780	22,933	24,118	25,329	26,567	27,833	29,127
8	**Domestic water demand**	m^3/d	3,325	0	5,868	7,229	8,712	10,320	12,059	13,931	15,940	18,092	20,389
9	**Tourists**	per year	2,255,134	2,237,198	2,281,942	2,327,581	2,374,132	2,421,615	2,470,047	2,519,448	2,569,837	2,621,234	2,673,659
10	**Gowth rate of tourists**	%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
11	Tourists per day	per day	6,178	6,129	6,252	6,377	6,504	6,635	6,767	6,903	7,041	7,181	7,325
12	**Coverage**		20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%
13	Toirist served		1,236	1,532	1,876	2,232	2,602	2,986	3,384	3,796	4,224	4,668	5,128
14	**Unit consuption rate**	lpcd	300	300	300	301	302	303	304	305	306	307	308
15	Constant growth rate	1	-	-	1	1	1	1	1	1	1	1	1
16	Water demand by tourists	per day	371	460	563	672	786	905	1,029	1,158	1,293	1,433	1,579
17	Average day of stay	days	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
18	**Commercial water demand**	m^3/d	1,297	1,609	1,969	2,351	2,750	3,166	3,600	4,053	4,524	5,016	5,528
19	**Total water demand**	m^3/d	4,622	1,609	7,837	9,581	11,462	13,486	15,659	17,984	20,465	23,107	25,916
20	**NRW**	%	18%	18%	17%	16%	15%	14%	13%	12%	11%	10%	10%
21	Average daily water demand	m^3/d	5,637	1,962	9,443	11,405	13,485	15,682	17,999	20,436	22,994	25,675	28,796
22	**Peak factor**		1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
23	Maximum daily water demand		7,046	2,453	11,803	14,257	16,856	19,602	22,499	25,545	28,743	32,093	35,995
24	Exsiting water supply capacity	m^3/d	8,000	8,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000
25	**Required expansion capacity**	m^3/d	-954	-5,547	2,803	5,257	7,856	10,602	13,499	16,545	19,743	23,093	26,995

Item	Year		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	**Population**		255840	264930	274080	283290	292560	301880	311250	320680	330170	339690	349260	358710
2	Pops growth rate	%	3.65%	3.55%	3.45%	3.36%	3.27%	3.19%	3.10%	3.03%	2.96%	2.88%	2.82%	2.71%
3	**Coverage**	%	75%	80%	81%	82%	83%	84%	85%	86%	87%	88%	89%	90%
4	Population served		191,880	211,944	222,005	232,298	242,825	253,579	264,563	275,785	287,248	298,927	310,841	322,839
5	Unit consumption rate	lpcd	119	120	121	122	123	124	125	126	127	128	129	130
6	Constant growth rate	1	1	1	1	1	1	1	1	1	1	1	1	1
7	Total domestic water demand	m^3/d	30,445	31,792	33,164	34,561	35,985	37,433	38,906	40,406	41,932	43,480	45,055	46,632
8	**Domestic water demand**	m^3/d	22,834	25,433	26,863	28,340	29,867	31,444	33,070	34,749	36,480	38,263	40,099	41,969
9	**Tourists**	per year	2,727,132	2,781,675	2,837,308	2,894,054	2,951,935	3,010,974	3,071,193	3,132,617	3,195,270	3,259,175	3,324,359	3,390,846
10	**Gowth rate of tourists**	%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
11	Tourists per day	per day	7,472	7,621	7,773	7,929	8,087	8,249	8,414	8,583	8,754	8,929	9,108	9,290
12	**Coverage**		75%	80%	83%	86%	89%	92%	95%	100%	100%	100%	100%	100%
13	Toirist served		5,604	6,097	6,452	6,819	7,198	7,589	7,994	8,583	8,754	8,929	9,108	9,290
14	**Unit consuption rate**	lpcd	309	310	311	312	313	314	315	316	317	318	319	320
15	Constant growth rate	1	1	1	1	1	1	1	1	1	1	1	1	1
16	Water demand by tourists	per day	1,732	1,890	2,007	2,127	2,253	2,383	2,518	2,712	2,775	2,840	2,905	2,973
17	Average day of stay	days	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
18	**Commercial water demand**	m^3/d	6,060	6,615	7,023	7,446	7,885	8,341	8,813	9,492	9,713	9,938	10,169	10,405
19	**Total water demand**	m^3/d	28,894	32,048	33,886	35,787	37,753	39,784	41,883	44,241	46,193	48,201	50,267	52,374
20	**NRW**	%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
21	Average daily water demand	m^3/d	32,105	35,609	37,651	39,763	41,947	44,205	46,537	49,157	51,326	53,557	55,853	58,193
22	**Peak factor**		1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
23	Maximum daily water demand		40,131	44,512	47,063	49,704	52,434	55,256	58,171	61,446	64,157	66,946	69,816	72,741
24	Exsiting water supply capacity	m^3/d	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000
25	**Required expansion capacity**	m^3/d	31,131	35,512	38,063	40,704	43,434	46,256	49,171	52,446	55,157	57,946	60,816	63,741

Water Supply Development Plan for the Proposed Service Areas (Scenario 2)

Item	Year		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Population		166,230	171,450	177,820	186,080	194,460	202,950	211,560	220,250	229,030	237,890	246,840	255,840	264,930	274,080	283,290	292,560	301,880	311,250	320,680	330,170	339,690	349,260	358,710
2	Pops growth rate	%	N/A	3.14%	3.72%	4.65%	4.50%	4.37%	4.24%	4.11%	3.99%	3.87%	3.76%	3.65%	3.55%	3.45%	3.36%	3.27%	3.19%	3.10%	3.03%	2.96%	2.88%	2.82%	2.71%
3	Coverage	%	30%	30%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	81%	82%	83%	84%	85%	86%	87%	88%	89%	90%
4	Population served		49,870	51,440	53,350	65,130	77,780	91,330	105,780	121,140	137,420	154,630	172,790	191,880	211,940	222,000	232,300	242,820	253,580	264,560	275,780	287,250	298,930	310,840	322,840
5	Unit consumption rate	lpcd	100	100	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140	142	144	146	148	150
6	Constant growth rate	2			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
7	Total domestic water demand	m^3/d	16,623	17,145	19,560	20,841	22,168	23,542	24,964	26,430	27,942	29,498	31,102	32,748	34,441	36,179	37,961	39,788	41,659	43,575	45,537	47,544	49,595	51,690	53,807
8	Domestic water demand	m^3/d	4,987	5,144	5,869	7,295	8,867	10,594	12,482	14,537	16,765	19,174	21,772	24,561	27,552	29,304	31,128	33,024	34,994	37,038	39,161	41,364	43,644	46,004	48,426
9	Tourists	per year	2,255,134	2,255,134	2,322,788	2,392,472	2,464,246	2,538,173	2,614,318	2,692,748	2,773,530	2,856,736	2,942,438	3,030,712	3,121,633	3,215,282	3,311,740	3,411,093	3,513,425	3,618,828	3,727,393	3,839,215	3,954,391	4,073,023	4,195,214
10	Gowth rate of tourists	%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
11	Tourists per day	per day	6,178	6,178	6,364	6,555	6,751	6,954	7,163	7,377	7,599	7,827	8,061	8,303	8,552	8,809	9,073	9,345	9,626	9,915	10,212	10,518	10,834	11,159	11,494
12	Coverage		30%	30%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	83%	86%	89%	92%	95%	100%	100%	100%	100%	100%
13	Toirist served		1,854	1,854	1,909	2,294	2,701	3,129	3,581	4,058	4,559	5,087	5,643	6,227	6,842	7,311	7,803	8,317	8,856	9,419	10,212	10,518	10,834	11,159	11,494
14	Unit consuption rate	lpcd	300	300	300	302	304	306	308	310	312	314	316	318	320	322	324	326	328	330	332	334	336	338	340
15	Constant growth rate	2	-	-	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
16	Water demand by tourists	per year	556	556	573	693	821	958	1,103	1,258	1,422	1,597	1,783	1,980	2,189	2,354	2,528	2,711	2,905	3,108	3,390	3,513	3,640	3,772	3,908
17	Average day of stay	days	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
18	Commercial water demand	m^3/d	1,946	1,946	2,005	2,425	2,873	3,351	3,861	4,402	4,979	5,591	6,241	6,931	7,663	8,240	8,848	9,490	10,166	10,879	11,866	12,296	12,741	13,201	13,678
19	Total daily water demand	m^3/d	6,933	7,090	7,873	9,719	11,740	13,946	16,343	18,939	21,744	24,765	28,013	31,492	35,215	37,544	39,976	42,514	45,160	47,917	51,027	53,660	56,385	59,205	62,104
20	NRW	%	18%	18%	17%	16%	15%	14%	13%	12%	11%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
21	Average daily water demand	m^3/d	8,460	8,650	9,490	11,570	13,810	16,220	18,780	21,520	24,430	27,520	31,130	34,990	39,130	41,720	44,420	47,240	50,180	53,240	56,700	59,620	62,650	65,780	69,000
22	Peak factor		1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
23	Maximum daily water demand		10,580	10,810	11,860	14,460	17,260	20,280	23,480	26,900	30,540	34,400	38,910	43,740	48,910	52,150	55,530	59,050	62,730	66,550	70,880	74,530	78,310	82,230	86,250
24	Exsiting water supply capacity	m^3/d	8,000	8,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000
25	Required expansion capacity	m^3/d	2,580	2,810	2,860	5,460	8,260	11,280	14,480	17,900	21,540	25,400	29,910	34,740	39,910	43,150	46,530	50,050	53,730	57,550	61,880	65,530	69,310	73,230	77,250
26	Total supply capacity	m^3/d		9,000	9,000	9,000	26,000	26,000	26,000	26,000	26,000	56,000	56,000	56,000	56,000	56,000	56,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000
27	Existing supply capacity	m^3/d		9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000
28	KTC project	m^3/d					17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000
29	Phase 1 project	m^3/d										30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
30	Phase 2 project	m^3/d																30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000

Water Supply Development Plan (Scenario 3)

Item	Year		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Population		166,230	171,450	177,820	186,080	194,460	202,950	211,560	220,250	229,030	237,890	246,840	255,840	264,930	274,080	283,290	292,560	301,880	311,250	320,680	330,170	339,690	349,260	358,710
2	Pops growth rate	%	N/A	3.14%	3.72%	4.65%	4.50%	4.37%	4.24%	4.11%	3.99%	3.87%	3.76%	3.65%	3.55%	3.45%	3.36%	3.27%	3.19%	3.10%	3.03%	2.96%	2.88%	2.82%	2.71%
3	Coverage	%	30%	30%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	81%	82%	83%	84%	85%	86%	87%	88%	89%	90%
4	Population served		49,869	51,435	53,346	65,128	77,784	91,328	105,780	121,138	137,418	154,629	172,788	191,880	211,944	222,005	232,298	242,825	253,579	264,563	275,785	287,248	298,927	310,841	322,839
5	Unit consumption rate	lpcd	100	100	110	113	116	119	122	125	128	131	134	137	140	143	146	149	152	155	158	161	164	167	170
6	Constant growth rate	3			3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
7	Total domestic water demar	m^3/d	16,623	17,145	19,560	21,027	22,557	24,151	25,810	27,531	29,316	31,164	33,077	35,050	37,090	39,193	41,360	43,591	45,886	48,244	50,667	53,157	55,709	58,326	60,981
8	Domestic water demand	m^3/d	4,987	5,144	5,868	7,359	9,023	10,868	12,905	15,142	17,590	20,256	23,154	26,288	29,672	31,747	33,915	36,181	38,544	41,007	43,574	46,247	49,024	51,911	54,883
9	Tourists	per year	2,255,134	2,237,198	2,326,686	2,419,753	2,516,543	2,617,205	2,721,893	2,830,769	2,944,000	3,061,760	3,184,230	3,311,600	3,444,064	3,581,826	3,725,099	3,874,103	4,029,067	4,190,230	4,357,839	4,532,153	4,713,439	4,901,976	5,098,055
10	Gowth rate of tourists	%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
11	Tourists per day	per day	6,178	6,129	6,374	6,629	6,895	7,170	7,457	7,756	8,066	8,388	8,724	9,073	9,436	9,813	10,206	10,614	11,039	11,480	11,939	12,417	12,914	13,430	13,967
12	Coverage		30%	30%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	83%	86%	89%	92%	95%	100%	100%	100%	100%	100%
13	Toirist served		1,854	1,839	1,912	2,320	2,758	3,227	3,729	4,266	4,839	5,452	6,107	6,805	7,549	8,145	8,777	9,446	10,155	10,906	11,939	12,417	12,914	13,430	13,967
14	Unit consuption rate	lpcd	300	300	300	303	306	309	312	315	318	321	324	327	330	333	336	339	342	345	348	351	354	357	360
15	Constant growth rate	3	-	-	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
16	Water demand by tourists	per year	556	552	574	703	844	997	1,163	1,344	1,539	1,750	1,979	2,225	2,491	2,712	2,949	3,202	3,473	3,763	4,155	4,358	4,571	4,795	5,028
17	Average day of stay	days	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
18	Commercial water deman	m^3/d	1,946	1,931	2,008	2,461	2,954	3,490	4,072	4,703	5,386	6,126	6,925	7,788	8,719	9,493	10,322	11,208	12,156	13,169	14,542	15,254	16,000	16,781	17,599
19	Total water demand	m^3/d	6,933	7,074	7,876	9,820	11,977	14,358	16,977	19,845	22,976	26,382	30,079	34,075	38,391	41,240	44,237	47,389	50,700	54,176	58,116	61,501	65,024	68,691	72,481
20	NRW	%	18%	18%	17%	16%	15%	14%	13%	12%	11%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
21	Average daily water deman	m^3/d	8,455	8,627	9,489	11,691	14,090	16,695	19,514	22,551	25,816	29,314	33,421	37,862	42,656	45,822	49,152	52,655	56,333	60,196	64,573	68,334	72,249	76,324	80,535
22	Peak factor		1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
23	Maximum daily water supply		10,569	10,784	11,861	14,613	17,613	20,869	24,392	28,189	32,269	36,642	41,776	47,327	53,321	57,277	61,441	65,818	70,417	75,245	80,717	85,418	90,311	95,405	100,669
24	Exsiting water supply capac	m^3/d	8,000	8,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000
25	Required expansion capac	m^3/d	2,569	2,784	2,861	5,613	8,613	11,869	15,392	19,189	23,269	27,642	32,776	38,327	44,321	48,277	52,441	56,818	61,417	66,245	71,717	76,418	81,311	86,405	91,669

Supporting Report

Chapter 4
Feasibility Study on Priority Project

SR 4.1 Selection of Water Source and Intake Method

Chapter 1. Process of New Water Source Selection

The Study on selection of water sources is composed of two stages:

Table 1.1 Two Staged Selection of New Water Source

Stage	Descriptions
Stage 1	A wide range of candidates for new water sources around the study area will be identified. Considering all possible alternatives, preliminary screening will be done in the first stage to pick up three to five alternatives as a long list. Then the alternatives listed in the long list are evaluated by various parameters to prepare a short list. Available intake methods for each water source are to be considered in the selection of water source. Provisional location of intake is studied in the respective water sources. The stage 1 activities will be carried out in 2 steps as detailed in the following study flow.
Stage 2	This stage will involve a more detailed and accurate comparative study for the selected alternatives in the short list. The total water supply systems are to be studied together in consideration of construction methods and work schedule. In the Second stage, the study will be conducted in the following two parts in consideration of the specialty of experts involving with the study at the Second stage. Study Part A: Study on the fundamentals as public water supply systems, including stability and availability of water amount, raw water quality, environmental aspects such as protected area/legal restriction, ground subsidence in the heritage sites, and opinion from related organizations/groups. Study Part B : Study on reality of the total water supply systems including structural & work plan/design, construction method and schedule, construction cost, and operation and maintenance cost

The study flow with breakdown items is shown as follows:

(A) Stage 1 Study Flow

I Study on New Water Source

1. Confirmation of Basic Conditions of Requirements for Study on New Water Source
2. Preparation of List of Alternative New Water Source (Long list)
3. Preparation of Parameters* for Selection of New Water Source (Stage1-Step 1 & 2)
4. Preparation of Criteria** of Parameters for Evaluation of New Water Source (Stage1-Step 1)
5. Evaluation of Alternative New Water Source (Stage1-Step 1)
6. Selection of New Water Source (Stage1-Step 1)
7. Criteria of Parameters for Evaluation of New Water Source (Stage1-Step 2)

*: Parameters (such as available water volume, water quality, protection areas, environmental impacts, etc.) to be used for the evaluation are explained in the following sections.
**: Criteria for evaluation are explained in the following sections. For the Stage 1 evaluation, the general category such as sufficient/good, acceptable/fair, bad/not acceptable, etc., based on the engineering judgment are used, as the Stage 1 study is the screening of alternatives from the long list to the short list.

II Study on Intake Method (Preparation of long list to narrow down to the short list)

1. Preparation of List of Alternative Intake Methods (Tonle Sap Lake)
2. Preparation of List of Alternative Intake Methods (New Canal from Tonle Sap Lake)
3. Preparation of List of Alternative Intake Methods (West Baray)
4. Preparation of List of Alternative Intake Methods (Groundwater)
5. Preparation of Parameters for Selection of Intake Method (General Parameter)
6. Preparation of Parameters for Selection of Intake Method (Special Parameter in case of Tonle Sap)
7. Preparation of Criteria of Parameters for Evaluation of Intake Methods
8. Evaluation of Alternative Intake Methods (Tonle Sap Lake)
9. Evaluation of Alternative Intake Methods (New Canal from Tonle Sap Lake)
10. Evaluation of Alternative Intake Methods (West Baray)
11. Evaluation of Alternative Intake Methods (Groundwater)

III Stage 1 Selection of New Water Sources in Combination with Intake Methods

1. Selection of Combination of Water Source and Intake Method
2. Confirmation of Study Items for Stage 2 Selection

IV Study on Alternative Routes for Raw Water Conveyance System in case of Tonle Sap Lake Water

1. Selection of Alternative Routes
2. Preparation of Parameters for Selection of Alternative Routes
3. Preparation of Criteria of Parameters for Evaluation of Alternative Routes
4. Evaluation of Alternative Routes

Note:The Study on Alternative Routes (IV) can be carried out in parallel with the studies for II and III.

(B) Stage 2 Study Flow

I Part A (Narrow down to the Part B selection)

1. Study on water amount
2. Study on water quality
3. Study on ground subsidence in the heritage sites
4. Study on environmental impacts (ecology, resettlement, and the other environmental items)
5. Study on opinion from related organizations/groups

II Part B (Technical evaluation based on or supplement to the Part A selection)

1. Study and evaluation on structural & work plan/design (preliminary design)
2. Study and evaluation on construction method and schedule (preliminary study)
3. Study and evaluation on construction cost estimate (preliminary estimate)
4. Study and evaluation on operation and maintenance cost (preliminary estimate)
5. Study and evaluation on economic/financial viability (preliminary evaluation)

III Selection of the Proposed Water Source

1-1 Study Area for Water Source Selection

The study area for new water source selection is widely established at the First Stage selection in consideration of the following points:

- The water sources located at comparatively far distance may sometimes become feasible by conveyance through canal or pipeline, as far as good in quality and sufficient water volume is available as well as natural and social conditions are advantageous.;
- In the past studies, the water source studies are made only within a comparatively narrow area near the Siem Reap City.
- The water sources, which are not selected at this time of project, may be useful as a future option.

The study area at the First Stage covers the following range in general.

Table 1.2 Study Area at the First Stage of New Water Source Selection

Direction of Area Range	General Limit of Study Area
North side	Khun Ream Mountain
South side	Tonle Sap Lake
East side	Roluos River System
West side	Sraeng River

The study area at the Stage 2 selection is the objective areas of the selected alternative water sources at the Stage 1 selection.

Chapter 2. Stage 1 Study on New Water Sources and Intake Methods

2-1 Stage 1 Selection of New Water Sources

2-1-1 Alternative New Water Sources, Stage 1-Step 1

The alternative new water sources are listed in the table below:

Table 2.1 Brief Features of Alternative New Water Sources

No.	Water Source	Brief Features as New Water Source
Alt. 1	Tonle Sap Lake	The lake is the largest natural lake in south east Asia and located on the south of the proposed service area. The natural conservation is also significant in and around the lake. There are some protection areas/lines which control the development and activities in the areas.
Alt. 2	West Baray	A large reservoir of 8km long and 2km wide originally constructed nearly a thousand years ago. There is one inlet connected/diverted from the Siem Reap River through a canal and one outlet from which a canal supplies water to an irrigation area. There are two projects in the past which proposed to use the reservoir water more efficiently, but the first project by Indian fund was suspended by interruption of UNESCO. And the implementation of the second project by Korean company is under negotiation with the government. The Baray and the surrounding area are designated as a protected area by APSARA (Authority).
Alt. 3	Groundwater	The major source of drinking water in the Study area is currently the groundwater. The water supply project (2003) by Japan's grant aid also uses the groundwater. Although no definite evidence is shown yet, most serious concern is the probable ground settlement resulting from additional/excessive withdrawal of groundwater. There are some people or groups who may criticize any development of groundwater resources.
Alt. 4	Siem Reap River	The river has the source in the mountain area located on the north of Siem Reap and runs through the areas of historic monuments and the central zone of Siem Reap City.
Alt. 5	Other Rivers	Besides the Siem Reap River, there are some other rivers running generally from the north to the south within a certain distance from the Siem Reap City.
Alt. 6	Other Existing Barays/ Ponds/ Reservoirs	There are some other barays/ ponds/ reservoirs beside the West Baray. It is considerable that the total impounding capacity is increased by using these other barays/ ponds/ reservoirs to regulate more effectively the remarkable difference of river flow between the dry season and the rainy season.
Alt. 7	Reservoir to be newly constructed	The reservoir is newly constructed. The original water source to supply the water to the newly constructed reservoir is the Tonle Sap Lake, the Siem Reap River, or the other rivers.

The alternative new water sources with breakdown are listed hereunder and the locations are shown in the following map of the major alternative water sources (Alt. 1 to 4).

Table 2.2 Alternative New Water Sources with Breakdown

No.		Water Source	
Alt. 1	Alt. 1A	Tonle Sap Lake（water body and lake side）	Water body within the Lake
	Alt. 1B		Canal connected to the Lake (Existing)
	Alt. 1C		Canal connected to the Lake (Newly constructed)
Alt. 2	Alt. 2A	West Baray Reservoir	Water intake directly from the baray
	Alt. 2B		Water intake from the existing canal
Alt. 3	Alt. 3A	Groundwater	Groundwater in the city (urban) zone

	Alt. 3B		Groundwater in the outskirt zone of the City (Not including the Lake side)
	Alt. 3C		Groundwater in the lake side
Alt. 4	Alt. 4A	Siem Riap River	Upstream stretch (Upper stream of French weir)
	Alt. 4B		Downstream stretch (Lower stream of French weir)
Alt. 5	Alt. 5A	Other Rivers (Singkea River,	Sraeng River
	Alt. 5B		Phiang River
	Alt. 5C		Puok River
	Alt. 5D		Roluos River
Alt. 6	Alt. 6A	Other Existing Barays/ Ponds/ Reservoirs	East
	Alt. 6B		North
	Alt. 6C		South (Loley)
	Alt. 6D		Phnum pok reservoir (Roluos)
	Alt. 6E		Trapeng Srah Srang
Alt. 7	Alt. 7A	Reservoir to be newly constructed	Land side new reservoir (water is taken from the rivers)
	Alt. 7B		Lake side new reservoir(water is taken from the Lake)
	Alt. 7C		Upper basin of the Siem Reap River (Khun Ream Mountain area)

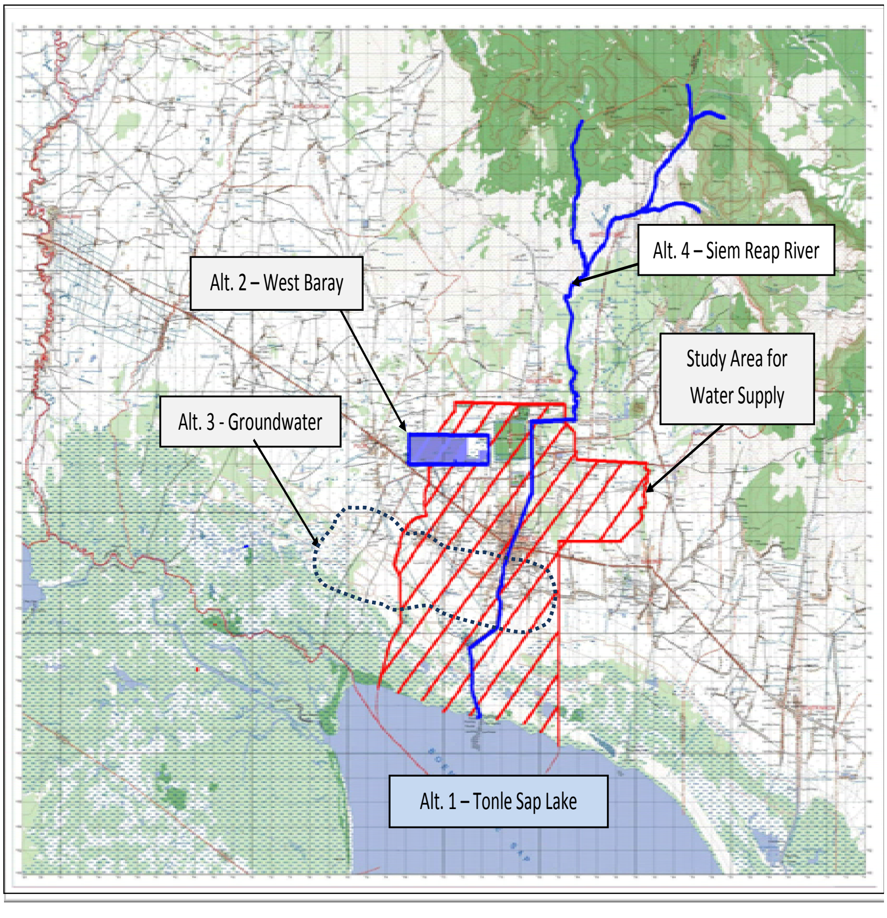


Figure 2.1 Location of Alternative Water Sources

2-1-2 Applied Parameters for Selection of New Water Sources, Stage 1-Step 1

The evaluation of Stage 1 alternatives is carried out by 2 steps. The evaluation of Step 1 reduces the alternatives for Step 2. The parameters to be used for evaluation of new water source at the stage 1 are listed in the table below:

Table 2.3 Parameters for Selection of New Water Sources, Stage1-Step 1&2

Selection Parameters		Remarks
Significant/Priority parameters (to be used for **Step 1** evaluation)		
P-1	Water volume for intake	Need to secure the required amount of intake water during both dry and rainy season. In other words, planned or designed water volume can be intake at dry season or low-water level.
P-2	Water quality	Need to consider the acceptable limits of water quality in accordance with the standards for water supply. Need to consider the extent/difficulty of the water treatment process.
P-3	Construction Cost (including difficulties)	An alternative has a high advantage or a less disadvantage in relation to construction cost. The each cost of purification plant, pipes (water supply or distribution pipes, etc.) or water tank are included for the total construction cost. Need to have no significant difficulties for construction of facilities. It is desirable that the construction period is not prolonged.
P-4	Operation & Maintenance Cost (including difficulties)	An alternative has a high advantage or a less disadvantage in relation to operation cost and the stable supply of electric power or operation is possible without any trouble. The alternative has a high advantage or a less disadvantage in relation to maintenance cost and functions of facilities can be maintained for long time. No difficulties for maintenance and repairing works are essential.
Other Parameters to be confirmed (to be used for **Step 2** evaluation)		
P-5	Water management laws/acts (including water right)	Need to confirm the necessity for securing new water right, when the existing water right in the water body has already established. In addition, the water right that is not legally established but considered as valid by customary practice will also be studied. Further the conditions/restrictions in relation to the laws and regulations for water/water resources management, other than the water right, shall also be considered during the study.
P-6	Relation with the other purposes of water uses	Need to consider the existing utilization of the water source especially in cases where the water body has multi-purposes uses such as agriculture/irrigation, industry, landscaping, navigation, fishery, tourism, etc., impact to the existing uses, the distribution method, etc. In the West Baray reservoir, for example, the utilization for irrigation purposes may be a major consideration in the study.
P-7	Impacts to archeological sites	Need to consider the probable impacts, especially in connection with the ground subsidence, on the archeological sites (historic remains) which are widely located in and around the Study area
P-8	Impact to ecology	Need to consider/evaluate the impact on the ecology (fauna and flora), especially within the natural protection/conservation areas.
P-9	Impact to life and land uses of inhabitants	Need to consider/evaluate the impact on the current activities and land utilization of inhabitants. It is required to have no adverse impacts on surrounding communities such as their impacts on community's life and livelihood. Consideration may also be made for sufficient mitigation measures taken for such impacts.
P-10	Land acquisition and resettlement	Need to evaluate and consider the impact, mitigation measures and alternative plans etc. on the land acquisition and resettlement in connection with the construction and operation of facilities.
P-11	Related organization/ group	Need to discuss probable issues/matters with the related organizations/ groups in regard to conservation/protection and uses of objective water sources and the surrounding areas. The consideration and discussion is necessary on the basis of scientific data/analyses preventing from troublesome interfere without the evidence. The countermeasures, if required, are also to be the subject of discussion. Agreement or consensus is to be obtained from the authorities concerned, if considered necessary.

2-1-3 Applied Criteria for Selection of New Water Sources, Stage 1-Step 1

The criteria to be used for the evaluation of priority parameters for new water source selection (at the step 1 of the stage 1) are listed in the table below:

Table 2.4 Criteria of Selection of New Water Sources, Stage 1-Step1

Category of Evaluation	Water quantity*	Water quality**	Construction*** (Cost and Difficulty)	Operation & maintenance*** (Cost and Difficulty)
A	Sufficient	Good	Low	Low
B	Acceptable	Acceptable	Medium	Medium
C	Insufficient	Not suitable	High	High
D****	Not sure	Not sure	Not sure	Not sure

Notes:

*: "Sufficient" means that the volume is sufficient for the long-term requirement and "Acceptable" means that the volume may be enough to be used at least for the short term new water supply requirement.

**: "Good" means that simple treatment is enough and "Acceptable" means that the water is usable although the conventional treatment is required.

*** :There are no definite figures of criteria to be established at the First Step selection. The decision of respective category is based on the engineering considerations; however, it is assumed that the following case is classified as Category B and the selection of Category is judged by the general comparison with the assumed case.

- Water source: A river (River channel bottom: 20-30 m wide, Water depth : 1-2m on an average, River banks : gentle slope and approximately 5m in height)
- Intake facility: Diversion weir (with gates) and Intake works
- Water transmission line (pipe): Generally flat land but with some undulation, pumping facility is required. The transmission main passes through the urban zone and the groundwater level is relatively high (within a few meters from the ground)

****: Category D (Not sure) means that it is probably B but there is possibility to become C according to the further detailed study.

2-1-4 Evaluation of Alternative New Water Sources, Stage 1-Step 1

The evaluation of priority parameters for new water source selection (at the step 1 of the stage 1) are carried out in applying the criteria adopted in the previous section and the results are shown in the following table.

Table 2.5 Evaluation of Alternative New Water Sources, Stage1-Step 1

Water source		Water quantity	Water quality	Construction (Cost and Difficulty)	Operation & maintenance (Cost and Difficulty)	Overall Judgment
Alt. 1	Tonle Sap Lake	A	B	D	D	Selected
Alt. 2	West Baray Reservoir	B	A or B	A or B	A	Selected
Alt. 3	Groundwater	A or B	A or B	A or B	A or B	Selected
Alt. 4	Siem Riap River	C	B or C	A or B	A or B	Not Selected
Alt. 5	Other Rivers	D	A or B	B or C	B or C	Not Selected
Alt. 6	Other Existing Barays/ Ponds/ Reservoirs	D	A or B	B or C	A or B	Not Selected
Alt. 7	Reservoir to be newly constructed	A or B	A or B	B or C	A or B	Not Selected

Some reference explanation on the table above is given below:

i) The Siem River is abandoned at the first step of evaluation due to shortage of water in the dry season is certain.

ii) Alternatives (5, 6, and 7) are also not selected to proceed to the next evaluation, mainly due to the rough evaluation of cost and availability of water volume.

2-1-5 Selection of New Water Sources, Stage 1-Step 1

The selection based on evaluation of priority parameters for new water source selection (at the step of the stage 1) are carried out and the results are shown in the table below:

Table 2.6 Tentative Selection of New Water Sources, Stage 1-Step 1

No.		Water source Name	
Alt. 1	Alt. 1A	Tonle Sap Lake（water body and lake side）	Water body within the Lake
	Alt. 1B		Canal connected to the Lake (Existing)
	Alt. 1C		Canal connected to the Lake (Newly constructed)
Alt. 2	Alt. 2A	West Baray Reservoir	Water intake directly from the baray
	Alt. 2B		Water intake from the existing canal
Alt. 3	Alt. 3A	Groundwater	Groundwater in the city (urban) zone
	Alt. 3B		Groundwater in the outskirt zone of the City (Not including the Lake side)
	Alt. 3C		Groundwater in the lake side

2-1-6 Applied Criteria for Selection of New Water Sources, Stage 1-Step 2

The criteria to be used for the evaluation of other parameters for new water source selection (at the step 2 of the stage 1) are listed in the table below:

Table 2.7 Criteria of Selection of New Water Sources, Stage 1-Step 2

Category of Evaluation	Issue of Water laws and right	Impact to Other uses	Impacts to Archeo -logical sites	Impact to ecology	Impact to life of inhabitants	Issue of Land acquisition and resettlement	Interference by Related Organization
A	Almost no impacts or issues are predicted (The alternative is satisfied with the condition of requirement.)						
B	Slight impacts or issues are predicted (The alternative does not have a big disadvantage thorough taking mitigation measures while it has several problems)						
C	Significant impacts or issues are predicted (The alternative is not satisfied with the condition of requirement, or, it has significant problems and the sufficient mitigation measure may be difficult to be taken.)						
D	Not sure at this stage of study						

Note: Since each evaluation item has different degrees of importance, the overall evaluation will be based on weighted ratings rather that by simple evaluation. The weighted ratings are based on the engineer's judgment at the first stage selection, although the engineer's judgment may accompany with some studies and data analyses.

2-1-7 Evaluation of Alternative New Water Sources, Stage 1-Step 2

The evaluation of other parameters for new water source selection (at the step 2 of the stage 1) is carried out and the results are shown in the following table.

Table 2.8 Evaluation of Alternative New Water Sources, Stage1-Step 2

Parameter		Tonle Sap			West Baray*		Groundwater		
No.	Description of parameters	Alt. 1A Lake	Alt. 1B Canal (exist)	Alt. 1C Canal (new)	Alt.2A Baray	Alt.2B Canal	Alt. 3A City	Alt. 3B Out-skirt	Alt. 3C Lake side
P-5	Water management laws/acts (including water right)	A or B	B or C	A or B	A or B	A or B	C	B or C	A or B
P-6	Relation with the other purposes of water uses	A or B	C	A or B	B or C	B or C	A	A	A
P-7	Impacts to archeological sites	A	A	A	D	A or B	D	A	A
P-8	Impact to ecology	D	A or B	B or C	A or B	A or B	A	A	A or B
P-9	Impact to life and land uses of inhabitants	A or B	C	A or B	A or B	A or B	A or B	A or B	A
P-10	Land acquisition and resettlement	B	B or C	B	A or B	A or B	B	B	A or B
P-11	Related organization/ group	D	B or C	D	C	D	C	D	D
Overall Judgment		Selected	Abandoned	Selected	Abandoned	Selected	Abandoned	Future option **	Selected

*: For the evaluation of West Baray, the breakdown alternatives (Alt. 2A and 2B) is not shown in the table, as the evaluation results are basically the same.
**: The groundwater development in the outskirt zone is decided as a future option, as the Alt 3C (lake side ground water) is considered as the representative of the outskirt zone.

The final selection of new water source at stage 1 is made in accordance with the results of evaluation shown above (for step 1 and step 2) and summarized in the table below:

Table 2.9 Selected New Water Sources in Stage 1

No.		Water source Name	
Alt. 1	Alt. 1A	Tonle Sap Lake（water body and lake side）	Water body within the Lake
	Alt. 1C		Canal connected to the Lake (Newly constructed canal)*
Alt. 2	Alt. 2B	West Baray Reservoir	Water intake from the existing canal
Alt. 3	Alt. 3C	Groundwater	Groundwater in the lake side

*: The appropriate distance and extension point of canal is to be studied at the Second stage study.

2-2 Stage 1 Selection of Intake Methods

2-2-1 Alternative Intake Methods, Stage 1- Step1

(1) Tonle Sap Lake (lake water body)

The alternative intake methods in case of Tonle Sap Lake (within the lake water body) as the water source are listed in the following table.

Table 2.10 Alternatives of Intake and Raw Water Transmission Main (A)

No.	Intake	Raw Water Transmission Main	Description
1A-a	Floating barge	Pipe	Floating-barge can move with the water level fluctuation. The intake pipe with the pump is installed in a barge located within the water body of the lake which has sufficient water depth even during the low-water season. A transmission pipe will laid from the barge to the lakeshore. The transmission pipe may be floated or be placed on the lake bed. The generator for pump operation may be installed in the barge or the electric transmission line may be laid down between the land side and the barge. The impact of navigation on the water body and the countermeasures (if required) will be considered in the detailed plan of this type.
1A-b	Intake tower	Pipe	The intake tower is constructed in a location where the water withdrawal is possible any time during the year, especially during the low-water season. The transmission pipe is placed between the intake tower and the water tank on land near the lakeshore during high-water season. The pump is located in the tower. The generator for pump operation may be installed in the tower or the electric transmission line may be laid between the shoreline and the tower. The intake tower is often selected as the site for the reservoir. But, in case of the Tonle Sap lake, major issues to consider will include the construction method, the construction cost, and also the scenic attraction.
1A-c	Intake frame box	Pipe	The intake frame box is placed on the lakebed to maintain a certain water depth for intake. From the frame, the water is transmitted by gravity to the water tank with pumping facilities located on the landside of lakeshore.
1A-d	Collecting pipe	Pipe	Instead of the intake frame box as explained above, the collection pipe is installed on the lakebed. The collecting pipe may pose some difficulty for maintenance due to clogging by sediments.
1A-e	Trolley lane	Pipe	The submerged pump is installed in a trolley that moves with the water level fluctuation of the lake, on a lane constructed on a slope of the lake bed. The construction of trolley lane may be difficult if the lakebed slope foundation is not sufficiently stable.

For understanding the image of alternative intake methods, the schematic illustration is shown in the figure below.

(2) New Canal from Tonle Sap Lake

The alternative intake methods in case of new canal connected to the Tonle Sap Lake as the water source are listed in the table below:

Table 2.11 Alternatives of Intake and Raw Water Transmission Main (B)

No.	Intake	Raw Water Transmission Main	Description
1B-a	Intake tower	Pipe	The intake tower is constructed in a water channel/canal with sufficient depth for water intake during the low water season. It is desirable if the access bridge can be constructed from the land to the tower.

1B-b	Intake gate	Pipe	The intake pipe is directly placed on the slope/bank of a water channel, which may already exist or be constructed by dredging.
1B-c	Intake frame box	Pipe	The intake frame box is placed on the canal-bed to maintain a certain water depth for intake. From the frame, the water is transmitted by gravity to the water tank with pumping facilities located on the landside of lakeshore.

For understanding the image of alternative intake methods, the schematic illustration is shown in the figure below.

(3) Existing Canal from West Baray

The alternative intake methods in case of West baray (existing canal) as the water source are listed in the table below:

Table 2.12 Alternative Intake Methods in case of West Baray(from the existing canal)

No.	Intake	Raw Water Transmission Main	Description
2B-a	Diversion weir +Intake gate	Open channel or Culvert channel	A gated diversion weir is constructed in the existing irrigation canal and the water is diverted to intake gate, which is constructed on the bank of canal. From the canal to the proposed WTP site, raw water transmission is made through a open channel or culvert channel, possibly by gravity.

For understanding the image of alternative intake methods, the schematic illustration is shown in the figure below.

(4) Groundwater

The alternative intake methods in case of Ground water as the water source are listed in the table below:

Table 2.13 Alternative Groundwater Intake (in the lake side)

No.	Intake	Raw Water Transmission Main	Description
3C-a	Well	pipe	On land near the lakeshore during the high-water season, wells (Possibly 50 ～60m in depth and capacity of approximately 1,000 $m^{3/}$day/well) with pumping facilities are constructed. The depth and number of well will depend on the possible capacity of water intake, the construction difficulties & cost, and the maintenance issues. The water seepage in the ground flows into the well through the bottom or holes of the walls of the well. The pumping facilities are installed in the well. The study on the locations, necessary number of well, and the distance between the wells may need detailed analysis possibly based on the pumping test.
3C-b	Well + collecting pipes	pipe	This may be a kind of dug well and the depth may be 10-20 m. The structure and function is almost the same. But, the collection pipes are extended from the well to contain the water seeping into the well. The study on diameter, length, numbers, locations/directions, material, etc. of the collecting pipe will consider various conditions such as seepage coefficient and prevention of clogging.

For understanding the image of alternative intake methods, the schematic illustration is shown in the figure below.

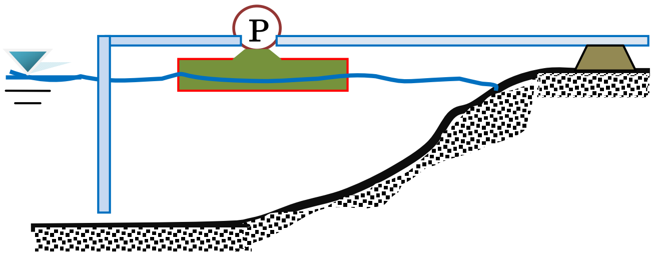
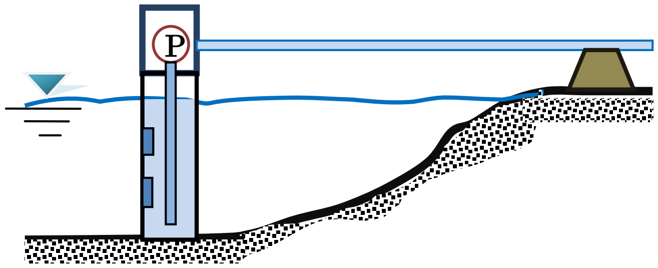
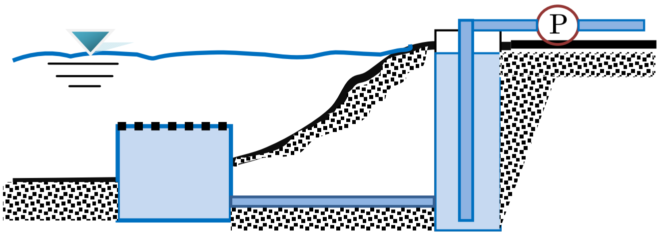
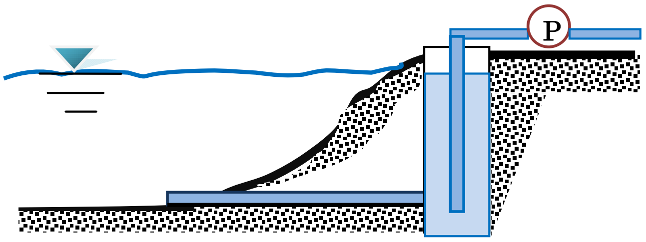
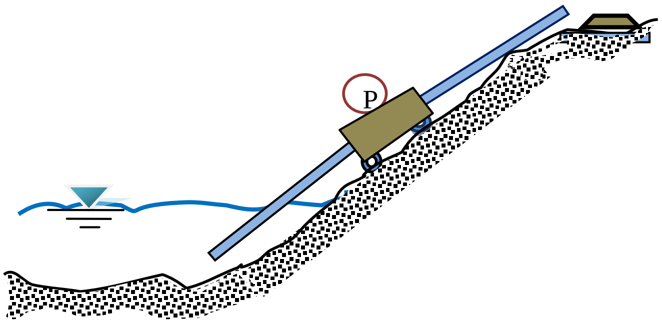
No.	Intake	Raw Water Transmission	Schematic Illustration
1A-a	Floating barge	Pipe	
1A-b	Intake tower	Pipe	
1A-c	Intake frame box	Pipe	
1A-d	Collecting pipe	Pipe	
1A-e	Trolley lane	Pipe	

Figure 2.2 Schematic Illustration of Alternative Intake Methods (Tonle Sap Lake)

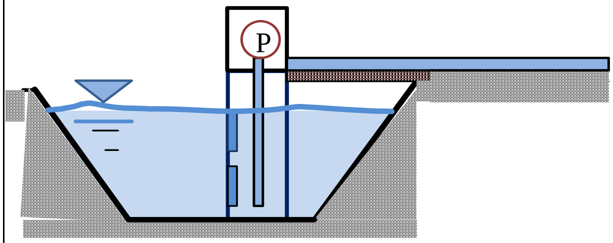
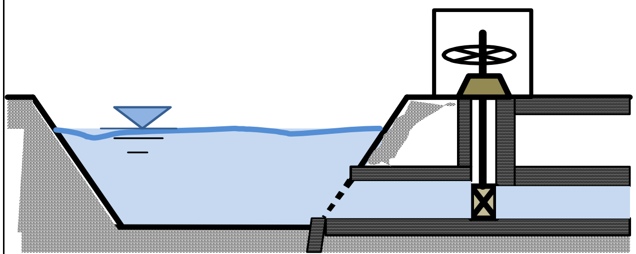
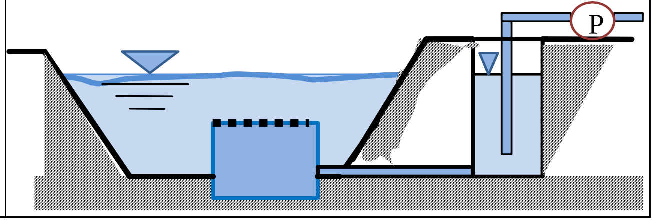
No.	Intake	Raw Water Transmission	Schematic Illustration
1B-a	Intake tower	Pipe	
1B-b	Intake gate	Pipe	
1B-c	Intake frame box	Pipe	

Figure 2.3 Schematic Illustration of Alternative Intake Methods (New canal of Tonle Sap Lake)

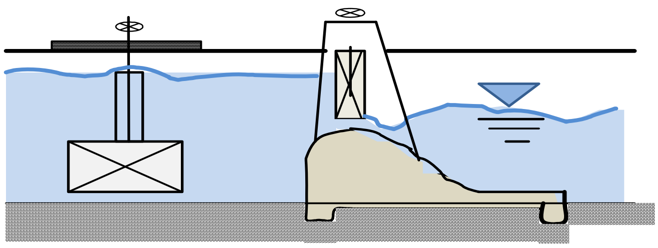
No.	Intake	Raw Water Transmission	Schematic Illustration
2B-a	Diversion weir +Intake gate	Open channel or Culvert channel	

Figure 2.4 Schematic Illustration of Alternative Intake Methods (West baray, Existing canal)

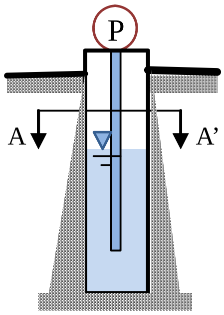
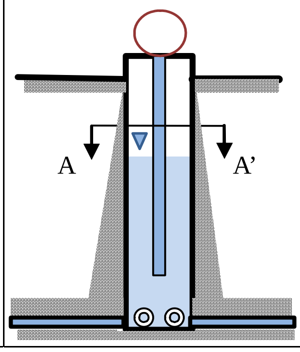
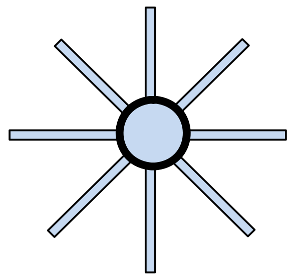
No.	Intake	Raw Water Transmission	Schematic Illustration	
3C-a	Well	Pipe		 AA' Section
3C-b	Well + collecting pipes	pipe		 AA' Section

Figure 2.5 Schematic Illustration of Alternative Intake Methods (Ground water)

2-2-2 Applied Parameters for Selection of Intake Methods

(1) General parameters

The general parameters for evaluation of intake methods are decided as shown in the table below:

Table 2.14 Parameters for Selection of Intake Method

Parameters		Description
GP-1	Capacity of intake volume	To secure the required volume of intake water
GP-2	Flexibility to variation of water level	To secure the function of intake water considering the variation of water level and discharge
GP-3	Construction cost and difficulties	To be not costly comparing with a typical method of intake and no significant difficulty for construction of facilities.
GP-4	O & M Cost and difficulties	To be not costly comparing with a typical method of intake and no significant difficulty for operation & maintenance of facilities
GP-5	Future expansion	To enable future expansion of facilities
GP-6	Archeological site	To have no significant impacts to archeological sites, which need acceptance by the APSARA Authority.
GP-7	Environmental impacts	To have no significant adverse impact on environmental conditions, such as ecology, public nuisance, etc.

(2) Special Parameters in case of Tonle Sap Lake

The special parameters for evaluation of intake methods in case of Tonle Sap lake are decided as shown in the table below:

Table 2.15 Special Parameters for Intake for Tonle Sap Lake

Parameters		Description
SP-1	Water level fluctuation (large)	The water level fluctuates to as much as 6-10 m almost every year. The study on intake system will evaluate the factors for such large fluctuation.
SP-2	Lake shoreline movement	The water intake method is required in consideration of the remarkable shifts of lakeshore line between rainy season and dry season. Although the degree of movement varies by location and year, it varies by more than 10 km at some areas.
SP-3	Shallow water level	To be flexible for secure the intake of water against the very shallow water depth (more or less 1m or shallower) during the low water season. The lake is unusually flat almost all the area including the central part, although the area is very large.
SP-4	Fishery, Tourism, Navigation	To have no significant impacts to the fishery, living, tourism, and navigation by local inhabitants in and around the lake.
SP-5	Related organization	To be possible to get consensus from various stakeholders/ affected organizations on the use of the lake and the water. The lake is very large and the natural conditions of the lake are rich. The lake is protected and conserved by the national law. Accordingly, there are various organizations and groups that involve in study and protection of the lake and the surrounding area, e.g., Mekong River Committee, IUCN, Tonle Sap Basin Authority, Ministry of Environment, Ministry of Fishery, Fisherman's groups, etc.

2-2-3 Applied Criteria for Selection of Intake Methods

The criteria for evaluation of parameters in intake methods are decided as shown in the table below:

Table 2.16 Criteria of Selection of Intake Methods

Category	GP	SP
A	Sufficiently satisfy the required condition.	No significant problem/impacts are predicted.
B	More or less satisfy the required condition.	Slight problem/impacts are predicted.
C	Not satisfy the required condition.	Significant problem/impacts are predicted.
D	Not sure *	Not sure*

*: Need to confirm by the further study/survey based on a specific plan.

2-2-4 Evaluation of Alternative Intake Methods

(1) Tonle Sap Lake

Evaluation for selection of intake method in case of Tonle Sap Lake (Water Body) is made and summarized in the table below:

Table 2.17 Evaluation by General Parameters of Intake Method of Tonle Sap Lake Water

	1A-a	1A-b	1A-c	1A-d	1A-e
Intake	Floating barge	Intake tower	Intake frame box	Collecting pipe	Trolley lane
GP-1	A	A	A	A	A
GP-2	A	B	A	A	B
GP-3	B or C	B or C	B or C	B or C	B or C
GP-4	B or C	B	B	B or C	B or C
GP-5	B	B	B	B	B
GP-6	A	A	A	A	A
GP-7	D	D	D	D	D

Table 2.18 Evaluation by Special Parameters of Intake Method of Tonle Sap Lake Water

	1A-a	1A-b	1A-c	1A-d	1A-e
Intake	Floating barge	Intake tower	Intake frame box	Collecting pipe	Trolley lane
SP-1	A	A	A	A	A
SP-2	B	B	B	B	B
SP-3	C	B	B	D	C
SP-4	D	D	B	B	B or C
SP-5	D	D	D	D	D
Overall	Abandoned	Selected	Selected	Selected	Abandoned

(2) New Canal from Tonle Sap Lake

Evaluation for selection of intake method in case of Tonle Sap Lake (Water Body) is made and summarized in the table below:

Table 2.19 Evaluation of Alternative Intake Methods by Canal

No.	1B-a	1B-b	1B-c
Intake	Intake tower	Intake Gate	Intake frame box
GP-1	A	A	A
GP-2	A or B	A or B	A
GP-3	B	B	B or C
GP-4	B	B	B or C
GP-5	B	B	B or C
GP-6	A	A	A
GP-7	B	B	B

Table 2.20 Evaluation of Alternative Intake Methods by Canal

No.	1B-a	1B-b	1B-c
Intake	Intake tower	Intake Gate	Intake frame box
SP-1	B	B	A
SP-2	A	A	A
SP-3	A	A	A
SP-4	A	A	A
SP-5	B	B	B
Overall	Selected	Selected	Abandoned

(3) Existing Canal from West Baray

Evaluation for selection of intake method in case of West Baray (Irrigation canal) is made and summarized in the table below:

Table 2.21 Evaluation of Alternative Intake Methods of West Baray

No.	2B-a
Intake	Diversion weir +Intake gate
GP-1	B
GP-2	A
GP-3	A
GP-4	A
GP-5	B
GP-6	D
GP-7	B
Overall	Selected

(4) Groundwater

Evaluation for selection of intake method in case of Groundwater is made and summarized in the table below:

Table 2.22 Evaluation of Alternative Intake Methods of Groundwater (in the lake side)

No.	3C-a	3C -b
Intake	Well	Well + Collecting pipes
GP-1	A or B	B
GP-2	A or B	A or B
GP-3	A or B	B
GP-4	A or B	C
GP-5	A	A or B
GP-6	D	D
GP-7	A or B	A or B
Overall	Selected	Abandoned

2-2-5 Stage 1 Selected Intake Methods

The selected intake methods at respective water source are shown in the tables below:

Table 2.23 Alt.1A: Selected Intake for Tonle Sap Lake Water

No.	Intake
1A-b	Intake tower
1A-c	Intake frame box
1A-d	Collecting pipe

Table 2.24 Alt. 1B: Selected Intake for Tonle Sap Lake Water by Canal

No.	Intake
1B-a	Intake tower
1B-b	Intake gate

Table 2.25 Alt. 2B: Selected Intake for West Baray Water by the Existing Canal

No.	Intake
2B-a	Diversion weir +Intake gate

Table 2.26 Alt.3C: Selected Intake for Groundwater in the Lake Side

No.	Intake
3C-a	Well
3C-b	Well + collecting pipes

2-3 Stage 1 Selected New Water Sources and Intake Methods

The conclusion of stage 1 selection of new water source in with combination with intake method is summarized in the table below:

Table 2.27 Selected Combination of Water Sources and Intake Methods, Stage 1

Water Source				Intake method	
No.	Name	Sub No.	Location	No.	Description
Alt.1	Tonle Sap Lake	Alt.1A	Water body within the Lake	Alt.1A-b	Intake tower
				Alt.1A-c	Intake frame box
				Alt.1A-d	Collecting pipe
		Alt.1C	Canal connected to the Lake (Newly constructed)	Alt.1C-a	Intake tower
				Alt.1C-b	Intake gate + Culvert
Alt.2	West Baray Reservoir	Alt.2B	Existing canal	Alt.2B-a	Diversion weir +Intake gate
Alt.3	Groundwater	Alt.3C	Groundwater in the lake side	Alt.3C-a	Well
				Alt.3C-b	Well + collecting pipes

2-4 Study on Alternative Routes for Transmission of Tonle Sap Lake Water

2-4-1 Alternative Routes

Three alternative routes are selected for Raw Water Transmission Main or Newly Constructed Canal, which is the water way from the Tonle Sap Lake. The location map of these alternative routes is shown in the figure below.

Table 2.28 Alternative Routes for Raw Water Transmission Main/Canal

Alternative Routes	Descriptions
Route A	To be located on 2km east from the north-south axis line
Route B	To be located on 6km west from the north-south axis line
Route C	To be located on 11km west from the north-south axis line, which is extended from the center of Angkor Thom and nearly parallel to the Siem Reap River stream line.

Note: The alternative routes are selected from some considerations including the following:

- To avoid the zoned areas by APSARA Authority.
- To avoid close to the outlet of artificial canal extended from the Phnom Kroam to the lake, where the water contamination is seen due to human activities.

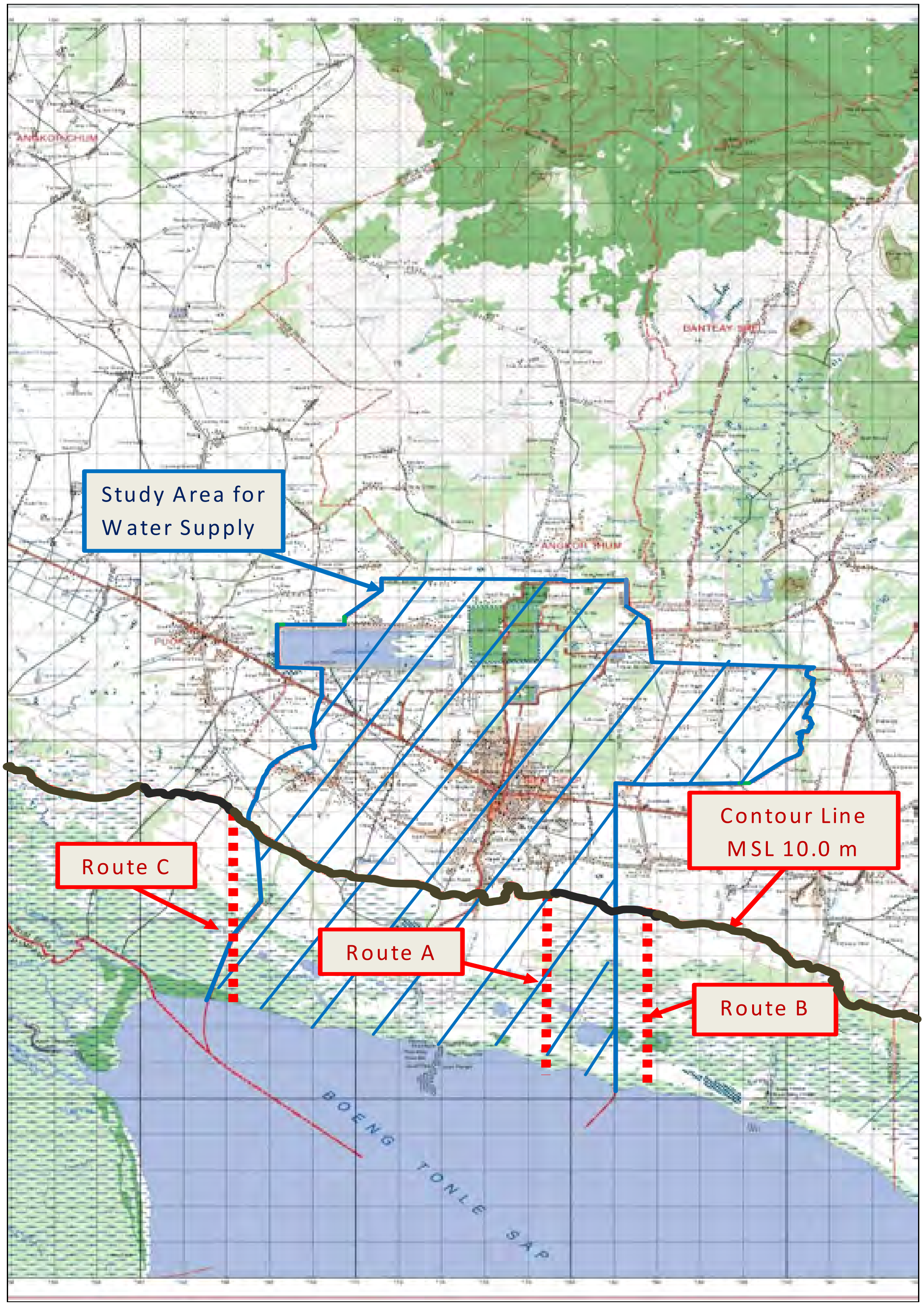


Figure 2.6 Alternative Routes for Raw Transmission Main from Tonle Sap Lake

The parameters for evaluation of alternative routes are shown in the table below:

Table 2.29 Parameters for Selection of Alternative Routes

Parameters		Description
P-1	Land acquisition	Need to evaluate the land acquisition cost and difficulties. It may be one of essential parameters for the selection of route.
P-2	Resettlement	Need to avoid the resettlement or minimize the numbers.
P-3	Water quality	Need to select carefully the location of intake (canal inlet) taking into consideration the water quality conditions and level of pollution due to human activities.
P-4	Construction Cost and Difficulties	Need to consider the impacts to the construction cost and difficulties. It is also desirable that the construction period is not prolonged due the selection of route.
P-5	Operation & Maintenance Cost and Difficulties	Need to consider the operation & maintenance cost and difficulties of the long term period and the stable supply of electric power or operation is possible without any trouble.
P-6	Archeological sites	Need to consider the probable impacts on the archeological sites (historic remains)
P-7	Fishery, Tourism, Navigation	Need to carefully study the probable impact and possible mitigation measures to fishery, tourism, and navigation.
P-8	Ecology	Need to consider/evaluate the impact on the ecology (fauna and flora), especially within the natural protection/conservation areas in and along the proposed route.
P-9	Related organization	Need to discuss probable issues/matters with the related organizations/ groups in regard to conservation/protection and uses of objective water sources and the surrounding areas. The consideration and discussion is necessary on the basis of scientific data/analyses preventing from troublesome interfere without the evidence. The countermeasures, if required, are also to be the subject of discussion. Agreement or consensus is to be obtained from the authorities concerned, if considered necessary.
P-10	Impact to life and land uses of inhabitants	Need to consider/evaluate the impact on the current activities and land utilization of inhabitants. It is required to have no adverse impacts on surrounding communities such as their impacts on community's life and livelihood. Consideration may also be made for sufficient mitigation measures taken for such impacts.
P-11	Future expansion	Need to have space to enable future expansion of facilities.

2-4-2 Applied Criteria for Selection of Alternative Routes

The criteria of parameters for evaluation of alternative routes are prepared as shown in Table 2.30.

Table 2.30 Criteria for Selection of Alternative Routes

Category of Evaluation	Parameters (P1 to P11)	
	By the requirement	By advantage
A	Sufficiently satisfy the requirement	Best (First)
B	Acceptably satisfy the requirement	Second
C	Insufficient to satisfy the requirement	Third
X	Not sure	N.A.

2-4-3 Selection of Alternative Routes

The evaluation of alternative route is made as summarized in Table 2.31.

Table 2.31 Evaluation by the Requirement of Respective Parameter

Parameter		Route A	Route B	Route C
No.	Description of parameters	East (near)	East(far)	West
P-1	Land acquisition	B	A	C
P-2	Resettlement	A	A	A
P-3	Water quality	B	B	B
P-4	Construction Cost and Difficulties	NA*	NA	NA
P-5	Operation & Maintenance Cost and Difficulties	NA	NA	NA
P-6	Archeological sites	A	A	A
P-7	Fishery, Tourism, Navigation	A	A	A
P-8	Ecology	B	B	B
P-9	Related organization	B or X	B or X	B or X
P-10	Impact to life and land uses of inhabitants	A	A	A
P-11	Future expansion	A	A	A
Overall judgment		Selected**	Selected**	Selected**

*: NA means "Not applicable for evaluation".
**: Selected means that no remarkable disadvantages are found to abandon the alternative at this stage of study.

Table 1.32 Evaluation of 3 Routes

Parameter		Route A	Route B	Route C
No.	Description of parameters	East (near)	East(far)	West
P-1	Land acquisition	B	A	C
P-2	Resettlement	NA	NA	NA
P-3	Water quality	NA	NA	NA
P-4	Construction Cost and Difficulties	A or B	A or B	C
P-5	Operation & Maintenance Cost and Difficulties	A or B	A or B	C
P-6	Archeological sites	NA	NA	NA
P-7	Fishery, Tourism, Navigation	NA	NA	NA
P-8	Ecology	NA	NA	NA
P-9	Related organization	NA	NA	NA
P-10	Impact to life and land uses of inhabitants	NA	NA	NA
P-11	Future expansion	NA	NA	NA
Overall Judgment		B	A	C

2-4-4 Stage 1 Selected Route

It is difficult to make sure the difference of advantage between Route A and Route B at this stage of study. Accordingly, both routes are selected, but the present priority is Route B. It is also necessary to say that the final route may be selected between these 2 routes or a route within some km east from Route B. In these areas, the difference of conditions such as the present land use, topography, vegetation, etc. are not remarkable, although the land price may be lower according to the distance from the town area.

Table 2.32 Selected Routes

Alternative Routes	Descriptions
Route A	To be located on 2km east from the north-south axis line, which is extended from the center of Angkor Thom and nearly parallel to the Siem Reap River stream line.
Route B	To be located on 6km west from the north-south axis line

Note: (1) These two routes are basically the same as the survey routes, which are already completed in July 2009.
(2) It is also noted that the route line may be modified partially according to the actual restriction or conditions at the site, although the straight line is assumed for the alternatives.

2-5 Topographic Survey for the Alternative Routes

Topographic survey field work has commenced on the 25th of June 2009 and finished on the 22nd of July 2009 and the data processing finished on the 30th of July 2009. This survey consist two parts, as part 1 for the route survey and second part of survey for the facility site. The part 1 was completed during the phase 1 stage, but, the part 2 will be implementing for phase II stages of this study.

Route surveys for the proposed raw water conveyance pipelines are 2 routes for the raw water conveyance pipelines from the proposed raw water intake site to the tentatively proposed water treatment plant (WTP) site (Approx. 15 km for route A and B). This route survey established 6 base points for route A and 4 points for route B. Their vertical control is transferred from ST12 (+19.334 a.m.s.l. at Ha Tien). Their horizontal control is done by using GPS based on WGS84.

Figure 2.7 Proposed Typical Profile for Intake

<u>Results</u>

The ground level at the proposed raw water intake site is between 0.0 m and 1.0 m msl. The tentative WTP site is above 10.0 m msl .

-Access road to the facilities

Access roads to the proposed facilities are necessary to secure easy operation and maintenance. The tentative WTP site and intake site are located in the isolated area and below the high water level during the rainy season. The topographic survey is showing that there is no proper road to access. The access road shall be included the construction work along the pipe line route.

-Embankment of WTP site

The embankment of WTP site is required. The tentative WTP sites are located on the ground level in between 10.0 and 11.0 m msl. The elevation of the proposed WTP site shall be designed above the designe high water level (11.0 m msl.). The construction work for WTP shall be included the embankment with the allowance height.

Chapter 3. Stage 2 Study on the Other Parameters for Alternative Water Sources

3-1 Water Volume Availability

3-1-1 Evaluation of Water Volume Availability

The water volume availability of alternative water sources selected at Stage 1 are studied at Stage 2 more in detail and summarized hereunder.

Table 3.1 Water Volume Availability of Alternative Water Sources

Water Source	Overall Evaluation	Descriptions of Evaluation
Tonle Sap Lake	Sufficient	The lake is huge with the surface area of approximately 2,500 km^2 at the lowest water level period and the water volume is sufficient for the water supply demand in the long term.
West Baray	Not sufficient for the long term requirements, possibly for short term requirements with considerable rehabilitation works for the existing faculties/works to diver the flow from the Siem Reap River	The reservoir capacity at present is approximately 48 million m^3. The capacity is very attractive to use the water effectively. The main water source of the baray is the Siem Reap River, from which the flow is diverted into the baray during the rainy season at present. There is one outlet from the baray and the irrigation canal is connected. There are several points of issues to know the accurate conditions of present water balance and uses. There are no specific rules of gate operation and no overall water management plan has been established. Then, available basic data are limited and the accuracy of existing data is not sure. Therefore, the Team analyzed an possible diversion from the Siem Reap river to the proposed water supply scheme based on the assumption detailed hereunder.
Groundwater	Assumed to be available with careful monitoring system for the impacts to the Angkor heritages	The groundwater is currently taken almost everywhere in the Siem Reap province. The area has high water table, in general the water table exists 1.0 – 4.0 m below the ground even in the dry season. The water table rises by approximately 2 m during the rainy season. The details will be analyzed and reported in Phase 3 under the Study.

3-1-2 Preliminary Analysis on Availability of West Baray Water

(1) Background

The JICA Study on Water Supply System for Siem Reap Region (Report prepared in June 2000) is the comprehensive detailed master plan study which started in December 1996. The detailed hydrological survey has been carried out as a part of the Study. The new gauging stations were established by the team for the measurement of water level and discharge in the Siem Reap River and in the West Baray, although the stations were established strangely only at the downstream side of the diversion point. The measurement results were used for the hydrological analyses of the river flow as well as the diversion flow to the West Baray.

However the period of the measurement and the analyses was short. For example, the daily inflow calculation for the West Baray was carried out only for the period from August to December 1998. A preliminary hydrological survey and analyses done by the Team is useful for the comprehensive water management study which should be carried out in the near future.

It is beneficial for the water supply sector to increase the reservoir capacity in the following two ways. One is to dredge or excavate the sedimentation in the reservoir. Another is to change the present HWL of the reservoir. In any ways, it is tedious procedures to secure the permission from the related organizations concerned in terms of minimizing the environmental impacts.

(2) Preliminary Analysis of Available Water Volume

Availability of water volume from the West Baray was estimated using the discharge records at UNTAC Bridge in the Siem Reap River. The records were obtained from the Hydrological section of MORAM. The gauging station at UNTAC Bridge dose not exists at present, however, the records are available from October 1969 until the end of 2004, although there are some months without the records. The UNTAC Bridge is located downstream of the diversion point to the West Baray. That is, the discharge of the diversion to the West Baray is not included. The diversion to the West baray is made generally from mid or late July until the reservoir water level reach to HWL or sufficiently higher level for the use of irrigation. The gates of diversion channel are generally closed and the French weir gate is opened during the period from October to December. The records at the UNTAC Bridge at least from January to June are assumed to be the original flow of the Siem Reap River.

It is difficult to confirm the reliability and accuracy of the records. However, the Team assumed that the records are reliable to use. The verification of the records shall be necessary in the water management study in the future.

Based on the daily flow records, the monthly maximum, minimum, and mean discharge figures are summarized as shown in the following tables. Frequency analysis of droughty water was then carried out by using the records from January to July in two cases.

The results are shown in Table 3.2 and Table 3.3. From the results of frequency analyses, it is possible to say as follows:

- Even during the dry season, the Siem Reap River has sufficient flow to divert a part of flow to the West Baray, *although the specific volume of availability has to be studied carefully in consideration of river maintenance flow*. For example, the river flow of 20 years return period is estimated to be 2.27 m3/s, which is equivalent to 196,128 m3/day and if 50,000 m3/d is required for the water supply. The balance of 146,128 m3/day (1.69 m3/s) can be released to the downstream for the river maintenance flow.
- During the rainy season (August to December), it is sufficient to divert the flow to the West Baray for the water supply in addition to the irrigation water users.

Table 3.2 Probability of Draughty Flow by Monthly Mean Discharge (at UNTAC Bridge: Jan. to July)

Return period (year)	Discharge (m^3/s)
50	1.58
20	2.27
10	3.04
5	4.16
2	6.77

Table 3.3 Probability of Draughty Flow by Monthly Minimum Discharge (at UNTAC Bridge: Jan. to July)

Return period (year)	Discharge (m^3/s)
50	0.46
20	0.97
10	1.42
5	1.94
2	2.85

On the other hand, the volume availability is confirmed from the different way of calculation. The possible river maintenance flow in the Siem Reap River during the low flow season (January to June) is calculated on monthly base by assuming that the diversion discharge to the West Baray is 0.5 m^3/s (43,200 m^3/day) and 1.0 m3/s (86,400 m^3/day) respectively. It is possible to divert the flow for the water supply more than 1.0 m3/s (86,400 m^3/day) on the condition that a certain volume of maintenance flow is reserved. The possible maintenance flow less than 1.0 m3/s is happened only 2 years during over 30 years.

Therefore, it is possible to take a certain amount of water for the water supply through the West Baray, if the proper water management with gate control and rehabilitation of some existing facilities is carried out and ignore the impact to the river environment.

It is then provisionally estimated from overall viewpoints of the study that approximately 50,000 m3/day is possible to introduce to the water sector from the existing irrigation canal. But, it is noted that the additional survey/study to confirm the data accuracy and carry out more comprehensive analyses, including the suitable gates control study, is required in case that the West Baray is selected as the water source.

Table 3.4 Monthly Discharge Records of the Siem Reap River at UNTAC Bridge

Year	Item	Dry season					Rainy season						Dry	Annual
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1969	Max.									-	7.540	9.020	8.140	-
	Mean									-	6.186	7.562	6.542	-
	Min.									-	5.060	6.570	5.420	-
1970	Max.	28.850	12.000	64.950	6.470	5.510	4.820	4.540	4.540	4.540	4.540	4.540	4.540	64.950
	Mean	10.189	8.904	16.519	5.946	5.185	4.568	4.540	4.540	4.540	4.540	4.540	4.540	6.728
	Min.	6.510	7.440	5.800	5.460	4.220	4.540	4.540	4.540	4.540	4.540	4.540	4.540	4.220
1971	Max.	8.270	26.920	27.440	205.020	5.900	5.200	4.350	4.640	4.490	4.540	4.540	10.800	205.020
	Mean	7.567	9.481	9.195	39.962	5.561	4.602	4.250	4.445	4.479	4.540	4.540	4.948	8.965
	Min.	7.000	6.400	5.500	5.500	5.200	4.050	3.930	4.280	4.380	4.540	4.540	4.540	3.930
1972	Max.	7.740	34.060	7.000	7.000	7.260	5.090	4.060	4.640	4.480	5.200	4.950	7.550	34.060
	Mean	7.363	10.334	7.000	7.000	6.428	4.632	4.039	4.424	4.480	4.945	4.950	5.453	5.963
	Min.	6.930	6.970	7.000	7.000	5.300	4.170	3.930	4.130	4.480	4.600	4.950	4.950	3.930
1974	Max.	166.890	182.500	145.700	13.800	5.990	4.840	4.260	4.490	4.830	4.830	6.200	6.850	182.500
	Mean	19.912	29.432	23.313	8.041	5.192	4.533	4.183	4.352	4.664	4.829	5.185	6.407	10.330
	Min.	7.300	10.100	9.350	6.080	4.860	4.140	4.110	4.260	4.500	4.800	4.800	5.590	4.110
1975	Max.	6.590	18.200	19.850	5.680	4.240	5.640	5.440	4.300	4.710	5.750	6.560	7.000	19.850
	Mean	5.750	8.995	9.008	4.369	4.202	4.451	4.840	3.998	4.348	4.809	5.327	6.245	5.463
	Min.	4.880	5.080	6.340	4.000	3.960	3.670	4.240	3.760	3.940	4.300	3.300	5.300	3.300
1976	Max.	6.700	13.800	24.900	7.980	4.930	4.520	4.040	4.140	4.730	7.100	10.700	8.000	24.900
	Mean	6.386	8.971	11.355	6.948	4.775	4.222	3.884	3.987	4.212	5.559	6.458	7.671	6.069
	Min.	6.090	6.590	6.700	5.980	4.540	3.820	3.730	3.870	4.010	4.600	5.400	7.250	3.730
1977	Max.	23.700	18.200	14.100	8.300	4.600	4.390	4.530	4.190	4.250	7.070	6.490	11.100	23.700
	Mean	8.571	8.671	7.781	5.243	4.163	4.226	4.292	4.041	3.942	5.470	5.688	7.614	5.644
	Min.	6.950	6.500	5.500	4.000	3.800	4.040	4.090	3.850	3.760	4.460	4.750	4.750	3.760
1978	Max.	22.300	11.900	93.600	10.200	6.600	5.640	4.450	3.610	4.150	5.190	5.880	20.950	93.600
	Mean	9.654	9.621	15.113	5.747	5.987	4.502	4.231	3.610	3.909	4.263	5.089	6.695	6.521
	Min.	7.020	8.200	6.600	2.600	5.400	4.140	3.800	3.610	3.700	3.760	4.600	5.550	2.600
1979	Max.	6.200	6.200	9.000	4.260	3.930	3.970	4.430	3.600	4.790	9.110	51.900	59.850	51.900
	Mean	5.902	5.553	7.024	3.944	3.726	3.505	3.659	3.482	3.768	4.456	7.047	14.936	4.733
	Min.	5.700	4.950	5.950	3.270	3.480	2.240	3.380	3.260	3.400	3.650	4.100	5.800	2.240
1980	Max.	20.200	106.000	198.000	42.700	6.650	5.110	5.030	4.700	4.350	11.840	6.400	15.230	198.000
	Mean	10.459	21.156	39.284	10.306	5.635	4.697	4.717	4.389	4.242	9.148	5.460	7.953	10.863
	Min.	6.580	8.450	10.600	6.690	4.990	4.370	4.100	4.200	4.010	4.180	5.000	6.000	4.010
1981	Max.	46.040	50.400	28.100	6.900	6.000	8.250	8.250	9.600	8.250	9.150	10.500	8.700	50.400
	Mean	15.413	18.776	12.341	4.255	3.972	6.709	6.878	6.910	7.239	7.301	9.285	8.685	9.007
	Min.	6.900	10.500	5.640	2.720	3.440	3.810	5.270	5.270	5.640	6.000	6.900	8.250	2.720
1982	Max.	10.500	11.940	9.150	7.350	9.550	2.350	2.350	2.350	2.350	2.350	7.310	3.810	11.940
	Mean	9.658	9.821	7.299	4.576	2.871	2.350	2.350	2.350	2.350	2.350	3.171	3.103	4.468
	Min.	9.150	7.800	5.270	2.720	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350
1983	Max.	6.000	84.030	203.860	14.340	8.700	9.150	10.980	8.700	10.050	8.250	10.980	10.500	203.860
	Mean	4.352	15.931	32.346	6.285	6.905	8.580	8.977	7.785	7.545	7.539	9.407	10.224	10.514
	Min.	3.440	3.810	9.600	3.080	4.910	7.350	7.350	7.350	6.900	6.900	6.900	10.050	3.080
1984	Max.	12.000	11.460	15.300	30.400	7.350	8.700	7.350	7.350	9.600	6.450	8.700	10.500	30.400
	Mean	10.548	9.074	9.268	6.921	6.639	6.531	6.523	6.697	5.534	4.748	7.451	8.366	7.267
	Min.	10.500	7.800	6.900	3.440	6.000	5.640	6.000	6.000	3.810	3.810	5.270	8.250	3.440
1985	Max.	8.250	54.250	8.700	3.810	6.000	6.900	4.540	6.000	4.910	8.600	7.800	8.200	54.250
	Mean	8.163	14.969	5.054	2.520	4.895	4.955	4.505	4.344	4.080	6.806	7.120	7.890	6.128
	Min.	7.800	4.540	3.440	2.350	2.350	4.180	4.180	3.810	3.440	5.400	6.600	7.400	2.350
1986	Max.	8.200	14.500	10.100	24.300	4.540	4.540	3.440	3.080	3.810	4.180	61.200	20.960	61.200
	Mean	7.826	6.911	6.392	4.980	3.539	3.082	2.964	2.883	3.284	3.822	11.716	8.663	5.218
	Min.	7.400	4.600	4.180	3.080	3.080	2.720	2.720	2.720	3.080	3.440	3.440	7.350	2.720
1987	Max.	41.800	18.000	56.900	14.800	6.200	5.080	5.830	6.590	6.200	6.590	7.180	10.100	56.900
	Mean	15.496	10.004	22.025	8.074	4.859	4.928	5.002	5.951	5.891	6.225	6.735	8.560	8.654
	Min.	8.540	8.540	8.540	5.450	3.950	4.330	4.610	5.450	5.450	6.200	6.400	6.980	3.950
1988	Max.	15.100	129.000	52.000	10.100	2.070	1.790	1.720	1.650	1.720	1.860	5.830	9.860	129.000
	Mean	7.277	16.196	19.044	4.945	1.833	1.755	1.655	1.650	1.641	1.684	3.471	4.842	5.559
	Min.	5.830	6.200	7.760	2.070	1.720	1.720	1.650	1.650	1.580	1.650	1.720	2.070	1.580
1989	Max.	5.830	5.450	5.080	4.330	5.450	5.450	6.200	6.200	5.450	6.840	7.380	7.510	7.380
	Mean	5.368	4.636	3.287	3.465	3.155	4.315	4.704	5.464	5.265	6.128	6.840	7.091	4.784
	Min.	4.700	3.200	2.070	2.830	2.830	2.830	3.950	5.080	5.080	5.740	5.570	6.840	2.070
1990	Max.	9.200	6.430	8.360	5.930	4.630	3.780	3.950	3.350	3.350	4.140	4.470	5.520	9.200
	Mean	6.045	5.768	5.803	4.383	3.697	3.300	3.203	3.239	3.212	3.593	3.684	4.067	4.175
	Min.	5.370	5.560	4.630	2.800	2.460	3.060	2.940	2.940	3.140	3.150	3.150	3.640	2.460
1991	Max.	9.800	6.240	8.360	5.750	5.590	4.060	3.100	3.420	3.420	3.700	6.100	14.500	9.800
	Mean	5.038	5.056	3.757	3.413	3.110	2.494	2.798	3.161	2.954	2.770	4.560	5.913	3.555
	Min.	4.470	3.810	2.130	1.650	2.340	2.080	2.340	2.850	2.850	2.530	3.100	4.900	1.650
1992	Max.	39.000	81.000	45.900	10.600	4.000	4.540	4.400	3.650	3.470	3.100	6.400	15.300	81.000
	Mean	13.223	44.703	18.561	6.230	3.371	3.763	3.242	3.326	3.288	2.858	4.760	9.410	9.757

	Min.	7.600	31.800	12.100	3.400	3.100	3.310	2.820	2.880	3.090	2.800	3.400	5.800	2.800
1993	Max.	28.200	13.900	11.500	5.800	4.000	4.230	6.820	3.530	3.890	4.000	3.980	4.020	28.200
	Mean	12.229	10.989	8.694	3.520	3.294	3.652	3.711	3.347	3.701	3.407	3.685	3.754	5.475
	Min.	7.900	8.300	5.800	2.800	2.800	2.800	3.220	3.130	3.550	2.760	3.490	3.560	2.760
1994	Max.	4.640	4.680	7.980	4.230	3.370	3.750	3.530	3.650	3.760	3.460	4.040	–	7.980
	Mean	4.006	4.406	4.582	3.642	2.993	3.593	3.358	3.360	3.506	3.260	4.040	–	3.704
	Min.	3.720	3.940	4.130	3.000	2.750	3.420	3.150	3.090	3.360	3.080	4.040	–	2.750
1997	Max.	3.692	3.382	4.174	3.367	4.778	12.898	14.045	58.906	148.992	82.532	10.290	14.640	148.992
	Mean	2.834	2.727	2.692	2.713	2.838	3.544	4.992	12.254	29.588	26.748	7.565	4.829	8.954
	Min.	2.388	2.370	2.366	2.405	2.370	2.369	2.368	2.581	2.734	9.813	4.273	2.531	2.366
1998	Max.	2.228	1.806	1.982	1.510	1.309	1.468	1.782	1.734	5.802	5.627	3.866	–	5.802
	Mean	1.812	1.429	1.215	1.231	1.174	1.217	1.196	1.111	1.786	2.090	2.092	–	1.487
	Min.	1.309	1.014	0.568	0.880	0.968	0.938	0.798	0.747	0.825	0.909	1.468	–	0.568
1999	Max.	1.930	4.319	1.687	2.116	5.512	6.103	6.103	6.103	3.571	–	–	2.496	6.103
	Mean	1.547	1.511	1.289	1.243	2.552	3.315	4.003	2.939	2.196	–	–	1.698	2.288
	Min.	1.030	0.880	0.798	0.676	0.938	1.641	2.496	1.687	1.468	–	–	1.030	0.676
2000	Max.	9.111	16.101	–	–	11.543	16.101	41.979	40.199	8.362	38.478	3.547	9.111	41.979
	Mean	3.996	9.414	–	–	3.090	8.098	16.061	13.206	3.920	7.718	2.016	4.828	7.502
	Min.	1.297	3.442	–	–	1.070	2.206	6.230	1.559	1.559	2.517	1.297	1.070	1.070
2001	Max.	12.933	9.111	16.101	–	–	–	–	–	16.101	38.478	26.675	16.101	38.478
	Mean	6.627	6.999	9.173	–	–	–	–	–	7.442	17.180	12.504	6.675	9.988
	Min.	3.821	4.743	4.743	–	–	–	–	–	2.206	8.056	4.743	3.547	2.206
2002	Max.	16.101	9.111	21.947	9.111	5.673	6.230	17.896	38.478	41.979	–	6.230	6.230	41.979
	Mean	6.466	5.993	13.653	5.473	4.372	4.294	7.067	27.161	24.684	–	4.660	5.003	10.382
	Min.	3.821	3.547	6.230	4.111	3.045	2.206	2.206	16.101	14.450	–	4.111	4.111	2.206
2004	Max.	4.482	4.355	4.052	4.355	4.111	7.097	6.230	–	–	–	23.986	12.933	23.986
	Mean	4.384	4.208	3.925	3.814	3.852	5.131	5.292	–	–	–	17.410	8.459	6.002
	Min.	4.355	4.111	3.821	3.442	3.547	4.111	4.111	–	–	–	5.447	5.447	3.442
Ground total	Max.	166.890	182.500	203.860	205.020	11.543	16.101	41.979	58.906	148.992	82.532	61.200	59.850	205.020
	Mean	7.918	10.728	11.200	6.109	4.129	4.318	4.704	5.492	5.723	6.099	6.262	6.657	6.669
	Min.	1.030	0.880	0.568	0.676	0.938	0.938	0.798	0.747	0.825	0.909	1.297	1.030	0.568

Note: The records of some years or months are not available. (Data source: MOWRAM.) , m^3/s)

Table 3.5 Monthly Mean Discharge of the Siem Reap River at UNTAC Bridge in case of 0.5 m^3/s diversion, m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total (m^3/s)	Total (m^3)
1970	9.689	8.404	16.019	5.446	4.685	4.068	8.052	125,916,393
1971	7.067	8.981	8.695	39.462	5.061	4.102	12.228	191,223,649
1972	6.863	9.953	6.500	6.500	5.928	4.132	6.646	104,505,807
1974	19.412	28.932	22.813	7.541	4.692	4.033	14.570	227,859,091
1975	5.250	8.495	8.508	3.869	3.702	3.951	5.629	88,031,883
1976	5.886	8.420	10.855	6.448	4.275	3.722	6.601	103,795,397
1977	8.071	8.171	7.281	4.743	3.663	3.726	5.943	92,931,917
1978	9.154	9.121	14.613	5.247	5.487	4.002	7.937	124,127,134
1979	5.402	5.053	6.524	3.444	3.226	3.005	4.442	69,467,026
1980	9.959	20.476	38.784	9.806	5.135	4.197	14.726	231,564,719
1981	14.913	18.276	11.841	3.755	3.472	6.209	9.744	152,384,651
1982	9.158	9.321	6.799	4.076	2.371	1.850	5.596	87,510,985
1983	3.852	15.431	31.846	5.785	6.405	8.080	11.900	186,094,117
1984	10.048	8.620	8.768	6.421	6.139	6.031	7.671	120,626,265
1985	7.663	14.469	4.554	2.020	4.395	4.455	6.259	97,885,632
1986	7.326	6.411	5.892	4.480	3.039	2.582	4.955	77,486,098
1987	14.996	9.504	21.525	7.574	4.359	4.428	10.398	162,604,416
1988	6.777	16.011	18.544	4.445	1.333	1.255	8.061	126,753,213
1989	4.868	4.136	2.787	2.965	2.655	3.815	3.537	55,319,373
1990	5.545	5.268	5.303	3.883	3.197	2.800	4.333	67,755,182
1991	4.538	4.556	3.257	2.913	2.610	1.994	3.311	51,782,852
1992	12.723	43.157	18.061	5.730	2.871	3.263	14.301	224,877,696
1993	11.729	10.489	8.194	3.020	2.794	3.152	6.563	102,633,294
1994	3.506	3.906	4.082	3.142	2.493	3.093	3.370	52,705,013
1997	2.334	2.227	2.192	2.213	2.338	3.044	2.391	37,394,918
1998	1.312	0.929	0.715	0.731	0.674	0.717	0.846	13,235,119
1999	1.047	1.011	0.789	0.743	2.052	2.815	1.410	22,044,166
2000	3.496	9.124	3.313	2.516	2.590	7.598	4.773	75,049,987
2002	5.966	5.493	13.153	4.973	3.872	3.794	6.208	97,089,392
2004	3.884	3.711	3.425	3.314	3.352	4.631	3.719	58,485,501
Mean	7.414	10.268	10.521	5.573	3.629	3.818	6.871	107,446,517

Table 3.6 Monthly Mean Discharge of the Siem Reap River at UNTAC Bridge in case of 1.0 m^3/s diversion, m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total (m^3/s)	Total (m^3)
1970	9.189	7.904	15.519	4.946	4.185	3.568	7.552	118,097,193
1971	6.567	8.481	8.195	38.962	4.561	3.602	11.728	183,404,449
1972	6.363	9.453	6.000	6.000	5.428	3.632	6.146	96,643,407
1974	18.912	28.432	22.313	7.041	4.192	3.533	14.070	220,039,891
1975	4.750	7.995	8.008	3.369	3.202	3.451	5.129	80,212,683
1976	5.386	7.920	10.355	5.948	3.775	3.222	6.101	95,932,997
1977	7.571	7.671	6.781	4.243	3.163	3.226	5.443	85,112,717
1978	8.654	8.621	14.113	4.747	4.987	3.502	7.437	116,307,934
1979	4.902	4.553	6.024	2.944	2.726	2.505	3.942	61,647,826
1980	9.459	19.976	38.284	9.306	4.635	3.697	14.226	223,702,319
1981	14.413	17.776	11.341	3.255	2.972	5.709	9.244	144,565,451
1982	8.658	8.821	6.299	3.576	1.871	1.350	5.096	79,691,785
1983	3.352	14.931	31.346	5.285	5.905	7.580	11.400	178,274,917
1984	9.548	8.120	8.268	5.921	5.639	5.531	7.171	112,763,865
1985	7.163	13.969	4.054	1.520	3.895	3.955	5.759	90,066,432
1986	6.826	5.911	5.392	3.980	2.539	2.082	4.455	69,666,898
1987	14.496	9.004	21.025	7.074	3.859	3.928	9.898	154,785,216
1988	6.277	15.511	18.044	3.945	0.833	0.755	7.561	118,890,813
1989	4.368	3.636	2.287	2.465	2.155	3.315	3.037	47,500,173
1990	5.045	4.768	4.803	3.383	2.697	2.300	3.833	59,935,982
1991	4.038	4.056	2.757	2.413	2.110	1.494	2.811	43,963,652
1992	12.223	42.657	17.561	5.230	2.371	2.763	13.801	217,015,296
1993	11.229	9.989	7.694	2.520	2.294	2.652	6.063	94,814,094
1994	3.006	3.406	3.582	2.642	1.993	2.593	2.870	44,885,813
1997	1.834	1.727	1.692	1.713	1.838	2.544	1.891	29,575,718
1998	0.812	0.429	0.268	0.241	0.175	0.221	0.358	5,593,647
1999	0.547	0.517	0.314	0.317	1.554	2.315	0.927	14,501,876
2000	2.996	8.624	2.813	2.016	2.090	7.098	4.273	67,187,587
2002	5.466	4.993	12.653	4.473	3.372	3.294	5.708	89,270,192
2004	3.384	3.211	2.925	2.814	2.852	4.131	3.219	50,623,101
Mean	6.914	9.769	10.024	5.076	3.129	3.318	6.372	99,642,472

3-2 Water Quality

3-2-1 Tonle Sap Lake Water Quality

The Team conducted water quality survey on 29th June in early rainy season and 6th October in late rainy season 2009. The sampling points were identified using a simplified GPS to be close to the proposed intake. The Tonle Sap Lake water quality in early rainy season was still low contamination of physical, chemical and heavy maters in general. However, there are some parameters exceeding the drinking water quality standards such as iron, turbidity, total coliform, and E-coli. The water qualities in later rainy season was within the drinking water quality standards, except for total coliform.

The other applicable data was done by JICA expert (JICA Technical Assistance Cooperation Phase II) for three months from March through June during dry season in 2009. These results were executed in the different sampling point and method from the Team. The result shows that some parameters are higher values than that of survey result done by the Team in iron, manganese, turbidity and color.

The raw water quality shows that the conventional water treatment processes including, coagulation, flocculation, sedimentation, filtration, and disinfection processes are applicable.

1) pH

The pH level of raw water is at 7.7 and 7.8 in the rainy season. Other applicable data reported the level at 6.6 as lowest recorded in dry season.

2) Turbidity

Turbidity in early rainy season recorded at 200 NTU is high compared to the drinking water quality standards. The JICA expert data in dry season shows extremely high at 1,860 NTU recorded on 22nd April 2009.

3) Alkalinity

The alkalinity shows at 190 mg/L in early rainy season. The JICA expert data shows level of 30's mg/l in average in dry season.

4) Iron

Iron value recorded at 3.3 mg/l exceeds the drinking water quality standard during rainy season. The maximum iron level was recorded at 13.2 mg/L during dry season.

5) Manganese

The manganese shows lower level than drinking water quality standards during rainy season. The JICA expert data during dry season shows at level 4.2 mg/L as maximum.

6) Other parameters

Total coliform and E-coliform are higher than drinking water quality standards in dry season. However, only total coliform is slightly beyond the standards while the E–coliform is zero in the rainy season.

3-2-2 West Baray Lake Water Quality

The applicable water quality survey was reported twice by JICA study. The first report was the JICA feasibility study in 2000. Second report is the JICA Study on Integrated Master Plan for Sustainable Development of Siem Reap in 2006. The results show that the level of total coliform, turbidity and pH exceed the water quality standards.

This raw water quality is required to be treated by the conventional water treatment processes including, coagulation, flocculation, sedimentation, filtration, and disinfection processes.

1) The level of pH is in between pH 6.9 and 10.
2) The level of turbidity is 9 NTU as maximum. (KTC data shows 24 FTU in November 2007.)
3) Total coliform is 300 MPN as maximum. The general bacteria is recorded 8,000 MPN/100 in May 2000. These are in the natural range of surface water.

3-2-3 Groundwater Quality

The available data shows that those parameters as pH, Iron, manganese and total coliform are exceeding the Cambodian drinking water standards.

Applicable water treatment processes will be the same as the existing WTP of SRWSA, including pre-chlorination, pH control, oxidation, filtration and disinfection. The applied treatment processes are common to the conventional water treatment processes as for Tonle Sap and West baray waters.

1) The level of pH is in between pH 4.1 and 6.1.

2) The maximum iron concentration is 1.94 mg/L.
3) The maximum manganese concentration is 1.9 mg/L.
4) Total Coliform is positive; the level is 94 MPN/100ml as maximum.

The results of general evaluation of water quality for the alternative water sources are summarized in the following table.

Table 3.7 Evaluation of Water Quality in Alternative Water Sources

Water Source	Summary of Evaluation
Tonle Sap lake	The water quality is acceptable as the water source in applying conventional water treatment processes to remove those items as iron, manganese, turbidity, color, etc.
West Baray (canal)	The water quality is more or less same as that of Tonle Sap Lake. The conventional water treatment processes are needed.
Groundwater (lake side)	The groundwater is contaminated by iron and manganese. The water treatment facilities, same as the existing WTP, is required for removing iron, manganese, pH, etc.

3-3 Protected Areas/Zones (Legal Restriction)

There are various agencies/organizations related to the protection of heritage sites, natural environment, or economic activities. Each agency is in charge of management and control of the respective protection site or zone. To implement the proposed project, the implementation agency needs to consult these agencies to get their permissions. The general information on the protected area and the responsible agencies are summarized in Table 3.8.

Table 3.8 Protected/Controlled Areas Related to Selection of Water Source

Agency in charge	Name of Protection area	Description/Purpose of the Protection	Required permission or Approval
APSARA	Protected Area	Area designated to conserve Angkor Archaeological Site in accordance with proposal of UNESCO. The area is categorized into 5 kinds of zones.	Any development project in the protected area is required prior consultation with APSARA.
UNESCO	World Heritage Site	Area inscribed in the World Heritage List of UNESCO	The whole area of 401km^2 with 90 temples is included in protected area of APSARA
	Tonle Sap Biosphere Reserve Area	Biosphere Reserve consists of three kind area, Core Area, Buffer Zone and Transition Zone. The Core Area is defined likewise national park or wildlife sanctuary as a long term protected area for conservation of natural resources and ecosystem. Buffer Zone is a buffering area to protect Core Area.	The same area of Multiple Use Area designated by MOE
MOE	Landscape Protected Area	Area designated to conserve the landscape of Angkor Archaeological Site	Application shall be submitted to MOE to get permission before construction of facilities in the area.
	Multiple Use Area （Same area as Buffer Zone of	Area to be used basically for multidiscipline, and at the same time environmental conservation is given importance to it.	Application shall be submitted to MOE to get permission before construction of facilities in the area.

	Tonle Sap Biosphere Reserve designated by UNESCO)	Conservation and utilization of the area should be harmonized to improve the living level of the poor around Tonle Sap Lake.	Water supply expansion project coincide with the target of the Multiple Use Area.
	Boeng Peareamg Conservation Area	Protected area of local community level. MOE is considering upgrading it to national level.	A lot of migratory birds have built nests in the forest of tall trees around the lake. A new pipeline or a new canal for water supply should not pass the area.
MOAFF	Strictly Protected Inundated Forest Area	Strictly Protected Inundated Forest Area has been set for sustainability of fishery resources and for important aquatic habitats to feed, spawn and breed since 1962, preventing agricultural activity from invading.	Application shall be submitted to MOAFF to get permission before construction of facility in the area. Since a few years ago the negotiation for widening the existing canal for a new port took almost one year, construction of a new canal require more cautious approach.
	Area for Community Fisheries	Almost inundated fishery domain allocated by MOAFF for sustainable management, conservation, development and use of fisheries resources, and for poverty reduction of local community. Community Fisheries are managed according to Agreement and Management Plan for Community Fishing Area.	Content of the project should be informed to members of the Community Fisheries in advance to get their agreement. Application shall be submitted to MOFF to get permission through Fisheries Administration.
	Fishing Lot	Fishing Lots are allocated through an auction system for exclusive exploitation over a two-year period. The artisanal and family fishermen are not permitted to enter the Lot and fish outside it during an open season of fishing from October to May.	Any facilities for water supply system cannot be constructed in Fishing Lots since they are managed by private companies during dry season.
	Fish Sanctuary Area	Conservation area for fish protected by Law.	Any facilities for water supply system cannot be constructed in Fish Sanctuary Area because it is a grand scale fish farm and fishing prohibited.
	Community Forest	Forest area designated based on the same policy of Community Fisheries	Community Forests are scattered in the area north to Siem Reap City, not in the study area.

The zoning by APSARA is summarized in the table below:

Table 3.9 Zoning by APSARA

Name	Category/Zone	Regulation/Remarks
Zone1	Monumental Sites	The areas which contain the most significant archaeological site in the country and therefore deserve the highest level of protection
Zone 2	Protected Archaeological Reserves	The areas rich in archaeological remains which need to be protected from damaging land use practices and inappropriate development

Zone 3	Protected Cultural Landscapes	The areas with distinctive landscape characteristics which should be protected on a account of their traditional features, land use practices, varied habitats, historic building, or man-made features from the past or of recent origin that contribute to the cultural value or reflect traditional lifestyles and patterns of land use
Zone 4	Sites of Archaeological, Anthropological or Historic Interest	Includes all other important archaeological sites, but of less significance than Monumental Sites, that require protection for research, education or tourist interest
Zone 5	The Socio economic and Cultural Development Zone of the Siem Reap region	This comprehensive zone including the Phnom Kulen, the shores of the Tonle Sap and the Angkor plain. It conforms largely to the catchment area of greater metropolitan Angkor during the ancient period and is rich in remains of both prehistoric and historic civilization

The zoning of Tonle Sap Biosphere Reserve is summarized in the table below:

Table 3.10 Zoning of Tonle Sap Biosphere Reserve (by Royal Decree on Protected Areas and Royal Decree on Tonle Sap Biosphere Reserve)

Category/Zone	Location/Area	Regulation/Remarks
Core Area	1. Prek Toal (21,342ha) 2. Boeng Tonle Chhmar (14,560ha) 3. Stoeng Sen (6,355ha)	Long term protected area and conservation of natural resources and ecosystem.
Buffer Zone	Covering the area of 541,482ha. Its boundary corresponds to the outer boundary of the Tonle Sap Multiple Use Area. and covered by inundated forest of a variety of species	Activities are managed to be consistent to the protection and conservation plan of the core areas. Fishery activities and other development plans will be managed based on existing law and regulations in a coordinated and cooperative manner. The buffer zone is also subject to experimental research and discovery of method for the management of inundated forest, fishery, agriculture, housing settlement, land use, water resources, navigation and tourism to ensure their sustainability, increased production, while preserving the environmental quality and fish.
Transition Zone	Between the outer boundary of Buffer zone and National roads No. 5 and 6.	Managed for the sustainable agriculture, human settlement, and land uses, without having adverse effects on the inundated forest, water quality and soils of the region around the Tonle Sap Lake.

3-4 Impact on Ground Subsidence in the Historical Heritage Sites

The provable impacts to ground subsistence in the historical heritage sites are evaluated with consideration of different opinions among specialists/experts who are interested in the matter of groundwater development.

The provable impacts to ground subsistence are estimated as summarized in Table 3.11.

Table 3.11 Impact on Ground Subsistence in the Historical Heritage

Representative heritage site	Tonle Sap lake	West Baray (Canal)	Groundwater (Lake side)
Angkor Wat	C	C	N/A
Angkor Tom and the surrounding area*	C	C	N/A
East Baray and the surrounding area**	C	C	C
Banteay Srei and the surrounding area***	C	C	C
Roluos****	C	C	NA
West Baray and Ak Yum	C	C	C
Phnom Krom	C	C	C

* : Bayon, Baphuon, Royal palace, Phimeanakas, Khleang, Prasat Sour Prat, Elephant terrace, Leperking Terrace, Phnom Bakheng, Baksei Chamkrong, Prea Pithu, Prea Palilay, Angkor Tom gates, Thommanon, Chau Say Tevoda

** : East baray, TaKev, Banteay Kdei, Ta Prohm, Sras Srang, Prasat Bat Chum, Prasat Kravan, Pre Rup, East Mebon, Banteay Samre, Ta Som, Neak Pean, North Baray, Krol Ko, Preah Khan

***: Banteay Srei, Phnom Kulen, Kbal Spean

****: Lolei, Preah Ko, Bakong

Category of evaluation: A; Serious impacts, B; Some impacts, C; No/a little impacts, N/A; Difficult to evaluate at present

3-5 Impact on Ecology

The impacts on ecology are also essential points to be taken into account for the selection of water source and intake method. Among three alternative water sources, the special attention should be paid to the Tonle Sap Lake, where the various species of fauna and flora live there under the unique natural conditions, especially due to seasonal variation of water levels.

The evaluation of impacts to ecology in alternative water sources is made as summarized in Table 3.12.

Table 3.12 Impacts on Ecology

Water Source	General Evaluation of Impacts	Descriptions
Tonle Sap Lake	B	In case of pipeline, measures shall be considered to mitigate impact on aquatic life around the intake because small fish is drawn into the pipe. In case of a new canal construction, since a large amount of soil will be moved and disturbed for a long period of construction, means of construction shall be considered not to give much impact on ecosystem. Route census for flora and fauna should be conducted along the site of pipelines or a new canal.
West Baray	C	There is no significant fauna and flora in and around the west baray and its outlet canal due to human activities in the past.
Ground water	C	The required facility areas for ground water development are neither wide nor large. And the locations can be shifted within a certain area, if necessary. Then the proposed locations are outside of the submerged zone during the high water season and ecological conditions are not significant for the protection.

Category of evaluation: A; Serious impacts, B; Some impacts, C; No/A little impacts, D; Difficult to evaluate at present

3-6 Impact on Land Acquisition and Resettlement

The land acquisition in relation with resettlement is one of the serious issues in the area.

However, the specific locations for the project are not confirmed yet. The impacts to land acquisition and resettlement are evaluated on the basis of general plans available as of October 2009.

Table 3.13 Impact on Land Acquisition and Resettlement (before mitigation measures)

Water Source	General Evaluation of Impacts	Description
Tonle Sap Lake	B or C	No resettlement is expected, but the land for project site should be acquired.
West Baray	B or C	No resettlement is expected, but the land for project site should be acquired.
Groundwater	B or C	No resettlement is expected, but the land for project site should be acquired.

Category of evaluation: A; Serious impacts, B; Some impacts, C; No/a little impacts, D; Difficult to evaluate at present

3-7 Other Environmental Impacts

The adverse environmental impacts to the following items are already evaluated above since these are considered significant to select the water source.

- Protected areas
- Ground subsidence
- Ecology
- Resettlement

There are many other environmental impacts, although the level of significance is comparatively low for the study on selection of water source. The general evaluation of environmental impacts to the other items is summarized in the table below:

Table 3.14 Environmental Impacts to the Other Items (before mitigation measures)

Items	Tonle Sap lake	West baray	Groundwater
Local economy such as employment and livelihood	C	C	C
Land use and utilization of local resources	B	B	B
Social institutions such as social infrastructure and local decision-making institutions	C	C	C
Existing social infrastructures and services	C	C	C
The poor, indigenous and ethnic people	C	C	C
Misdistribution of benefit and damage	C	C	C
Local conflict of interests	C	C	C
Water Usage or Water Rights and Rights of Common	B	B	C
Sanitation	C	C	C
Hazards (Risk) Infectious diseases such as HIV/AIDS	B	B	B
Topography and Geographical feature	C	C	C
Soil Erosion	C	C	C
Hydrological Situation	C	C	C
Coastal Zone (Mangroves, Coral reefs, Tidal flats, etc.)	C	C	C
Meteorology	C	C	C
Landscape	B	B	B
Global Warming	C	C	C
Air Pollution	B	B	B
Water Pollution	B	B	B

Soil Contamination	C	C	C
Waste	B	B	B
Noise and Vibration	B	B	B
Offensive Odor	C	C	C
Bottom sediment	C	C	C
Accidents	B	B	B

A: Significant/Serious impacts B: Some (not serious) impacts C:Little impacts NA: Unknown (at present level of study)

The environmental impacts could be mitigated by taking appropriate mitigation measures. It is necessary to evaluate the impact level together with possible mitigation measures as summarized in Table 3.15.

Table 3.15 Mitigation Measures

Items	Tonle Sap lake	West baray	Groundwater
Land use and utilization of local resources	Alteration of agricultural land, inundated forest area and fishery domain for Community Fisheries should be minimized for the project site.		
Water usage or water rights and rights of common	New pipelines or canal should be set not to disturb navigation and fishing.	Water from West baray should be utilized not to give significant adverse impact to irrigation. Monitoring plan should be formulated for water management.	Groundwater should not be used if alternative source is available.
Hazards (Risk) Infectious diseases such as HIV/AIDS	Project owner and/or contractor should make a health management plan and conduct workers' healthcare every day during construction.		
Landscape	New facilities appear after completion of the project and give some impacts to the existing landscape. The appearance should be harmonized with the surrounding area.		
Air Pollution	There is usually no significant impact on the air except a critical incident. Monitoring plan and emergency plan should be developed to prevent air pollution due to chlorine.		
Water Pollution	There is usually no significant impact on river water except a critical incident because wastewater is discharged from the water treatment facility not exceeding the standard of Cambodia. Monitoring plan and emergency plan should be developed to prevent water pollution due to unusual discharge of wastewater.		
Waste	There is little impact if the sludge is regularly taken away to the final disposal site of solid waste and disposed of properly.		
Noise and Vibration	There is usually little impact on the surrounding area due to noise and vibration emitted from water treatment facility because they are small. Power generator used at the time of blackout should be stored in the room with thick walls to prevent strong noise from getting out directly.		
Accidents	There is accidents during construction. The contractor should prepare Safety Management Plan including Safety Education Plan for labors. Medical care system should be set up also.		

3-8 Opinion/Suggestion by Major Influential Organizations

(1) Organizations Related to the Project

The organizations related to the selection of water source are listed with some reference information in the table below:

Table 3.16 Major Organization Related to the Project

Name of Organization	Mandate	Major law(s) to be referred	Points of relation to the selection of water source
APSARA	Conservation of archaeologically important areas	Sub-Decree of Organization and Functioning of the Office of Director-General of the APSARA Authority, May 9th, 2008	Project site should be located basically outside of five Zones designated by APSARA. Negotiation (& permission) within the zones is required.
UNESCO	Conservation of World Cultural Heritage Area, and Core Area in Tonle Sap Biosphere Reserve (TSBS)	N/A	Project site should be located outside of five Zones designated by APSARA according to UNESCO's direction. Main facility should be located outside of Buffer Zone of TSBS Negotiation(& permission) is required depending on the situation
TSA	Conservation and Development of Tonle Sap Basin Area. Coordination among relevant central governments	Royal Decree on Creation Authority Tonle Sap June 30, 2009	Water should be provided from Tonle Sap Lake. Negotiation (& permission) is required depending on the situation
MOAFF (DOF)	Management of agriculture, forestry and fishery activities	Law on Fisheries	There are protected or controlled areas in Tonle Sap Lake. Negotiation & permission is required, depending on the situation.
MOWRAM	Management of water and water resources	Water management law	Overall responsible organization for water management. It is necessary to get approval for the development and use of water
MOE	Protection and promotion of environmental quality and public health Assessment of environmental impact	Law on Environmental Protection and Natural Resource Management 24 Dec. 1996/ 1998	There are protected areas to be considered (Landscape Protected Area, Multiple Use Area and Community Protected Area.). Required to conduct IEIA & EIA to get approval

Note: The other organizations such as MIME, Provincial Government of Siem Reap, SRWSA, and MEF are not included in the above list, as their position is neutral and fair for the selection of water source. Actually, no specific restrictions or conditions are given for the study from these agencies.

(2) Opinion/Suggestion by Major Related Organizations

The following organizations are closely related to implementation of the Project.

- APSARA
- UNESCO
- TSA
- Fishery Dept. of MOAFF
- MOWRAM

The questionnaires were sent or handed over to the respective organization and the explanation and the discussion was made in reference to the outline summarized in Table 3.17 to get their opinion or suggestion prior to the final evaluation by the Team. These questionnaires are required to know the opinion/stance of the organization (not personal view of manager/staff).

The main subjects are opinions to the three alternative water sources from the viewpoints of management by the respective organization.

Table 3.17 Brief of Alternative Water Sources to the Related Organizations

Items	Tonle Sap Lake	West Baray	Groundwater
Location	Tonle Sap Lake	Canal from West Baray	Groundwater near the Lake
Intake volume	50,000 ~ 70,000 m^3 /day (Tentatively assumed)		
Intake method	Canal from the Lake (newly excavated) +Intake structure at the canal (with pump)	Intake (from the existing canal)	Wells (1,000m^3/day/well, 60m deep, 500m interval)

The opinion at respective organization was obtained from the following way.

Table 3.18 Methods of Collecting Opinions from the Related Organizations

Organization	Methods of collecting opinions
APSARA	The questionnaires prepared by the Team were sent to APSARA. Then, meeting/discussions were made with a representative of APSARA.
UNESCO	Based on the questionnaires prepared by the team and verbal supplementary explanation of the proposed project, the interview was conducted to the representative staff of Culture unit and in charge of Angkor temple area.
TSA	Based on the questionnaires prepared by the team and verbal supplementary explanation of the proposed project, the interview was conducted to the Secretary of State.
MOWRAM	No written questionnaires were given, as some information and discussion on the JICA study was already verbally explained before. The interview was conducted to the general manager of DOWRAM in Siem Reap.
Fishery Administration of MOAFF	Based on the questionnaires prepared by the team and verbal supplementary explanation of the proposed project, the interview was conducted to the deputy director general of the Fishery Administration.

The points of opinions/suggestions by major influential organizations are summarized in the table below:

Table 3.19 Opinion/Suggestion on the Water Sources by Major Related Organizations

Organization	Water Source	positive or negative	Opinion/Suggestion
APSARA	Tonle Sap Lake	A	Little impact on archaeological site
	West Baray	B or N/A	Baray is a cultural heritage
	Groundwater	B or N/A	Impact on Cultural Heritage
UNESCO	Tonle Sap Lake	A	Little impact on archaeological site
	West Baray	A or B	Archaeological Excavation should be conducted before rehabilitation of Baray. /No new gate can be constructed.
	Groundwater	A or N/A	Depending on distance between wells and archaeological site.
TSA	Tonle Sap Lake	A	Water volume is enough for foreseeable future.
	West Baray	N/A	Water volume is not enough to supply water.
	Groundwater	N/A	Water volume is not enough to supply water.

MOWRAM	Tonle Sap Lake	N/A	High cost and technical difficulty is expected.
	West Baray	A	Economically beneficial. More water can be taken.
	Groundwater	N/A	No specific negative points are shown.
Fishery Dept. of MOAFF	Tonle Sap Lake	A	Fishing Lot should not be disturbed. Need of agreement of Community Fisheries
	West Baray	N/A	No comment
	Groundwater	N/A	No comment

General level of positive or negative
A: Positive, B: Negative, NA: Not sure/No answer
Note: Some misunderstanding opinions are not counted. For example, some officers said their opinion by assuming that the water is taken from the West Baray directly or the groundwater is taken not so far from the heritage site.

There are some other related agencies/organizations such as follows:

- MIME
- MOE
- Provincial Government of Siem Reap
- MEF

However, it is considered reasonable to make discussion with these agencies after the draft results of evaluation on the selection of water source with the intake methods are prepared. For example, MOE needs the results of environmental assessment study (EIA or IEIA)

3-9 Stage 2 - Part A Evaluation

The results of evaluation of three water source alternatives are summarized in the table below:

Table 3.20 Part A Evaluation

Parameter	Water Source Alternatives		
	Tonle Sap Lake	West Baray (canal)	Groundwater (lake side)
Water Volume	A	NA	NA
Water Quality	B	B	B
Protected Area	B	NA	NA
Ground Subsidence (Historical heritages)	A	A	NA
Impacts to Ecology	B	A	A
Impacts to Land acquisition and Resettlement	B	B	B
Other Environmental Impacts	B	B	B
Opinion by Organizations	B	B	NA

Note:
A: Sufficient, good, or no-impacts
B: Acceptable or, no significant adverse impacts
C: Not acceptable or significant adverse impacts
NA: Reliable evaluation is difficult without further study or confirmation

3-10 Comparative Study on Water Supply Systems of the Selected Water Sources and Intake Methods, Stage 2 – Part B

This section describes the engineering details, as Part B of Stage 2 selection of water source and intake method, to identify the most appropriate combination of water source and intake method. Main issues to discuss hereunder are smooth implementation in short term basis and expandability towards the long term development plan for the entire water supply systems. The proposed water supply systems are composed of all the facilities including raw water intake, WTP, transmission pipelines, and distribution network.

The major conditions/assumptions for comparative study are summarized as follows:

- Intake capacity of approximately 70,000 m^3/d is considered according to the proposed development plan;
- Conventional treatment process is applied for raw water of West Baray and Tonle Sap Lake based on the water quality analysis; and
- Conventional water treatment processes including, oxidation, sedimentation, filtration, and disinfection is adapted to groundwater treatment.

3-10-1 Planned WTP Locations for Each Water Source

The WTP locations by water sources are planned to come up with the cost estimates. Deep wells are allocated as same manner as the exiting deep well arrangement as plotted Figure 3.1 Location Plan for Deep Well System. The same structure of deep wells is applied as the existing deep wells of SRWSA.

The planned location of WTP, taking raw water from West Baray, is located beside the existing WTP in reference to the KTC proposal. A total of water supply systems are schematized in Figure 3.2.

For Tonle Sap water supply system, Figure 3.3 shows a total water supply system including assumed raw water conveyance root and WTP location.

3-10-2 Proposed Water Supply Facilities for Each Water Source

To evaluate the alternatives by water sources, a preliminary design for the intake, WTP, and transmission pipelines are prepared as described in Table 3.23.

3-10-3 Basis for Cost Estimates

The construction cost was estimated on the direct construction cost, not including the indirect cost and other contingencies. The details of indirect cost and other contingencies are assumed in the preliminary financial analysis. The unit construction costs were prepared using the following data/information;

- Unit costs provided by SRWSA;
- Unit costs provided by some contractor for the Siem Reap Waste Water Management Project funded by AFD; and
- Unit costs provided by International Contractors in the site.

3-10-4 Comparison of Overall Construction Cost

The result of construction cost estimation is shown in the following table. The water supply system using Tonle Sap Lake water is identified as the most economical. The details of cost estimation for 75,000 m^3/d are referred to the following chapter.

Table 3.21 Cost Comparison for Each Water Supply Systems

Water Source	Intake	WTP	Transmission /Distribution	Total
Ground Water	25,003,000	20,253,000	58,904,000	104,160,000
West Baray Lake	7,117,000	21,521,000	71,470,000	100,108,000
Tonle Sap Lake	18,825,000	21,521,000	58,904,000	99,250,000

Unit in US$

3-11 Stage 2 - Part B Evaluation

Table 3.24 summarizes a result of Stage 2 – Part B evaluation.

3-12 Recommended Raw Water Source

The Project aims stable water supply without interruption of water supply, with suitable water quality to meet the Cambodia drinking water standards, and with reasonable cost (water tariff).

To achieve the target as public water supply systems, the Tonle Sap Lake water is proposed as most appropriate water source for the Project. The intake from the Lake may pass through the environmental restricted areas under control of the relevant authorities so that the practical measures, which should be carefully identified from now on, should be taken properly to mitigate such impacts with close coordination with the relevant authorities concerned. The Tonle Sap system will provide SRWSA with the second choice of the raw water source as sustainable water supply systems in both short term and long term basis.

Another possible raw water source for the Project is the water from the West Baray, however the availability of water amount is not in stable as public water supply systems. The Team recommends to use some limited amount of the water as urgently supplement the water to the increasing water demand in a short term basis.

Groundwater source is applied solely for the current water supply systems of SRWSA. There are no sign has been identified scientifically to prove the impact to the Angkor heritages. However, still many organization and/or groups including SRWSA are afraid of the impact to the heritages to be happened in the future if the large scaled groundwater exploitation will not stop. The Team will then recommend that only those people reside in the remote areas from the City center where the public water supply is not applicable due to the economic and technical efficiencies can use the groundwater source.

Table 3.22 Evaluation on the Other Parameters Except for Cost and Technical Issues

Water source	Overall Evaluation
Tonle Sap lake	Acceptable as a new water source, although some mitigation measures have to be taken for environmental impacts and the concession of development is obtained from some relevant agencies or groups.
West Baray (outlet canal)	It is difficult to guarantee the available water volume for the long term requirements. It is required to carry out the comprehensive study of water management of the Siem Reap River system, which included West Baray, moats of heritage sites, etc. The study is essential and quite significant for various aspects, including river environmental improvement, conservation of heritage sites, flood mitigation, etc. in addition to the effective water uses for water supply and irrigation. But, such comprehensive study takes a few years. Further, the relation with the KTC project is required to be considered carefully, as the project takes water from the canal of West Baray when the current contract negotiation becomes successful.
Ground water (lake side)	There are some uncertain issues for the development. It is too early to properly evaluate the issues on the groundwater development by this JICA Study as the groundwater study/survey is included as Phase 3 study and the conclusion is available in mid-late 2010. Some specialists who are involved in the conservation of Angkor heritage sites show their opposite position against the development of groundwater. Even if the scientific discussions with them are taken, it will consume considerable time and effort to settle the issue.

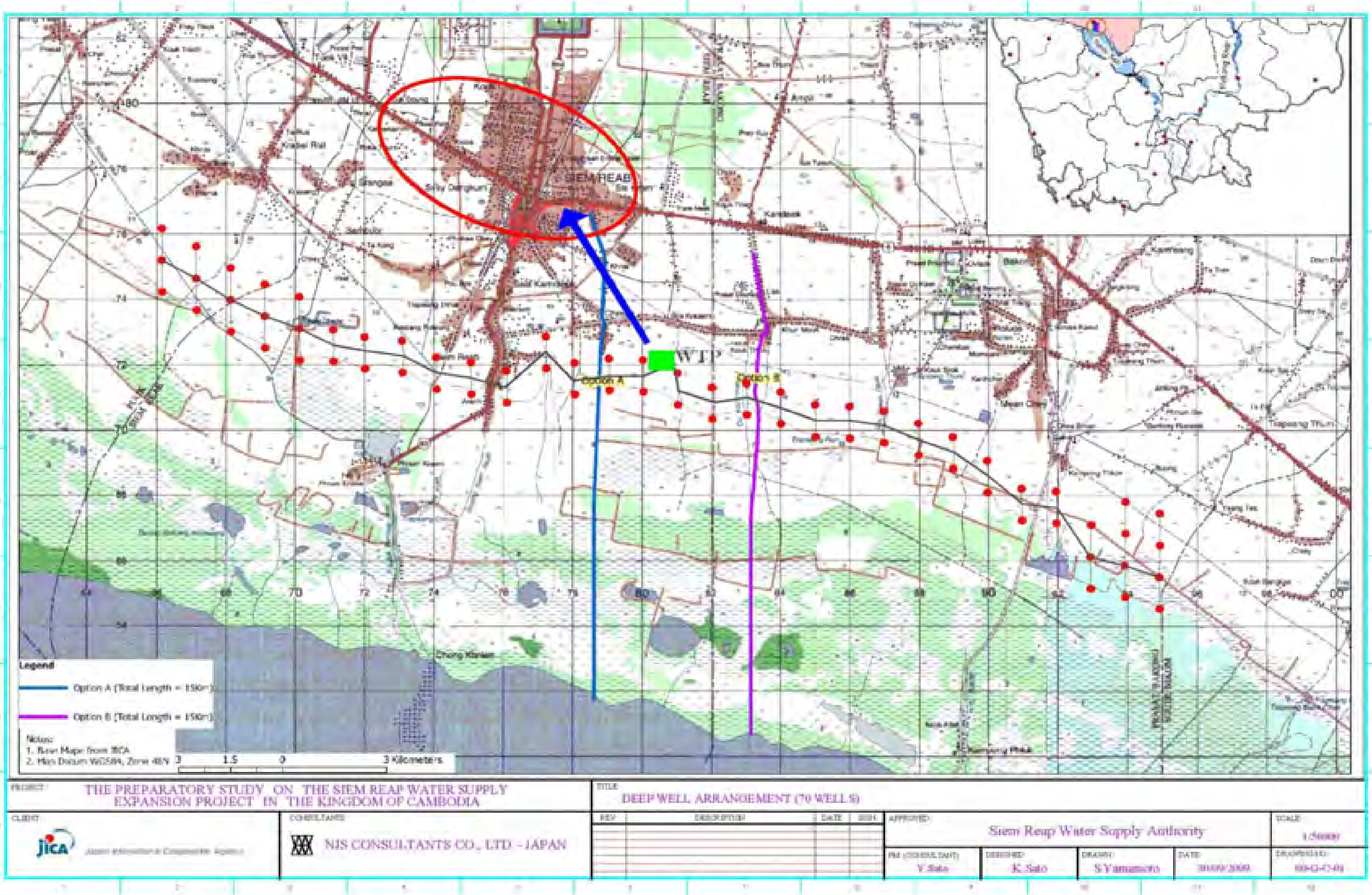


Figure 3.1 Location Plan for Deep Well System

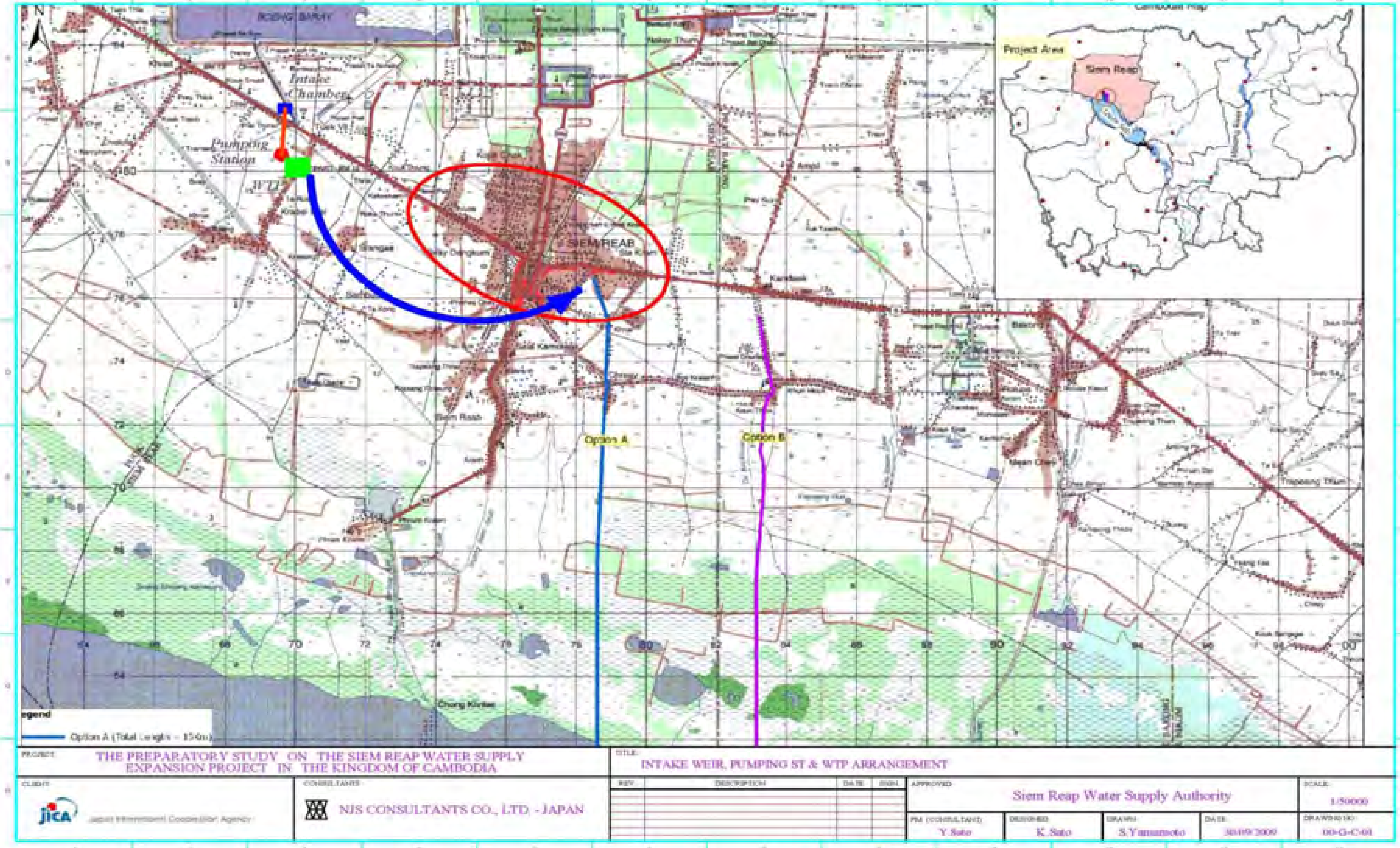


Figure 3.2 Location Plan for West Baray WTP System

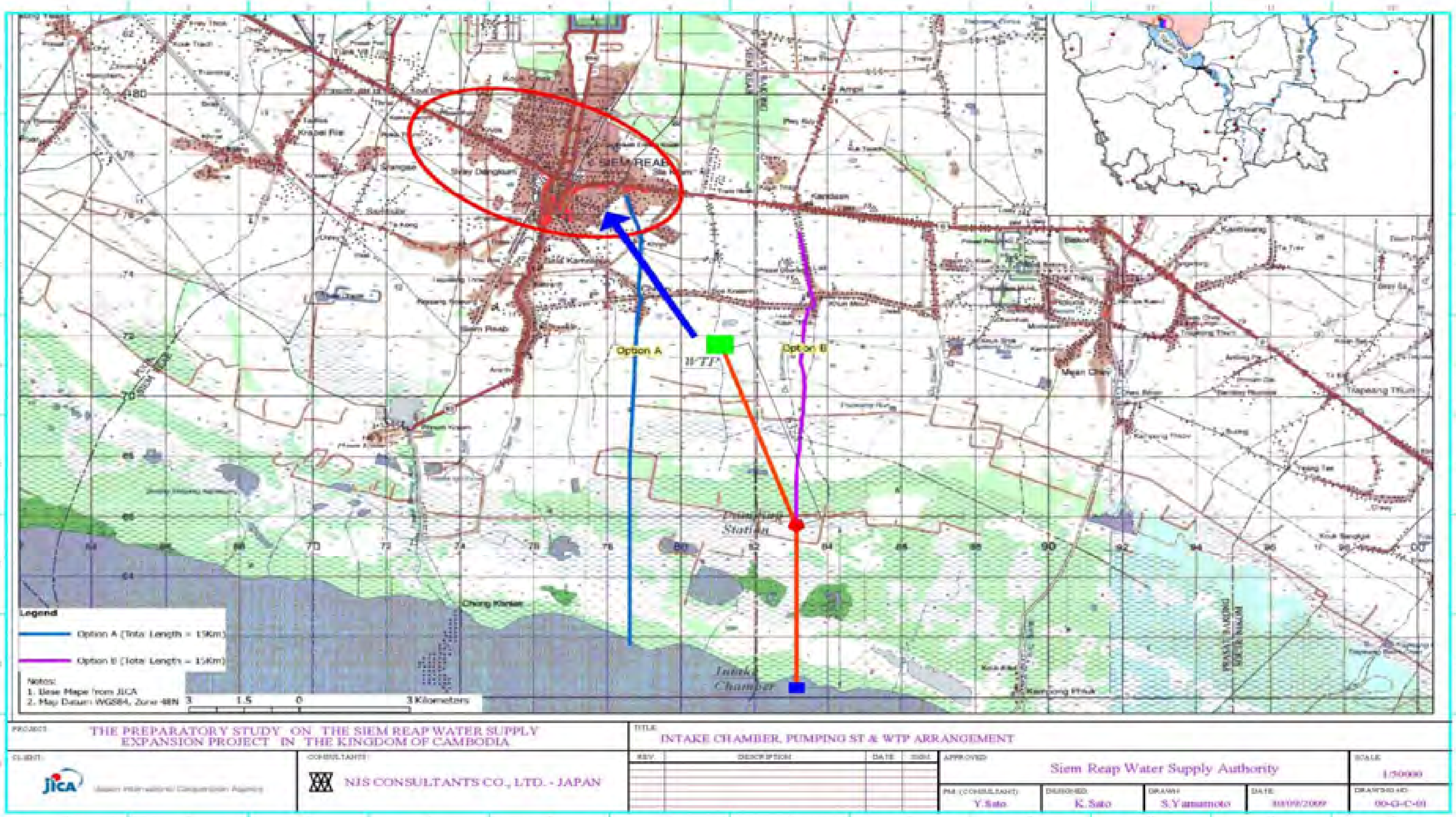


Figure 3.3 Location Plan for Tonle Sap WTP System

Table 3.23 Preliminary Facility Plan for Each Water Source

Water Source	**Ground Water**	**West Baray Lake**	**Tonle Sap Lake**
Location	The wells location is in the wide area of south part of the city. The water treatment plant is located in the southeast part of city.	The intake with pumping station is nearby the existing canal from the West Baray Lake. The water treatment plant is located within 1.5 km away from the intake.	The location of intake is 12 km south from the candidate site of water treatment plant. The intake pumping station is designed with appropriate location in between intake and water treatment plant. The water treatment plant is located in the southeast part of city.
Intake	Intake Facility: Deep Wells, 70 wells, 60m deep Conveyance Pipeline: Steel/D.I. Conveyance Pipe Line, Approx. 75 km	Intake Facility: Intake and intake pumping station Conveyance Pipeline: Steel Conveyance Pipe Line, Approx. 2.0 km	Intake Facility: Intake Chamber and intake pumping station Conveyance Pipeline: Concrete/Steel Conveyance Pipe Line, Approx. 12 km
Water Treatment	Water Treatment Process pH adjustment, pre chlorination, oxidation, filtration and disinfection. Water Treatment Facilities: Receiving well, lime dosing, pre-chlorination, oxidation basin, rapid sand filter, and post-chlorination.	Water Treatment Process: pH adjustment, pre chlorination, coagulation, flocculation, sedimentation, filtration and disinfection. Water Treatment Facilities: Receiving well, lime dosing, pre-chlorination, sedimentation basin, rapid sand filter, and post-chlorination.	Water Treatment Process: pH adjustment, pre chlorination, coagulation, flocculation, sedimentation, filtration and disinfection. Water Treatment Facilities: Receiving well, lime dosing, pre-chlorination, sedimentation basin, rapid sand filter, and post-chlorination.
Transmission /Distribution	Transmission Facilities: Transmission pipelines and transmission pumping station. Distribution Facilities: Distribution pipelines, elevated water tank and lifting pump station.	Transmission Facilities: Transmission pipelines and transmission pumping station. Distribution Facilities: Distribution pipelines, elevated water tank and lifting pump station. Notes: Additional transmission/distribution network is included for the expected water demand in the eastern part of city.	Transmission Facilities: Transmission pipelines and transmission pumping station. Distribution Facilities: Distribution pipelines, elevated water tank and lifting pump station.

Table 3.24 Sage 2 – Part B Evaluation for Each Water Source

Water Source	Ground Water	West Baray	Tonle Sap Lake
Structural Design and Work Plan	✓ **Short term plan only** ✓ **Considerable numbers of wells and connection pipelines** ✓ **Unavoidable environmental issues** <u>Concerned Issues</u> - Considerable numbers of wells are needed. - Monitoring facilities for ground water and land subsidence are needed. - Conventional water treatment process excluding the sedimentation basin. - Land acquisitions for each well are difficult. - Site can be located in the southern part of town. - Easy access to the existing distribution network.	✓ **Short term plan only** ✓ **Rehabilitation of the existing weirs and environmental issues** ✓ **Overlapped WTSs in west** <u>Concerned Issues</u> - Land acquisition is troublesome. - Weir for water level control is necessary. - Rehabilitation for existing facilities such as weir are needed. - Far from the eastern part where major increase future demand is expected. - Available water is limited so that future expansion is impossible. - Conventional water treatment process are needed.	✓ **Possible long term plan** ✓ **Ideal water supply scheme from existing WEST and proposed EAST WTPs.** <u>Concerned Issues</u> - Intake chamber and pump station are needed. - Water level fluctuation of the lake is to be considered. - Location of intake pumping station is to be considered. - Proposed WTP site is close to those areas where major water demand increase is projected. - Easy access to the existing distribution network. - Conventional water treatment process is needed.
Construction Method and Schedule	✓ **Long access roads to wells** ✓ **Land acquisition for the sites** <u>Concerned Issues</u> - Construction period is long due to the considerable numbers of wells. - Access roads to each wells are necessary.	✓ **Permission for related agencies** ✓ **Land acquisition** <u>Concerned Issues</u> - Permission for rehabilitation of the existing facilities are required from many agencies concerned. - Land acquisition for the water treatment plant is troublesome.	✓ **Careful construction due to water level fluctuation** <u>Concerned Issues</u> - Construction schedule for intake chamber shall be considered. - Seasonal water level changes shall be considered.
Construction, Operation and Maintenance Costs	✓ **Well water level monitoring** ✓ **Security for numerous scattered wells** ✓ **Annual O&M cost is estimated 2.2 Mill.$** ✓ **Comparative cost is estimated 104 Mill.$** <u>Concerned Issues</u> - Raw water conveyance pipelines are long and costly. - Tough O & M for many wells. - O & M for monitoring facilities is must. - Security for many wells is required.	✓ **Careful O&M** ✓ **Annual O&M cost is estimated 1.7 Mill.$** ✓ **Comparative cost is estimated 100 Mill. $** <u>Concerned Issues</u> - Operation for the water level fluctuation of West Baray and canal is troublesome. - Long distribution/transmission pipelines to the city are necessary and costly. - Land acquisition is tedious and costly.	✓ **Careful O&M** ✓ **Annual O&M cost is estimated 1.6 Mill.$** ✓ **Comparative cost is estimated 99 Mill. $** <u>Concerned Issues</u> - Careful operation for seasonal water quality fluctuation is required. - Land price is reasonable.
Evaluation	**Not recommended for long term plan**	**Not recommended for long term plan**	**<u>Generally good for short/long term plan</u>**

JICA/ NJS Consultants Co., Ltd

Water Quality Survey

for

Preparatory Study on the Siem Reap Water Supply Expansion Project

Prepared by

KEY CONSULTANTS CAMBODIA

Phnom Penh, July 2009

Table of Contents

1. Introduction

1.1 Background

Japanese Government funded to Cambodia Government through JICA to preparatory Study on the Siem Reap Water Supply Expansion Project. The project has been carried out to collect water quality data on the raw water sources for the project in the Tonle Sap lake.

Water quality survey is the most important for the Siem Reap Water Supply Expansion Project that needs to carry out in reasonable time of the seasonal changing in the project area. In Cambodia there is only two seasons: dry season start (November to April) and rainy season start (May to September). Therefore, the surface water quality source in the project area can change of physical aspect in relationship to season as well as climate change impact to surface water quality.

1.2 Objective

The main objective of the study is utilized to evaluate suitable of the water sources as the raw water for the proposed water treatment processes for the project.

1.3 Scope of the Work

The scope of work for our team is the "Water Quality Survey" of the water source from the surface water in the Siem Reap City.

Each samples, including the following 21 indices, were sampled and analyzed twice in early and latter half of rainy season (DO, SS, pH, Odour, Taste (Threshold taste), Colour, Turbidity, Transparency, NO_2, NO_3, Ammonium-N, Chloride, Total nitrogen, Total phosphate, Iron, Manganese, Hardness, TDS, Total coliform, E-coli, Alkalinity).

Each samples, including the following 11 indices, were sampled and analyzed one time in early rainy season (Cyanide, Mercury, Copper, Zinc, Lead, Hexavalent chromium, Cadmium, Arsenic, Fluoride, Phenols, Chlorophyll a).

1.4 Staffing

The staffs involved in this survey list below:

Mr. Taing Sophannara, Water and Wastewater Engineering, Team Leader

Mr. Sao Vibol, Environmental specialist

Mr. Chou Kim Sorn, GIS specialist

2 Methodology

2.1 Water Sampling

- Water sampling was taken at the day time

- Sampling points and location are described in table 1

- Water samples were kept in cool box and sun protection after taking from the field and the samples were sent to laboratory in Phnom Penh at the same day for analysis.

- Surface water sample was taken from Tonle Sap lake that located in Kbal chhroy Mleang, Chong Khneas commune, Siem Reap district, Siem Reap province.

2.2 Water Quality Measurement and Analysis

Ministry of Environment (MoE) lab in Phnom Penh was selected for conducting water quality measurement and analysis. There are six parameters such as Do, pH, Odour, Taste (Threshold taste), Turbidity, and Transparency were measured at the field.

The method measurement and analysis is followed by the Japanese and Cambodia standard for the examination of surface water quality (see in the table 1).

Table 1: Examination method for each parameter

Nº	Items	Method
1	Dissolved Oxygen (DO)	DO Meter
2	Total Suspended Solid (TSS)	Dried at 105^{0}C
3	pH	pH Meter
4	Odour	Directly inhale
5	Taste	Directly drinking
6	Colour	Nephelometric
7	Turbidity	Photometer
8	Transparency	Shechi dist
9	Nitrite (NO_2)	IC (Anion) ICS 90 Dionec
10	Nitrate (NO_3)	IC (Anion) ICS 90 Dionec
11	Ammonium-N	IC (Cation) ICS 90 Dionec
12	Chloride	IC (Anion) ICS 90 Dionec
13	Total nitrogen	$K_2S_2O_8$ Decomposition UV
14	Total phosphate	$K_2S_2O_8$ Decomposition Molybdenum blue
15	Iron	EPA – ICP MS (ELAN 9000)
16	Manganese	EPA – ICP MS (ELAN 9000)
17	Hardness	Titration
18	Total Dissolved Solid (TDS)	TDS Meter
19	Total coliform	MPN Multiple Tubes
20	E-coli	Microplate
21	Alkalinity	Titration
22	Cyanide	Pyridin – Pyrazolons Spectrophotometer
23	Mercury	EPA – ICP MS (ELAN 9000)
24	Copper	EPA – ICP MS (ELAN 9000)
25	Zinc	EPA – ICP MS (ELAN 9000)
26	Lead	EPA – ICP MS (ELAN 9000)
27	Hexavalent chromium	Diphenylcarbazide (Spectrophotometer)
28	Cadmium	EPA – ICP MS (ELAN 9000)
29	Arsenic	EPA – ICP MS (ELAN 9000)
30	Fluoride	IC (Anion) ICS 90 Dionec
31	Phenols	Distitation
32	Chlorophyll a	Aceton-Methanol Extraction Spectrophotometer

2.3 Observation

The water sampling site has been observed on environmental sanitation conditions in odor to proof on the pollution at/around the sampling point. The observation remarks have been recorded in part of results.

3. Activities

This is the first time (early rainy season) that water sampling has been carried out in only one site and water sampling date is 29 June 2009. There are some parameters has been measured at the field include pH, DO, Turbidity, Transparency, Odour and Taste and other remaining parameters were measured at MoE lab in Phnom Penh. During water sampling, the engineer and sampling taker conducted environmental observation nearby sampling point.

Table 2 shows about the type of water sources in large Siem Reap area, sampling point/location, and date/time of water taken.

Table 2: Water sampling location with date and time

Date/Time	Sample #	Source	Area name	GPS	
				X	Y
29/6/2009 9:30 AM	S1	Tonle Sap Lake	Kbal Chhroy Mleang Treatment Plant (intake)	378209	1462006

Tonle Sap Lake that is located in Kbal Chhroy Mleang, Chong Khneas commune, Siem Reap district, Siem Reap province was selected for measuring surface water quality in odor to preparatory study on the Siem Reap water supply expansion project. The sampling point is take about 11 Km. from Phnom Krom and around 15 Km. from the central Siem Reap province (Phsar Leu). Figure 1 show about the sampling location.

Figure 1: Water sampling location

4 Results

4.1 Observation

At the present, there is no pollution source discharge into the sampling site or around. Therefore, the pollution source is located in Chong Khneas community where floating villages and settlements on the lake with far a way around 10 Km. from sampling point. Figure 2 shows about environmental condition at/around sampling point.

Figure 2: Environmental condition at/around sampling point

The environmental condition at/around the sampling point also has been described in the table 3. Expected that more pollution load turbidity and dissolve oxygen will be happened in the Tonle Sap lake as well as sampling during early to middle rainy season and Mekong river has a moderate flow that can be recovered the water quality changing in reasonable distance.

The effect of water change with the flooded forest may have a negative effect on water quality in the lake once water level is high enough to inundate adjacent forest areas. The effect is due to organic matter in the forest that robs the water of oxygen.

Table 3: Environmental condition in the sampling point

Sample #	Source	Location	Environmental condition
S1	Tonle Sap Lke	Kbal Chhroy Mleang Treatment Plant (intake)	Sampling point far a way from the pollution source (settlements on the lake). It's take about 10 km., no polluted source around or nearby sampling point.

4.2 Water Quality Measurement and Analysis

The results of surface water quality measurement are showed in Table 4. The results are compiled both on site measurement and Lab analysis (MoE). The detail measurement methodology of each parameter showed in laboratory sheet (attached in annex 2). The results are compared to Cambodia standard drinking water quality, Ministry of Industry Mines and Energy (MIME, January 2004). The analysis report from laboratory was attached in the annex 1.

Table 4: Results of surface water quality examination

No.	Description of Item	Unit	MIME-DWQS	S1
A	**Microbiological Test**			
1	Total coliform	Count/100ml	0	9.3×10^2
2	E.coli	MPN/100ml	0	56
B	**Physical and Chemical Test**			
3	pH		6.5-8.5	7.7
4	DO	mg/l	>6	5.4
5	Total Suspended Solid (TSS)	mg/l		498
6	Odour	-		Slight muddy
7	Taste (Threshold taste)	-		Acceptable
8	Color	Pt-4		100
9	Turbidity	NTU	5	200
10	Transparency	Dept (cm)		2.5
11	Nitrite (NO_2)	mg/l	3	ND<0.1
12	Nitrate (NO_3)	mg/l	50	2.53
13	Ammonium-N	mg/l	1.5	0.05
14	Chloride	mg/l	250	6.81
15	Total nitrogen	mg/l		3.50
16	Total phosphate	mg/l		1.04
17	Iron	mg/l	0.3	3.333
18	Manganese	mg/l	0.1	0.05604
19	Hardness	mg/l	300*	107
20	Total Dissolve solid (TDS)	mg/l	800	55.50
21	Alkalinity	mg/l		190.00
22	Cyanide	mg/l	0.07	ND<0.04
23	Mercury	mg/l	1	0.0018
24	Copper	mg/l	1	ND<0.0003
25	Zinc	mg/l	3	0.00648
26	Lead	μg/l	10	2.57

27	Hexavalent chromium	µg/l	50	10
28	Cadmium	µg/l	3	ND<0.2
29	Arsenic	µg/l	50	0.94
30	Fluoride	mg/l	1.5	0.23
31	Phenols	mg/l		ND<0.025
32	Chlorophyll a	µg/l		5.80

MIME DWQS- Ministry of Industry Mines and Energy, Drinking Water Quality Standard, January 2004

* Hardness is expressed as mg/L $CaCO_3$

The results of water quality test showed that the Total Coliform and E-Coli are higher than drinking water quality standard. Figure 3 shows about the microbial aspect present in the Tonle Sap Lake. This result is relation with the natural phenomena as well as from the decay of animals, fish, or its manure washed out from the forest or deposit in the water body itself. Normally, the surface water is generally higher concentration of indicator bacteria than ground. The WHO recommended that for treated water or water in a distribution pipeline network it is likely that the number of microbial aspect per 100 ml will be around zero. If count exceed 50 colonies per 100 ml then the water supply is heavily contaminated and need requires immediate remedial action.

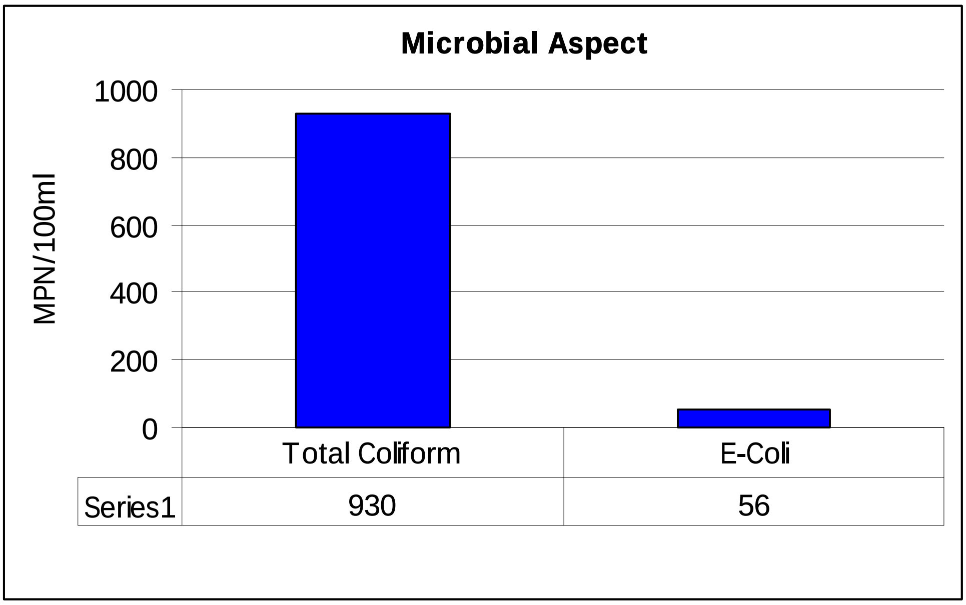


Figure 3: Microbial aspect presented in sampling site

Turbidity of Tonle Sap lake in period of study (early rainy season) is quite high if compared to Cambodia drinking water quality standard. During rainy season or after storm event, turbidity is usually higher than normal and most of turbidity in surface water comes from erosion of material such as: clay, silt, rock fragments, and colloid. Increased turbidity levels can cause the variety of problems for people, plants and animals. Water becomes no longer suitable for drinking.

Iron value (3.333 mg/l) is higher exceed than drinking water quality standard (0.3 mg/l). However, dissolved oxygen is saturate 5.4 mg/l that can provide reasonable living condition to the fish. Therefore, Fe has no bad effects on health, there are many problems concerning on high concentration of iron. The problems are related to taste, straining of cloth during washing and clogging of system components.

The other parameters such as physical, chemical and heavy metals are lower value than Cambodia drinking water quality standard even these water are not yet treated (raw water).

5 Conclusions and Recommendations

5.1 Conclusions

From day to day the discharging from urban area as well as from the settlements on the lake will be increased pollution into the Tonle Sap Lake. In generally the water quality results at the sampling site were still low contamination of physical, chemical and heavy maters as well (see in the table 4). However, there are some parameters also higher than water quality standard such as Iron, Turbidity, Total Coliform, and E-Coli which impacts to surface water quality.

It can be concluded that Tonle Sap Lake, especially at the sampling site is still good surface water quality in odor to "Preparatory Study on the Siem Reap Water Supply Expansion Project".

5.2 Recommendations

According to water quality measurements of the thirty-two parameters in Tonle Sap Lake area and in early rainy season (29 June 2009), this sampling site can be considered as a water source of town water supply.

However, properly protect/control of discharging waste from urban, settlements, and fishing into the Lake. Especially, reduce number of floating community on the lake is required.

JICA/ NJS Consultants Co., Ltd

Water Quality Survey

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Prepared by

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Phnom Penh, October 2009

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1. Introduction

1.1 Background

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Water quality survey is the most important for the Siem Reap Water Supply Expansion Project that needs to carry out in reasonable time of the seasonal changing in the project area. In Cambodia there is only two seasons: dry season start (November to April) and rainy season start (May to September). Therefore, the surface water quality source in the project area can change of physical aspect in relationship to season as well as climate change impact to surface water quality.

1.2 Objective

The main objective of the study is utilized to evaluate suitable of the water sources as the raw water for the proposed water treatment processes for the project.

1.3 Scope of the Work

The scope of work for our team is the "Water Quality Survey" of the water source from the surface water in the Siem Reap City.

Each samples, including the following 22 indices, were sampled and analyzed in latter half of rainy season (Temperature, DO, SS, pH, Odour, Taste (Threshold taste), Color, Turbidity, Transparency, NO_2, NO_3, Ammonium-N, Chloride, Total nitrogen, Total phosphate, Iron, Manganese, Hardness, TDS, Total coliform, E-coli, Alkalinity).

1.4 Staffing

The staffs involved in this survey list below:

Mr. Taing Sophannara, Water and Wastewater Engineering, Team Leader

Mr. Sao Vibol, Environmental specialist

Mr. Chou Kim Sorn, GIS specialist

2. Methodology

2.1 Water Sampling

- Water sampling was taken at the day time
- Sampling points and location are described in table 1

- Water samples were kept in cool box and sun protection after taking from the field and the samples were sent to laboratory in Phnom Penh at the same day for analysis.

- Surface water sample was taken from Tonle Sap lake that located in Kbal chhroy Mleang, Chong Khneas commune, Siem Reap district, Siem Reap province.

2.2 Water Quality Measurement and Analysis

Ministry of Environment (MoE) lab in Phnom Penh was selected for conducting water quality measurement and analysis. There are seven parameters such as Temperature, Do, pH, Odor, Taste (Threshold taste), Turbidity, and Transparency were measured at the field.

The method measurement and analysis is followed by the Japanese and Cambodia standard for the examination of surface water quality (see in the table 1).

Table 1: Examination method for each parameter

Nº	Items	Method
1	Temperature	Thermometer
2	pH	pH Meter
3	Odor	Directly inhale
4	Taste	Directly drinking
5	Transparency	Shechi dist
6	Dissolved Oxygen (DO)	DO Meter
7	Turbidity	Photometer
8	Colour	Nephelometric
9	Total Suspended Solid (TSS)	Dried at 105^0C
10	Total Dissolved Solid (TDS)	TDS Meter
11	Hardness	Titration
12	Alkalinity	Titration
13	Nitrite (NO_2)	IC (Anion) ICS 90 Dionec
14	Nitrate (NO_3)	IC (Anion) ICS 90 Dionec
15	Ammonium-N	IC (Cation) ICS 90 Dionec
16	Chloride	IC (Anion) ICS 90 Dionec
17	Total nitrogen	$K_2S_2O_8$ Decomposition UV
18	Total phosphate	$K_2S_2O_8$ Decomposition Molybdenum blue
19	Iron	EPA – ICP MS (ELAN 9000)
20	Manganese	EPA – ICP MS (ELAN 9000)
21	Total coliform	MPN Multiple Tubes
22	E-coli	Microplate

2.3 Observation

The water sampling site has been observed on environmental sanitation conditions in order to proof on the pollution at/around the sampling point. The observation remarks have been recorded in part of results.

3. Activities

This is the second time (latter half of rainy season) for water sampling has been carried out in only one site and water sampling date is 6 October 2009. There are some parameters has been measured at the field include Temperature, pH, DO, Turbidity, Transparency, Odor and Taste and other remaining parameters were measured at MoE lab in Phnom Penh. During water sampling, the engineer and sampling taker conducted environmental observation nearby sampling point.

Table 2 shows about the type of water sources in large Siem Reap area, sampling point/location, and date/time of water taken.

Table 2: Water sampling location with date and time

Date/Time	Sample #	Source	Area name	GPS	
				X	Y
06/10/2009 9:00 AM	S1	Tonle Sap Lake	Kbal Chhroy Mleang Treatment Plant (intake)	378209	1462006

Tonle Sap Lake that is located in Kbal Chhroy Mleang, Chong Khneas commune, Siem Reap district, Siem Reap province was selected for measuring surface water quality in order to preparatory study on the Siem Reap water supply expansion project. The sampling point is take about 11 Km. from Phnom Krom and around 15 Km. from the central Siem Reap province (Phsar Leu). Figure 1 show about the sampling location.

Figure 1: Water sampling location

4. Results

4.1 Observation

At the present, there is no pollution source discharge into the sampling site or around. Therefore, the pollution source is located in Chong Khneas community where floating villages and settlements on the lake with far a way around 10 Km. from sampling point. Figure 2 shows about environmental condition at/around sampling point.

Figure 2: Environmental condition at/around sampling point

The environmental condition at/around the sampling point also has been described in the table 3. Based on field observation found that the water quality in this time is good if compared to the previous observation due to the clear water with low turbidity and high of dissolve oxygen. For the previous observation found that more pollution load turbidity and dissolve oxygen was happened in the Tonle Sap lake as well as sampling site during early rainy season and Mekong river has a moderate flow that can be recovered the water quality changing in reasonable distance.

The effect of water change with the flooded forest may have a negative effect on water quality in the lake once water level is high enough to inundate adjacent forest areas. The effect is due to organic matter in the forest that robs the water of oxygen.

Table 3: Environmental condition in the sampling point

Sample #	Source	Location	Environmental condition
S1	Tonle Sap Lke	Kbal Chhroy Mleang Treatment Plant (intake)	Sampling point far a way from the pollution source (settlements on the lake). It's take about 10 km., no polluted source around or nearby sampling point.

4.2 Water Quality Measurement and Analysis

The results of surface water quality measurement are showed in Table 4. The results are compiled both on site measurement and Lab analysis (MoE). The detail measurement methodology of each parameter and analysis report showed in laboratory sheet (attached in annex 1). The results are compared to Cambodia standard drinking water quality, Ministry of Industry Mines and Energy (MIME, January 2004).

Table 4: Results of surface water quality examination

No.	Description of Items	Unit	MIME-DWQS	S1
A	**Microbiological Test**			
1	Total coliform	Count/100ml	0	<30
2	E.coli	MPN/100ml	0	0
B	**Physical and Chemical Test**			
3	Temperature	^0C	-	29.40
4	pH	-	6.5-8.5	7.80
5	Odor	-	-	Normal
6	Taste	-	-	Normal
7	Transparency	Dept (cm)	-	74.50
8	Dissolved Oxygen (DO)	mg/l	>6	7.30
9	Turbidity	NTU	5	3.5
10	Color	Pt-4	-	30
11	Total Suspended Solid (TSS)	mg/l	-	44.00
12	Total Dissolved Solid (TDS)	mg/l	800	51.30
13	Hardness	mg/l	300	83.30
14	Alkalinity	mg/l	-	4.20
15	Nitrite (NO2)	mg/l	3	<0.10
16	Nitrate (NO3)	mg/l	50	<0.10

17	Ammonium (NH4)	mg/l	1.5	0.24
18	Chloride (Cl)	mg/l	250	4.02
19	Total Nitrogen (T-N)	mg/l	-	0.58
20	Total Phosphorus (T-P)	mg/l	-	0.26
21	Iron (Fe)	µg/l	0.3 (mg/l)	0.51
22	Manganese (Mn)	µg/l	0.1 (mg/l)	ND<0.3

MIME DWQS- Ministry of Industry Mines and Energy, Drinking Water Quality Standard, January 2004

* Hardness is expressed as mg/L $CaCO_3$

The results of water quality test showed that only Total Coliform is slightly exceed than drinking water quality standard while the E-Coli is zero. Figure 3 shows about the microbial aspect present in the Tonle Sap Lake. This result is relation with the natural phenomena as well as from the decay of animals, fish, or its manure washed out from the forest or deposit in the water body itself. Normally, the surface water is generally present concentration of indicator bacteria than groundwater. The WHO recommended that for treated water or water in a distribution pipeline network it is likely that the number of microbial aspect per 100 ml will be around zero. If count exceed 50 colonies per 100 ml then the water supply is heavily contaminated and need requires immediate remedial action.

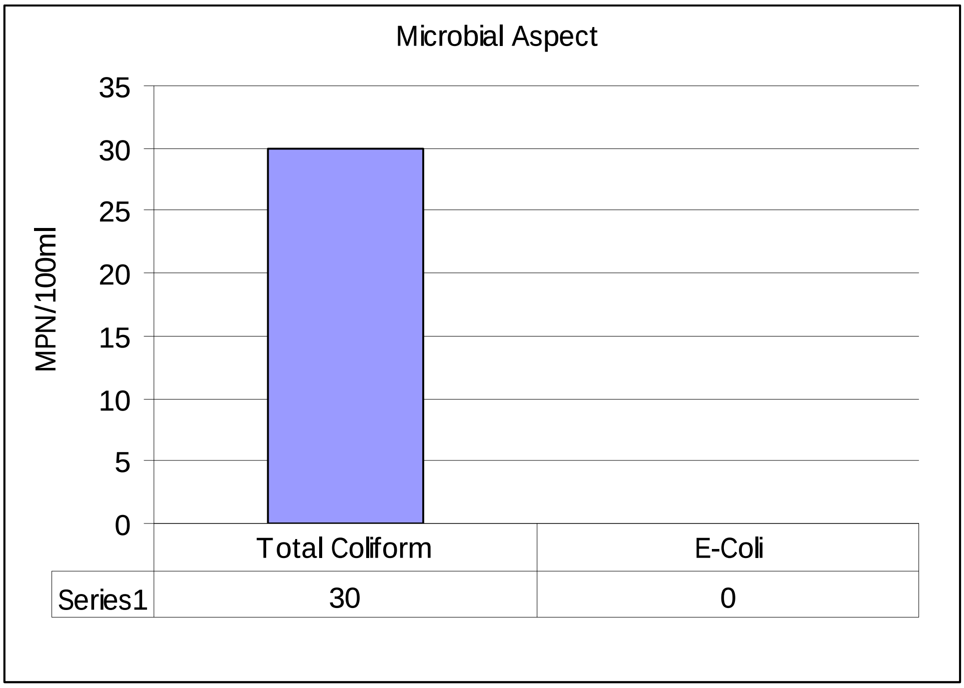


Figure 3: Microbial aspect presented in sampling site

Turbidity at the sampling site in this time is quite good if compared to Cambodia drinking water quality standard and the previous results that showed the high concentration. These due to the Tonle Sap lake is diluted with rainwater.

The other parameters such as physical, chemical and metals are lower value than Cambodia drinking water quality standard even these water are not yet treated (raw water).

5 Conclusions and Recommendations

5.1 Conclusions

From day to day the discharging from urban area as well as from the settlements on the lake may be increased pollution into the Tonle Sap Lake. In generally the water quality results at the sampling site were lower than drinking water quality standard including physical, chemical and metals as well (see in table 4). However, there is one parameter that showed higher than drinking water quality standard namely Total Coliform which impacts to surface water quality.

These, it can be concluded that Tonle Sap Lake, especially at the sampling site is good condition for surface water quality to "Preparatory Study on the Siem Reap Water Supply Expansion Project".

5.2 Recommendations

According to water quality measurements of the twenty-two parameters in Tonle Sap Lake area and in latter half of rainy season (06 October 2009), this sampling site can be considered as a water source of town water supply.

However, properly protect/control of discharging waste from urban, settlements, and fishing into the Lake. Especially, reduce number of floating community on the lake is required.

Summary of Other Water Quality Survey

Results of Water Quality Analyses by the Team

A water quality analysis was undertaken to examine the safety and appropriateness of the water for potable use and also to give reference data for the design of water treatment facilities. The general conditions of water sampling and analyses are summarized in the following table.

Table 1 Summary of Water Sampling and Analysis Survey Method

Items	Descriptions
Location (See Figure 1 and Figure 2)	Tonle Sap Lake : Nnear the tentatively proposed intake site Area name: Kbal Chhroy Mleangiem, Chong Khneas Commune, Siem Reap District, Approx. 11 km east from Phnom Krom, approx. 15 km south from the central zone of the Province (Phsar Leu), and approx. 4 km west from the outlet of the existing canal
Coordinates of sampling site	X:378209, Y:1462006
Sub contractor	KEY Consultants Cambodia Team Leader: Mr. Taing Sophannara
Laboratory for the test	Ministry of Environment
Sampling Frequency and Time	2 times 29th June 2009 and 6th October 2009
Methods of measurement and analysis	Followed by the Japanese and Cambodia standard Note: Examination method of each parameter is shown in following table.
Examination items	32 items in total

Figure 1 Area View at the Sampling Point

Figure 2 Location of Sampling Point

The list of test parameters and the test methods are shown in the following Table 2.

Table 2 Examination Method for Each Parameter

N°	Items	Method
1	Dissolved Oxygen (DO)	DO Meter
2	Total Suspended Solid (TSS)	Dried at 105^0C
3	pH	pH Meter
4	Odour	Directly inhale
5	Taste	Directly drinking
6	Colour	Nephelometric
7	Turbidity	Photometer
8	Transparency	Shechi dist
9	Nitrite (NO_2)	IC (Anion) ICS 90 Dionec
10	Nitrate (NO_3)	IC (Anion) ICS 90 Dionec
11	Ammonium-N	IC (Cation) ICS 90 Dionec
12	Chloride	IC (Anion) ICS 90 Dionec
13	Total nitrogen	$K_2S_2O_8$ Decomposition UV
14	Total phosphate	$K_2S_2O_8$ Decomposition Molybdenum blue
15	Iron	EPA – ICP MS (ELAN 9000)
16	Manganese	EPA – ICP MS (ELAN 9000)
17	Hardness	Titration
18	Total Dissolved Solid (TDS)	TDS Meter
19	Total coliform	MPN Multiple Tubes
20	E-coli	Microplate
21	Alkalinity	Titration
22	Cyanide	Pyridin – Pyrazolons Spectrophotometer
23	Mercury	EPA – ICP MS (ELAN 9000)
24	Copper	EPA – ICP MS (ELAN 9000)
25	Zinc	EPA – ICP MS (ELAN 9000)
26	Lead	EPA – ICP MS (ELAN 9000)
27	Hexavalent chromium	Diphenylcarbazide (Spectrophotometer)
28	Cadmium	EPA – ICP MS (ELAN 9000)
29	Arsenic	EPA – ICP MS (ELAN 9000)
30	Fluoride	IC (Anion) ICS 90 Dionec
31	Phenols	Distitation
32	Chlorophyll a	Aceton-Methanol Extraction Spectrophotometer

The results of water quality examination which has been carried out two times in 2009 are shown in the following tables.

Table 3 Water Quality Data by The Team (June 29, 2009)

No.	Description of Item	Unit	MIME-DWQS	S1
A	**Microbiological Test**			
1	Total coliform	Count/100ml	0	9.3×10^2
2	E.coli	MPN/100ml	0	56
B	**Physical and Chemical Test**			
3	pH		6.5-8.5	7.7
4	DO	mg/l	>6	5.4
5	Total Suspended Solid (TSS)	mg/l		498
6	Odour	-		Slight muddy
7	Taste (Threshold taste)	-		Acceptable
8	Color	Pt-4		100
9	Turbidity	NTU	5	200
10	Transparency	Dept (cm)		2.5
11	Nitrite (NO_2)	mg/l	3	ND<0.1

12	Nitrate (NO_3)	mg/l	50	2.53
13	Ammonium-N	mg/l	1.5	0.05
14	Chloride	mg/l	250	6.81
15	Total nitrogen	mg/l		3.50
16	Total phosphate	mg/l		1.04
17	Iron	mg/l	0.3	3.333
18	Manganese	mg/l	0.1	0.05604
19	Hardness	mg/l	300*	107
20	Total Dissolve solid (TDS)	mg/l	800	55.50
21	Alkalinity	mg/l		190.00
22	Cyanide	mg/l	0.07	ND<0.04
23	Mercury	mg/l	1	0.0018
24	Copper	mg/l	1	ND<0.0003
25	Zinc	mg/l	3	0.00648
26	Lead	µg/l	10	2.57
27	Hexavalent chromium	µg/l	50	10
28	Cadmium	µg/l	3	ND<0.2
29	Arsenic	µg/l	50	0.94
30	Fluoride	mg/l	1.5	0.23
31	Phenols	mg/l		ND<0.025
32	Chlorophyll a	µg/l		5.80

MIME DWQS: Ministry of Industry Mines and Energy, Drinking Water Quality Standard, Jan. 2004
* Hardness is expressed as mg/L $CaCO_3$

Table 4 Water Quality Data by The Team (October, 2009)

No.	Description of Items	Unit	MIME-DWQS	S1
A	**Microbiological Test**			
1	Total coliform	Count/100ml	0	<30
2	E.coli	MPN/100ml	0	0
B	**Physical and Chemical Test**			
3	Temperature	^0C	-	29.40
4	pH	-	6.5-8.5	7.80
5	Odor	-	-	Normal
6	Taste	-	-	Normal
7	Transparency	Dept (cm)	-	74.50
8	Dissolved Oxygen (DO)	mg/l	>6	7.30
9	Turbidity	NTU	5	3.5
10	Color	Pt-4	-	30
11	Total Suspended Solid (TSS)	mg/l	-	44.00
12	Total Dissolved Solid (TDS)	mg/l	800	51.30
13	Hardness	mg/l	300	83.30
14	Alkalinity	mg/l	-	4.20
15	Nitrite (NO2)	mg/l	3	<0.10
16	Nitrate (NO3)	mg/l	50	<0.10
17	Ammonium (NH4)	mg/l	1.5	0.24
18	Chloride (Cl)	mg/l	250	4.02
19	Total Nitrogen (T-N)	mg/l	-	0.58
20	Total Phosphorus (T-P)	mg/l	-	0.26
21	Iron (Fe)	µg/l	0.3 (mg/l)	0.51
22	Manganese (Mn)	µg/l	0.1 (mg/l)	ND<0.3

Existing Water Quality Data

Tonle Sap Lake

The team for Project on Capacity Building for Water Supply System in Cambodia Phase 2 carried out the water quality sampling and analysis from March to June (late of dry season to early of rainy season) in 2009 weekly at 2 points, which are both located almost in the same area of proposed intake site and the water sampling site by this JICA Study Team. The sampling was carried out 13 times (at 2 sampling points) in total and the analysis was made for 9 parameters every time. The test results are summarized in the following tables.

Table 5 Water Quality Data by JICA Capacity Building Project (1)

Testing Date	Sample N. 1, Location N = 1313574, E = 10352277, Depth = 0.33m								
	Fe mg/L	Mn mg/L	NH3 - N mg/L	SO4 mg/L	Turbidity (NTU)	Alkalinity (mg/L)	Color (TCU)	pH	Conduc. (μs/cm)
03/25/09	3.01	0.10	0.15	< 2	240.00	26.30	149.38	7.60	81.00
04/03/09	2.67	0.10	0.17	< 2	99.60	21.33	154.29	7.66	69.00
04/09/09	3.22	0.20	0.28	4.00	457.00	19.33	240.83	6.81	64.90
04/22/09	3.29	0.40	0.48	8.00	1860.00	22.67	271.15	6.66	88.80
04/29/09	2.09	0.30	0.36	8.00	356.00	69.33	131.80	6.81	172.50
05/05/09	2.94	0.00	0.21	4.00	546.00	44.67	75.36	7.24	139.30
05/18/09	3.40	1.00	0.43	6.00	1618.00	43.33	167.12	7.05	122.30
05/20/09	6.13	0.00	0.33	4.00	618.00	34.66	570.67	7.28	115.70
05/27/09	4.91	0.30	0.41	< 2	589.00	34.67	570.67	6.91	117.00
06/02/09	6.87	0.10	0.46	< 2	873.00	28.00	108.45	6.85	94.50
06/08/09	7.14	4.20	0.32	< 2	570.00	38.67	74.40	7.47	115.50
06/16/09	6.60	0.90	0.27	< 2	393.00	45.33	82.01	7.43	129.50
06/23/09	6.01	0.10	0.26	2.00	386.00	48.67	99.65	7.38	123.20
AVERAGE	4.48	0.59	0.32	2.77	661.97	36.69	207.37	7.17	110.25

(Sampling site 1)

Table 6 Water Quality Data by JICA Capacity Building Project (2)

Testing Date	Sample N.2, Location N = 1313370, E = 10352232, Average Depth = 0.80m								
	Fe mg/L	Mn mg/L	NH3 - N mg/L	SO4 mg/L	Turbidity (NTU)	Alkalinity (mg/L)	Color (TCU)	pH	Conduc. (μs/cm)
03/25/09	3.78	0.30	0.28	< 2	239.00	28.00	135.41	7.50	82.00
04/03/09	2.71	0.00	0.03	< 2	154.00	22.00	182.89	7.88	75.90
04/09/09	3.67	0.10	0.28	3.00	309.00	21.66	267.07	7.08	65.60
04/22/09	6.57	0.40	0.70	6.00	813.00	25.33	570.67	6.71	101.90
04/29/09	5.47	0.10	0.25	4.00	439.00	46.66	429.48	7.59	138.00
05/05/09	3.52	0.20	0.49	5.00	411.00	46.67	138.44	7.53	136.40
05/18/09	1.33	0.60	0.03	5.00	485.00	42.00	61.03	7.34	124.20
05/20/09	6.26	0.00	0.30	< 2	543.00	36.00	570.67	7.75	112.50
05/27/09	5.58	0.20	0.29	< 2	746.00	28.67	570.67	6.99	110.00

06/02/09	13.20	0.50	0.24	< 2	548.00	33.33	85.37	6.94	107.40
06/08/09	6.99	3.60	0.20	< 2	457.00	53.33	94.94	7.65	137.70
06/16/09	6.99	0.50	0.39	< 2	571.00	44.67	63.92	7.46	120.30
06/23/09	6.01	0.50	0.36	< 2	496.00	45.33	105.62	7.81	117.10
AVERAGE	5.55	0.54	0.30	1.77	477.77	36.43	252.01	7.40	109.92

(Sampling site 2)

Table 7 Comparison with the Water Quality Standards of Drinking water

Item	Parameter	Unit	Sample 1	Sample 2	MIME, DWQS
1	Iron, Fe	mg/L	**4.48**	**5.55**	0.3
2	Manganese, Mn	mg/L	0.59	0.54	0.1
3	Ammonia, NH3	mg/L	0.32	0.30	1.5
4	Sulfate, SO4	mg/L	3.69	3.00	250
5	Turbidity	FTU	**661.97**	**477.77**	5
6	Alkalinity	mg/L	36.69	36.43	-
7	Color	TCU	**207.38**	**252.02**	5
8	pH	-	7.17	7.40	6.5-8.5
9	Conductivity	μS/cm	110.25	109.92	1600

Note: The comparison with the drinking water standard is only for reference. (Average results)(By the capacity building project)

The JICA Study on Integrated Master Plan for Sustainable Development of Siem Reap (2006) carried out the water quality survey in the Tonle Sap Lake and the results are summarized in the following table.

Table 8 Water Quality of Tonle Sap Lake (December 2004), by JICA Study

Parameter	Tonel Sap	Cambodia Standards
pH	7.2	6.5-8.5
DO (mg/L)	6.0	2.0-7.5
SS (mg/L)	**102.**	2 1-15
COD (mg/L)	**23.06**	1-8
Total-N (mg/L)	1.123	0.1-0.6
Total-P (mg/L)	0.048	0.005-0.05
Total Coliform (MPN/100ml)	**11000**	<1000

(report prepared in 2006)

Drinking Water Quality Standards

The Cambodian Drinking Water Quality Standards are shown as follows:

All water supply systems should be tested for water quality parameters set out in Table 9 through Table 12 prior to commissioning to ensure compliance with DWS. Small water supply systems (those serving less than 100 people or delivering less than 10 m^3/day) should be tested for priority parameters set out in Table 13.

Table 9 Bacteriological Standard

Parameter	Maximum Value
Thermotolerant (Fecal) Coliforms or E. coli	0 per 100 mL
Total coliforms	0 per 100 mL

Table 10 Inorganic Constituents of Health Significance

Parameter	Maximum Value* mg/L, (ppm)
Arsenic	0.05
Barium	0.7
Cadmium	0.003
Chromium	0.05
Cyanide	0.07
Fluoride	1.5
Lead	0.01
Mercury	0.001
Nickel	0.02
Nitrate as NO_3^-	50
Nitrite as NO_2^-	3
Selenium	0.01

* For very low concentrations, laboratory results are reported in µg/L or ppb. Note the conversion: 1 mg/**L** (ppm) = 1000 µg/L (ppb)

Table 11 Organic Constituents of Health Significance

Parameter*	Maximum Value** µg/L (ppb)
Polychlorinated biphenyls (PCBs)	0.5
Benzene	10
Disinfection-by-product	
Trihalomethanes	250
Pesticides	
2,4 D	30
Aldrin and Dieldrin	0.3
Carbofuran	10
Chlordane	0.2
DDT	20
Dichlorvos	1
Dimethoate	6
Endosulfan	30
Endrin	0.6
Glyphosate	10
Heptachlor	0.3
Hexaclorobenzene	1
Methyl parathion	0.3
Mevinphos	5
Monocrotophos	1
Paraquat	30
Parathion	10
Permethrin	20

*Routine monitoring for organic constituents is not required unless there is a potential for contamination of water supplies.
**For very low concentration, laboratory results are reported in µg/L or ppb. Note the conversion: 1 mg/L (ppm) = 1000 µg/L (ppb)

Table 12 Physical and Chemical Quality (aesthetic quality)

Parameter	Maximum Value, mg/L
Taste	Acceptable
Odor	Acceptable
Color	5 TCU
Turbidity	5 NTU
Residual chlorine	0.2-0.5
pH	6.5 – 8.5 (no unit)
Aluminum	0.2
Ammonia	1.5
Chloride	250
Copper	1

Hardness*	300
Hydrogen Sulfide	0.05
Iron	0.3
Manganese	0.1
Sodium	200
Sulfate	250
Total dissolved solids**	800
Zinc	3

* Hardness is expressed as mg/L $CaCO_3$
**Conductivity (μS/cm) can also be measured and it is roughly equivalent to twice the TDS value.

Table 13 Priority Parameters in Small Water Supplies

Parameter*	Maximum Value
pH	6.5-8.5
Turbidity	5 NTU
Arsenic	0.05 mg/L
Iron	0.3 mg/L
Total Dissolved Solids (TDS)	800 mg/L
Thermo-tolerant Coli-forms or *E. coli*	0 per 100 mL

*Additional parameters such as conductivity can be monitored but these are the minimum requirements.

There are also the water quality standards for the environmental conservation controlled under MOE in Cambodia, although they are not shown in this report.

i) Type of the hazardous substances
ii) Effluent standard for pollution sources discharging wastewater to public water areas or sewer
iii) Type of pollution sources required having a permission from Ministry of Environment before discharging or transporting their wastewater
iv) Water Quality Standard in public water areas for bio-diversity conservation (for River, Lakes/Reservoirs, and Coastal Water)
v) Water Quality Standard in public water areas for public health protection

SR 4.3 REPORT of JAR TEST RESULT

1. Examination on Water Treatment Process

In Phase 2 of the Study, a series of jar test were conducted to examine appropriate water treatment process for Tonle Sap lake water. The samples for jar test were collected at the candidate intake site of Tonle Sap Lake once a month during dry season (December 2009 - March 2010). The study team examined appropriate water treatment process for the lake water in order to obtain the treated water quality to be complied with "National Drinking Water Quality Standard" (NDWQS). The details are described hereafter.

National Drinking Water Quality Standard

Parameter	pH	Turbidity	Color	Fe	Mn
Standard	6.5 - 8.5	5 NTU	5 TCU	0.3 mg/L	0.1 mg/L

1-1 Jar Test-1

Jar test-1 was carried out for the sample water collected on December 25, 2009.

(1) Water quality of raw water

The water quality of sample water is shown below.

Table 1.1 Water Quality of Raw Water

pH	Turbidity (FTU)	Color		Fe (mg/L)		Mn (mg/L)	
		(ACU)	(TCU)	Total	Dissolved	Total	Dissolved
6.95	13	70	43	0.85	0.40	0.3	0.1

(Note) Shading cells show values to comply with NDWQS.

<u>Apparent Color and True Color</u>

Table 1.2 and Figure 1.1 represent "Color" along with turbidity of the raw water filtrated by using different type of filter papers. The dissolved substance is defined as the substances which pass through filter media with having 1 micrometer (μ m) of pore size. Thus, True Color (TCU) is measured for the sample water filtered by No. 5C filter paper (particle size to be collected: 1 μ m, collection efficiency: 93% of 0.3 μ m Dioctyl Phthalic Acid (DOP) particle). The others are regarded as Apparent Color (ACU) which contains the suspended solids.

Table 1.2 Apparent Color and True Color of Raw Water

Sample by different filter papers	Turbidity (FTU)	Color	
		Value	Remarks
1. Raw water (without any filter)	13	70	Apparent Color
2. Filtered by Coffee filter paper	10	53	
3. Filtered by Filter paper No.5A	9	52	
4. Filtered by Filter paper No.5C	8	43	True Color

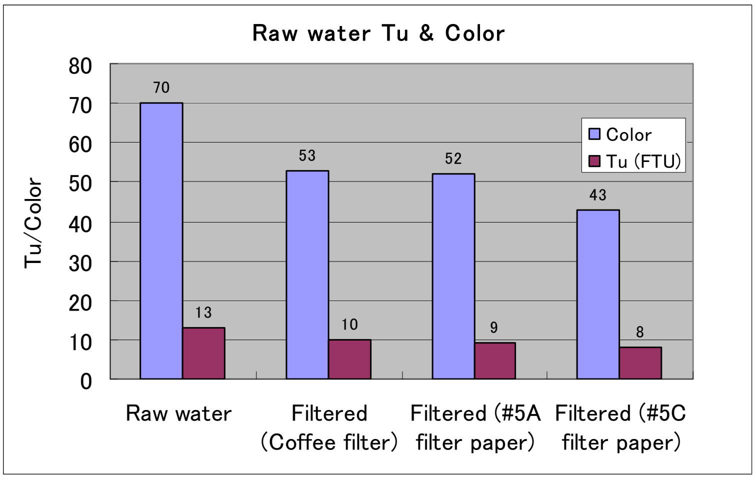


Figure 1.1 Color of Raw Water Filtrated by Different Filter Paper

<u>Dissolved Iron (Fe) and Dissolved Manganese (Mn)</u>

Same with the above, Dissolved Fe and Mn are regarded as the ones which pass through No.5C filter paper.

(2) Procedure of Jar Test

The jar test was carried out in the following manner.

1) Fill 1 L of sample water into 1 L beaker;

2) For pretreatment, add different dosing rates of lime (Slaked Lime) or 0.1% HCL solution for adjusting coagulation pH;

3) Add 30 mg/L * of Aluminum sulfate;

4) Rapid mixing for 2 minutes followed by slow mixing for 10 minutes;

5) Settle the sample for 15 minutes;

6) Filtrate the settled water by No.5A** filter paper and get "treated water".

(Note) *Dosing rate of aluminum sulfate was determined by preliminary test as well as operation record of Phum Prek WTP in Phnom Pehn.

** Filterability of No. 5A filter paper is equivalent to performance of sand filter.

For water quality examination, spectrophotometer (HACH, DR/2000) was used for Turbidity, Color, Fe (Total and dissolved) and Mn (Total and dissolved). As for measuring pH, the electrode type pH meter (TOA, HM-20P) was used.

(3) Result of Jar Test

Table 1.3 presents water quality of the treated water obtained from Jar Test-1.

Table 1.3 Result of Jar Test-1

No.	Chemicals used			pH	Turbidity (FTU)		Color		Fe (mg/L)		Mn (mg/L)	
	Alum (mg/L)	Lime (mg/L)	1%HCL (mL)		Settled water	Filt. water	(ACU)	(TCU)	Total	Dissolved	Total	Dissolved
1	30	-	1	5.26	5	1	3	3	0.02	0.01	0.0	0.0
2	30	-	0.75	5.46	5	1	4	3	0.01	0.01	0.0	0.0
3	30	-	0.5	5.74	4	1	3	3	0.01	0.01	0.0	0.1
4	30	-	0.25	6.20	3	1	4	3	0.01	0.01	0.0	0.0
5	30	-	-	6.40	3	1	5	3	0.01	0.00	0.0	0.0
6	30	2	-	6.51	3	1	5	5	0.01	0.00	0.1	0.0
7	30	4	-	6.70	2	1	5	5	0.01	0.00	0.0	0.0
8	30	6	-	6.85	4	3	7	6	0.01	0.00	0.0	0.0

(Note) Shading cells show values to comply with NDWQS.

<u>Turbidity and Color</u>

As for turbidity and color, it is conformed that treated water to comply with NDWQS was obtained by proper chemicals dosing. In particular, it is noted that coagulation with lower pH rang showed the favorable performance on color removal.

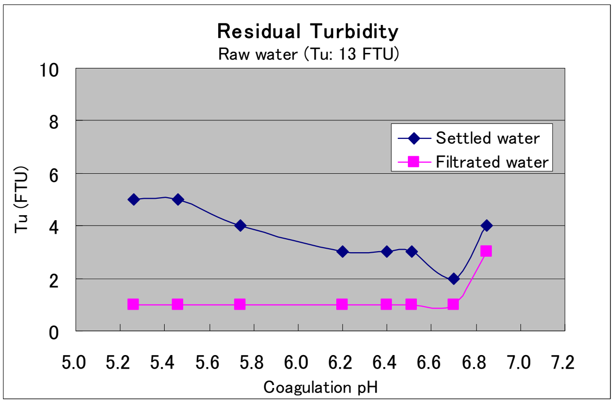


Figure 1.2 Turbidity of Treated Water

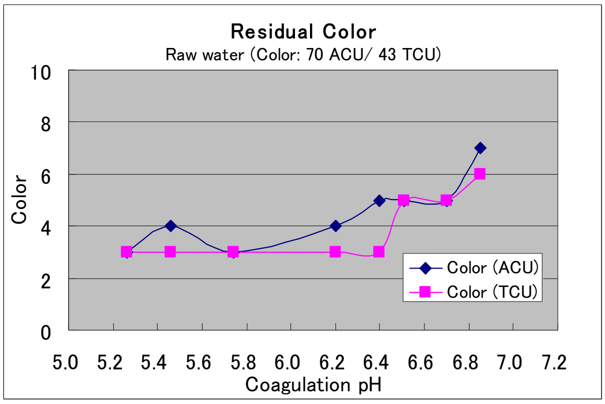


Figure 1.3 Color of Treated Water

Fe and Mn removal

As for Fe and Mn, every sample showed the results which comply with NDWQS.

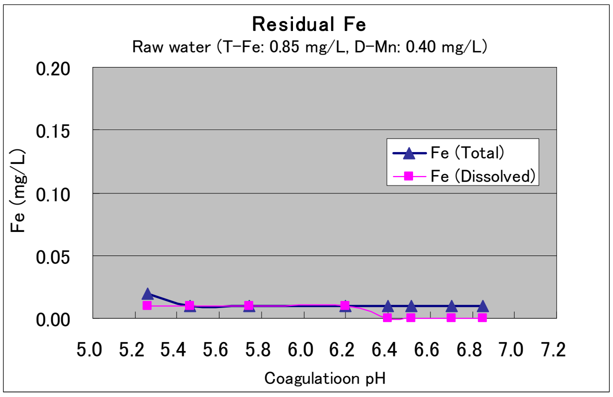


Figure 1.4 Fe of Treated Water

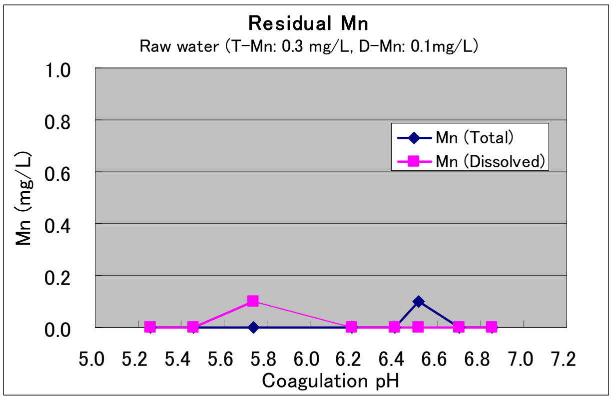


Figure 1.5 Mn of Treated Water

From the above results, it implies that conventional type of rapid sand filtration process be adopted for water treatment of Tonle Sap lake water. Also, it implies that pH control by post alkali will be required according to chemicals dosing rates or coagulation pH.

However, turbidity, color, dissolved Fe and Mn of the raw water examined in Jar Test-1 was rather in lower level. Thus, it is necessary to examine the samples containing high turbidity, color, Fe and Mn.

1-2 Jar Test-2

Sample water was collected on January 28, 2010. In addition, the sediment accumulated in the lake bed was also collected to prepare sample water of high turbidity.

(1) Water quality of raw water

The water quality of sample water is shown in Table 1.6.

Table 1.6 Water Quality of Raw Water

pH	Turbidity	Color		Fe (mg/L)		Mn (mg/L)	
	(FTU)	(ACU)	(TCU)	Total	Dissolved	Total	Dissolved
7.31	21	106	66	0.70	0.29	0.5	0.3

(Note) Shading cells show values to comply with NDWQS.

(2) Jar test

The procedure of jar test was same as in Jar Test-1. Dosing rate of Aluminum Sulfate was 30 mg/L for each sample. Coagulation pH was adjusted with 6.5 to 7.2 by adding lime or HCL.

Table 1.7 Result of Jar Test-2

Sample	Chemicals used			pH	Tu	Color		Fe (mg/L)		Mn (mg/L)	
	Alum (mg/L)	Lime (mg/L)	1%HCL (mL)		(FTU)	(ACU)	(TCU)	Total	Dissolved	Total	Dissolved
1	30	6	-	7.20	3	16	11	0.03	0.02	0.1	0.1
2	30	3	-	7.10	2	12	10	0.12	0.03	0.2	0.0
3	30	-	-	7.05	2	7	5	0.02	0.03	0.3	0.0
4	30	-	0.4	6.88	1	8	6	0.06	0.02	0.2	0.1
5	30	-	0.8	6.73	1	9	4	0.01	0.01	0.1	0.2
6	30	-	1.2	6.48	2	7	4	0.03	0.00	0.1	0.1

(Note) Shading cells show values to comply with NDWQS.

Turbidity and Color

The residual turbidity of every sample satisfied NDWQS. The treated water with coagulation pH of 7.1 or more showed higher values of residual color.

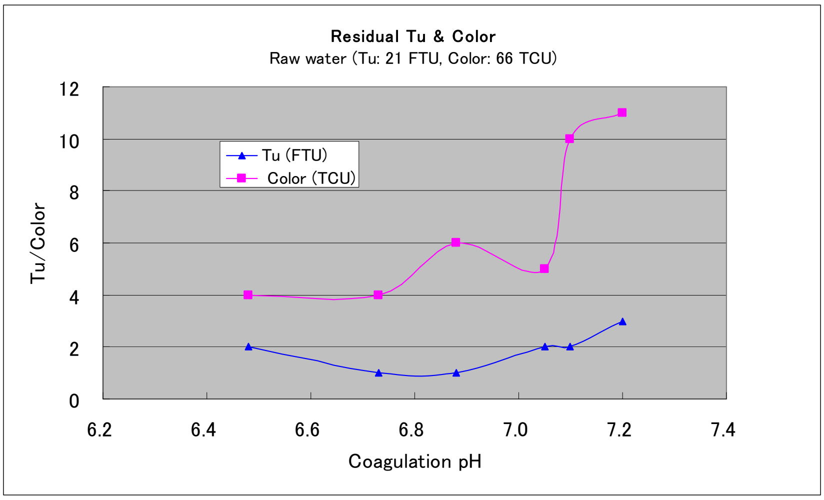


Figure 1.6 Turbidity and Color of Treated Water

Fe and Mn

As for Fe, most of the samples showed the results to meet NDWQS. While, there was instability in Mn removal, although some of the treated water complied with NDWQS.

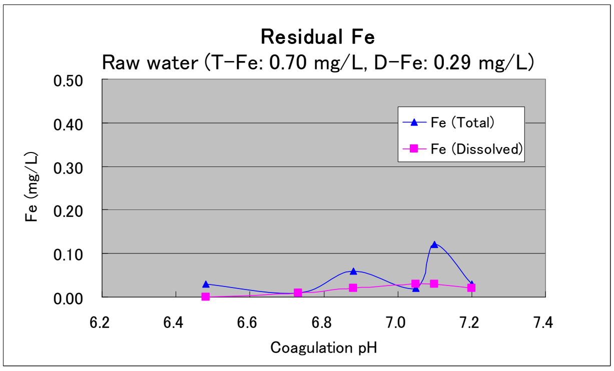


Figure 1.7 Residual Fe

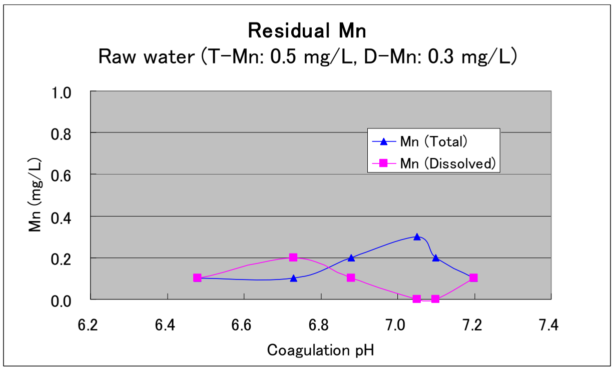


Figure1.8 Residual Mn

1-3 Jar Test-3

In order to examine the raw water of high turbidity (500 FTU*), the sample water was prepared by mixing Tonle Sap lake water with the sediments collected on January 28, 2010.

Note* The reason of preparing 500 FTU sample is referred to Section 2

(1) Water quality of raw water

The water quality of sample water is shown in Table 1.8.

Table 1.8 Water Quality of Raw Water

pH	Turbidity (FTU)	Color		Fe (mg/L)		Mn (mg/L)	
		(ACU)	(TCU)	Total	Dissolved	Total	Dissolved
6.85	500	2,300	200	10	0.88	14	1.4

(Note) Shading cells show values to comply with NDWQS.

(2) Jar test

The procedure of jar test was same as in Jar Test-2. Dosing rate of Aluminum sulfate was 60 mg/L * for each sample. Coagulation pH was adjusted with 5.5 to 7.1 by adding lime or 1% HCL solution.

Note* 60mg/L of dosing rate is referred to Section 2

Table 1.9 Result of Jar Test-3

No.	Chemicals used			pH	Tu (FTU)	Color		Fe (mg/L)		Mn (mg/L)	
	Alum (mg/L)	Lime (mg/L)	1%HCL (mL)			(ACU)	(TCU)	Total	Dissolved	Total	Dissolved
1	60	12	-	7.10	2	11	7	0.04	0.02	0.4	0.3
2	60	8	-	6.98	2	10	6	0.03	0.02	0.4	0.3
3	60	4	-	6.69	1	6	3	0.01	0.01	0.4	0.2
4	60	-	-	6.29	1	5	3	0.04	0.02	0.3	0.3
5	60	-	0.5	5.95	1	4	3	0.05	0.02	0.3	0.2
6	60	-	1.0	5.53	1	8	5	0.06	0.06	0.3	0.3

(Note) Shading cells show values to comply with NDWQS.

500 FTU Sample

Slow Mixing

Setting

Filtration

Turbidity and Color

Residual turbidity of every treated water satisfied NDWQS. As for color, the residual color complied with the standard was obtained in the treated water with coagulation pH 5.5 to 6.7. This implies that careful operation will be required for maintaining the optimum range of coagulation pH.

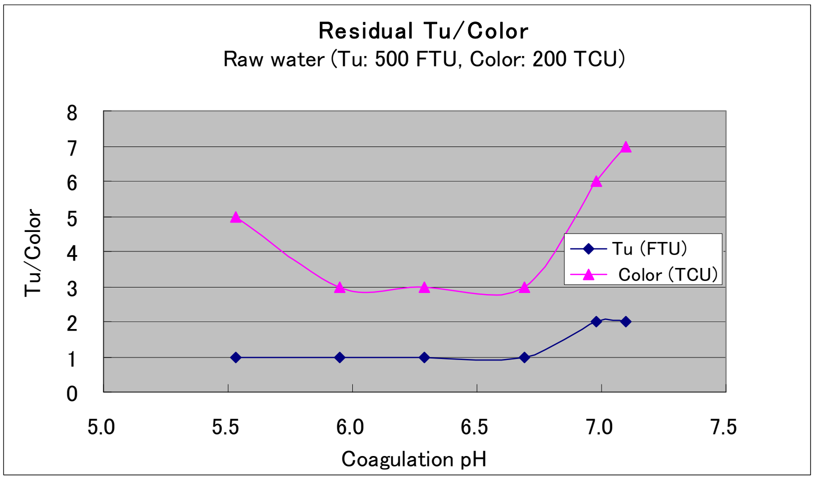


Figure 1.9 Turbidity and Color of Treated Water

Fe and Mn

As for both total and dissolved Fe, every sample of treated water showed the results to fully comply with NDWQS, although raw water contained higher concentration of Fe. On the other hand, residual Mn of treated water exceeded NDWQS of 0.1 mg/L. This implied that pre-chlorination or intermediate-chlorination be considered for raw water containing higher concentration of Mn.

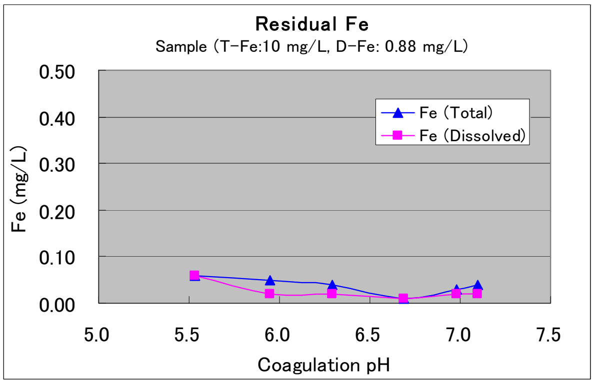


Figure 1.10 Residual Fe

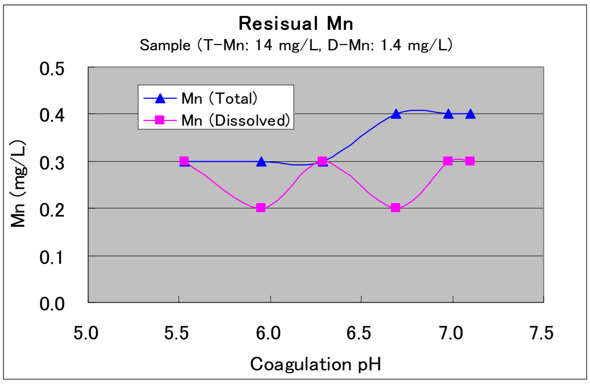
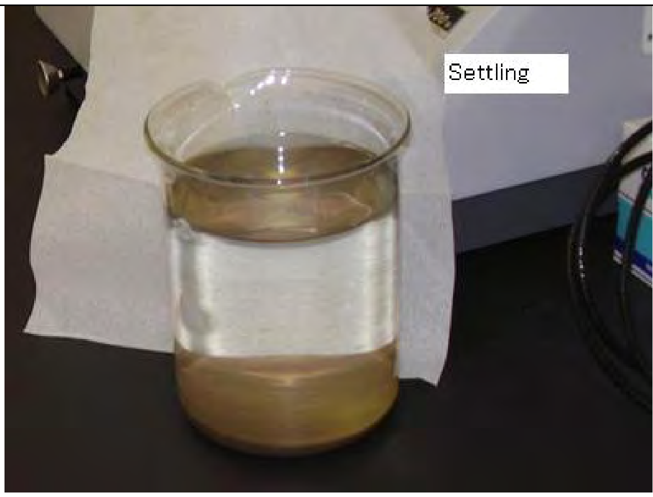


Figure 1.11 Residual Mn

<u>Additional Jar Test for 2,000 FTU Sample</u>

Furthermore, high turbidity water of 2,000 FTU* was prepared and examined by adding 150 mg/L of Aluminum Sulfate and 8 mg/L of lime. The residual turbidity and color of the treated water was measured as 1 FTU and 3 TCU respectively.

Rapid Mixing (2,000 FTU sample)



Settling

1-4 Jar Test-4

Jar test-4 was carried out for the sample collected on February 17, 2010.

(1) Water quality of raw water

The water quality of sample water is shown in Table 1.10. The algae were observed in the sample water. It is considered high pH arises from activity of algae.

Table 1.10 Water Quality of Raw Water

pH	Turbidity (FTU)	Color		Fe (mg/L)		Mn (mg/L)	
		(ACU)	(TCU)	Total	Dissolved	Total	Dissolved
8.74	89	448	81	0.39	0.07	1.8	0.3

(Note) Shading cells show values within NDWQS.

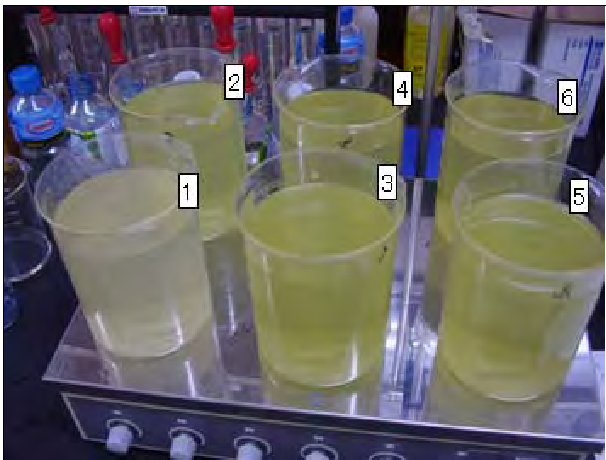
(2) Jar test

The procedure of jar test was same as in Jar Test-3. Dosing rate of Aluminum sulfate was 30 mg/L for each sample. Coagulation pH was adjusted with 5.8 to 7.5 by adding lime or chlorine water. The reason of adding chlorine instead of HCL was to verify the effect to algae removal along with adjusting coagulation pH.

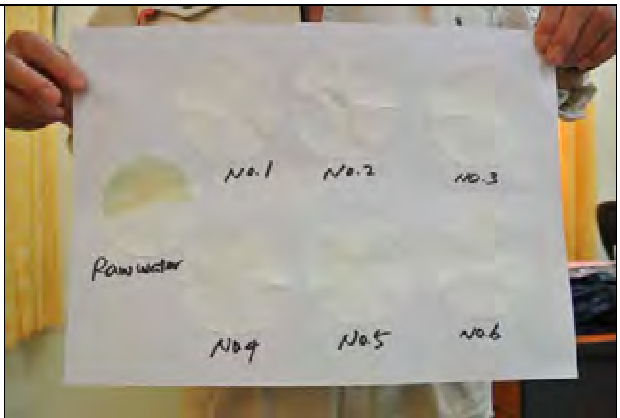
Table 1.11 Result of Jar Test-4

No	Chemicals used			pH	Tu (FTU)	Color		Fe (mg/L)		Mn (mg/L)	
	Alum (mg/L)	Lime (mg/L)	Pre-Chl. (mg/L)			(ACU)	(TCU)	Total	Dissolved	Total	Dissolved
1	30	-	3.8	5.76	2	3	2	0.01	0.00	0.1	0.0
2	30	-	2.3	6.28	3	9	3	0.01	0.01	0.2	0.0
3	30	-	0.8	6.66	4	14	7	0.01	0.01	0.1	0.0
4	30	-	-	6.96	5	19	12	0.03	0.02	0.2	0.1
5	30	3	-	7.20	6	27	17	0.04	0.02	0.2	0.1
6	30	6	-	7.52	7	28	22	0.04	0.03	0.2	0.1

(Note) Shading cells show values within NDWQS.



Samples with Different Chemical Dosing (Sample 1 looks white due to high concentration of pre-chlorine.)



Residuals in No.5A Filter Paper

Turbidity and Color

Residual turbidity complied with NDWQS was obtained in the sample with pH of lower than 7.0. Residual color to meet NDWQS was obtained in the samples with coagulation pH of lower than 6.3. This implied that the optimum coagulation pH for both turbidity and color removal will be more or less 6.0.

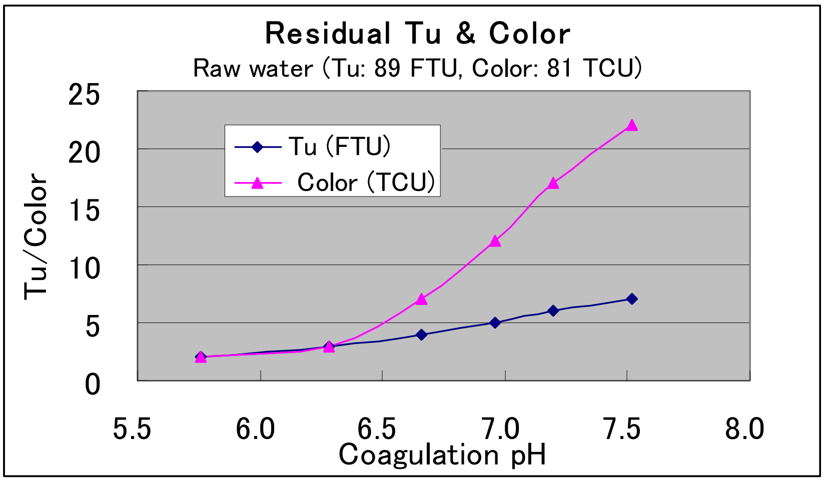


Figure 1.12 Turbidity and Color of Treated Water

<u>Fe and Mn</u>

As for both total and dissolved Fe, every sample of treated water showed the results to fully comply with NDWQS. As for dissolved Mn of treated water, all samples showed the results to meet NDWQS, however, the total Mn with coagulation pH of 7.0 or higher showed slightly higher compared to the standard.

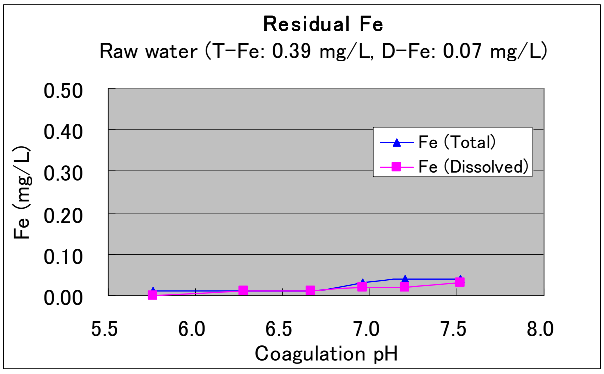


Figure 1.13 Residual Fe

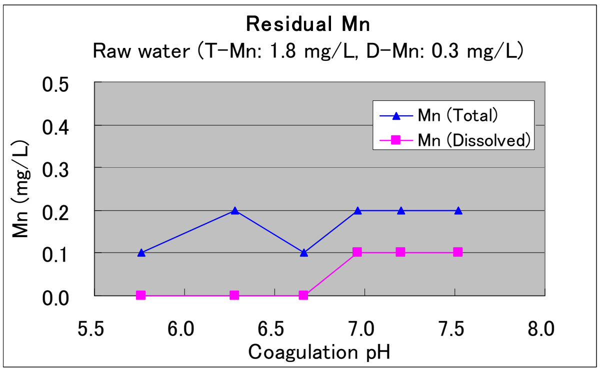


Figure 1.14 Residual Mn

1-5 Jar Test-5

Jar test-5 was carried out for the sample collected on March 17, 2010.

(1) Water quality of raw water

The water quality of sample water is shown in Table 1.12. The algae were observed in the sample water as same in the previous case.

Table 1.12 Water Quality of Raw Water

pH	Turbidity (FTU)	Color		Fe (mg/L)		Mn (mg/L)	
		(ACU)	(TCU)	Total	Dissolved	Total	Dissolved
7.32	150	896	268	2.45	0.86	4.1	0.8

(Note) Shading cells show values within NDWQS.

(2) Jar test

The procedure of jar test was same as in Jar Test-4. Dosing rate of Aluminum sulfate was 40 mg/L for each sample. Coagulation pH was adjusted with 5.8 to 7.5 by adding lime or chlorine water.

Table 1.13 Result of Jar Test-5

No.	Chemicals used			pH	Tu (FTU)	Color		Fe (mg/L)		Mn (mg/L)	
	Alum (mg/L)	Lime (mg/L)	Pre-Chl. (mg/L)			(ACU)	(TCU)	Total	Dissolved	Total	Dissolved
1	40	-	3.8	5.72	3	12	4	0.04	0.01	0.1	0.0
2	40	-	3.0	5.86	3	10	4	0.04	0.02	0.1	0.0
3	40	-	2.3	6.02	2	11	3	0.06	0.03	0.1	0.0
4	40	-	0.8	6.29	3	13	6	0.06	0.03	0.2	0.0
5	40	3	-	6.52	2	11	8	0.06	0.02	0.2	0.0
6	40	6	-	6.70	8	38	23	0.13	0.10	0.2	0.1

(Note) Shading cells show values within NDWQS.

<u>Turbidity and Color Removal</u>

Residual turbidity complied with NDWQS was obtained in the samples with pH of lower than 6.5. Residual color to meet the standard was obtained in the samples with coagulation pH of lower than 6.0. Again, this implied that the optimum coagulation pH exists in rather lower range. It is considered that the algae prevail compared to clay particles in the raw water of dry season, which relates to higher color and requires a larger dosing rate of Aluminum or pre-chlorine with lower range of coagulation pH.

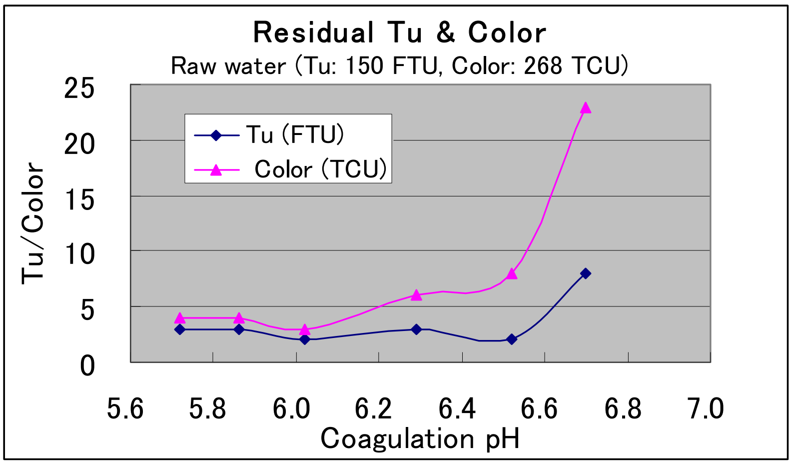


Figure 1.15 Turbidity and Color of Treated Water

Fe and Mn

As for both total and dissolved Fe, all samples except for sample No.6 showed the results to comply with NDWQS. Regarding the residual Mn, as same in residual color, higher removal was obtained in the samples with lower coagulation pH.

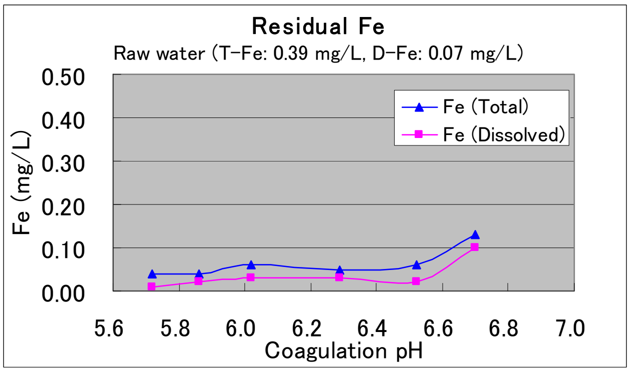


Figure 1.16 Residual Fe

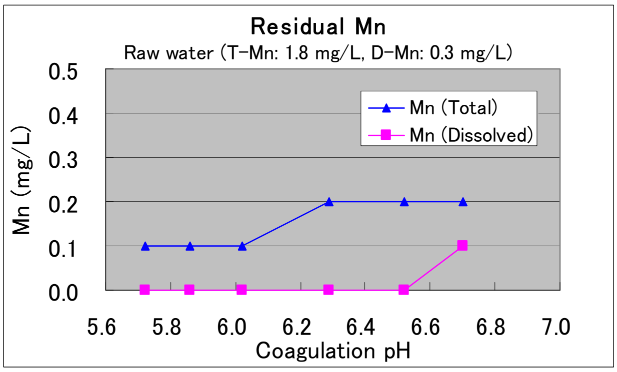


Figure 1.17 Residual Mn

1-6 Jar Test-6

Jar test-6 was carried out for the same sample examined in Jar Teat-6. The purpose of this examination was to verify whether any difference in water quality of the treated water exists by using HCL in stead of chlorine for adjusting coagulation pH with lower range.

(2) Jar test

The procedure of jar test was same as in Jar Test-5. Dosing rate of Aluminum sulfate was 40 mg/L for each sample. Coagulation pH was adjusted with 5.4 to 6.3 by adding 0.1% HCL solution. Water quality analysis was carried out for turbidity, color, total Mn and dissolved Mn and compared with the results of Jar Test-5.

Table 1.14 Result of Jar Test-6

Sample	Chemicals used		pH	Tu (FTU)	Color (TCU)	Mn (mg/L)	
	Alum (mg/L)	0.1%HCL (mL)				Total	Dissolved
1	40	1.25	5.38	1	1	0.1	0.1
2	40	1.0	5.69	1	0	0.1	0.2
3	40	0.75	5.86	2	1	0.3	0.1
4	40	0.5	6.02	2	2	0.3	0.3
5	40	0.25	6.11	2	4	0.4	0.1
6	40	-	6.30	3	6	0.2	0.1

(Note) Shading cells show values within NDWQS.

Turbidity and Color

In comparison between the result of previous Jar Test-5 and this Jar test 6, the residual turbidity and color in Jar test-6 showed the tendency of better water quality in the coagulation pH of 6.0 or lower.

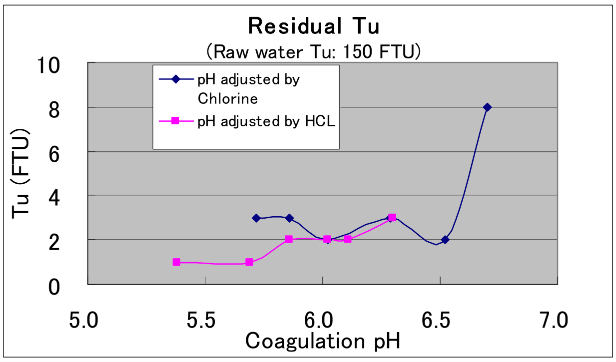


Figure 1.18 Residual Turbidity

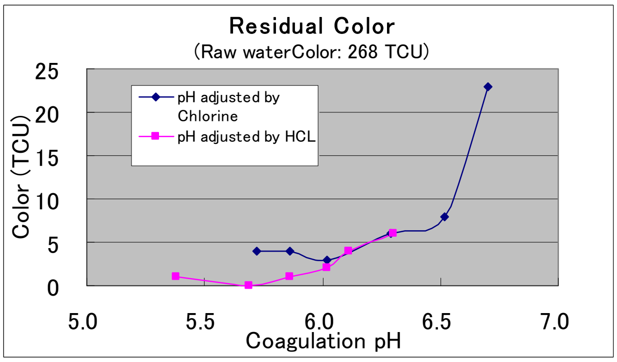


Figure 1.19 Residual Color

Mn

On the other hand, the residual Mn showed significant difference compared to the result of the previous Jar Test-5. It was verified that the pre-chlorine has a significant advantage for Mn removal.

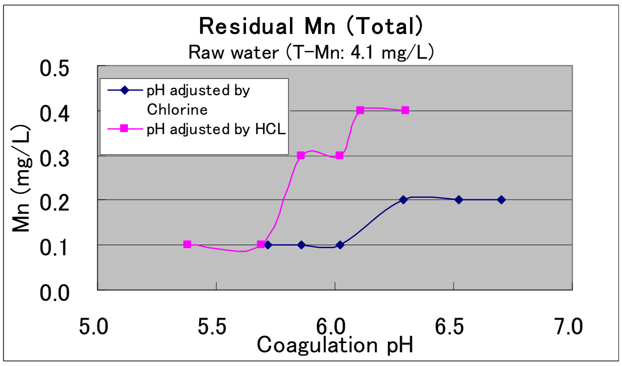


Figure 1.20 Residual Mn (Total)

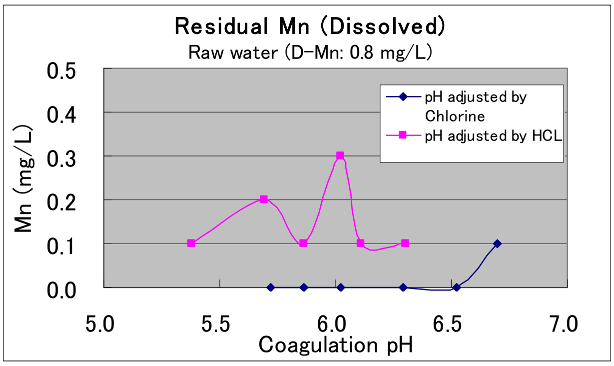


Figure 1.22 Residual Mn (Dissolved)

1-7 Conclusion

Water quality of the treated water

From a series of jar test for Tonle Sap lake water, the results of water quality of the treated water are shown in the figures by parameter as follow.

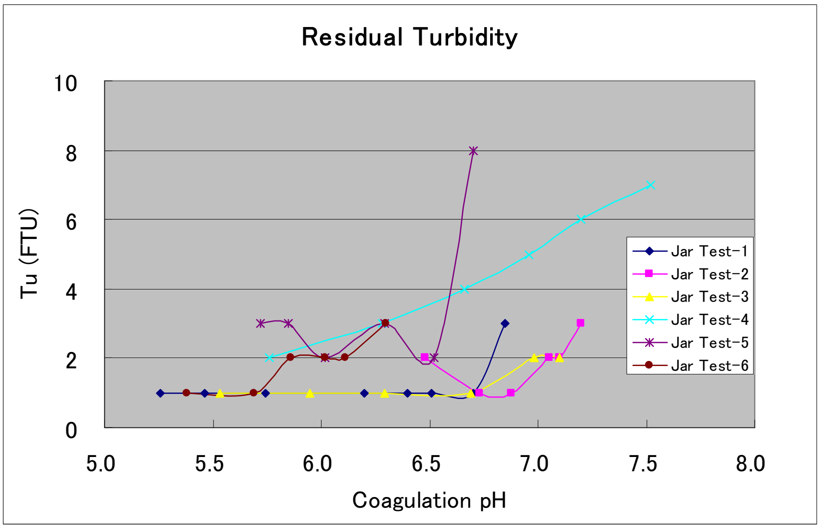


Figure 1.23 Residual Turbidity in a Series of Jar Test

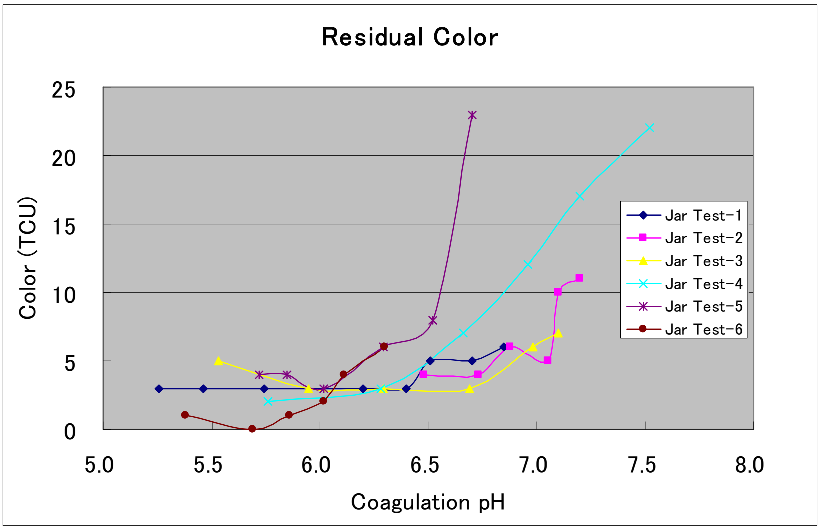


Figure 1.24 Residual Color in a Series of Jar Test

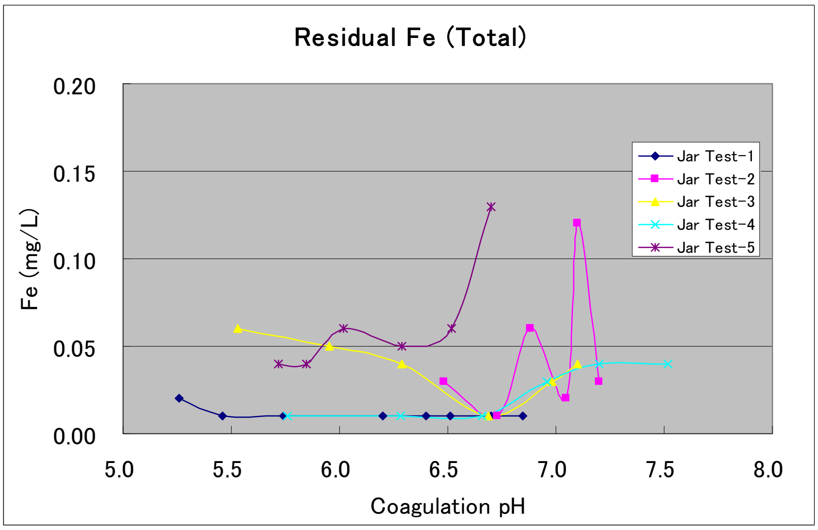


Figure 1.25 Residual Fe (Total) in a Series of Jar Test

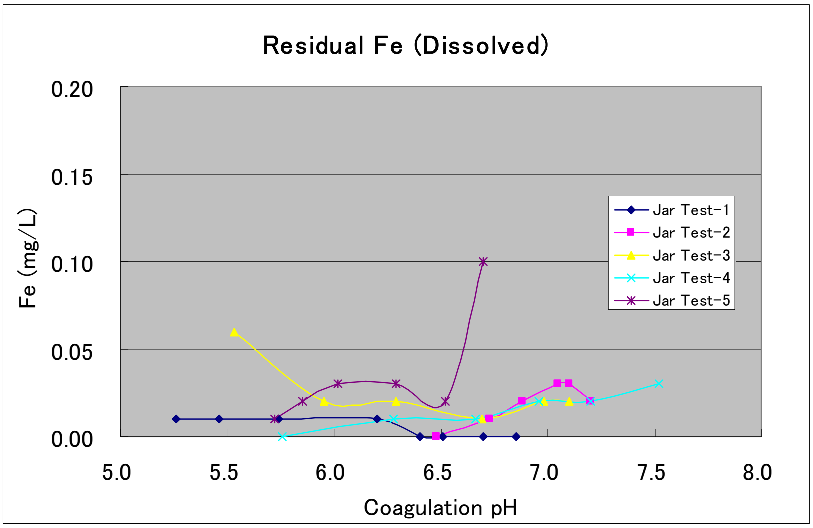


Figure 1.26 Residual Fe (Dissolved) in a Series of Jar Test

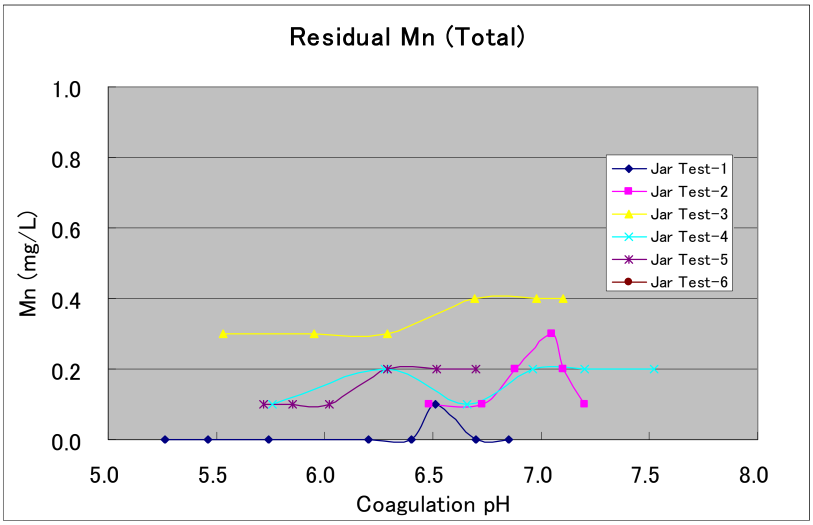


Figure 1.27 Residual Mn (Total) in a Series of Jar Test

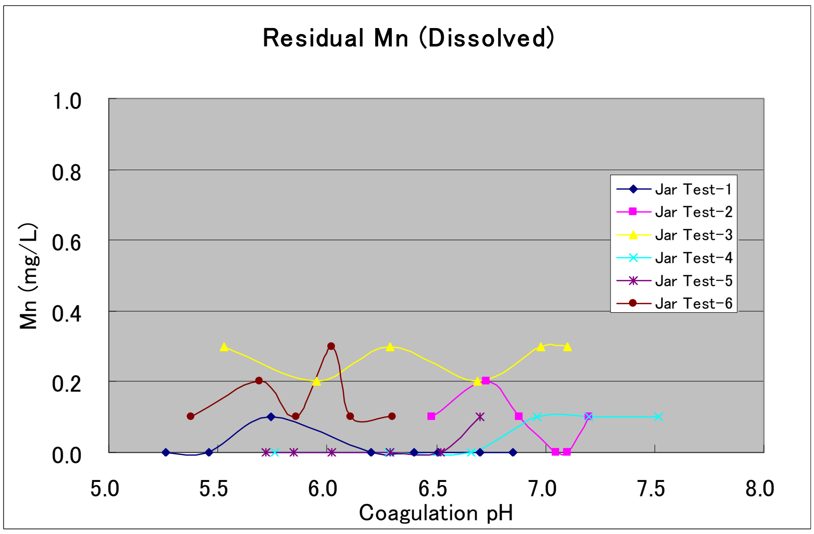


Figure 1.28 Residual Mn (Dissolved) in a Series of Jar Test

Findings and Conclusions

The findings and conclusions of examination on water treatment process for Tonle Sap lake water through a series of the jar test are:

1) It was confirmed that turbidity, color, Fe (Total and Dissolved) and Mn (Total and Dissolved) of the treated water complied with NDWQS by appropriate chemicals feeding.
2) It is considered that the organic substances such as algae are the factor of high turbidity as well as high color of the Tonle Sap lake water in dry season.
3) In particular, it was observed that raw water color significantly decreased in the coagulation pH range of around 6.0. This implies the necessity of post-alkali in order to maintain pH of the tap water within NDWQS.
4) Likewise, algae were significantly removed in lower coagulation pH.
5) The significant difference was observed in Mn removal by the pre-treatment using chlorine.

Based on above, it is considered that the conventional type of rapid sand filtration system with pre-chlorine and post-lime will be appropriate water treatment process for Tonle Sap lake water.

2. Study on Chemicals and Dosing Rates

2-1 Water Quality of Phum Prek WTP

Presently, available water quality data of Tonle Sap Lake is very limited. However, it is considered that water quality of the Phum Prek WTP in Phnom Phen City will be useful for examining water treatment process for Tonle Sap Lake water, since the WTP intakes the raw water from the Tonle Sap River, a tributary of the Mekong River. The river water flows down from the Tonle Sap Lake during dry season, while the water from the Mekong River flows into the Tonle Sap Lake through the Tonle Sap River. The seasonal change of water level of the Tonle Sap River reaches to 10 m same as that of the Tonle Sap Lake.

Thus, it is considered that raw water quality of Phum Prek WTP will be regarded as almost same as Tonle Sap lake water, although the water quality of the lake water through the year has not been available.

In examining water treatment process as well as chemicals dosing rate for lake water, the data and experiences at Phum Prek WTP will be useful reference materials.

(1) Available Data on Water Quality for Latest 4 Years

Table 2.6 - Table 2.13 represent the monthly data of the raw water and treated water quality of the WTP for latest 4 years (2006-2009). Among them, the important parameters (pH, turbidity, color, alkalinity, Fe, Mn) in examining water treatment process are excerpted as below.

Table 2.1 Water Quality of Raw Water (2006-2009)

		pH			Tubidity (NTU)			Color (TCU)			Alkalinity (mg/L)			Fe (mg/L)	Mn (mg/L)
		max	ave	min	max	ave	min	max	ave	min	max	ave	min	ave	ave
06	Jan	7.54	7.18	7.05	118	51	30	20	15	9	37	39	40	0.76	0.10
	Feb	7.69	7.27	7.07	105	54	33	22	16	10	34	38	40	0.89	0.10
	Mar	7.76	7.44	7.27	127	61	40	42	20	9	34	33	43	0.90	0.00
	Apr	7.84	7.56	7.10	110	74	48	62	39	7	36	43	53	1.63	0.30
	May	7.96	7.48	7.10	130	62	13	61	22	3	45	60	80	1.26	0.10
	Jun	7.85	7.57	7.17	207	172	153	34	13	5	52	64	76	0.23	0.10
	Jul	7.62	7.44	7.24	500	254	45	74	20	8	37	45	57	3.14	0.10
	Aug	7.69	7.39	7.13	680	381	230	62	20	11	30	36	45	3.85	0.10
	Sep	7.41	7.14	6.91	379	124	27	28	19	8	40	44	48	0.14	0.20
	Oct	7.93	7.20	6.96	264	80	20	54	22	21	30	38	44	0.13	0.20
	Nov	7.13	7.01	6.95	200	105	70	22	13	6	30	36	42	0.07	0.10
	Dec	7.36	7.20	7.06	115	71	48	15	11	6	32	40	45	0.12	0.10
07	Jan	7.21	7.09	6.95	158	63	40	24	17	11	30	35	40	0.10	0.20
	Feb	7.20	7.10	7.02	110	64	50	35	25	16	30	36	40	0.70	0.10
	Mar	7.15	6.98	6.79	125	53	35	47	26	18	28	33	38	0.35	0.10
	Apr	7.43	6.99	6.65	75	51	33	53	29	6	26	37	60	0.22	0.20
	May	7.69	7.30	6.74	110	48	18	149	40	5	26	49	70	0.28	0.10
	Jun	8.37	7.17	6.52	155	63	13	190	97	12	22	41	70	0.20	0.10
	Jul	7.45	7.22	6.77	451	141	45	202	72	28	24	44	70	1.66	0.06
	Aug	7.75	7.36	7.05	860	394	50	112	59	23	n.a.	46	64	0.17	0.03
	Sep	7.57	7.30	6.98	390	227	80	81	33	11	38	47	54	0.06	0.06
	Oct	7.48	7.20	7.04	386	140	50	81	45	8	34	42	52	0.14	0.05
	Nov	7.20	7.03	6.52	120	81	45	32	22	12	30	36	44	0.01	0.08
	Dec	7.36	6.95	6.62	158	102	50	30	24	15	30	33	38	n.a.	0.05
08	Jan	7.14	6.93	6.75	210	91	46	37	24	14	32	34	36	0.10	0.001
	Feb	7.04	6.92	6.82	141	79	54	53	32	18	30	33	36	0.22	0.116
	Mar	7.05	6.92	6.78	109	86	69	65	41	18	30	32	36	0.52	0.000
	Apr	7.51	7.03	6.80	145	89	51	104	50	8	28	37	60	0.41	0.119
	May	7.79	7.22	6.90	134	79	26	204	60	10	28	48	65	0.03	0.046
	Jun	7.32	7.16	6.98	303	142	61	91	53	23	44	51	64	0.13	0.049
	Jul	7.53	7.29	7.15	484	182	78	111	53	26	44	51	58	0.27	0.042
	Aug	7.41	7.30	7.17	749	427	196	92	52	22	42	52	64	0.13	0.082
	Sep	7.44	7.33	7.33	309	152	33	125	57	20	38	52	62	0.18	0.008
	Oct	7.39	7.16	7.16	93	49	32	52	25	15	42	48	56	0.28	0.006
	Nov	7.22	7.08	7.08	93	63	41	35	22	14	32	38	44	0.11	0.000
	Dec	7.23	7.14	7.14	100	79	64	53	26	15	34	38	48	0.10	0.040
09	Jan	7.17	7.10	6.95	104	86	63	49	34	15	30	34	38	0.19	0.032
	Feb	7.14	7.07	6.98	143	83	58	52	38	24	30	33	36	0.19	0.024
	Mar	7.15	7.06	6.88	152	101	59	257	75	23	30	33	38	0.52	0.000
	Apr	7.28	7.06	6.91	175	118	86	260	147	65	30	33	59	0.79	0.068
	May	7.85	7.21	6.93	213	125	38	256	125	10	28	46	70	0.92	0.024
	Jun	7.71	7.43	7.23	108	91	71	106	62	26	42	50	62	0.23	0.023
	Jul	7.45	7.33	7.19	584	252	71	103	57	21	36	47	60	0.33	0.020
	Aug	7.40	7.29	7.16	318	174	50	42	25	11	32	36	54	0.16	0.003
	Sep	7.39	7.25	7.11	226	92	32	50	28	14	32	39	48	0.08	0.009
	Oct	7.45	7.10	6.90	545	172	22	87	34	12	27	33	40	0.35	0.016
	Nov	7.19	7.04	6.84	132	96	61	26	16	6	26	29	33	0.13	0.007
	Dec	7.21	7.13	7.05	673	160	59	27	14	6	30	31	32	0.11	0.000

Table 2.2 Water Quality of Treated Water (2006-2009)

		pH			Turbidity (NTU)			Color (TCU)			Fe (mg/L)	Mn (mg/L)
		max	ave	min	max	ave	min	max	ave	min	ave	ave
06	Jan	7.42	6.96	6.70	1.50	0.77	0.26	5.00	3.30	1.70	0.03	0.10
	Feb	7.42	6.97	6.74	1.70	0.82	0.33	5.34	2.79	0.94	0.03	0.10
	Mar	7.38	7.08	6.75	1.50	0.90	0.45	5.30	2.54	0.56	0.04	0.00
	Apr	7.56	7.15	6.73	3.00	1.16	0.31	12.6	4.97	2.54	0.03	0.40
	May	7.53	7.05	6.71	1.60	0.55	0.18	3.59	1.93	0.29	0.01	0.10
	Jun	7.54	7.22	6.98	0.85	0.29	0.13	4.32	1.16	0.14	0.01	0.10
	Jul	7.28	6.92	6.67	1.10	0.38	0.12	3.30	1.06	0.10	0.02	0.20
	Aug	7.30	6.96	6.74	1.50	0.37	0.16	4.49	0.94	0.20	0.01	0.10
	Sep	7.12	6.93	6.70	0.87	0.32	0.14	2.57	1.33	0.43	0.01	0.20
	Oct	7.61	6.93	6.50	0.76	0.32	0.15	3.34	1.37	0.21	0.01	0.20
	Nov	7.06	6.84	6.67	0.85	0.32	0.12	4.70	1.86	0.39	0.02	0.10
	Dec	7.25	7.00	6.80	0.90	0.42	0.16	4.20	2.14	0.75	0.00	0.10
07	Jan	7.01	6.86	6.71	1.00	0.67	0.31	4.60	3.30	2.30	0.02	0.20
	Feb	7.00	6.90	6.70	1.50	0.66	0.35	5.00	3.00	2.00	0.00	0.10
	Mar	6.95	6.71	6.50	1.20	0.70	0.30	5.00	3.00	2.00	0.03	0.10
	Apr	7.13	6.76	6.50	1.80	0.55	0.16	5.00	3.00	1.00	0.01	0.10
	May	7.65	7.10	6.38	2.20	0.58	0.15	6.13	2.56	0.72	0.03	0.00
	Jun	7.83	6.81	6.05	4.00	0.94	0.16	9.80	3.48	0.78	0.02	0.20
	Jul	7.27	6.96	6.37	1.10	0.38	0.12	5.40	1.51	0.45	0.02	0.03
	Aug	7.56	6.90	6.65	0.72	0.35	0.16	2.42	0.87	0.12	0.01	0.03
	Sep	7.47	7.11	6.78	0.65	0.32	0.13	3.57	1.18	0.64	0.01	0.05
	Oct	7.26	7.06	6.81	2.50	0.42	0.12	5.21	1.30	0.63	0.01	0.05
	Nov	7.64	7.02	6.50	1.20	0.51	0.18	3.01	1.93	0.68	0.01	0.10
	Dec	7.31	6.92	6.50	1.00	0.49	0.17	3.01	1.71	0.78	0.00	0.03
08	Jan	8.83	6.92	6.60	2.70	0.48	0.15	4.35	2.16	0.72	0.06	0.000
	Feb	6.93	6.80	6.69	0.77	0.50	0.25	4.10	2.33	1.31	0.02	0.000
	Mar	6.83	6.68	6.58	0.98	0.48	0.25	4.27	2.60	0.96	0.01	0.000
	Apr	7.21	6.73	6.51	2.10	0.59	0.25	6.76	3.34	1.67	0.04	0.157
	May	7.50	6.90	6.50	0.83	0.44	0.24	4.06	1.88	0.69	0.01	0.044
	Jun	7.06	6.89	6.67	0.38	0.26	0.14	2.12	1.08	0.34	0.02	0.005
	Jul	7.35	7.04	6.85	0.81	0.30	0.16	1.93	0.74	0.11	0.01	0.059
	Aug	7.25	7.10	6.89	0.91	0.38	0.16	2.47	1.14	0.33	0.01	0.064
	Sep	7.33	7.12	6.93	2.10	0.94	0.40	11.89	2.82	0.53	0.03	0.043
	Oct	7.13	6.99	6.87	1.57	1.12	0.77	5.15	3.67	1.76	0.04	0.000
	Nov	7.05	6.87	6.71	1.50	1.12	0.81	5.27	3.29	1.43	0.02	0.015
	Dec	6.95	6.89	6.82	1.82	1.22	0.89	7.07	4.39	2.47	0.04	0.025
09	Jan	6.95	6.75	6.63	2.85	1.94	1.33	10.18	6.60	3.60	0.09	0.016
	Feb	6.75	6.65	6.54	2.67	1.66	1.13	8.91	5.93	3.43	0.09	0.021
	Mar	6.74	6.62	6.52	2.23	1.50	0.57	9.58	4.92	2.28	0.01	0.000
	Apr	6.78	6.57	6.40	2.44	1.19	0.60	10.64	3.89	2.52	0.05	0.009
	May	7.16	6.76	6.51	5.50	1.62	0.52	10.22	4.13	1.09	0.05	0.073
	Jun	7.21	6.93	6.73	1.27	0.71	0.56	8.65	2.10	1.18	0.01	0.001
	Jul	7.06	6.83	6.66	0.95	0.75	0.39	3.35	1.87	1.08	0.02	0.007
	Aug	7.02	6.84	6.64	0.98	0.69	0.50	2.80	1.09	0.30	0.01	0.000
	Sep	7.03	6.87	6.66	1.27	0.75	0.55	3.60	1.80	0.49	0.03	0.001
	Oct	7.01	6.82	6.51	1.44	0.91	0.58	5.05	2.77	0.75	0.01	0.001
	Nov	7.24	6.97	6.79	1.01	0.67	0.37	6.86	2.50	1.04	0.01	0.002
	Dec	7.27	7.13	6.98	1.40	0.71	0.30	4.31	2.41	1.31	0.02	0.019

Turbidity and Color of the Raw Water

Figure 2.1 and Figure 2.2 presents monthly data of turbidity and color of raw water respectively. It is generally expected that some correlation exists between turbidity and color, however, there is no significant correlation in the case of Phum Prek WTP as shown in Figure 2.3.

The peak of turbidity has occurred usually in August in rainy season, and that of color has occurred in the end of dry season as shown in Figure 2.4. Thus, peak time of turbidity and color is different.

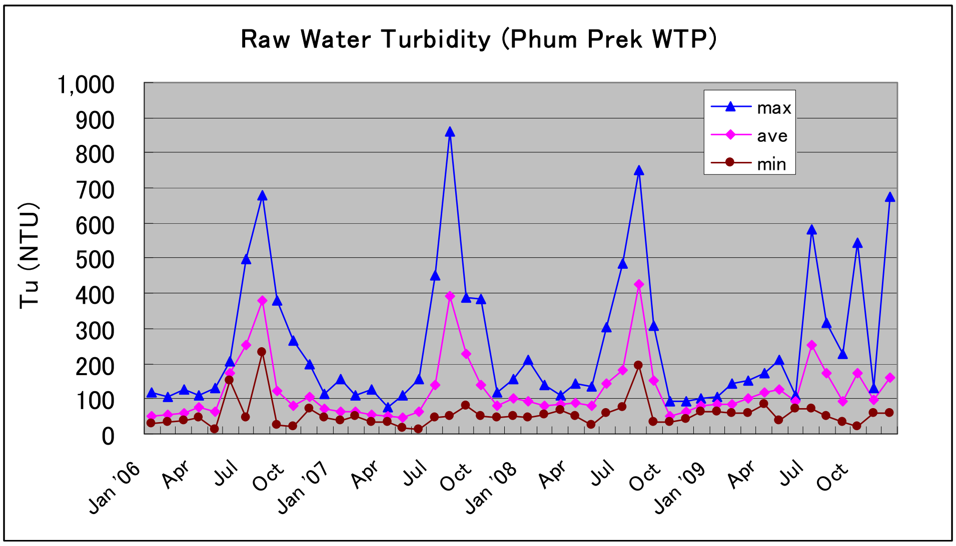


Figure 2.1 Raw Water Turbidity

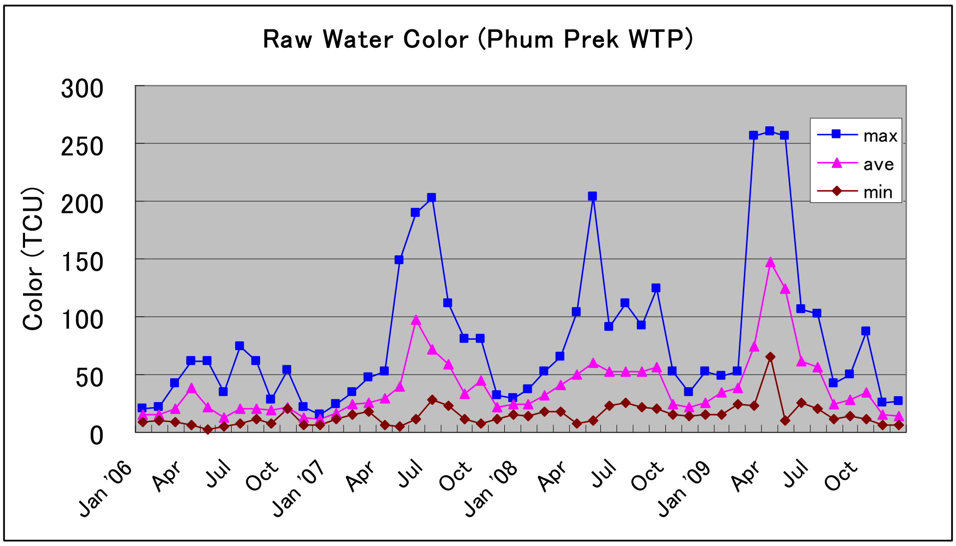


Figure 2.2 Raw Water Color

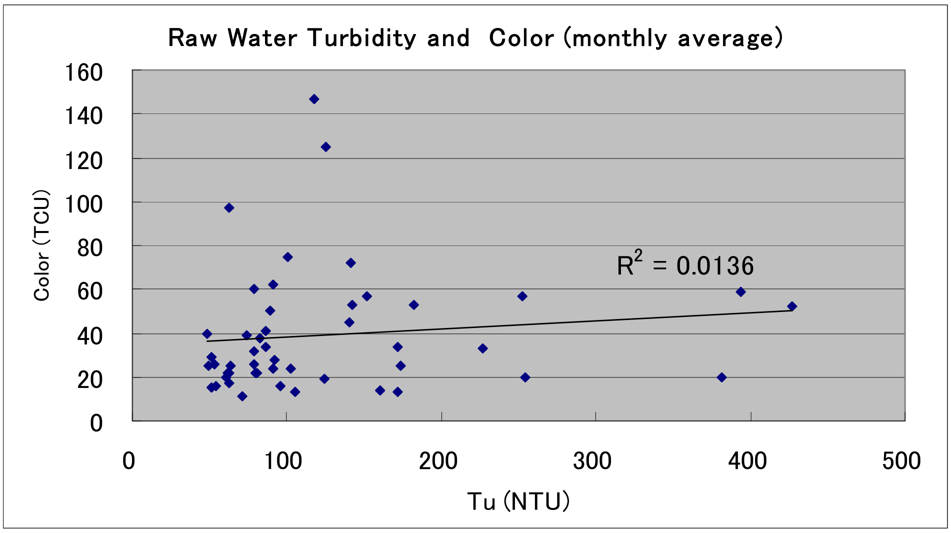
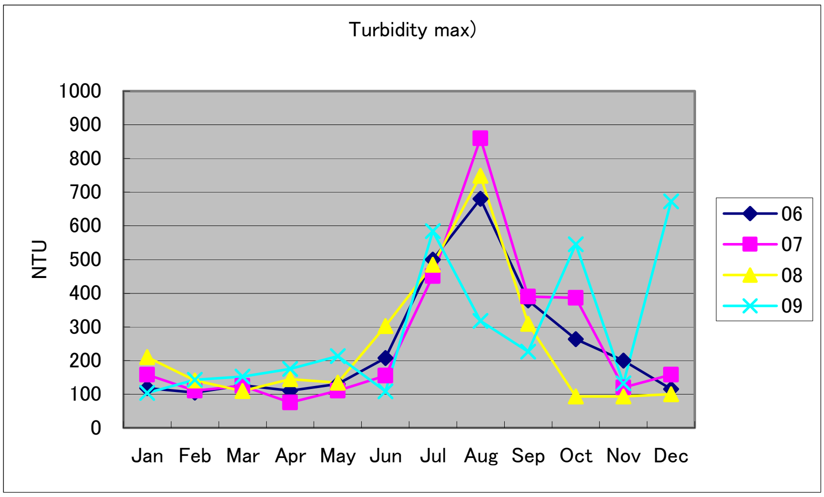


Figure 2.3 Relation between Turbidity and Color of Raw Water



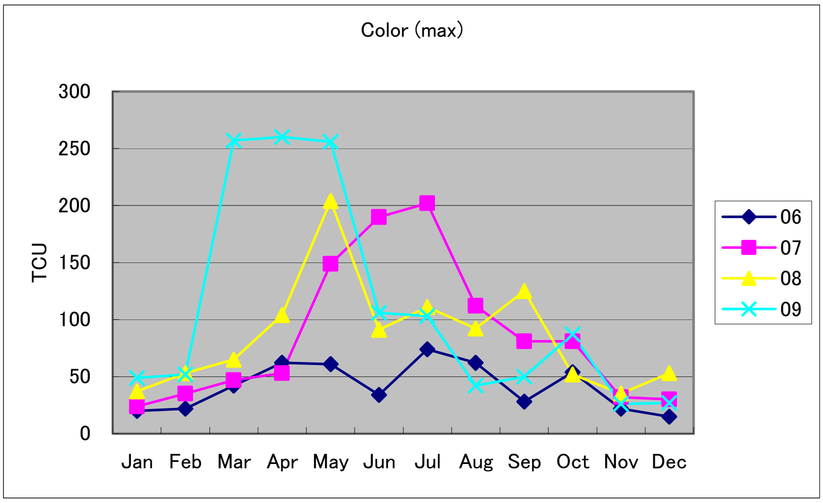


Figure 2.4 Peak Time of Turbidity and Color

Based on the data on raw water turbidity, the maximum turbidity is estimated to be 600 NTU with 95% non excess probability and 500 NTU with 90% non excess probability.

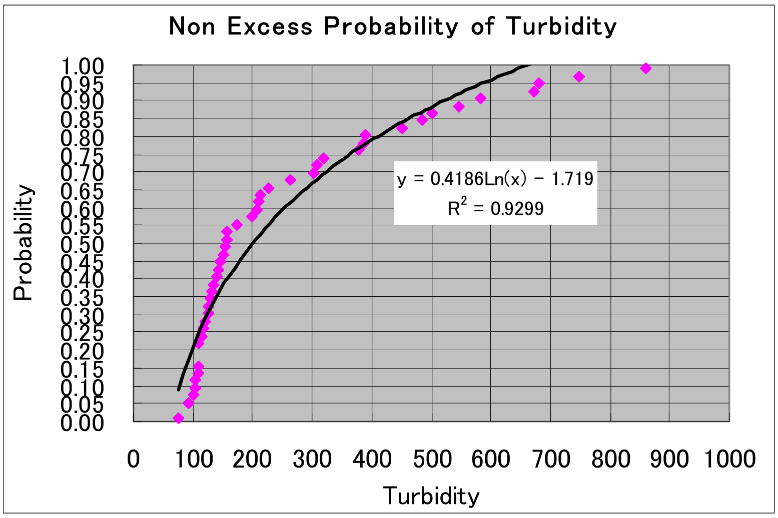


Figure 2.5 Probability of Occurrence of Maximum Turbidity

Turbidity and Color of the Treated Water

On the other hand, differently from the case of raw water, a significant correlation between turbidity and color of the treated water is observed as shown in Figure 2.6.

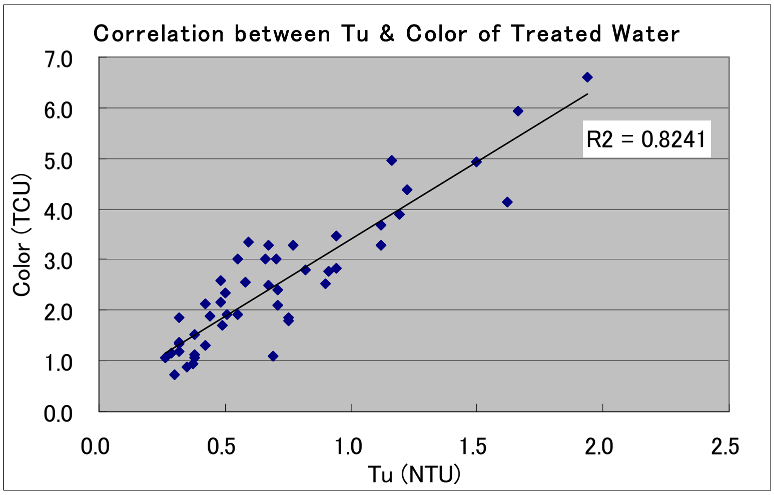


Figure 2.6 Correlation between Turbidity and Color of Treated Water

Fe and Mn

Figure 2.7 and Figure 2.8 shows monthly average of dissolved Fe and Mn, respectively. Fe of raw water has been well removed. As for dissolved Mn, water quality of the treated water shows the values complied with NDWQS. However, it is noted that dissolved Mn in raw water shows the tendency of decreasing.

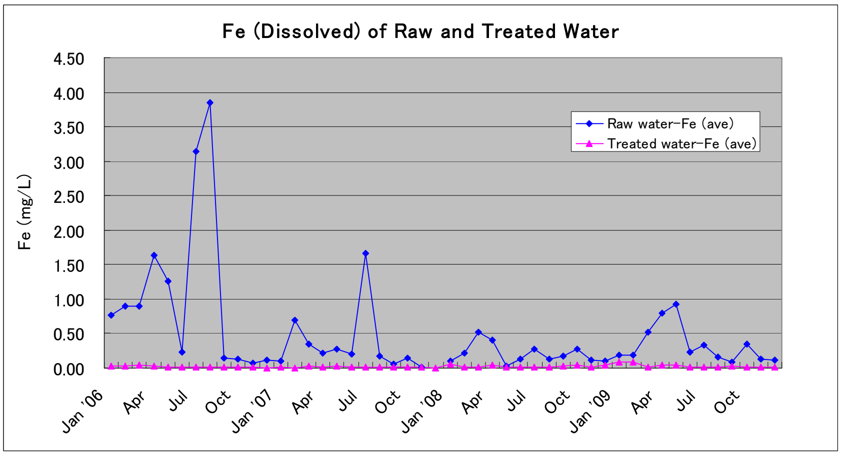


Figure 2.7 Fe (Dissolved) of Raw and Treated Water

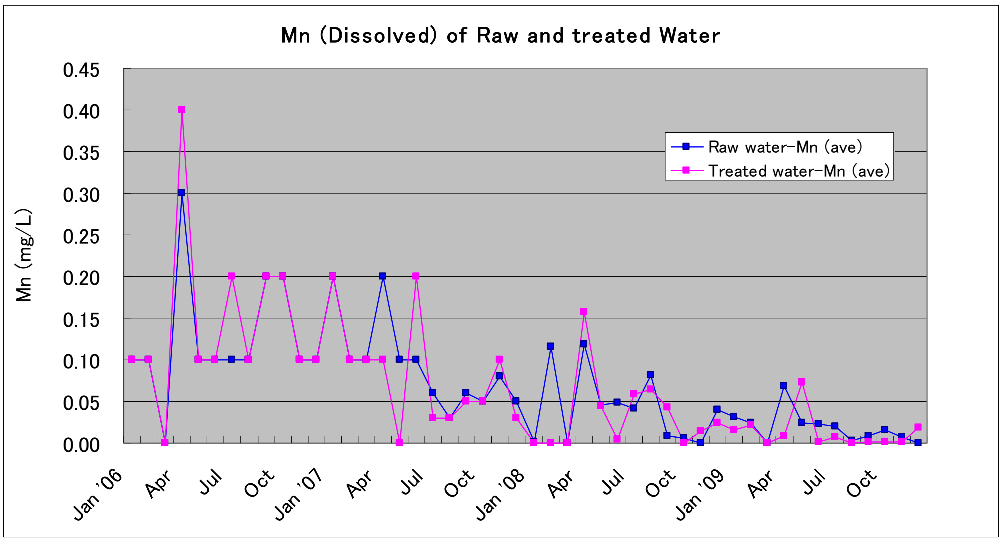


Figure 2.8 Mn (Dissolved) of Raw and Treated Water

Algae

Table 2.3 represents species and number of the algae (Cyanophytes, Diatomas and Chlorophytes) contained in the raw, settled, filtrated and distributed water for the 6th week (February 1 - 7) 2010. This explains that the algae were removed by the conventional water treatment process (pre-chlorine + coagulation + sedimentation + filtration) of Phum Prek WTP.

From the data, it is calculated that 99.1% of Cyanophytes, 99.2% of Diatomas, 97.1% of Chlorophytes were removed.

With regard to this, the ultimate algae removal will be expected by further improvement of operation of the WTP.

Table 2.3 Result of Algae

Classification	Species	Unit	Raw water	Sed. water	Filt. water	Dist. water
Cyanophytes	Anabaena macropsora	cel, colo	1000	66	14	6
	Anabaena sp.	colonies	2180	90	54	28
	Anabaena virquieri	colonies	10	4	0	0
	Aphanocapsa sp.	colonies	20	56	4	0
	Anaphanothes sp.	colonies	16	10	2	0
	Croococus sp.	cells	40	21	0	0
	Croococus turqidus	cells	22	168	8	0
	Microcystis aeroginosa	colonies	340	0	0	0
	Microcystis wesenbergii	colonies	45	13	0	0
	Oscilatoria tenuis	colonies	20	40	0	0
	Oscilatoria sp.	colonies	40	22	0	0
	Phormidium tenue	colonies	26	12	8	0
	Total number of cells & colonies		3759	502	90	34
Diatoms	Achnathes afinis	cells	578	336	4	0
	Aulacoseira distans	cells	50	0	0	0
	Aulacoseira granulata	cells	170	0	0	0
	Coconeis placenta	cells	1	0	0	0
	Cyclotella sp.	cells	88	39	10	8
	Cymbella prostita	cells	7	2	0	0
	Cymbella ventricosa	cells	10	4	0	0
	Diatoma sp.	cells	23	8	0	0
	Gemphonema sp.	cells	7	2	0	0
	Gyrosigma spenserii	cells	9	5	0	0
	Navicula sp.	cells	30	12	3	1
	Nitzchia actinastroides	cells	72	16	0	0
	N. Palea	cells	31	5	0	0
	Surirella ovata	cells	8	3	0	0
	Synedra acus	cells	6	2	0	0
	Synedra ulna	cells	16	8	0	0
	Total number of cells		1106	442	17	9
Chlorophytes	Ankistrodesmus falcatus		51	28	5	0
	Chlamydomonas		720	85	54	10
	Closterium moniliferum		47	22	2	4
	Coccomyxa sp.		54810	22432	1796	1580
	Coelastrum cambricum		20	12	4	0
	Cosmarium sp.		20	18	4	4
	Crucigenia crucifera		40	16	6	0
	Crucigenia lauterbornii		10	4	0	0
	Crucigenia tetrapedia		30	15	4	0
	Dictyospharium sp.		20	10	2	2
	Eudorina elegans		10	4	0	0
	Elakatothrix gelatimosa		50	30	4	3
	Kirchneriella contrta		40	14	2	0
	Kirchneriella lunaris		50	11	4	0
	Hormidium sp.		70	50	0	0
	Oocystis sp.		50	17	2	6
	Pandrina morum		40	10	0	0
	Periastrum simplex		10	2	0	0
	Periastrum duplex		20	6	0	0
	Planktpsharia sp.		96	20	0	0
	Scenedesmus opoliensis		20	5	0	0
	Scenedesmus sp.		24	7	0	0
	Selenastrum gracile		11	2	0	0
	Sphaerocystis sp.		18	3	0	0
	Spondylosium sp.		8	2	0	0
	Total number of colonies & cells		56285	22825	1889	1609

2-2 Study on Chemicals to be Used

(1) Chemicals to be used

Based on the results of a series of jar test as well as experiences at the Phum Prek WTP, the chemicals to be used are proposed as below.

1) Solid Aluminum Sulfate (as coagulant
2) Slaked Lime (as pre-alkali and post-alkali)
3) Chlorine (as pre-chlorine and post-chlorine)

Table 2.4 Chemicals Dosing Rates (Monthly average, 2009)

Month	Alum (mg/L)	Lime (mg/L)	Chlorine (mg/L)
Jan.	16.23	5.87	2.09
Feb.	18.53	8.40	2.09
Mar.	25.56	12.39	2.20
Apr.	35.28	14.19	2.63
May	37.88	7.83	2.69
Jun.	18.79	6.84	2.48
Jul.	19.43	8.46	2.07
Aug.	16.23	7.30	2.21
Sep.	16.41	7.80	1.72
Oct.	17.38	6.43	1.56
Nov.	18.86	6.65	2.00
Dec.	19.51	8.35	2.03

(2) Dosing Rates

As reference materials in designing chemicals feeding equipment, dosing rates of respective chemicals were examines as follow.

<u>Solid Aluminum Sulfate</u>

Figure 2.9 represents the relation between raw water turbidity and dosing rates of Aluminum Sulfate which was obtained from the results of a series of jar test described above. In addition, it is estimated that the maximum turbidity is 600 NTU with 95% non excess probability and 500 NTU with 90% non excess probability in case of Phum Prek WTP as described in the above Sec. 2.1.

Thus, it is considered that some 60 mg/L of Aluminum Sulfate as a maximum rate will be appropriate.

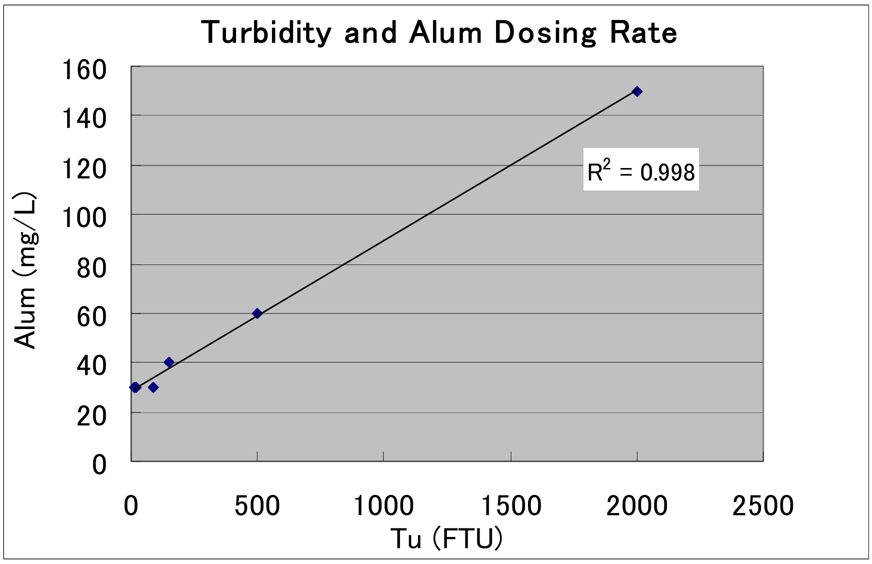


Figure 2.9　Raw Water Turbidity and Aluminum Dosing Rate

Slaked Lime

The raw water alkalinity of Phum Prek WTP for the latest 4 years has varied from 22 mg/L to 80 mg/L. Alkalinity is important parameter along with pH in water treatment with using Aluminum Sulfate. In the viewpoint of designing chemicals equipment, it is reasonable to refer to the minimum values of raw water alkalinity. The mean of the minimum values of alkalinity is calculated to be 30 mg/L, which is considered to be reasonable to determine dosing rate of pre-lime.

In addition, as observed in jar test, it is considered that pH control at outlet of the WTP be required according to raw water quality and/ or coagulation pH.

For example, Table 2.5 represents Langelier's Index of Phum Prek WTP which was calculated by applying Nodel method* with the water quality data of Year 2009. This Langelier's Index indicates the characteristic of corrosive water.

Thus, at this moment, it is considered that a total of some 60 mg/L of Slaked Lime for pre and post alkali as maximum.

Table 2.5　Langelier's Index (Monthly average, 2009)

Month	pH	TDS (mg/L)	Temp. (℃)	Ca-Hardness (mg/L)	Alkalinity (mg/L)	pHs	Langelier's Index
Jan.	6.75	44	26.0	32	25	8.9	-2.15
Feb.	6.65	44	28.2	32	25	8.8	-2.15
Mar.	6.62	48	30.0	34	33	8.9	-2.28
Apr.	6.57	58	30.6	43	20	8.8	-2.23
May	6.76	74	30.3	58	30	8.4	-1.64
Jun.	6.93	78	29.5	54	39	8.4	-1.47

Jul.	6.83	66	28.6	46	35	8.5	-1.67
Aug.	6.84	53	28.5	41	32	8.6	-1.76
Sep.	6.87	54	28.7	36	30	8.6	-1.73
Oct.	6.82	48	28.4	35	26	8.7	-1.88
Nov.	6.97	48	28.3	34	25	8.8	-1.83
Dec.	7.13	53	27.6	43	29	8.6	-1.47

[Nodel Method]*

Langelier's Index = pH – pHs

pHs = (9.3 + A value + B value) – (C value + D value)

TDS (mg/L)	A value	Ca-Hardness (mg/L)	C value	Alkalinity (mg/L)	D value
50～300	0.1	10～11	0.6	10～11	1
400～1,000	0.2	12～13	0.7	12～13	1.1
		14～17	0.8	14～17	1.2
Temp. (° C)	B value	18～22	0.9	18～22	1.3
0～1	2.6	23～27	1	23～27	1.4
2～6	2.5	28～34	1.1	28～35	1.5
7～9	2.4	35～43	1.2	36～44	1.6
10～13	2.3	44～55	1.3	45～55	1.7
14～17	2.2	56～69	1.4	56～69	1.8
18～21	2.1	70～87	1.5	70～88	1.9
22～27	2	88～110	1.6	89～110	2
28～31	1.9	111～138	1.7	111～139	2.1
32～37	1.8	139～174	1.8	140～176	2.2
38～43	1.7	175～220	1.9	177～220	2.3
44～50	1.6	230～270	2	230～270	2.4
51～56	1.5	280～340	2.1	280～350	2.5
57～63	1.4	350～430	2.2	360～440	2.6
64～71	1.3	440～550	2.3	450～550	2.7
72～81	1.2	560～690	2.4	560～690	2.8
		700～870	2.5	700～880	2.9
		800～1,000	2.6	890～1,000	3

Chlorine

Chlorine will be used not only for disinfection as post-chlorine, but also pre-chlorine as pretreatment against the dissolved Fe, dissolved Mn, ammonium nitrogen, algae, etc. Chlorine will be also utilized for adjusting coagulation pH. Referring to the results of jar test and the experiences at Phum Prek WTP, it is considered that maximum 5 mg/L for pre-chlorine and 2 mg/L for post-chlorine will be reference value.

Table 2.6 Raw Water Quality, Phum Prek WTP (2006)

នាយកដ្ឋានផលិតកម្មនិងផ្គត់ផ្គង់ទឹក
ការិយាល័យផលិតកម្ម
ផ្នែកពិសោធន៍

Phum Water Treatment Plant

Raw Water Quality in 2006

	Month			1	2	3	4	5	6	7	8	9	10	11	12	Yearly
	Number of day			31	28	31	30	31	30	31	31	30	31	30	31	Min-Aver-Max
	Parameter	Unit														
1	Color	TCU	Minimum	9	10	9	7	3	5	8	11	8	21	6	6	3.0
			Average	15	16	20	39	22	13	20	20	19	22	13	11	19
			Maximum	20	22	42	62	61	34	74	62	28	54	22	15	74
2	Temperature	°c	Minimum	26.7	26.3	28.0	28.3	28.4	29.3	27.0	26.0	27.1	26.2	28.0	25.2	25.2
			Average	27.9	28.9	29.6	30.1	30.5	30.7	28.3	27.6	28.6	28.3	29.0	27.7	28.9
			Maximum	30.0	31.0	30.9	31.7	32.5	32.5	29.4	29.7	29.8	29.7	31.0	30.4	32.5
3	Conductivity	μS/cm	Minimum	92	86	86	90	102	153	83	79	87	68	76	84	68
			Average	94	90	92	103	137	172	117	89	96	87	82	90	104
			Maximum	97	95	114	141	207	207	165	101	104	97	88	93	207
4	pH		Minimum	7.05	7.07	7.27	7.10	7.10	7.17	7.24	7.13	6.91	6.96	6.95	7.06	6.91
			Average	7.18	7.27	7.44	7.56	7.48	7.57	7.44	7.39	7.14	7.20	7.01	7.20	7.32
			Maximum	7.54	7.69	7.76	7.84	7.96	7.85	7.62	7.69	7.41	7.93	7.13	7.36	7.96
5	Turbidity	NTU	Minimum	30	33	40	48	13	153	45	230	27	20	70	48	13
			Average	51	54	61	74	62	172	254	381	124	80	105	71	124
			Maximum	118	105	127	110	130	207	500	680	379	264	200	115	680
6	Suspended Solids	mg/l	Minimum	28	21	28	29	8	12	31	116	16	14	62	37	8
			Average	47	49	47	46	37	38	205	282	92	65	86	55	87
			Maximum	114	102	98	79	81	96	431	474	276	220	121	84	474
7	Total dissolved solids	mg/l	Minimum	46	43	43	45	60	77	42	40	44	34	38	42	34
			Average	47	45	46	57	69	86	59	45	48	44	41	45	53
			Maximum	49	48	57	70	104	104	83	51	52	49	44	47	104
8	Absorbance		Minimum	0.089	0.193	0.170	0.060	0.033	0.023	0.051	0.055	0.013	0.070	0.070	0.067	0.013
			Average	0.117	0.105	0.201	0.227	0.130	0.075	0.095	0.094	0.119	0.120	0.130	0.098	0.126
			Maximum	0.147	0.154	0.246	0.346	0.330	0.197	0.249	0.240	0.980	0.250	0.940	0.123	0.980
9	Ca hardness	mg/l	Minimum	22	16	22	23	36		36	32		22	18	22	16
			Average	25	20	23	26	38	50	37	33	36	25	20	26	30
			Maximum	29	23	26	28	40		38	34		27	21	28	40
10	Total hardness	mg/l	Minimum	35	36	32	33	40		48	41		29	28	34	28
			Average	38	38	38	35	54	56	50	42	46	35	31	41	42
			Maximum	40	42	52	38	64		51	42		40	35	56	64
11	Magnesium hardness	mg/l	Minimum													
			Average	13	18	28	12	16	6	28	9	18	12	11	16	16
			Maximum													

12	Alkalinity	mg/l	Minimum	37	34	34	36	45	52	37	30	40	30	30	32	30.0
			Average	39	38	[illegible]3	43	60	64	45	36	44	38	36	40	43
			Maximum	40	40	43	53	80	76	57	45	48	44	42	45	80
13	Organic Substance	mg/l	Minimum		13.0	11.8	12.4	7.20	7.04	13.5	20.1	5.9	11.9	12.5	12.4	5.9
			Average		15.6	16.1	14.3	14.1	7.82	17.1	23.7	11.7	14.4	17.5	13.9	15.1
			Maximum		17.7	18.7	18.7	20.1	8.22	20.6	28.0	17.1	18.0	21.1	16.0	28.0
14	Total Coliform	cfu/100ml	Minimum	4800	7600	11200	6000	9000	2600	30000	25000	11000	8000	1000	8000	1000
			Average	272760	41333	44640	12000	22500	5475	138300	49800	27750	21950	33440	14700	37444
			Maximum	100000	100000	80000	20100	46000	13200	300000	74000	42000	44000	72000	24400	300000
15	Faecal Coliform	cfu/100ml	Minimum	2600	2000	110	1000	2600	3200	60000	6000	1000	1000	400	200	110
			Average	9440	3933	2782	2000	3650	15100	108050	15400	4500	2700	1600	1100	14188
			Maximum	33200	5800	7000	3400	6000	26400	200000	34000	8000	7000	4000	2400	200000
16	Aluminium	mg/l	Result	0.001	0.003	0.000	0.002	0.012	0.000	0.001	0.008	0.001	0.007	0.002	0.000	0.003
17	Ammonia	mg/l	Result	0.463	0.512	0.050	0.293	0.230	0.280	1.500	0.037	0.183	0.097	0.134	0.073	0.321
18	Ammonium-N	mg/l	Result	0.380	0.420	0.061	0.240	0.190	0.230	1.230	0.030	0.150	0.080	0.110	0.060	0.265
19	Carbon Dioxide	mg/l	Result	13	8	12	6	8	6	8	9	15	17	13	18	11
20	Copper	mg/l	Result	0.09	0.05	0.10	0.07	0.05	0.04	0.04	0.07	0.06	0.04	0.02	0.00	0.05
21	Chloride	mg/l	Result	20	20	15	18	23	25	15	10	1.05	1.00	1.00	15	14
22	Cyanide	mg/l	Result	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.005	0.005	0.002	0.001	0.002
23	Total Chromium	mg/l	Result	0.00	0.00	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.008
24	Chromium Hexa	mg/l	Result	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.004
25	Fluoride	mg/l	Result	0.13	0.14	0.00	0.08	0.16	0.00	0.05	0.15	0.20	0.07	0.13	0.16	0.11
26	Iron	mg/l	Result	0.76	0.89	0.90	1.63	1.26	0.23	3.14	3.85	0.14	0.13	0.07	0.12	1.09
27	Manganese	mg/l	Result	0.10	0.10	0.00	0.30	0.10	0.10	0.10	0.10	0.20	0.20	0.10	0.10	0.13
28	Nitrate Nitrogen	mg/l	Result	1.50	1.70	1.60	1.30	2.40	1.80	1.50	1.40	0.33	2.90	1.40	1.10	1.58
29	Nitrate	mg/l	Result	6.63	7.51	7.07	5.75	10.61	7.95	6.63	6.19	1.50	12.82	6.19	4.86	6.98
30	Nitrite Nitrogen	mg/l	Result	0.005	0.005	0.046	0.007	0.007	0.009	0.006	0.004	0.004	0.007	0.005	0.004	0.009
31	Nitrite	mg/l	Result	0.016	0.016	0.151	0.023	0.023	0.030	0.020	0.013	0.013	0.022	0.016	0.013	0.030
32	Phosphate	mg/l	Result	0.12	0.01	0.18	0.35	1.98	0.12	0.07	0.08	0.06	0.15	0.05	0.05	0.27
33	Sulfide	mg/l	Result	0.004	0.004	0.002	0.005	0.003	0.001	0.005	0.003	0.002	0.007	0.003	0.004	0.004
34	Sulfate	mg/l	Result	1.0	1.0	1.0	6.0	13.0	16.0	8.0	5.0	4.0	2.0	0.0	3.0	5.0
35	Zinc	mg/l	Result	0.06	0.07	0.01	0.06	0.04	0.03	0.12	0.01	0.02	0.01	0.01	0.01	0.04

Table 2.7 Raw Water Quality, Phum Prek WTP (2007)

នាយកដ្ឋានផលិតកម្មនិងផ្គត់ផ្គង់ទឹក
ការិយាល័យផលិតកម្ម
ផ្នែកពិសោធន៍

Phum Prek WTP
Raw Water Quality 2007

	Month			1	2	3	4	5	6	7	8	9	10	11	12	Yearly
	Number of day			31	28	31	30	31	30	31	31	30	31	30	31	Min,Aver,Max
	Parameter	Unit														
1	Color	TCU	Minimum	11	16	18	6	5	12	28	23	11	8	12	15	5.0
			Average	17	25	26	29	40	97	72	59	33	45	22	24	40.8
			Maximum	24	35	47	53	149	190	202	112	81	81	32	30	202
2	Temperature	°c	Minimum	25.5	25.0	27.0	28.0	28.0	27.4	26.9	25.0	26.2	26.0	25.3	25.4	25.0
			Average	27.1	27.0	29.0	30.0	30.0	30.4	28.6	27.7	28.1	27.6	27.3	27.2	28.3
			Maximum	28.8	30.0	31.0	31.0	32.0	31.8	30.2	29.3	29.60	28.9	28.7	28.9	32.0
3	Conductivity	µS/cm	Minimum	74	76	82	77	77	65	65	86	101	82	76	76	65
			Average	82	87	87	99	137	120	116	109	115	102	83	80	101
			Maximum	91	92	98	164	204	213	175	147	131	133	97	82	213
4	pH		Minimum	6.95	7.02	6.79	6.65	6.74	6.52	6.77	7.05	6.98	7.04	6.52	6.62	6.52
			Average	7.09	7.10	6.98	6.99	7.30	7.17	7.22	7.36	7.30	7.20	7.03	6.95	7.14
			Maximum	7.21	7.20	7.15	7.43	7.69	8.37	7.45	7.75	7.57	7.48	7.20	7.36	8.37
5	Turbidity	NTU	Minimum	40	50	35	33	18	13	45	50	80	50	45	50	13
			Average	63	64	53	51	48	63	141	394	227	140	81	102	119
			Maximum	158	110	125	75	110	155	451	860	390	386	120	158	860
6	Suspended Solids	mg/l	Minimum	30	28	18	18	13	10	27	28	59	31	32	44	10
			Average	50	47	35	30	32	47	114	286	179	106	64	81	89
			Maximum	122	103	83	48	77	98	366	596	319	305	102	120	596
7	Total Dissolved Solid	mg/l	Minimum	37	38	41	39	39	33	33	43	51	41	38	38	33
			Average	41	44	44	49	69	60	58	55	58	51	42	40	51
			Maximum	46	46	49	82	102	107	88	74	61	66	49	41	107
8	Absorbance		Minimum	0.122	0.160	0.105	0.096	0.047	0.074	0.132	0.013	0.073	0.055	0.101	0.107	0.013
			Average	0.152	0.193	0.197	0.245	0.230	0.490	0.335	0.220	0.151	0.200	0.130	0.143	0.224
			Maximum	0.180	0.233	0.260	1.183	0.760	0.910	0.963	0.390	0.319	0.322	0.159	0.189	1.183
9	Ca hardness	mg/l	Minimum	16	20	18	16	14	12	21	16	26	30	22	20	12
			Average	19	22	19	19	26	27	33	26	35	33	25	21	25
			Maximum	22	24	20	22	36	44	40	36	40	40	29	22	44
10	Total Hardness	mg/l	Minimum	29	32	28	26	23	20	30	26	42	40	31	30	20
			Average	32	37	31	30	44	45	39	40	48	44	36	34	38
			Maximum	36	48	34	34	62	69	44	51	52	52	42	40	69
11	Magnesium hardness	mg/l	Minimum	9	12	10	10	9	8	2	10	10	9	9	9	2
			Average	13	15	12	11	18	18	6	14	13	11	11.2	13	13
			Maximum	14	24	14	12	26	25	9	15	16	13	14	18	26

12	Alkalinity	mg/l	Minimum	30	30	28	26	26	22	24		38	34	30	30	22
			Average	35	36	33	37	49	41	44	46	47	42	36	33	40
			Maximum	40	40	38	60	70	70	70	64	54	52	44	38	70
13	Organic Substance	mg/l	Minimum	14.20	13.20	20.00	18.70	10.00	4.70	7.63	14.70	8.60	10.2	8.54	11.32	4.70
			Average	17.80	16.40	22.00	20.30	17.00	17.00	12.80	23.40	9.93	12.2	15.55	12.58	16.41
			Maximum	20.70	20.10	24.00	21.70	22.40	27.00	16.80	33.80	14.70	14.40	22.97	13.55	33.80
14	Dissolved Oygen		Minimum		5.00	4.73	4.50	4.00	3.66	4.78	5.47	6.30	5.03	5.50	6.25	3.66
			Average	7.12	5.40	5.00	4.70	5.40	6.03	5.63	6.08	6.53	6.47	6.12	6.54	5.81
			Maximum		5.80	6.11	5.80	6.50	7.17	6.41	6.86	6.81	7.44	6.70	6.68	7.44
15	Total Coliform	cfu/100ml	Minimum	3600	5000	8800	7800	2600	3900	5400	4400	9000	4800	2800	5600	2600
			Average	12040	57733	15450	44750	92750	5275	23100	14400	11600	11200	7440	7900	25303
			Maximum	28800	120000	25400	80000	210000	8800	50000	19200	17000	14000	10800	10800	210000
16	Faecal Coliform	cfu/100ml	Minimum	200	3200	600	800	1000	200	2000	400	4000	800	600	400	200
			Average	2080	26133	4150	6700	37650	2675	10600	6240	5050	2450	880	1300	8826
			Maximum	3000	60000	13200	22000	105000	4900	30000	17000	7000	5000	1000	3200	105000
17	Aluminium	mg/l	Result	0.001	0.002	0.025	0.001	0.002	0.007	0.003	0.000	0.001	0.002	0.000	0.000	0.004
18	Ammonia	mg/l	Result	0.10	0.10	0.17	0.27	0.01	0.01	0.15	0.122	0.061	0.073	0.085	0.049	0.100
19	Ammonium nitrogen	mg/l	Result	0.08	0.08	0.14	0.22	0.07	0.08	0.12	0.10	0.05	0.06	0.07	0.04	0.093
20	Carbon Dioxide	mg/l	Result	12	10	23	22	13	6	15	5	2	3	4	4	9.9
21	Copper	mg/l	Result	0.01	0.02	0.01	0.01	0.06	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.014
22	Chloride	mg/l	Result	11	10	8.5	20	13	21	14	17.3	12.5	17.5	14	16	14.57
23	Cyanide	mg/l	Result	0.010	0.003	0.004	0.001	0.002	0.002	0.001	0.001	0.001	0.003	0.001	0.002	0.003
24	Chromium total	mg/l	Result	0.02	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.009
25	Chromium Hexa	mg/l	Result	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.008
26	Fluoride	mg/l	Result	0.00	0.10	0.13	0.13	0.11	0.14	0.21	0.16	0.20	0.25	0.13	0.08	0.137
27	Iron	mg/l	Result	0.10	0.70	0.35	0.22	0.28	0.20	1.66	0.17	0.06	0.14	0.01		0.354
28	Manganese	mg/l	Result	0.20	0.10	0.10	0.20	0.10	0.10	0.06	0.03	0.06	0.05	0.08	0.05	0.094
29	Nitrate nitrogen	mg/l	Result	1.40	1.30	1.70	1.80	1.80	1.10	1.50	1.60	1.40	1.50	1.00	1.20	1.442
30	Nitrate	mg/l	Result	6.19	5.7	7.51	7.96	8.00	4.86	6.63	7.07	6.19	6.63	4.42	5.30	6.372
31	Nitrite nitrogen	mg/l	Result	0.008	0.010	0.021	0.009	0.007	0.005	0.014	0.005	0.007	0.007	0.005	0.005	0.009
32	Nitrite	mg/l	Result	0.026	0.02	0.07	0.029	0.023	0.016	0.046	0.016	0.023	0.023	0.016	0.016	0.027
33	Zinc	mg/l	Result	0.02	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.01	0.01	0.010
34	Phosphate	mg/l	Result	0.09	0.00	0.11	0.11	0.10	0.07	0.12	0.06	0.08	0.36	0.04	0.10	0.103
35	Sulfide	mg/l	Result	0.002	0.01	0.011	0.027	0.005	0.016	0.005	0.006	0.002	0.007	0.00	0	0.008
36	Sulfate	mg/l	Result	1	0	2	1	7	26	6	8	7	9	5	2	6.17

Table 2.8 Raw Water Quality, Phum Prek WTP (2008)

រដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ

នាយកដ្ឋានផលិតកម្ម និងផ្គត់ផ្គង់ទឹក

ការិយាល័យផលិតកម្ម

ផ្នែកពិសោធន៍

Raw Water Quality 2008

Phum Prek WTP

	Month			1	2	3	4	5	6	7	8	9	10	11	12	Yearly
	Number of day			31	28	31	30	31	30	31	31	30	31	30	31	Min,Aver,Max
	Parameter	Unit														
1	Temperature	°c	Minimum	25.4	26.0	27.9	29.8	29.0	28.5	28.1	26.8	27.2	28.7	26.7	26.1	25.4
			Average	27.2	27.7	29.0	30.5	29.9	29.5	29.1	27.9	28.5	29.5	28.5	26.6	28.7
			Maximum	28.4	28.8	30.0	31.5	30.9	30.5	29.8	29.5	29.70	30.4	29.6	27.0	31.5
2	pH		Minimum	6.75	6.82	6.78	6.80	6.90	6.98	7.15	7.17	7.13	7.01	6.92	7.04	7.17
			Average	6.93	6.92	6.92	7.03	7.22	7.16	7.29	7.30	7.33	7.16	7.08	7.14	7.33
			Maximum	7.14	7.04	7.05	7.51	7.79	7.32	7.53	7.41	7.44	7.39	7.22	7.23	7.79
3	Turbidity	NTU	Minimum	46	54	69	51	26	61	78	196	33	32	41	64	26
			Average	91	79	86	89	79	142	182	427	152	49	63	79	127
			Maximum	210	141	109	145	134	303	484	749	309	93	93	100	749
4	Conductivity	µS/cm	Minimum	80	79	76	87	89	122	115	105	98	96	82	82	76
			Average	83	83	85	102	137	153	137	122	123	110	86	87	109
			Maximum	86	87	98	148	189	200	172	144	138	119	95	90	200
5	Suspended Solids	mg/l	Minimum	40	27	43	21	17	45	63	144	19	20	30	42	17
			Average	74	55	59	54	51	116	151	323	127	38	51	67	97
			Maximum	143	110	99	98	76	246	353	527	245	69	75	95	527
6	Total Dissolved Solid	mg/l	Minimum	40	40	38	44	45	23	58	53	49	48	41	41	23
			Average	42	42	43	51	69	58	68	61	61	55	43	44	53
			Maximum	43	44	49	78	95	123	86	72	69	60	48	45	123
7	Total coliform	cfu/100ml	Minimum	4000	14800	8600	15200	13800	9600	11000	2200	1200	2300	1800	700	700
			Average	7300	43100	38120	31350	65750	31640	17850	17720	9850	5780	3775	2520	22896
			Maximum	12600	64600	96800	56000	183000	52200	25600	29400	23000	9800	5500	3200	183000
8	Faecal coliform	cfu/100ml	Minimum	200	3200	600	2200	3200	2400	2400	200	400	200	200	100	100
			Average	950	7050	3520	6050	29675	38320	7500	3350	3125	1120	400	380	8453
			Maximum	3000	11000	8400	10000	91500	152000	10600	9200	10000	2200	700	700	152000
9	Ca hardness	mg/l	Minimum	17	18	16	18	18	34	34	34	36	30	20	18	16
			Average	19	20	18	20	32	37	35	42	40	34	23	21	28
			Maximum	20	21	20	21	47	41	36	46	44	40	26	24	47
10	Total hardness	mg/l	Minimum	28	28	24	28	26	46	42	44	54	44	31	35	24
			Average	31	29	29	33	46	51	47	55	60	52	37	38	42
			Maximum	36	30	36	46	64	58	52	62	64	64	40	40	64
11	Magnesium hardness	mg/l	Minimum	9	9	6	9	8	8	8	10	12	14	11	16	6
			Average	12	15	11	14	13	15	12	14	20	18	14	18	13
			Maximum	16	36	16	26	20	22	17	16	26	24	20	21	36

12	Alkalinity	mg/l	Minimum	32	30	30	28	28	44	44	42	38	42	32	34	28
			Average	34	33	32	37	48	51	51	[illegible]	52	48	38	38	43
			Maximum	36	36	36	60	65	64	58	64	62	56	44	48	65
13	Organic Substance	mg/l	Minimum	12.99	14.72	13.29	10.21	5.29	6.96	6.16	10.50	6.95	9.48	8.22	12.03	5.29
			Average	14.98	17.71	17.44	16.69	9.81	9.71	13.44	20.56	9.01	9.86	11.55	15.19	13.83
			Maximum	16.43	22.12	23.10	23.06	14.10	13.29	21.65	34.03	12.64	10.74	13.27	19.31	34.03
14	Dissolved Oxygen	mg/l	Minimum	5.63	5.02	5.28	2.96	4.09	3.66	5.52	5.80	6.40	5.77	5.50	6.11	2.96
			Average	6.30	5.83	5.69	5.31	5.79	5.35	6.49	6.22	6.61	6.12	5.95	6.51	5.99
			Maximum	7.15	6.79	6.11	6.17	7.05	6.27	7.87	6.50	6.83	6.64	6.87	6.86	7.87
15	Color	TCU	Minimum	14.80	18.87	18.99	9.92	10.12	23.02	26.35	22.83	20.01	15.08	14.38	15.99	26.35
			Average	24.03	32.82	41.16	50.33	60.07	53.11	53.05	52.09	57.02	25.86	22.52	26.74	60.07
			Maximum	37.30	53.87	65.23	104.2	204.5	91.57	111.2	92.15	125.59	52.97	35.58	53.24	204.50
16	UV.absorption		Minimum	0.110	0.149	0.138	0.070	0.049	0.108	0.148	0.104	0.112	0.102	0.045	0.086	0.149
			Average	0.155	0.221	0.291	0.354	0.298	0.220	0.248	0.202	0.231	0.173	0.131	0.147	0.354
			Maximum	0.210	0.326	0.419	0.656	0.795	0.354	0.961	0.240	0.429	1.070	0.182	0.268	1.070
17	Aluminium	mg/l	Result	0.000	0.001	0.001	0.003	0.015	0.006	0.002	0.005	0.00	0.009	0.001	0.001	0.004
18	Ammonia	mg/l	Result	0.085	0.122	0.11	0.23	0.10	0.305	0.317	0.070	0.098	0.160	0.070	0.037	0.142
19	Ammonium nitrogen	mg/l	Result	0.07	0.10	0.09	0.19	0.08	0.25	0.26	0.06	0.08	0.13	0.06	0.03	0.117
20	Carbon dioxide	mg/l	Result	8	7	7	10	8	20	5	6	12	6	5	16	9.2
21	Copper	mg/l	Result	0.00	0.03	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.009
22	Chloride	mg/l	Result	15	19	17.5	16.0	19.5	22.5	20	11.5	20	15	14	16	17.17
23	Cyanide	mg/l	Result	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.004	0.001	0.002	0.002	0.001	0.002
24	Chromium total	mg/l	Result	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.010
25	Chromium hexa	mg/l	Result	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.004
26	Fluoride	mg/l	Result	0.05	0.17	0.00	0.33	0.11	0.04	0.19	0.00	0.02	0.04	0.00	0.00	0.079
27	Iron	mg/l	Result	0.10	0.22	0.52	0.41	0.03	0.13	0.27	0.13	0.18	0.28	0.11	0.10	0.207
28	Manganese	mg/l	Result	0.001	0.116	0.000	0.119	0.046	0.049	0.042	0.082	0.008	0.006	0.000	0.040	0.042
29	Nitrate nitrogen	mg/l	Result	1.40	1.30	1.30	1.50	1.50	1.30	1.20	1.20	0.90	1.00	1.40	1.30	1.275
30	Nitrate	mg/l	Result	6.19	5.75	5.75	6.63	6.63	5.75	5.30	5.30	3.98	4.42	6.19	5.75	5.637
31	Nitrite nitrogen	mg/l	Result	0.002	0.007	0.013	0.006	0.027	0.012	0.015	0.008	0.007	0.007	0.005	0.005	0.010
32	Nitrite	mg/l	Result	0.007	0.023	0.043	0.020	0.089	0.039	0.049	0.026	0.023	0.023	0.016	0.016	0.031
33	Zinc	mg/l	Result	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.02	0.01	0.01	0.014
34	Phosphate	mg/l	Result	0.11	0.08	0.09	0.08	0.09	0.20	0.12	0.06	0.09	0.18	0.16	0.20	0.122
35	Sulfide	mg/l	Result	0.003	0.002	0.005	0.013	0.002	0.006	0.017	0.007	0.006	0.011	0.005	0.000	0.006
36	Sulfate	mg/l	Result	1	1	1	10	15	13	9	8	7	8	1	1	6.25

Table 2.9 Raw Water Quality, Phum Prek WTP (2009)

រដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ
នាយកដ្ឋានផលិតកម្ម និងផ្គត់ផ្គង់ទឹក
ការិយាល័យផលិតកម្ម
ផ្នែកពិសោធន៍

Raw Water Quality 2009
Phum Prek WTP

	Month			1	2	3	4	5	6	7	8	9	10	11	12	Yearly
	Number of day			31	28	31	30	31	30	31	31	30	31	30	31	Min,Aver,Max
	Parameter	Unit														
1	Temperature	°c	Minimum	24.2	27.0	29.7	30.2	29.3	29	27.5	27.5	27.4	26.8	26.6	26.7	24.2
			Average	26.0	28.3	30.2	30.8	30.5	29.8	28.8	28.7	28.8	28.4	28.4	27.6	28.9
			Maximum	27.3	30.1	30.7	31.3	31.4	30.2	30.1	29.0	29.7	29.7	30.2	28.5	31.4
2	pH		Minimum	6.95	6.98	6.88	6.91	6.93	7.23	7.19	7.16	7.11	6.90	6.84	7.05	7.23
			Average	7.10	7.07	7.06	7.06	7.21	7.43	7.33	7.29	7.25	7.10	7.04	7.13	7.43
			Maximum	7.17	7.14	7.15	7.28	7.85	7.71	7.45	7.4	7.39	7.45	7.19	7.21	7.85
3	Turbidity	NTU	Minimum	63	58	59	86	38	71	71	50	32	22	61	59	22
			Average	86	83	101	118	125	91	252	174	92	172	96	160	129
			Maximum	104	143	152	175	213	108	584	318	226	545	132	673	673
4	Conductivity	µS/cm	Minimum	75	76	76	81	98	121	86	77	86	69	69	81	69
			Average	82	81	82	94	125	148	124	100	102	85	75	83	98
			Maximum	88	87	93	130	181	179	158	122	121	104	81	84	181
5	Suspended Solids	mg/l	Minimum	55	45	42	48	27	54	59	28	20	15	44	45	15
			Average	73	69	79	85	83	80	204	146	72	129	75	139	103
			Maximum	99	93	131	144	175	99	463	269	214	428	81	540	540
6	Total Dissolved Solid	mg/l	Minimum	38	38	38	42	49	61	43	39	43	35	35	40	35
			Average	41	41	41	47	63	74	62	50	51	43	38	41	49
			Maximum	51	44	47	65	91	90	79	61	61	52	42	42	91
7	Total coliform	cfu/100ml	Minimum	500	1990	120	610	1900	2800	3100	4930	4680	1800	1020	3240	120
			Average	1485	4213	2686	5610	19175	35940	23475	36386	12278	4450	2256	101220	20765
			Maximum	2640	6350	9100	15820	36500	152600	80000	127400	29620	10020	4020	376100	376100
8	Faecal coliform	cfu/100ml	Minimum	100	50	20	20	200	500	300	200	1370	250	180	750	20
			Average	285	428	964	1951	7500	19020	14400	6400	1943	1338	576	3440	4854
			Maximum	840	1010	3640	6780	14200	87200	54500	24800	2760	3360	1120	6500	87200
9	Ca hardness	mg/l	Minimum	13	12	10	20	22	28	22	24	25	22	16	18	10
			Average	15	14	16	21	31	37	32	32	27	26	18	21	24
			Maximum	18	17	18	21	44	50	44	38	30	33	19	23	50
10	Total hardness	mg/l	Minimum	28	30	27	33	36	46	40	35	35	27	27	31	27
			Average	29	31	31	36	48	54	47	44	37	33	29	34	38
			Maximum	31	31	33	40	62	70	56	50	38	37	31	36	70
11	Magnesium hardness	mg/l	Minimum	13	14	11	13	12	10	12	11	6	4	10	8	4
			Average	14	16	14	16	18	17	15	12	9	7	11	13	13
			Maximum	16	18	17	20	22	22	16	13	12	9	12	18	22

12	Alkalinity	mg/l	Minimum	30	30	30	30	28	42	36	32	32	27	26	30	26
			Average	34	33	33	33	46	50	47	4[illegible]	39	33	29	31	37
			Maximum	38	36	38	59	70	62	60	54	48	40	33	32	70
13	Organic Substance	mg/l	Minimum	12.64	12.03	20.17	16.49	10.71	6.66	11.04	9.15	7.58	10.74	13.89	17.36	6.66
			Average	16.51	17.01	22.87	24.00	18.05	8.35	23.52	16.16	9.95	16.52	17.90	21.23	17.67
			Maximum	21.13	22.62	25.69	35.50	24.12	10.71	31.74	19.95	12.64	20.86	21.24	29.43	35.50
14	Dissolved Oxygen	mg/l	Minimum	6.20	4.93	4.96	5.30	3.84	5.65	6.08	4.39	5.57	5.22	4.90	4.92	3.84
			Average	6.79	5.53	5.43	5.98	4.80	6.77	7.18	6.67	6.59	5.64	5.6	6.05	6.02
			Maximum	7.12	5.86	5.85	6.56	5.91	7.31	7.67	8.11	7.40	6.56	6.24	6.66	8.11
15	Color	TCU	Minimum	15.65	24.33	23.77	65.38	10.56	26.61	21.09	11.18	14.15	12.45	6.74	6.58	65.38
			Average	34.97	38.68	75.43	147.11	125.91	62.68	57.49	25.24	28.72	34.58	16.98	14.56	147.11
			Maximum	49.88	52.04	257.69	260.67	256.73	106.54	103.75	42.25	50.52	87.92	26.10	27.41	260.67
16	UV,absorption		Minimum	0.102	0.183	0.183	0.330	0.050	0.143	0.125	0.017	0.100	0.099	0.024	0.034	0.330
			Average	0.205	0.242	0.397	0.699	0.601	0.283	0.244	0.141	0.199	0.173	0.121	0.135	0.699
			Maximum	0.271	0.287	0.921	1.094	1.262	0.489	0.428	0.235	0.54	0.345	0.190	0.64	1.262
17	Aluminium	mg/l	Result	0.002	0.002	0.001	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.001	0.000	0.001
18	Ammonia	mg/l	Result	0.24	0.21	0.11	1.21	0.66	0.16	0.18	0.00	0.66	0.22	0.171	0.109	0.328
19	Ammonium nitrogen	mg/l	Result	0.20	0.17	0.09	0.99	0.51	0.13	0.15	0.00	0.54	0.18	0.14	0.09	0.266
20	Carbon dioxide	mg/l	Result	21	26	7	20	1.5	5	3	5	5	4	8	9	9.5
21	Copper	mg/l	Result	0.01	0.02	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.010
22	Chloride	mg/l	Result	13.5	12.0	17.5	15.0	14.5	21.5	15.0	12.5	14.0	10.0	8.5	10	13.67
23	Cyanide	mg/l	Result	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.002	0.001
24	Chromium total	mg/l	Result	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.006
25	Chromium hexa	mg/l	Result	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.003
26	Fluoride	mg/l	Result	0.14	0.00	0.00	0.01	0.02	0.14	0.00	0.11	0.14	0.12	0.12	0.02	0.068
27	Iron	mg/l	Result	0.19	0.19	0.52	0.79	0.92	0.23	0.33	0.16	0.08	0.35	0.13	0.11	0.333
28	Manganese	mg/l	Result	0.032	0.024	0.000	0.068	0.024	0.023	0.020	0.003	0.009	0.016	0.007	0.000	0.019
29	Nitrate nitrogen	mg/l	Result	1.10	1.10	1.30	1.00	0.60	1.40	1.20	1.20	1.70	1.20	1.10	1.30	1.183
30	Nitrate	mg/l	Result	4.860	4.862	5.75	4.42	2.652	6.190	5.300	5.304	7.510	5.300	4.860	5.74	5.229
31	Nitrite nitrogen	mg/l	Result	0.01	0.004	0.013	0.021	0.008	0.06	0.014	0.003	0.003	0.004	0.004	0.005	0.012
32	Nitrite	mg/l	Result	0.033	0.013	0.043	0.069	0.026	0.197	0.046	0.009	0.009	0.013	0.013	0.016	0.041
33	Zinc	mg/l	Result	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.02	0.011
34	Phosphate	mg/l	Result	0.23	0.21	0.09	0.48	0.41	0.19	0.22	0.06	0.38	0.14	0.17	0.08	0.222
35	Sulfide	mg/l	Result	0.005	0.015	0.005	0.022	0.018	0.005	0.009	0.004	0.001	0.010	0.002	0.006	0.009
36	Sulfate	mg/l	Result	0	0	1	2	1	14	10	3	8	3	1	1	3.67

Table 2.10 Treated Water Quality, Phum Prek WTP (2006)

នាយកដ្ឋានផលិតកម្មនិងផ្គត់ផ្គង់ទឹក
ការិយាល័យផលិតកម្ម
ផ្នែកពិសោធន៍

Phum Prek Water Treatment Plant

Treated Water Quality in 2006

	Month					1	2	3	4	5	6	7	8	9	10	11	12	Yearly
No	No. Day					31	28	31	30	31	30	31	31	30	31	30	31	Min-Aver-Max
	parameter	unit	NDWQS	WHO														
1	Color	TCU	5	15	Minimum	1.70	0.94	0.56	2.54	0.29	0.14	0.10	0.20	0.43	0.21	0.39	0.75	0.10
					Average	3.30	2.79	2.54	4.97	1.93	1.16	1.06	0.94	1.33	1.37	1.86	2.14	2.12
					Maximum	5.00	5.34	5.30	12.6	3.59	4.32	3.30	4.49	2.57	3.34	4.70	4.20	12.6
2	Temperature	°c			Minimum	26.9	27.5	27.7	28.3	28.3	29.3	26.0	26.0	27.0	26.4	28.1	25.3	25.3
					Average	27.9	28.9	29.6	30.2	30.4	30.5	28.3	27.4	28.7	28.4	29.3	27.7	28.9
					Maximum	29.6	30.8	30.5	31.5	31.8	31.4	30.0	28.5	30.0	29.7	30.7	30.2	31.8
3	Conductivity	µS/cm		400	Minimum	101	95	99	103	120	159	102	96	94	80	83	91	80
					Average	106	103	105	119	155	179	131	110	108	97	94	99	117
					Maximum	113	110	113	148	190	208	175	129	121	111	104	105	208
4	pH		6.50-8.50	6.50-8.50	Minimum	6.70	6.74	6.75	6.73	6.71	6.98	6.67	6.74	6.7	6.50	6.67	6.80	6.50
					Average	6.96	6.97	7.08	7.15	7.05	7.22	6.92	6.96	6.93	6.93	6.84	7.00	7.00
					Maximum	7.42	7.42	7.38	7.56	7.53	7.54	7.28	7.30	7.12	7.61	7.06	7.25	7.61
5	Turbidity	NTU	5	5	Minimum	0.26	0.33	0.45	0.31	0.18	0.13	0.12	0.16	0.14	0.15	0.12	0.16	0.12
					Average	0.77	0.82	0.90	1.16	0.55	0.29	0.38	0.37	0.32	0.32	0.32	0.42	0.55
					Maximum	1.50	1.70	1.50	3.00	1.60	0.85	1.10	1.50	0.87	0.76	0.85	0.90	3.00
6	Suspended solids	mg/l		1	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Average	0.49	0.55	0.53	0.80	0.19	0.06	0.24	0.00	0.15	0.16	0.10	0.08	0.28
					Maximum	2.00	2.00	1.00	2.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	2.00
7	Total dissolved solids	mg/l	800	1000	Minimum	51	48	48	50	60	60	56	48	47	40	42	46	40
					Average	53	57	53	60	78	90	66	55	54	49	47	49	59
					Maximum	57	60	57	74	95	104	88	65	61	56	52	53	104
8	Absorbance				Minimum	0.030	0.038	0.048	0.048	0.014	0.014	0.008	0.010	0.001	0.010	0.029	0.027	0.001
					Average	0.044	0.054	0.058	0.062	0.036	0.020	0.016	0.015	0.021	0.030	0.036	0.041	0.036
					Maximum	0.057	0.066	0.068	0.087	0.059	0.027	0.035	0.031	0.048	0.040	0.050	0.062	0.087
9	Free available chlorine	mg/l	0.20-0.50	0.10-1.00	Minimum	0.30	0.60	0.47	0.28	0.32	0.88	0.79	0.70	0.60	0.63	0.22	0.60	0.22
					Average	1.01	1.08	1.02	0.99	1.21	1.17	1.13	1.09	0.93	0.97	0.98	1.01	1.05
					Maximum	1.50	1.60	1.51	1.67	1.90	1.55	1.64	1.49	1.10	1.40	1.25	1.32	1.90
10	Total available chlorine	mg/l		2	Minimum	0.47	0.74	0.80	0.76	0.46	0.93	0.89	0.84	0.71	0.75	0.84	0.74	0.46
					Average	1.17	1.26	1.22	1.24	1.42	1.31	1.62	1.19	1.04	1.10	1.12	1.14	1.24
					Maximum	1.65	1.80	1.70	2.01	2.10	1.70	1.80	1.63	1.51	1.60	1.39	1.41	2.10
11	Ca hardness	mg/l		70	Minimum	27	20	22	25	38		38	32		24	24	29	20
					Average	30	24	26	28	41	54	39	34	37	28	26	30	33
					Maximum	33	29	29	30	44		40	36		32	28	32	44

12	Total hardness	mg/l	300	100	Minimum	39	34	37	35	48		50	46		32	32	39	32
					Average	[illegible]	40	41	40	61	66	53	[illegible]7	52	39	35	41	46
					Maximum	42	44	50	44	75		56	48		44	39	43	75
13	Magnesium hardness	mg/l		30	Minimum													0.00
					Average	11	16	15	12	10	12	14	13	15	11	9	11	12
					Maximum													
14	Alkalinity	mg/l		350	Minimum	26	22	23	26	26	44	23	22	28	20	20	28	20
					Average	31	27	27	30	41	56	34	29	37	31	30	34	34
					Maximum	34	34	34	40	66	66	50	36	44	36	34	40	66
15	Organic substance	mg/l			Minimum		2.73	4.17	3.31	2.73	2.34	0.86	1.04	0.45	2.58	1.67	2.95	0.45
					Average		4.48	5.50	4.97	5.20	2.43	1.78	2.21	2.00	3.33	2.89	3.98	3.52
					Maximum		6.32	6.77	6.77	8.36	2.63	3.61	3.30	3.74	4.04	3.80	5.01	8.36
16	Total Coliform	cfu/100ml		0	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
					Average	0	0	0	0	0	0	0	0	0	0	0	0	0
					Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0
17	Faecal Coliform	cfu/100ml		0	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
					Average	0	0	0	0	0	0	0	0	0	0	0	0	0
					Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Aluminium	mg/l	0.20	0.05-0.20	Result	0.013	0.015	0.004	0.002	0.011	0.058	0.005	0.022	0.027	0.004	0.008	0.014	0.015
19	Ammonia	mg/l	1.5		Result	0.012	0.000	0.000	0.049	0.000	0.000	0.000	0.000	0.000	0.010	0.110	0.000	0.015
20	Ammonia Nitrogen	mg/l		0.05-0.50	Result	0.010	0.000	0.000	0.040	0.000	0.000	0.000	0.000	0.000	0.010	0.090	0.000	0.013
21	Carbone Dioxide	mg/l			Result	13	12	23	11	14	12	12	8	17	20	20	24	16
22	Copper	mg/l	1	0.02-1.0	Result	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.02	0.02	0.06
23	Chloride	mg/l	250	25-250	Result	18	25	23	19	24	26	16	13	2.5	2.8	1.8	16	16
24	Cyanide	mg/l	0.07	0.07-1.0	Result	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.002	0.005	0.005	0.002	0.001	0.002
25	Chromium Total	mg/l		0.05	Result	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.01
26	Chromium Hexa	mg/l	0.05	0.05	Result	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Fluoride	mg/l	1.5	0.1-1.5	Result	0.14	0.16	0.00	0.00	0.18	0.09	0.09	0.06	0.19	0.05	0.11	0.14	0.10
28	Iron	mg/l	0.3	1.0-0.30	Result	0.03	0.03	0.04	0.03	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.00	0.02
29	Manganese	mg/l	0.1	0.05-0.5	Result	0.10	0.10	0.00	0.40	0.10	0.10	0.20	0.10	0.20	0.20	0.10	0.10	0.14
30	Nitrate Nitrogen	mg/l			Result	2.50	2.10	1.70	3.20	2.50	1.90	1.90	1.40	0.33	1.70	1.50	1.20	1.83
31	Nitrate	mg/l	50	5.0-50	Result	11.1	9.28	7.51	14.1	11.1	8.40	8.39	6.19	1.50	7.51	6.63	5.30	8.08
32	Nitrite Nitrogen	mg/l			Result	0.004	0.004	0.005	0.004	0.005	0.005	0.005	0.004	0.005	0.006	0.004	0.004	0.005
33	Nitrite	mg/l	3	1.0-3.0	Result	0.013	0.013	0.016	0.013	0.016	0.016	0.016	0.013	0.016	0.019	0.013	0.013	0.015
34	Phosphate	mg/l			Result	0.01	0.01	0.06	0.07	0.11	0.05	0.08	0.02	0.00	0.05	0.01	0.03	0.04
35	Sulfide	mg/l	0.05	0	Result	0.004	0.003	0.001	0.000	0.002	0.002	0.003	0.002	0.001	0.000	0.003	0.008	0.002
36	Sulfate	mg/l	250	25-250	Result	12	12	15	26	26	23	23	24	19	18	10	12	18
37	Zinc	mg/l	3	0.5-3.0	Result	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.00	0.01	0.01	0.01	0.00	0.01

Table 2.11 Treated Water Quality, Phum Prek WTP (2007)

នាយកដ្ឋានផលិតកម្មនិងផ្គត់ផ្គង់ទឹក
ការិយាល័យផលិតកម្ម
ផ្នែកពិសោធន៍

Phum Prek WTP
Treated Water Quality 2007

	Month					1	2	3	4	5	6	7	8	9	10	11	12	Yearly
	Number of day					31	28	31	30	31	30	31	31	30	31	30	31	Min,Aver,Max
	parameter	unit	CNDWQS	WHO														
1	Color	TCU	5	15	Minimum	2.30	2.00	2.00	1.00	0.72	0.78	0.45	0.12	0.64	0.63	0.68	0.78	0.12
					Average	3.30	3.00	3.00	3.00	2.56	3.48	1.51	0.87	1.18	1.30	1.93	1.71	2.24
					Maximum	4.60	5.00	5.00	5.00	6.13	9.80	5.40	2.42	3.57	5.21	3.01	3.01	9.80
2	Temperature	°c			Minimum	25.7	25.0	28.0	28.0	28.0	27.7	26.3	25.0	25.2	25.3	25.2	25.1	25.0
					Average	27.3	27.0	29.0	30.0	30.0	30.2	28.5	28.8	27.7	27.5	27.1	27.0	28.3
					Maximum	29.0	30.0	30.0	31.0	31.0	31.7	30.1	29.1	31.5	28.5	28.5	28.8	31.7
3	Conductivity	μS/cm		400	Minimum	80	86	97	92	101	87	108	109	122	111	88	96	80
					Average	92	103	105	120	155	142	137	131	137	124	105	105	121
					Maximum	105	113	115	168	214	216	189	164	155	154.00	116	115	216
4	pH		6.5-8.5	6.5-8.5	Minimum	6.71	6.70	6.50	6.50	6.38	6.05	6.37	6.65	6.78	6.81	6.50	6.50	6.05
					Average	6.86	6.90	6.71	6.76	7.10	6.81	6.96	6.90	7.11	7.06	7.02	6.92	6.93
					Maximum	7.01	7.00	6.95	7.13	7.65	7.83	7.27	7.56	7.47	7.26	7.64	7.31	7.83
5	Turbidity	NTU	5	5	Minimum	0.31	0.35	0.30	0.16	0.15	0.16	0.12	0.16	0.13	0.12	0.18	0.17	0.12
					Average	0.67	0.66	0.70	0.55	0.58	0.94	0.38	0.35	0.32	0.42	0.51	0.49	0.55
					Maximum	1.00	1.50	1.20	1.80	2.20	4.00	1.10	0.72	0.65	2.50	1.20	1.00	4.00
6	Suspended Solids	mg/l		1	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Average	0.40	0.40	0.30	0.10	0.43	0.38	0.18	0.08	0.02	0.19	0.55	0.76	0.32
					Maximum	1.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00
7	Total Dissolved Solids	mg/l	800	1000	Minimum	40	43	49	46	51	44	54	55	61	55	44	48	40
					Average	46	52	53	60	78	71	69	66	69	62	53	53	61
					Maximum	53	57	58	84	107	108	95	82	78	77	58	58	108
8	Absorbance				Minimum	0.053	0.051	0.057	0.044	0.022	0.024	0.017	0.012	0.014	0.011	0.025	0.024	0.011
					Average	0.059	0.068	0.068	0.065	0.047	0.051	0.029	0.019	0.021	0.025	0.040	0.035	0.044
					Maximum	0.072	0.185	0.190	0.283	0.107	0.100	0.037	0.027	0.035	0.049	0.141	0.049	0.283
					Minimum	0.50	0.50	0.60	0.46	0.46	0.43	0.61	0.68	0.75	0.35	0.10	0.63	0.10

9	FAC	mg/l	0.2-0.5	0.1-1	Average	0.97	0.91	0.90	0.99	0.99	0.96	0.95	0.94	0.93	0.92	0.82	0.89	0.93
					Maximum	1.36	1.50	1.40	1.80	1.67	1.42	1.47	1.40	1.45	1.33	1.20	1.25	1.80
10	TAC	mg/l		2	Minimum	0.65	0.58	0.70	0.64	0.66	0.67	0.70	0.76	0.84	0.45	0.17	0.77	0.17
					Average	1.15	1.07	1.10	1.20	1.16	1.12	1.07	1.04	1.020	1.03	0.94	1.01	1.08
					Maximum	1.72	1.75	1.70	2.00	1.97	1.62	1.61	1.64	1.55	1.45	1.30	1.35	2.00
11	Ca hardness	mg/l		70	Minimum	20	24	20	24	20	24	28	20	40	36	28	26	20
					Average	23	28	23	26	33	37	36	32	43	41	31	29	32
					Maximum	26	30	26	30	44	50	40	42	44	50	32	32	50
12	Total hardness	mg/l	300	100	Minimum	30	34	32	35	26	28	40	30	50	44	40	38	26
					Average	39	40	37	38	50	54	50	46	54	52	41	41	45
					Maximum	46	45	42	42	66	70	58	57	60	62	44	44	70
13	Magnesium hardness			30	Minimum	10	10	12	11	16	14	12	10	8	8	8	10	8
					Average	16	12	14	12	17	17	14	14	11	11	10	12	13
					Maximum	20	15	16	14	22	20	18	15	16	13	12	14	22
14	Alkalinity	mg/l		350	Minimum	24	26	17	16	16	10	14	20	28	24	26	24	10
					Average	30	31	26	28	42	32	35	36	40	35	32	30	33
					Maximum	36	34	30	40	65	64	56	58	48	48	38	36	65
15	Organic Substance	mg/l			Minimum	5.01	4.60	3.00	4.70	2.63	2.34	0.14	0.14	1.23	1.30	1.49	1.77	0.14
					Average	6.25	5.90	6.00	5.40	4.30	4.29	2.32	2.42	1.87	2.40	4.28	2.53	4.00
					Maximum	7.97	7.40	9.00	6.30	6.11	5.88	5.88	4.30	3.07	2.90	6.06	3.43	9.00
16	Dissolved Oxygen	mg/l			Minimum		7.10		6.20	5.56	6.93	6.83	6.08	7.24	7.20	6.70	6.85	5.56
					Average	7.61	7.30	7.00	6.30	6.61	7.15	7.02	7.27	7.45	7.60	7.06	7.10	7.12
					Maximum		7.50		6.40	7.41	7.48	7.36	8.02	7.77	7.90	7.72	7.29	8.02
17	Total Coliform	cfu/100ml		0	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
					Average	0	0	0	0	0	0	0	0	0	0	0	0	0
					Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Faecal Coliform	cfu/100ml		0	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
					Average	0	0	0	0	0	0	0	0	0	0	0	0	0
					Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0
19	Aluminium	mg/l	0.2	0.05-0.2	Result	0.007	0.020	0.008	0.006	0.009	0.082	0.063	0.026	0.072	0.067	0.033	0.026	0.035
20	Ammonia	mg/l	1.5		Result	0.000	0.070	0.000	0.000	0.000	0.000	0.120	0.010	0.037	0.012	0.000	0.000	0.021

21	Ammonia nitrogen	mg/l		0.05-0.5	Result	0.00	0.06	0.00	0.00	0.00	0.00	0.10	0.01	0.03	0.01	0.00	0.00	0.02
22	Carbon Dioxide	mg/l			Result	15	8	28	35	13	14	18	15	4	4	5	7	13.8
23	Copper	mg/l	1	0.02-1.0	Result	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
24	Chloride	mg/l	250	25-250	Result	12	16	14	22	18	23	18	19	20	19	16.5	20	18.1
25	Cyanide	mg/l	0.07	0.07-1.0	Result	0.01	0.004	0.004	0.001	0.001	0.004	0.001	0.001	0.001	0.004	0.001	0.002	0.00
26	Chromium Total	mg/l		0.05	Result	0.01	0.00	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
27	Chromium Hexa	mg/l	0.05	0.05	Result	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
28	Fluoride	mg/l	1.5	0.1-1.5	Result	0.00	0.10	0.16	0.27	0.17	0.22	0.25	0.17	0.28	0.10	0.08	0.07	0.16
29	Iron	mg/l	0.3	1.0-0.3	Result	0.02	0.00	0.03	0.01	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02
30	Manganese	mg/l	0.1	0.05-0.5	Result	0.20	0.1	0.10	0.10	0.00	0.20	0.03	0.03	0.05	0.05	0.10	0.03	0.08
31	Nitrate nitrogen	mg/l			Result	1.60	1.40	1.50	1.90	2.20	1.70	1.80	1.70	1.50	1.60	1.20	1.40	1.63
32	Nitrate	mg/l	50	5.0-50	Result	7.07	6.20	6.63	8.40	9.70	7.51	7.95	7.51	6.63	7.07	5.30	6.19	7.18
33	Nitrite nitrogen	mg/l			Result	0.006	0.010	0.004	0.006	0.005	0.005	0.004	0.004	0.005	0.005	0.006	0.005	0.01
34	Nitrite	mg/l	3	1.0-3.0	Result	0.02	0.02	0.01	0.019	0.016	0.016	0.013	0.013	0.016	0.017	0.020	0.016	0.02
35	Zinc	mg/l	3	0.5-3.0	Result	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
36	Phosphate	mg/l			Result	0.11	0.10	0.05	0.06	0.01	0.04	0.08	0.06	0.22	0.16	0.04	0.04	0.08
37	Hydrogen sulfide	mg/l	0.05	0	Result	0.000	0.000	0.007	0.018	0.003	0.002	0.001	0.000	0.000	0.004	0.000	0.000	0.00
38	Sulfate	mg/l	250	25-250	Result	11	12	12	15	25	36	17	18	17	17	16	15	17.6

Table 2.12 Treated Water Quality, Phum Prek WTP (2008)

រដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ

នាយកដ្ឋានផលិតកម្ម និងផ្គត់ផ្គង់ទឹក

ការិយាល័យផលិតកម្ម/ផ្នែកពិសោធន៍

Treated Water Quality 2008

Phum Prek WTP

	Month					1	2	3	4	5	6	7	8	9	10	11	12	Yearly
	Number of day					31	28	31	30	31	30	31	31	30	31	30	31	Min,Ave,Max
	parameter	unit	CNDWQS	WHO														
1	Temperature	°c			Minimum	25.3	26.2	27.4	29.2	28.5	28.2	28.1	26.5	27.1	28.7	27.2	26.1	25.3
					Average	26.9	27.5	28.6	29.9	29.6	29.4	28.9	27.8	28.5	29.5	28.5	26.6	28.5
					Maximum	28.2	28.5	29.7	30.9	30.6	30.3	29.6	29.4	29.8	30.4	29.6	27.0	30.9
2	pH		6.5-8.5	6.5-8.5	Minimum	6.60	6.69	6.58	6.51	6.50	6.67	6.85	6.89	6.93	6.87	6.71	6.82	6.93
					Average	6.92	6.80	6.68	6.73	6.90	6.89	7.04	7.10	7.12	6.99	6.87	6.89	7.12
					Maximum	8.83	6.93	6.83	7.21	7.50	7.06	7.35	7.25	7.33	7.13	7.05	6.95	8.83
3	Turbidity	NTU	5	5	Minimum	0.15	0.25	0.25	0.25	0.24	0.14	0.16	0.16	0.40	0.77	0.81	0.89	0.14
					Average	0.48	0.50	0.48	0.59	0.44	0.26	0.30	0.38	0.94	1.12	1.12	1.22	0.65
					Maximum	2.70	0.77	0.98	2.10	0.83	0.38	0.81	0.91	2.10	1.57	1.50	1.82	2.70
4	Conductivity	µS/cm		400	Minimum	105	112	109	132	134	148	147	129	104	101	86	86	86
					Average	113	117	122	151	173	181	164	144	130	114	90	92	133
					Maximum	126	124	138	192	217	231	178	168	151	123	99	96	231
5	Suspended solids	mg/l		1	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Average	0.20	0.03	0.00	0.05	0.02	0.05	0.00	0.03	0.37	0.45	0.55	0.50	0.19
					Maximum	1.00	0.50	0.00	1.00	0.50	0.50	0.00	0.50	2.00	1.00	1.00	1.00	2.00
6	Total Dissolved Solids	mg/l	800	1000	Minimum	53	56	55	66	67	74	74	65	52	51	43	43	43
					Average	57	59	61	76	87	91	82	72	65	57	45	46	67
					Maximum	63	62	69	96	109	116	89	84	76	62	50	48.00	116
7	FAC	mg/l	0.2-0.5	0.1-1	Minimum	0.60	0.58	0.63	0.58	0.72	0.81	0.66	0.52	0.60	0.68	0.72	0.89	0.52
					Average	0.86	0.79	0.78	0.95	1.18	1.10	1.10	0.93	0.78	0.85	0.99	1.01	0.94
					Maximum	1.20	1.00	0.90	1.47	1.48	1.42	1.59	1.19	1.02	1.03	1.25	1.25	1.59
8	TAC	mg/l		2	Minimum	0.73	0.76	1	0.78	0.86	0.92	0.72	0.59	0.69	0.76	0.85	1	0.59
					Average	1.01	0.96	0.98	1.19	1.38	1.22	1.21	1.02	0.89	0.96	1.11	1.15	1.09
					Maximum	1.30	1.22	1.12	1.64	1.70	1.51	1.70	1.27	1.09	1.17	1.41	1.41	1.70
9	Total coliform	cfu/100ml	0	0	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
					Average	0	0	0	0	0	0	0	0	0	0	0	0	0
					Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0

10	Faecal coliform	cfu/100ml	0	0	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
					Average	0	0	0	0	0	0	0	0	0	0	0	0	0
					Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Ca hardness	mg/l		70	Minimum	28	30	22	30	20	42	40	40	34	30	20	19	19
					Average	30	32	30	39	37	46	48	45	40	34	23	22	36
					Maximum	31	35	34	56	52	51	58	50	48	40	26	24	58
12	Total hardness	mg/l	300	100	Minimum	40	40	28	42	32	54	50	50	48	42	33	32	28
					Average	44	44	42	50	52	58	62	60	60	50	37	38	50
					Maximum	48	48	56	70	70	64	73	66	66	62	42	42	73
13	Magnesium hardness	mg/l		30	Minimum	10	10	6	8	10	10	10	10	10	12	10	10	6
					Average	14	12	13	12	15	12	17	15	20	16	14	16	15
					Maximum	17	16	26	14	20	14	25	22	26	22	18	22	26
14	Alkalinity	mg/l		350	Minimum	28	22	18	18	18	32	34	32	30	32	26	26	18
					Average	30	27	24	24	33	41	41	45	45	40	30	29	34
					Maximum	33	30	26	34	58	50	52	62	57	46	38	34	62
15	Organic substance	mg/l			Minimum	3.65	3.20	4.34	1.77	0.66	0.31	1.20	1.22	1.89	2.84	3.47	2.43	0.31
					Average	4.53	5.11	5.40	5.35	1.77	0.79	1.84	2.00	2.21	3.54	3.90	4.39	3.40
					Maximum	5.37	5.94	5.78	7.50	3.16	1.53	2.77	3.08	2.52	4.74	5.05	6.01	4.45
16	Dissolved oxygen	mg/l			Minimum	6.93	7.10	6.52	6.35	6.00	6.72	6.78	6.78	7.03	6.90	7.07	7.31	6.00
					Average	7.23	7.26	6.88	6.68	7.05	7.15	7.47	7.17	7.19	7.09	7.21	7.54	7.16
					Maximum	7.54	7.49	7.23	6.94	7.57	7.57	8.94	7.70	7.37	7.43	7.36	7.8	8.94
17	Color	TCU	5	15	Minimum	0.72	1.31	0.98	1.67	0.69	0.34	0.11	0.33	0.53	1.76	1.43	2.47	0.11
					Average	2.16	2.33	2.60	3.34	1.88	1.08	0.74	1.14	2.82	3.67	3.29	4.39	2.45
					Maximum	4.35	4.10	4.27	6.76	4.06	2.12	1.93	2.47	11.89	5.15	5.27	7.07	11.89
18	UV,absorption				Minimum	0.032	0.042	0.050	0.046	0.012	0.012	0.012	0.016	0.019	0.033	0.035	0.034	0.050
					Average	0.049	0.057	0.082	0.078	0.042	0.025	0.021	0.020	0.037	0.046	0.043	0.048	0.082
					Maximum	0.065	0.070	0.055	0.106	0.071	0.035	0.033	0.026	0.232	0.061	0.052	0.064	0.232
19	Aluminium	mg/l	0.2	0.05-0.2	Result	0.087	0.006	0.006	0.007	0.025	0.052	0.042	0.050	0.044	0.034	0.021	0.015	0.032
20	Ammonia	mg/l	1.5		Result	0.00	0.0[illegible]	0.00	0.01	0.00	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.002
21	Ammonia nitrogen	mg/l		0.05-0.5	Result	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	Carbon dioxide	mg/l			Result	9	5	11	13	10	22	8	10	6	14	12	23	11.9
23	Copper	mg/l	1	0.02-1.0	Result	0.01	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0	0.01	0.01	0.01
24	Chloride	mg/l	250	25-250	Result	20	22.5	19.5	20.0	22.5	23	22.5	17.5	18.5	16.5	16	18.5	19.8

25	Cyanide	mg/l	0.07	0.07-1.0	Result	0.001	0.001	0.001	0.002	0.001	0.001	0.005	0.001	0.004	0.001	0.002	0.001	0.00
26	Chromium total	mg/l		0.05	Result	0.[illegible]	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
27	Chromium hexa	mg/l	0.05	0.05	Result	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01
28	Fluoride	mg/l	1.5	0.1-1.5	Result	0.24	0.11	0.09	0.38	0.27	0.09	0.23	0.05	0.09	0.18	0.03	0	0.15
29	Iron	mg/l	0.3	1.0-0.3	Result	0.06	0.02	0.01	0.04	0.01	0.02	0.01	0.01	0.03	0.04	0.02	0.04	0.03
30	Manganese	mg/l	0.1	0.05-0.5	Result	0.000	0.000	0.000	0.157	0.044	0.005	0.059	0.064	0.043	0.000	0.015	0.025	0.034
31	Nitrate nitrogen	mg/l			Result	1.30	1.70	1.30	1.60	2.00	1.70	1.80	1.40	1.30	1.20	1.20	1.10	1.47
32	Nitrate	mg/l	50	5.0-50	Result	5.75	7.51	5.75	7.07	8.84	7.51	7.96	4.86	5.75	5.30	5.30	4.86	6.37
33	Nitrite nitrogen	mg/l			Result	0.004	0.009	0.005	0.006	0.006	0.007	0.007	0.008	0.005	0.005	0.004	0.005	0.01
34	Nitrite	mg/l	3	1.0-3.0	Result	0.013	0.030	0.016	0.020	0.020	0.023	0.023	0.026	0.016	0.017	0.013	0.016	0.02
35	Zinc	mg/l	3	0.5-3.0	Result	0.00	0.01	0.00	0.01	0.00	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.01
36	Phosphate	mg/l			Result	0.08	0.09	0.07	0.05	0.05	0.02	0.06	0.03	0.06	0.04	0.06	0.25	0.07
37	Sulfide	mg/l	0.05	0	Result	0.004	0.001	0.002	0.001	0.001	0.000	0.000	0.001	0.002	0.000	0.003	0.000	0.00
38	Sulfate	mg/l	250	25-250	Result	15	22	22	32	27	31	29	25	14	12	9	10	20.7

Table 2.13 Treated Water Quality, Phum Prek WTP (2009)

- រដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ

នាយកដ្ឋានផលិតកម្ម និងផ្គត់ផ្គង់ទឹក

ការិយាល័យផលិតកម្ម/ផ្នែកពិសោធន៍

Treated Water Quality 2009
Phum Prek WTP

	Month					1	2	3	4	5	6	7	8	9	10	11	12	Yearly
	Number of day					31	28	31	30	31	30	31	31	30	31	30	31	Min,Ave,Max
	parameter	unit	CNDWQS	WHO														
1	Temperature	˚c			Minimum	24.2	27.1	29.6	29.9	29.2	28.9	27.1	27.2	27.4	26.9	26.6	26.6	24.2
					Average	26.0	28.2	30.0	30.6	30.3	29.5	28.6	28.5	28.7	28.4	28.3	27.6	28.7
					Maximum	27.3	30.0	30.6	31.2	30.9	29.9	30.0	29.6	29.7	29.4	30.0	28.5	31.2
2	pH		6.5-8.5	6.5-8.5	Minimum	6.63	6.54	6.52	6.40	6.51	6.73	6.66	6.64	6.66	6.51	6.79	6.98	6.98
					Average	6.75	6.65	6.62	6.57	6.76	6.93	6.83	6.84	6.87	6.82	6.97	7.13	7.13
					Maximum	6.95	6.75	6.74	6.78	7.16	7.21	7.06	7.02	7.03	7.01	7.24	7.27	7.27
3	Turbidity	NTU	5	5	Minimum	1.33	1.13	0.57	0.60	0.52	0.56	0.39	0.50	0.55	0.58	0.37	0.30	0.30
					Average	1.94	1.66	1.50	1.19	1.62	0.71	0.75	0.69	0.75	0.91	0.67	0.71	1.09
					Maximum	2.85	2.67	2.23	2.44	5.50	1.27	0.95	0.98	1.27	1.44	1.01	1.40	5.50
4	Conductivity	µS/cm		400	Minimum	81	84	83	104	123	131	95	84	95	85	87	102	81
					Average	88	88	95	116	147	155	132	106	108	96	95	105	111
					Maximum	94	94	108	150	176	184	165	128	124	112	106	108	184
5	Suspended solids	mg/l		1	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
					Average	0.84	0.78	0.98	0.37	0.65	0.03	0.02	0.08	0.02	0.05	0.00	0.13	0.33
					Maximum	2.00	1.00	2.00	1.00	2.50	0.50	0.50	1.00	0.50	0.50	0.00	1.00	2.50
6	Total Dissolved Solids	mg/l	800	1000	Minimum	41	42	42	52	62	66	48	42	48	43	44	51	41
					Average	44	44	48	58	74	78	66	53	54	48	48	53	56
					Maximum	47	47	54	75	88	92	83	64	62	66	53	54	92
7	FAC	mg/l	0.2-0.5	0.1-1	Minimum	0.70	0.83	0.90	0.66	0.66	0.40	0.64	0.65	0.57	0.55	0.67	0.76	0.40
					Average	0.93	0.96	1.03	0.94	0.87	0.79	0.85	0.85	0.78	0.79	0.94	0.92	0.89
					Maximum	1.09	1.16	1.24	1.39	1.14	1.02	1.15	0.99	0.97	1.03	1.23	1.12	1.39
8	TAC	mg/l		2	Minimum	0.87	1.00	1.08	0.85	0.81	0.64	0.79	0.76	0.67	0.64	0.80	0.91	0.64
					Average	1.09	1.15	1.21	1.13	1.03	0.94	0.98	0.94	0.87	0.90	1.07	1.05	1.03
					Maximum	1.29	1.31	1.44	1.62	1.34	1.14	1.30	1.09	0.99	1.13	1.38	1.27	1.62
9	Total coliform	cfu/100ml	0	0	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
					Average	0	0	0	0	0	0	0	0	0	0	0	0	0
					Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0

10	Faecal coliform	cfu/100ml	0	0	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
					Average	0	0	0	0	0	0	0	0	0	0	0	0	0
					Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Ca hardness	mg/l		70	Minimum	28	30	22	30	20	42	40	40	34	30	20	19	19
					Average	30	32	30	39	37	46	48	45	40	34	23	22	36
					Maximum	31	35	34	56	52	51	58	50	48	40	26	24	58
12	Total hardness	mg/l	300	100	Minimum	40	40	28	42	32	54	50	50	48	42	33	32	28
					Average	44	44	42	50	52	58	62	60	60	50	37	38	50
					Maximum	48	48	56	70	70	64	73	66	66	62	42	42	73
13	Magnesium hardness	mg/l		30	Minimum	10	10	6	8	10	10	10	10	10	12	10	10	6
					Average	14	12	13	12	15	12	17	15	20	16	14	16	15
					Maximum	17	16	26	14	20	14	25	22	26	22	18	22	26
14	Alkalinity	mg/l		350	Minimum	28	22	18	18	18	32	34	32	30	32	26	26	18
					Average	30	27	24	24	33	41	41	45	45	40	30	29	34
					Maximum	33	30	26	34	58	50	52	62	57	46	38	34	62
15	Organic substance	mg/l			Minimum	3.65	3.20	4.34	1.77	0.66	0.31	1.20	1.22	1.89	2.84	3.47	2.43	0.31
					Average	4.53	5.11	5.40	5.35	1.77	0.79	1.84	2.00	2.21	3.54	3.90	4.39	3.40
					Maximum	5.37	5.94	5.78	7.50	3.16	1.53	2.77	3.08	2.52	4.74	5.05	6.01	4.45
16	Dissolved oxygen	mg/l			Minimum	6.93	7.10	6.52	6.35	6.00	6.72	6.78	6.78	7.03	6.90	7.07	7.31	6.00
					Average	7.23	7.26	6.88	6.68	7.05	7.15	7.47	7.17	7.19	7.09	7.21	7.54	7.16
					Maximum	7.54	7.49	7.23	6.94	7.57	7.57	8.94	7.70	7.37	7.43	7.36	7.8	8.94
17	Color	TCU	5	15	Minimum	0.72	1.31	0.98	1.67	0.69	0.34	0.11	0.33	0.53	1.76	1.43	2.47	0.11
					Average	2.16	2.33	2.60	3.34	1.88	1.08	0.74	1.14	2.82	3.67	3.29	4.39	2.45
					Maximum	4.35	4.10	4.27	6.76	4.06	2.12	1.93	2.47	11.89	5.15	5.27	7.07	11.89
18	UV,absorption				Minimum	0.032	0.042	0.050	0.046	0.012	0.012	0.012	0.016	0.019	0.033	0.035	0.034	0.050
					Average	0.049	0.057	0.082	0.078	0.042	0.025	0.021	0.020	0.037	0.046	0.043	0.048	0.082
					Maximum	0.065	0.070	0.055	0.106	0.071	0.035	0.033	0.026	0.232	0.061	0.052	0.064	0.232
19	Aluminium	mg/l	0.2	0.05-0.2	Result	0.087	0.006	0.006	0.007	0.025	0.052	0.042	0.050	0.044	0.034	0.021	0.015	0.032
20	Ammonia	mg/l	1.5		Result	0.00	0.0[illegible]	0.00	0.01	0.00	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.002
21	Ammonia nitrogen	mg/l		0.05-0.5	Result	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	Carbon dioxide	mg/l			Result	9	5	11	13	10	22	8	10	6	14	12	23	11.9
23	Copper	mg/l	1	0.02-1.0	Result	0.01	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0	0.01	0.01	0.01
24	Chloride	mg/l	250	25-250	Result	20	22.5	19.5	20.0	22.5	23	22.5	17.5	18.5	16.5	16	18.5	19.8

25	Cyanide	mg/l	0.07	0.07-1.0	Result	0.001	0.001	0.001	0.002	0.001	0.001	0.005	0.001	0.004	0.001	0.002	0.001	0.00
26	Chromium total	mg/l		0.05	Result	0.[illegible]	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
27	Chromium hexa	mg/l	0.05	0.05	Result	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01
28	Fluoride	mg/l	1.5	0.1-1.5	Result	0.24	0.11	0.09	0.38	0.27	0.09	0.23	0.05	0.09	0.18	0.03	0	0.15
29	Iron	mg/l	0.3	1.0-0.3	Result	0.06	0.02	0.01	0.04	0.01	0.02	0.01	0.01	0.03	0.04	0.02	0.04	0.03
30	Manganese	mg/l	0.1	0.05-0.5	Result	0.000	0.000	0.000	0.157	0.044	0.005	0.059	0.064	0.043	0.000	0.015	0.025	0.034
31	Nitrate nitrogen	mg/l			Result	1.30	1.70	1.30	1.60	2.00	1.70	1.80	1.40	1.30	1.20	1.20	1.10	1.47
32	Nitrate	mg/l	50	5.0-50	Result	5.75	7.51	5.75	7.07	8.84	7.51	7.96	4.86	5.75	5.30	5.30	4.86	6.37
33	Nitrite nitrogen	mg/l			Result	0.004	0.009	0.005	0.006	0.006	0.007	0.007	0.008	0.005	0.005	0.004	0.005	0.01
34	Nitrite	mg/l	3	1.0-3.0	Result	0.013	0.030	0.016	0.020	0.020	0.023	0.023	0.026	0.016	0.017	0.013	0.016	0.02
35	Zinc	mg/l	3	0.5-3.0	Result	0.00	0.01	0.00	0.01	0.00	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.01
36	Phosphate	mg/l			Result	0.08	0.09	0.07	0.05	0.05	0.02	0.06	0.03	0.06	0.04	0.06	0.25	0.07
37	Sulfide	mg/l	0.05	0	Result	0.004	0.001	0.002	0.001	0.001	0.000	0.000	0.001	0.002	0.000	0.003	0.000	0.00
38	Sulfate	mg/l	250	25-250	Result	15	22	22	32	27	31	29	25	14	12	9	10	20.7

SR 4.4 Alternative Study on Raw Water Intake Facilities

As for raw water intake facility for F/S, the Study Team strongly recommends a combination of intake chamber and pump station with raw water conveyance/transmission pipelines.

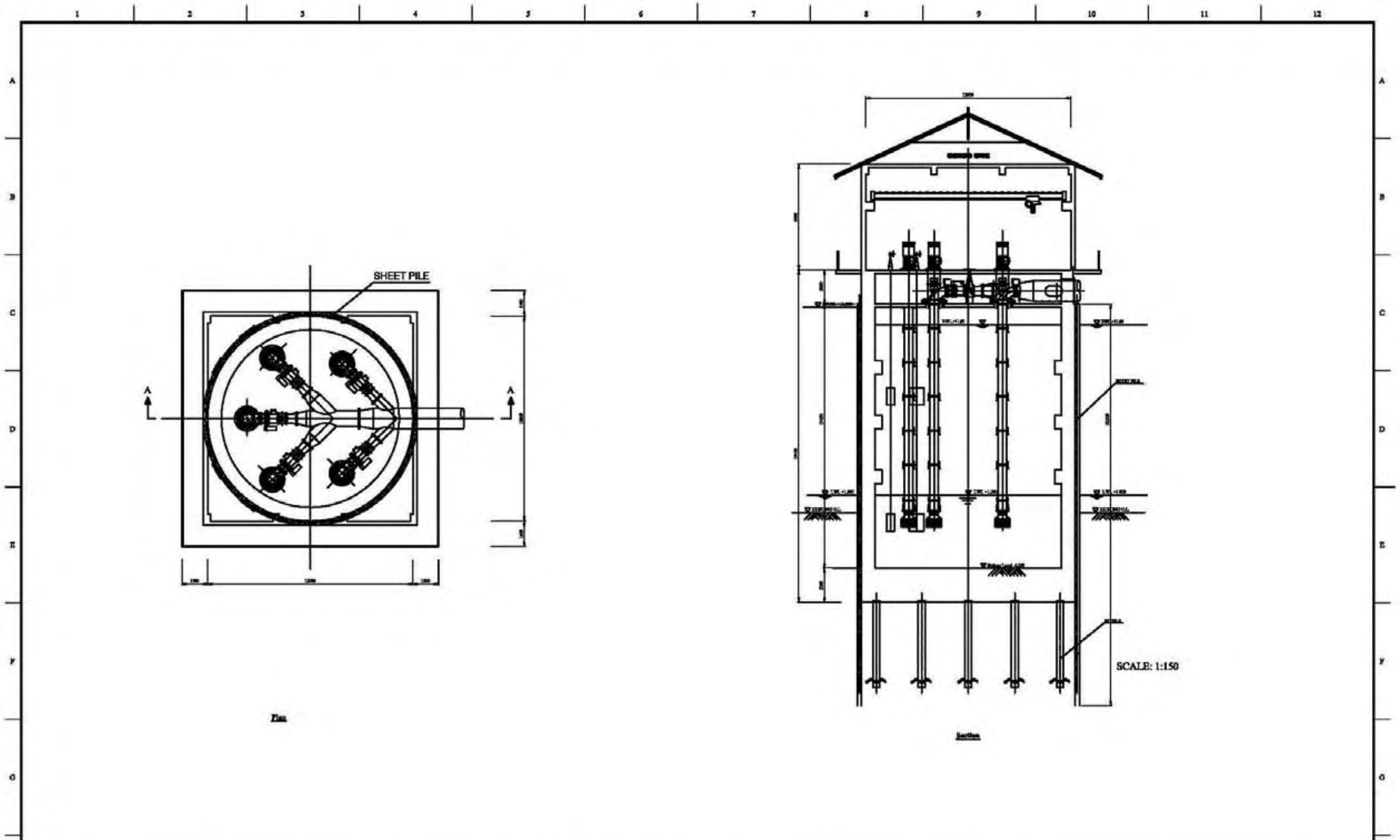
In examining the appropriate location of pump station, the construction cost of overall intake facilities by different location of the pump station was analyzed under the following conditions.

- Raw water conveyance pipe between intake and pump station is assumed as ϕ1,200 mm concrete pipe to avoid sediment in the pipeline as well as minimize construction cost.
- Raw water transmission pipe between pump station and WTP will be ductile iron pipe with 800 mm diameter considering the economical velocity of pipeline in pumping system.
- In case of construction of pump station at 0 km, the intake tower will be constructed instead of intake chamber. At the same time, the structure of the dry pit for pump equipment will be excluded from the intake tower/pump station.

The result of cost analysis is shown in the following table indicating that the construction cost of the intake facility with pump station to be constructed at around 6 km away from intake site will be lowest.

Table of Cost Analysis of Intake Facility by Different Location of Pump Station

Water Conveyance Pipe Line Cost Analysis (Concrete Pipe; ϕ 1,200mm, Pressure Pipe; ϕ 800mm)															
Items \ Location of Pumping Station	0km	1km	2km	3km	4km	5km	6km	7km	8km	9km	9.6km	10km	11km	12km	13km
100 Target Year - 2017,2022/23															
<Water Supply Projects>															
110 Siem Reap WTP	**21,319,500**	**21,231,000**	**20,182,000**	**19,404,000**	**18,849,000**	**18,565,000**	**18,463,000**	**18,583,000**	**18,975,000**	**19,636,000**	**20,123,000**	**20,473,422**	**21,644,244**	**22,911,910**	**24,336,420**
111 Cost of Intake Chamber	**0**	**161,000**	**161,000**	**161,000**	**161,000**	**161,000**	**161,000**	**161,000**	**161,000**	**161,000**	**161,000**	**161,000**	**161,000**	**161,000**	**161,000**
112 Cost of Water Conveyance Pipe (13.000 km)	**16,458,000**	**15,601,000**	**14,702,000**	**14,074,000**	**13,669,000**	**13,535,000**	**13,583,000**	**13,853,000**	**14,395,000**	**15,206,000**	**15,783,000**	**16,193,422**	**17,454,244**	**18,871,910**	**20,446,420**
a Cost in use of Concrete Pipe (Gravity Flow)	**0**	**731,000**	**1,373,000**	**2,193,000**	**3,190,000**	**4,364,000**	**5,627,000**	**7,066,000**	**8,684,000**	**10,478,000**	**11,625,000**	**12,524,422**	**15,008,244**	**17,648,910**	**20,446,420**
b Cost in use of DCIP (Pressure Flow)	**16,458,000**	**14,870,000**	**13,329,000**	**11,881,000**	**10,479,000**	**9,171,000**	**7,956,000**	**6,787,000**	**5,711,000**	**4,728,000**	**4,158,000**	**3,669,000**	**2,446,000**	**1,223,000**	**0**
(b-a) 3.4 km From WTP	4,157,000	4,157,000	4,157,000	4,157,000	4,157,000	4,157,000	4,157,000	4,157,000	4,157,000	4,157,000	4,158,000	3,669,000	2,446,000	1,223,000	0
(b-a-1) Cost of Pipe (US$)	2,708,440	2,708,440	2,708,440	2,708,440	2,708,440	2,708,440	2,708,440	2,708,440	2,708,440	2,708,440	2,709,000	2,390,294	1,593,529	796,765	0
(b-a-2) Cost of Excavation (US$)	1,448,777	1,448,777	1,448,777	1,448,777	1,448,777	1,448,777	1,448,777	1,448,777	1,448,777	1,448,777	1,449,000	1,278,529	852,353	426,176	0
(b-b) From 3.4 km away from WTP to 13.0 km	12,301,000	10,713,000	9,172,000	7,724,000	6,322,000	5,014,000	3,799,000	2,630,000	1,554,000	571,000	0	0	0	0	0
(b-b-1) Cost of Pipe (US$)	7,647,360	6,850,760	6,054,160	5,257,560	4,460,960	3,664,360	2,867,760	2,071,160	1,274,560	477,960	0	0	0	0	0
(b-b-2) Cost of Excavation (US$)	4,653,753	3,862,615	3,118,015	2,466,489	1,861,501	1,349,588	930,751	558,450	279,225	93,075	0	0	0	0	0
113 Cost of Intake Pumping Station	**4,861,500**	**5,469,000**	**5,319,000**	**5,169,000**	**5,019,000**	**4,869,000**	**4,719,000**	**4,569,000**	**4,419,000**	**4,269,000**	**4,179,000**	**4,119,000**	**4,029,000**	**3,879,000**	**3,729,000**
Civil/Building Works	624,500	1,328,000	1,328,000	1,328,000	1,328,000	1,328,000	1,328,000	1,328,000	1,328,000	1,328,000	1,328,000	1,328,000	1,328,000	1,328,000	1,328,000
Mechanical Electrical Works	4,237,000	4,141,000	3,991,000	3,841,000	3,691,000	3,541,000	3,391,000	3,241,000	3,091,000	2,941,000	2,851,000	2,791,000	2,701,000	2,551,000	2,401,000
Total	**21,319,500**	**21,231,000**	**20,182,000**	**19,404,000**	**18,849,000**	**18,565,000**	**18,463,000**	**18,583,000**	**18,975,000**	**19,636,000**	**20,123,000**	**20,473,422**	**21,644,244**	**22,911,910**	**24,336,420**
Minimum Construction Cost							◎								



PROJECT: THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

CLIENT:	CONSULTANTS:	REV.	DESCRIPTION	DATE	SIGN.	TITLE:		
SIEM REAP WATER SUPPLY AUTHORITHY	NJS CONSULTANTS CO., LTD. - JAPAN					RAW WATER INTAKE TOWER PLAN AND SECTIONS		
JAPAN INTERNATIONAL COOPERATION AGENCY	KOKUSAI KOGYO CO., LTD.-JAPAN					SCALE: 1/200	DATE: 30/09/2009	DRAWING NO.: SR-01-C-100

SR 4.5 Comparison of Raw Water Conveyance/Transmission Pipeline

Comparison of Raw Water Conveyance/Transmission Pipeline

Raw Water Conveyance Pipe Diameter (mm)	Raw Water Conveyance Pipe Distance (m)	Raw Water Transmission Pipe Diameter (mm)	Raw Water Transmission Pipe Distance (m)	Construction Case	Construction Condition	Length of Concrete Pipe for Water Conveyance (m)	Cost of Concrete Pipe for Raw Water (US$)	Length of Pressure Pipe for Water Transmission (m)	Cost of Transmission Pipe for Raw Water (US$)	Cost in Phase-I (US$)	Cost in Phase-II (US$)	Total Cost (US$)	Economical Evaluation
				Case-1	2 Pipelines Simultaneous Construction	19,200	11,644,000	6,800	4,158,000	-	-	15,802,000	
					Phase-I (2 Raw Water Conveyance Pipelines & 1 Raw Water Transmission Pipeline)	19,200	11,644,000	3,400	2,547,000	14,191,000	-		
				Case-2	Phase-II (1 Raw Water Transmission Pipeline)	0	0	3,400	1,611,000	-	1,611,000	15,802,000	◎
1,200	9,600	800	3,400		Total	19,200	11,644,000	6,800	4,158,000	-	-		
					Phase-I (1 Raw Water Conveyance Pipeline & 1 Raw Water Transmission Pipeline)	9,600	7,811,000	3,400	2,547,000	10,358,000	-		
				Case-3	Phase-II (1 Raw Water Conveyance Pipeline & 1 Raw Water Transmission Pipeline)	9,600	7,811,000	3,400	1,611,000	-	9,422,000	19,780,000	
					Total	19,200	15,622,000	6,800	4,158,000	-	-		
				Case-1	2 Pipelines Simultaneous Construction	19,200	12,650,000	6,800	4,158,000	-	-	16,808,000	
					Phase-I (2 Raw Water Conveyance Pipelines & 1 Raw Water Transmission Pipeline)	19,200	12,650,000	3,400	2,547,000	15,197,000	-		
				Case-2	Phase-II (1 Raw Water Transmission Pipeline)	0	0	3,400	1,611,000	-	1,611,000	16,808,000	
1,500	9,600	800	3,400		Total	19,200	12,650,000	6,800	4,158,000	-	-		
					Phase-I (1 Raw Water Conveyance Pipeline & 1 Raw Water Transmission Pipeline)	19,200	8,467,000	3,400	2,547,000	11,014,000	-		
				Case-3	Phase-II (1 Raw Water Conveyance Pipeline & 1 Raw Water Transmission Pipeline)	0	8,467,000	3,400	1,611,000	-	10,078,000	21,092,000	
					Total	19,200	16,934,000	6,800	4,158,000	-	-		
				Case-1	2 Pipelines Simultaneous Construction	19,200	15,105,000	6,800	4,158,000	-	-	19,263,000	
					Phase-I (2 Raw Water Conveyance Pipelines & 1 Raw Water Transmission Pipeline)	19,200	15,105,000	3,400	2,547,000	17,652,000	-		
				Case-2	Phase-II (1 Raw Water Transmission Pipeline)	0	0	3,400	1,611,000	-	1,611,000	19,263,000	
1,800	9,600	800	3,400		Total	19,200	15,105,000	6,800	4,158,000	-	-		
					Phase-I (1 Raw Water Conveyance Pipeline & 1 Raw Water Transmission Pipeline)	9,600	9,927,000	3,400	2,547,000	12,474,000	-		
				Case-3	Phase-II (1 Raw Water Conveyance Pipeline & 1 Raw Water Transmission Pipeline)	9,600	9,927,000	3,400	1,611,000	-	11,538,000	24,012,000	
					Total	19,200	19,854,000	6,800	4,158,000	-	-		

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SOIL INVESTIGATION REPORT BY USING STANDARD PENETRATION TEST (SPT)

PROJECT:

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXSPANSION PROJECT IN THE KINGDOM OF CAMBODIA

Location: Water Treatment Plant Site

Prepared by: Mr. Chea Serey Vuth

Geotechnical Manager

PHNOM PENH, 05 March, 2010

CONTENTS

1 General

1.1 Introduction

Soil investigation is a requirement for feasibility and detail engineering design of structures. It is to determine subsoil conditions beneath the project site and physical and geo-technical characteristics of the underlying soil strata. The purpose of this investigation is to determine the end bearing capacity of deep foundation or shallow foundation by using Standard Penetration Test (SPT) results and provide economical cost and especially safety of construction.

1.2 Geology and Landform

Cambodia is geologically composed of three different structures; they are mostly Triassic, Jurassic-Cretaceous and Quaternary. The Triassic period covers a large area in the east, Jurassic-Cretaceous Era forming important highlands in the west and, between them, the Quaternary basin occupy the whole central plain of the country.

The area of the site is situated in the Quaternary Era of central plain of Cambodia (Inside of The Tonle sap Lack). The soil deposit encountered during site investigation is recently formed by alluvial of the river a rounding the lack, (a $Q_{III\,-}$ a Q_{VI}). The soil stretching the project site is reported to comprise yellow, gray Clayey Sand and Sandy clay, lean clay strata, because the project site is formed by the sediments of alluvial and the environmental area. The alluvial sediments of the project area flow from vicinity high land to fulfill swamp, lack or flat area. Therefore the project area occurred historically from year after years; era after era by deposited layer by layers from the sediment of high land and vicinity area.

2 Geo-technical Investigation

Partner of Construction and Development Services Inc. was commissioned to undertake field geo-technical investigation on 12 to 26 February 2010 (dry season) at The Siem Reap province inside of tonle sap lack for this particular project to determination of subsoil condition, its relative density, consistency, classification and characteristics of soil properties, especially geological and geo-technical condition of the soil beneath the Project Site for the construction design proposed of Water treatment Plant and Pipeline (Siem Reap Water Supply Authority)

2.1 Objective and Scope

The objective of soil investigation is contributed to analyzing various subsoil conditions including their characteristics and composition status of strata distributed beneath the project area. The scopes and the objectives of the subsurface investigation included the following tasks:

- An actual field observation and inspection.

- Soil boring and carry out the Standard Penetration Test at the proposed location site. (see location plan of borehole)
- Samples collection, preservation and transportation to the laboratory in Phnom Penh.
- Laboratory testing of the soil samples from split-barrel sampler of Standard Penetration Test and Undisturbed by thin-walled sampler.
- Interpretation and evaluation of the field and Laboratory test results.
- Determination of the factual characteristics of soil and engineering properties of soil for the purpose of getting a conclusive data to support the recommendation for the construction design.
- Prepare factual report.

2.2 Site Methodology

Subsurface exploration was carried out to determine the arrangement of soil stratums and engineering properties of the underlying soils, particularly strength and deformation characteristics for foundation design of the project. The field operations were carried out in accordance with ASTM Standards as summarizing below:

- Standard Penetration test (SPT) ASTM D-1586
- Field Soil classification ASTM D-2487, D-2488
- Preservation and Transportation of soil samples ASTM D-4220
- Ground Water Table Observation ASTM D-4750
- Carry out soil boring.

  The main activities of the whole field investigations consisted of the following tasks:
- Date and Location of boring test.
- Elevation of boring site
- Geological setting and sub-surface stratigraphy
- Borehole logs
- Water table
- Soil classifications and descriptions
- Recommendations for foundation designs and excavation, trenching, embankment and filling
- Photographs showing sceneries of the work with soil samples in core box
- Map showing location of the boreholes
- Results of field tests
- Results of laboratory tests
- Carry out Standard Penetration Test (SPT) at 1.00m intervals
- Seal and label all disturbed and undisturbed soil samples in the core boxes and deliver to the laboratory (Protected from the exposure to the sun).
- Collect disturbed and undisturbed soil samples at 1.00 meters intervals and every soil strata changes.
- The borehole depth terminated when the N-value of SPT exceeds 30 blow counts or considered to be supported structure load.

Soil boring

Boring Machine used in the project area is UNIMOG-909, 40 meters depth capacity and the diameter of 180 mm, equip with SPT. A hollow stem flight auger was employed in this operation. The process is continued boring every 1.00 meters depth, than take out the center rod to operate the thin-walled sampler and SPT test. The field soil classification and observation such as soil name, consistency, color, soil strata, percent of soil grain size estimation, ground water table, seal and label, protection from sun shine, making note and putting in core boxes are undertaken. All disturbed and undisturbed samples were transported to laboratory.

Standard Penetration Test (SPT)

After the borehole has advanced to required depth, the center rod is withdrawn and replace with thin-wall sampler (59mm) into the natural soil in order to get undisturbed sample and than put split barrel sampler into soil layer to do SPT test. The correct depth after boring out the soil is also checked.
The Standard Penetration Test (SPT) uses 63.50 Kg drive weight at free fall height of 760 mm to drive standard split barrel and the number of blows for every 150 mm penetration is noted. The first 150mm are the setting blow and the total number of blows for the last 300mm is the N-value. The samples extracted by the split spoon sampler (ASTM D-1586) during the penetration test will be tested for their engineering properties. Procedure is repeated on each succeeding depth down to the bottom of the borehole. The water level in the borehole is measured 24 hours after completion of boring works.

2.3 Laboratory Test

The soil samples extracted to represent the different strata from machine auger borings and SPT test were subjected to soil testing laboratory for evaluation and analysis in accordance with ASTM Standard methods and specifications to classify them for their engineering values.
The laboratory-testing program was divided into two following parts:

- Natural water content determination ASTM D-2216,
- Atterberg limit ASTM D-4318,
- Specific Gravity of Soil ASTM D-854 and ASTM C-128,
- Sieve Analysis ASTM D-421 and ASTM D-422,
- Wet Unit weight. Dry Unit weight
- Soil Classification ASTM D-2488.
- Unconfined compressive strength

2.4 Contract Phase

The soil investigation was carried out in the following two contracts.

- Phase 1: Proposed intake pumping station (BH 6,7,11, and 12) and raw water intake pipeline routes (BH8, 13, 14 and 15) and
- Phase 2: Proposed WTP site (BH 9 and 10) and pipeline route (BH 1, 2, 3, 4, and 5).

The locations are summarized in item 5.

3 Findings

3.1 Subsoil condition

Underlying the site are mostly cohesionless soil layers (Clayey Fine Sand, Silty Sand and Gravelly) and covert by cohesive soil layers (lean Clay and Sandy lean Clay) at surface ground to the end of boring. The cohesive soil layers stretched beneath the project site are soft to firm medium plasticity clay. For relative density of Sandy Soil layers are loose to medium dense compact. In accordance to its USCS classifications are CL AND SC with locations below:

BH-1 (N: 1473273.113, E: 383187.981), Elevation: 10.045m
- From 0.00m to 1.50m: Soft yellow, light-gray low plasticity Clay and with N-Value of SPT, 3 blows
- From 1.50m to 5.00m: Loose light-gray, red, yellow Clayey Sand mixture and with N-Value of SPT, 2 to 4 blows

BH-2 (N: 1473273.113, E: 375538.993), Elevation: 12.096m
- From 0.00m to 2.50m: Loose yellow, gray Silty Sand (SM) and with N-Value of SPT, from 6 to 8 blows
- From 2.50m to 5.00m: Firm brown, gray low plasticity Clay and with N-Value of SPT, 7 blows.

BH-3 (N: 1475818.739, E: 378619.044), Elevation: 13.592m
- From 0.00m to 1.50m: Loose gray clayey Sand (SC) and with N-Value of SPT, 5 blows
- From 1.50m to 2.50m: Medium dense red, gray Clayey sand and with N-Value of SPT, 14 blows.
- From 2.50m to 5.05m: Medium dense red, gray Clayey sand and with SPT, 5 blows.
- From 5.05m to 5.50m: Firm yellow, gray medium plasticity Clay and with SPT, 6 blows.

BH-4 (N: 1478987.86, E: 377680.013), Elevation: 16.166m
- From 0.00m to 2.50m: Medium to loose reddish, gray clayey Sand (SC) and with N-Value of SPT, from 12 to 9 blows
- From 2.50m to 3.50m: Firm gray medium plasticity clay and with N-Value of SPT, 7 blows.
- From 3.50m to 5.00m: Loose yellow, gray Clayey sand and with SPT, 7 blows.

BH-5 (N: 1478347.450, E: 374621.470), Elevation: 14.358m
- From 0.00m to 2.50m: Firm light-gray low plasticity Clay (CL) and with N-Value of SPT, 5 blows
- From 2.50m to 3.50m: Loose yellow, gray clayey Sand and with N-Value of SPT, 8 blows.
- From 3.50m to 5.00m: Stiff yellow, gray medium plasticity Clay and

with SPT, 9 blows.

BH-6: Intake Pump a long option A (N: 1469942.129, E: 378328.091), Elev: 7.14m
- From 0.00m to 1.50m: Loose yellowish, gray clayey Sand and with N-Value of SPT, 4 blows, (SC)
- From 1.50m to 2.50m: Soft yellowish medium plasticity clay and with N-Value of SPT, 4 blows, (CI)
- From 2.50m to 4.05m: Loose yellowish fine Sand and with N-Value of SPT, 6 blows, (SC)
- From 4.05m to 7.50m: Stiff yellow, gray medium to low plasticity Clay and with N-Value of SPT from 11 to 12 blows, (CL)
- From 7.50m to 13.50m: Medium dense yellow, gray clayey Sand with a little gravel and with N-Value of SPT from 10 to 27 blows), (SC)
- From 13.50m to 20.50m: Hard brown, grayish medium plasticity Clay and with N- Value of SPT from 37 to 50 blows), (CI)

BH-7: Intake Pump a long option A (N: 1469935.795, E: 378377.686), Elev: 7.09m
- From 0.00m to 1.50m: Stiff brown low plasticity Clay and with N-Value of SPT, 9 blows, (CL)
- From 1.50m to 3.50m: Stiff to firm yellow, brown medium plasticity clay and with N-Value of SPT, 12 to 5 blows, (CI)
- From 3.50m to 9.50m: Very stiff yellow, light-gray medium plasticity Clay and with N-Value of SPT, 17 to 23 blows, (CI)
- From 9.50m to 13.50m: Very stiff yellow, light-gray low plasticity Clay and with N-Value of SPT from 27 to 29 blows), (CL)
- From 13.50m to 20.50m: Hard yellow, light-gray medium plasticity Clay and with N-Value of SPT from 75 to 34 blows), (CI)

BH-8: Distribution Chamber a long option A (N: 1468478.700, E: 378225.444), Elevation: 6.23m
- From 0.00m to 3.05m: Firm to stiff reddish, gray clay, sand mixtures low plasticity Clay and with N-Value of SPT, 5 to 9 blows, (CL)
- From 3.05m to 7.05m: Firm to stiff yellowish, reddish, gray medium to low plasticity clay and with N-Value of SPT, 7 to 9 blows, (CI-CL)
- From 7.05m to 7.50m: Loose yellowish, gray clayey and with N-Value of SPT, 9 blows (SC)
- From 7.50m to 10.50m: Very stiff yellow, gray low plasticity Clay and with N-Value of SPT from 12 to 15 blows, (CL)
- From 10.50m to 12.50m: Medium dense yellowish, light-gray Clayey Sand and with N-Value of SPT from 15 to 21 blows, (SC)
- From 12.50m to 19.50m: Hard yellow, red, gray medium plasticity Clay and with N-Value of SPT from 24 to 91 blows, (CI)
- From 19.50m to 20.50m: Very dense reddish, gray clayey Sand and with N-Value of SPT, 89 blows, (SC)

BH-9 : WTP site (N: 1470994.422, E: 382167.847) Elevation: 8.21m
- From 0.00m to 3.05m: Loose red, gray clayey Sand with little gravel and with N-Value of SPT, 6 to 3 blows

- From 3.05m to 4.50m: Stiff yellow, gray medium plasticity clay, lean clay and with N-Value of SPT, 10 blows
- From 4.50m to 12.05m: Loose yellow, red, gray clayey Sand and with N-Value of SPT, 6 to 8 blows
- From 12.05m to 16.50m: Medium dense light-gray clayey sand with little gravel and with N-Value of SPT from 13 to 20 blows.

BH-10 : WTP site (N: 1470879.937, E: 382175.621) Elevation: 8.21m
- From 0.00m to 4.05m: Loose yellowish clayey Sand with little gravel and with N-Value of SPT, 2 to 9 blows.
- From 4.05m to 5.30m: Firm yellow, gray medium plasticity clay and with N-Value of SPT, 6 blows.
- From 5.30m to 13.05m: Loose gray clayey Sand with a little gravel and with N-Value of SPT is 7 (to 9) blows
- From 13.05m to 16.00m: Medium dense light-gray clayey sand and with N-Value of SPT from 14 to 23 blows
- From 16.00m to 16.50m: Dense brown clayey sand and with N-Value of SPT is 36 blows.

BH-11: Intake Pump Station a long option B (N: 1469615,175 E: 382925.686), Elevation: 7.07m
- From 0.00m to 1.50m: Firm yellow, brown medium Clay medium plasticity Clay and with N-Value of SPT, 5 blows, (CI)
- From 1.50m to 2.50m: Loose gray, brown clayey Sand and with N-Value of SPT, 5 blows, (SC)
- From 2.50m to 5.50m: Stiff yellow, red, gray medium plasticity Clay and with N-Value of SPT, 11 to 9 blows (CI)
- From 5.50m to 8.50m: Loose gray Clayey Sand and with N-Value of SPT from 6 to 7 blows, (SC)
- From 8.50m to 11.50m: Firm to stiff gray low plasticity Clay and with N-Value of SPT from 5 to 12 blows, (CL)
- From 11.50m to 13.50m: Medium to loose yellowish, gray Clayey Sand and with N-Value of SPT from 11 to 8 blows, (SC)
- From 13.50m to 15.50m: Very dense to medium dense reddish, clayey Sand and with N-Value of SPT, 53 to 27 blows, (SC)
- From 15.50m to 16.95m: Very stiff yellow low plasticity Clay and with N-Value of SPT, 27 to 23 blows, (CL)
- From 16.95m to 17.85m: Medium dense yellow, gray clayey sand and with N-Value of SPT, 26 blows, (CL)
- From 17.85m to 18.50m: Very stiff yellow, gray medium plasticity Clay and with N-Value of SPT, 29 blows, (CI)
- From 18.50m to 20.50m: Hard gray medium to low plasticity Clay and with N-Value of SPT, 35 to 23 blows, (CI-CL)

BH-12: Intake Pump Station a long option B (N: 1469615,142 E: 382975.637), Elevation: 7.09m
- From 0.00m to 2.50m: Loose dark-gray, brown Clayey Sand and with N-Value of

SPT, 3 to 4 blows, (SC)

- From 2.50m to 5.50m: Firm yellow, gray medium plasticity Clay with gravel and with N-Value of SPT, 5 blows, (CI-CL)
- From 5.50m to 13.50m: Loose yellowish, gray Clayey Sand and with N-Value of SPT, 5 to 9 blows (SC)
- From 13.50m to 15.50m: Very dense to medium dense yellowish, gray Clayey Sand and with N-Value of SPT from 50 to 27 blows, (SC)
- From 15.50m to 16.50m: Very stiff brown, gray low plasticity Clay and with N-Value of SPT 23 blows, (CL)
- From 16.50m to 17.40m: Medium dense gray Clayey Sand and with N-Value of SPT from 21 blows, (SC)
- From 17.40m to 19.65m: Hard gray low to medium dense Clayey Sand and with N-Value of SPT, 21 to 37 blows, (CL-CI)
- From 19.65m to 20.10m: Dense gray clayey Sand and with N-Value of SPT 39 blows, (CL)

BH-13: Intake Pipeline option B (N: 1468699.450, E: 382834.053), Elevation: 6.32m

- From 0.00m to 1.50m: Soft gray low plasticity Clay and with N-Value of SPT, 3 blows, (CL)
- From 1.50m to 2.50m: Loose brown clayey Sand and with N-Value of SPT, 9 blows, (SC)
- From 2.50m to 5.50m: Soft to firm brown, gray medium to low plasticity Clay and with N-Value of SPT, 4 to 6 blows (CI-CL)
- From 5.50m to 10.50m: Loose gray Clayey Sand and with N-Value of SPT from 4 to 6 blows, (SC)
- From 10.50m to 12.05m: Stiff to Very stiff brown, gray low plasticity Clay and with N-Value of SPT from 8 to 22 blows, (CL)
- From 12.05m to 14.50m: Medium dense gray, brown Clayey Sand and with N-Value of SPT from 23 to 20 blows, (SC).
- From 14.50m to 18.75m: Hard yellow, gray medium to low plasticity Clay and with N-Value of SPT, 41 to 33 blows, (CI-CL)
- From 18.75m to 20.10m: Very dense to dense yellow, gray brown Clayey Sand and with N-Value of SPT, 55 to 31 blows, (CL)

BH-14: Intake Chamber Station a long option A (N: 1462006, E: 378209), Elevation: 1.12m

- From 0.00m to 3.00m: Stiff red, gray high plasticity Clay and with N-Value of SPT,8 to 9 blows, (CH).
- From 3.00m to 3.50m: Medium dense yellow, gray clayey sand and with N-Value of SPT 10 blows,
- From 3.50m to 18.30m: Very stiff to hard yellow, red, gray medium to high plasticity Clay and with N-Value of SPT,28 to15 blow (CH-CI).
- From 18.30m to 20.50m: Medium dense yellow, light-gray Clayey Sand and with N-Value of SPT, 20 to 23 blows (SC).

BH-15: Intake Chamber Station a long option B (N: 1460658, E: 382766), Elevation: 1.197m

- From 0.00m to 1.50m: Stiff reddish, gray medium plasticity Clay and with N-Value of SPT, 11 blows, (CH).
- From 1.50m to 2.50m: Very stiff reddish, gray medium to high plasticity Clay and with N-Value of SPT,27 blows, (CH).
- From 2.50m to 5.50m: Hard to stiff reddish, gray medium plasticity Clay and with N-Value of SPT, 32 to 13 blows (CI).
- From 5.50m to 10.50m: Hard yellow, reddish, gray high plasticity Clay and with N-Value of SPT, 30 to 37 blows (CH).
- From 10.50m to 12.50m: Hard yellow, gray medium plasticity Clay and with N-Value of SPT, 40 to 36 blows (CI).
- From 12.50m to 17.40m: Hard yellow, gray high plasticity Clay and with N-Value of SPT, 39 to 26 blows (CH).
- From 17.40m to 19.50m: Very stiff yellow, gray medium plasticity Clay and with N-Value of SPT, 26 to 17 blows (CI).

3.2 Underground water condition

The ground water met during operation of boring is one of the important factors for soil investigation because the variation of ground water level, the characteristic of soil mechanic also can be changed.

The underground water level encountered shown in table below:

Borehole Nº	Borehole depth m	Underground Water level m		Date of boring	Elevation (m)
		during boring operation	during after 24 hours		
BH.1	5.00	2.15	2.05	18/02/10	10.045
BH.2	5.00	2.50	1.95	17/02/10	12.096
BH.3	5.00	2.00	2.04	17/02/10	13.592
BH.4	5.00	No	No	18/02/10	16.166
BH.5	5.00	3.00	2.55	17/02/10	14.358
BH.6	20.50	0.40	0.15	21/02/10	7.14
BH.7	20.50	0.30	0.10	23/02/10	7.09
BH.8	19.50	0.45	0.32	14/02/10	6.23
BH.9	16.50	2.25	0.45	13/02/10	8.21
BH.10	16.50	2.25	0.45	12/02/10	8.12
BH.11	20.50	1.50	0.45	17/02/10	7.07
BH.12	20.50	1.30	0.40	18/02/10	7.09
BH.13	20.50	-0.80	0.40	14/02/10	6.32
BH.14	20.50	1.60	1.60	23/02/10	1.12
BH.15	19.50	1.45	1.45	25/02/10	1.197

4 Conclusion and Recommendation

Laboratory tested results and field operation showed that the stratigraphy of subsoil layers beneath project area are:

Meyerhof's Pile Bearing-Capacity Equation

Meyerhof (1951, 1963) proposed a bearing Capacity equation similar to that of Terzaghi but included a shape factor sq with the term Nq . He also includeddepth factors di and Table 4-4 (Bearing-Capacity factors for the Meyerhof, Hensen, and Vesc' bearing-capacity equations):

- Bearing Capacity for CLAY:

Qb = Pile Area * 7.8* **C**, (KN)

- Friction for CLAY:

Qf = Pile Perimeter * Friction Increment *** CA, (KN)**

- Bearing Capacity for Sand:

Qb = Pile Area * Nq* **Vertical Stress**, (KN)

- Friction increment for Sand:

Qf = Pile Perimeter * Vertical Stress* Tan Delta* Ratio of Horiz. to Vertical Stress**, (KN)**

- Ultimate Load (Qult) :

Qult = Qb + Qf, (KN)

- Allowable load Pile Bearing Capacity:

Qall = Qult / Fs, (KN), Fs= 3, Safety Factor

- For Distribution Pipeline Borehole No.: **(BH-1)**

N: 143273.113, E: 383187, Elevation: 10.045m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	2.00	2.03	3.30	5.33	3	1.78	+ 8.045
	4.00	8.16	6.41	12.57		4.19	+ 6.045

- For Distribution Pipeline Borehole No.: **(BH-2)**

N: 1474337.493, E: 375538.993, Elevation: 12.096m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	2.00	1.90	4.13	6.03	3	2.01	+ 10.096
	4.00	4.42	1.54	5.96		1.99	+ 8.096

- For Distribution Pipeline Borehole No.: **(BH-3)**

N: 1475818.739, E: 378619.044, Elevation: 13.592m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	2.00	2.54	6.55	9.09	3	3.03	+ 11.592
	4.00	7.36	8.40	15.76		5.25	+ 9.592

- For Distribution Pipeline Borehole No.: **(BH-4)**

N: 1478987.86, E: 377680.013, Elevation: 16.166m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	2.00	4.50	2.89	7.39	3	2.46	+ 14.166
	4.00	7.31	7.61	14.92		4.97	+ 12.166

- For Distribution Pipeline Borehole No.: **(BH-5)**

N: 1478347.450, E: 374621.470, Elevation: 14.358m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	2.00	2.80	4.97	7.77	3	2.59	+ 12.358
	4.00	10.90	4.97	15.86		5.29	+ 10.358

- For Intake Pump Station Borehole No.: **(BH-6),** A long line Option A

N: 1469942.129, E: 378328.091, Elevation: 7.14m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	4.00	4.75	2.41	7.16	3	2.39	+ 3.14
	6.00	8.67	2.52	11.19		3.73	+ 1.14
	8.00	14.97	18.16	33.13		11.04	- 0.86
	10.00	26.56	22.67	49.22		16.41	- 2.86
	12.00	42.53	35.53	78.06		26.02	- 4.86
	14.00	56.46	6.64	63.10		21.03	- 6.86
	16.00	67.02	8.13	75.15		25.05	- 8.86
	18.00	75.62	6.38	82.00		27.33	- 10.86

- For Intake Pump Station Borehole No.: **(BH-7)**, A long line Option A

Intake Pump Station, N: 1469935.795, E: 378377.686, Elevation: 7.09m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	4.00	4.78	2.34	7.12	3	2.37	+ 3.09
	6.00	12.82	5.84	18.66		6.22	+ 1.09
	8.00	17.19	3.59	20.77		6.92	- 0.91
	10.00	20.64	3.00	23.64		7.88	- 2.91
	12.00	28.15	5.13	33.29		11.10	- 4.91
	14.00	32.63	3.70	36.33		12.11	- 6.91
	16.00	42.96	10.75	53.72		17.91	- 8.91
	18.00	54.59	9.85	64.44		21.48	- 10.91

- For Intake pipeline route, **(BH-8)** A long line Option A

N: 1468478.700, E: 378225.444, Elevation: 6.23m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	4.00	21.48	19.90	41.38	3	13.79	+ 2.23
	6.00	28.62	3.23	32.25		10.75	+ 0.23
	8.00	35.24	4.30	39.55		13.18	- 1.77
	10.00	39.21	2.03	41.24		13.75	- 3.77
	12.00	54.58	43.02	97.59		32.53	- 5.77
	14.00	68.11	17.24	85.34		28.45	- 7.77
	16.00	81.77	6.85	88.62		29.54	- 9.77
	18.00	95.71	9.43	105.14		35.05	- 11.77

- For Treatment Plat Borehole No.: **(BH-9)**

N: 1470994.422, E: 382167.847, Elevation: 8.21m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	4.00	7.88	4.90	12.77	3	4.26	+ 4.21
	6.00	14.59	12.26	26.85		8.95	+ 2.21
	8.00	23.93	16.20	40.14		13.38	+ 0.21
	10.00	35.82	25.58	61.40		20.47	- 1.79
	12.00	50.15	30.36	80.51		26.84	- 3.79
	14.00	67.64	35.56	103.20		34.40	- 5.79

- For Treatment Plat Borehole No.: **(BH-10)**

N: 1470879.937, E: 382175.621, Elevation: 8.12m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	4.00	4.93	1.71	6.65	3	2.22	+ 4.12
	6.00	11.50	11.12	22.62		7.54	+ 2.12
	8.00	20.36	16.10	36.47		12.16	+ 0.12
	10.00	31.53	18.00	49.53		16.51	- 1.88
	12.00	45.37	24.22	69.60		23.20	- 3.88
	14.00	63.67	45.18	108.85		36.28	- 5.788

- For Intake Pump Station Borehole No.: (BH-11), A long line Option B
  N: 146961.175, E: 382925.686, Elevation: 7.07m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	4.00	6.74	3.96	10.70	3	3.57	+ 3.07
	6.00	12.34	10.43	22.77		7.59	+ 1.07
	8.00	20.83	15.52	36.35		12.12	- 0.93
	10.00	24.98	5.04	30.02		10.01	- 2.93
	12.00	35.12	26.5	61.61		20.54	- 4.93
	14.00	56.08	251.53	307.61		102.54	- 6.93
	16.00	69.93	5.11	75.03		25.01	- 8.93
	18.00	96.21	85.8	182.00		60.67	- 10.93

- For Intake Pump Station Borehole No.: (BH-12), A long line Option B
  Intake Pump Station, N: 146961.142, E: 382975.637, Elevation: 7.09m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	4.00	3.43	1.75	5.18	3	1.73	+ 3.09
	6.00	7.81	11.32	19.13		6.38	+ 1.09
	8.00	16.99	15.18	32.17		10.72	- 0.91
	10.00	28.74	19.28	48.01		16.00	- 2.91
	12.00	43.67	29.15	72.81		24.27	- 4.91
	14.00	66.49	218.23	284.72		94.91	- 6.91
	16.00	80.64	3.64	84.28		28.09	- 8.91
	18.00	96.44	5.26	101.70		33.90	- 10.91

- For Intake pipeline route, (BH-13) A long line Option B
  N: 1468699.450, E: 382834.053, Elevation: 6.32m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	4.00	5.04	2.44	7.48	3	2.49	+ 2.32
	6.00	9.02	8.43	17.44		5.81	+ 0.32
	8.00	16.72	12.76	29.48		9.83	- 1.68
	10.00	23.10	3.13	26.23		8.74	- 3.68
	12.00	32.60	39.71	72.31		24.10	- 5.68
	14.00	49.26	41.04	90.29		30.10	- 7.68
	16.00	55.62	6.38	62.00		20.67	- 9.68
	18.00	64.60	8.43	73.02		24.34	- 11.68

- For Intake Chamber (BH-14) A long line Option A

N: 1462006, E: 378209, Elevation: 1.12m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	4.00	4.58	0.79	5.38	3	1.79	- 2.88
	6.00	7.16	2.38	9.53		3.18	- 4.88
	8.00	13.15	8.01	21.16		7.05	- 6.88
	10.00	20.59	5.12	25.70		8.57	- 8.88
	12.00	26.17	4.52	30.69		10.23	- 10.88
	14.00	35.28	7.95	43.22		14.41	- 12.88
	16.00	38.41	1.85	40.26		13.42	- 14.88
	18.00	44.56	5.52	50.09		16.70	- 16.88

- For Intake Chamber (BH-15) A long line Option B

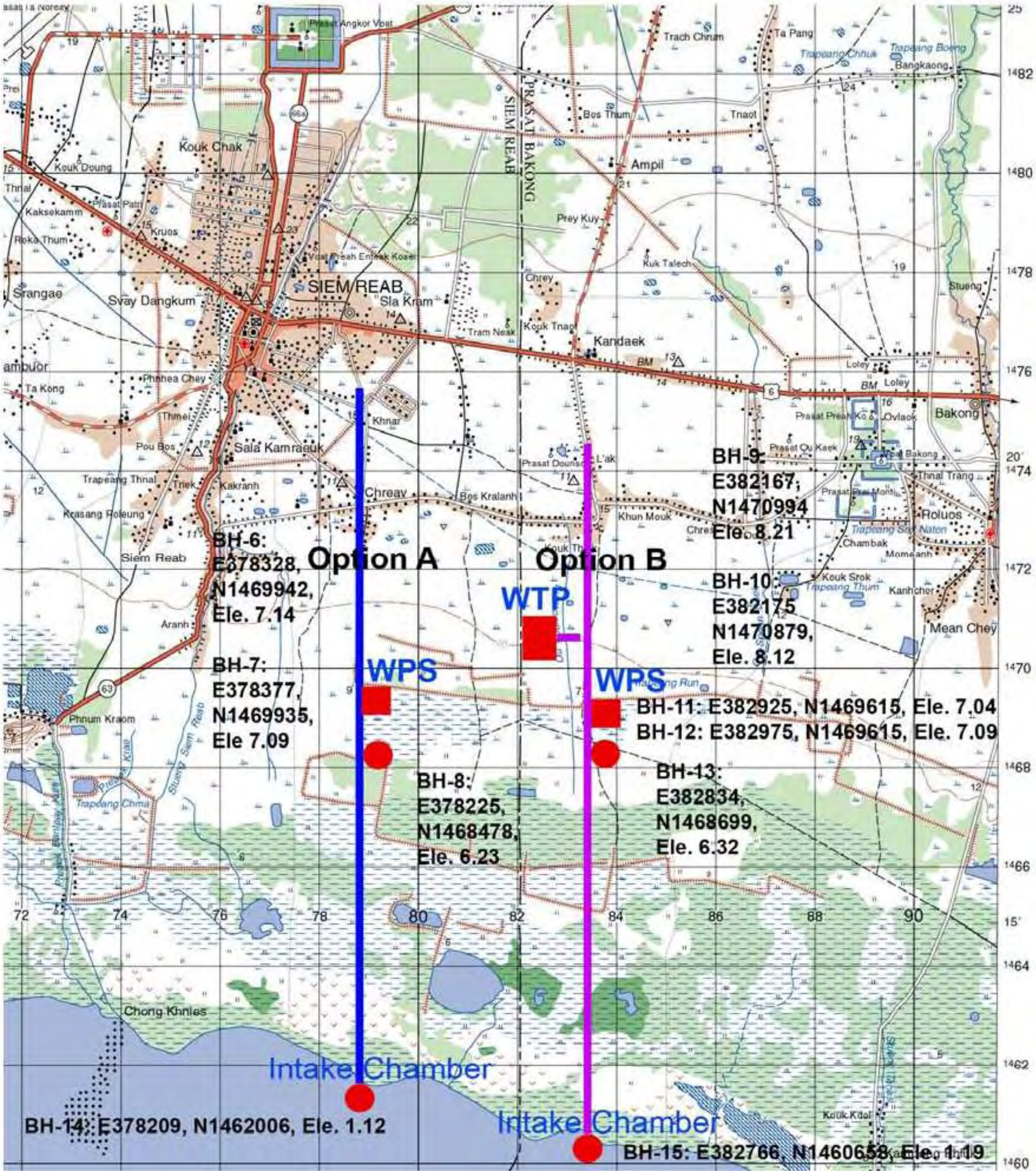
N: 1460658, E: 382766, Elevation: 1.197m

Diameter (m)	Pile Length (m)	Friction (Tons)	Bearing Capacity (Tones)	Ultimate Load (Tones)	Safety factor	Allowable Load (Tons)	Elevation (m)
0.30 x 0.30	4.00	10.40	7.21	17.60	3	5.87	- 2.80
	6.00	15.12	3.02	18.14		6.05	- 4.80
	8.00	19.87	3.85	23.72		7.91	- 6.80
	10.00	27.15	8.17	35.32		11.77	- 8.80
	12.00	42.18	12.65	54.82		18.27	- 10.80
	14.00	47.10	4.64	51.74		17.25	- 12.80
	16.00	56.25	7.76	64.01		21.34	- 14.80
	18.00	64.63	7.13	71.76		23.92	- 16.80

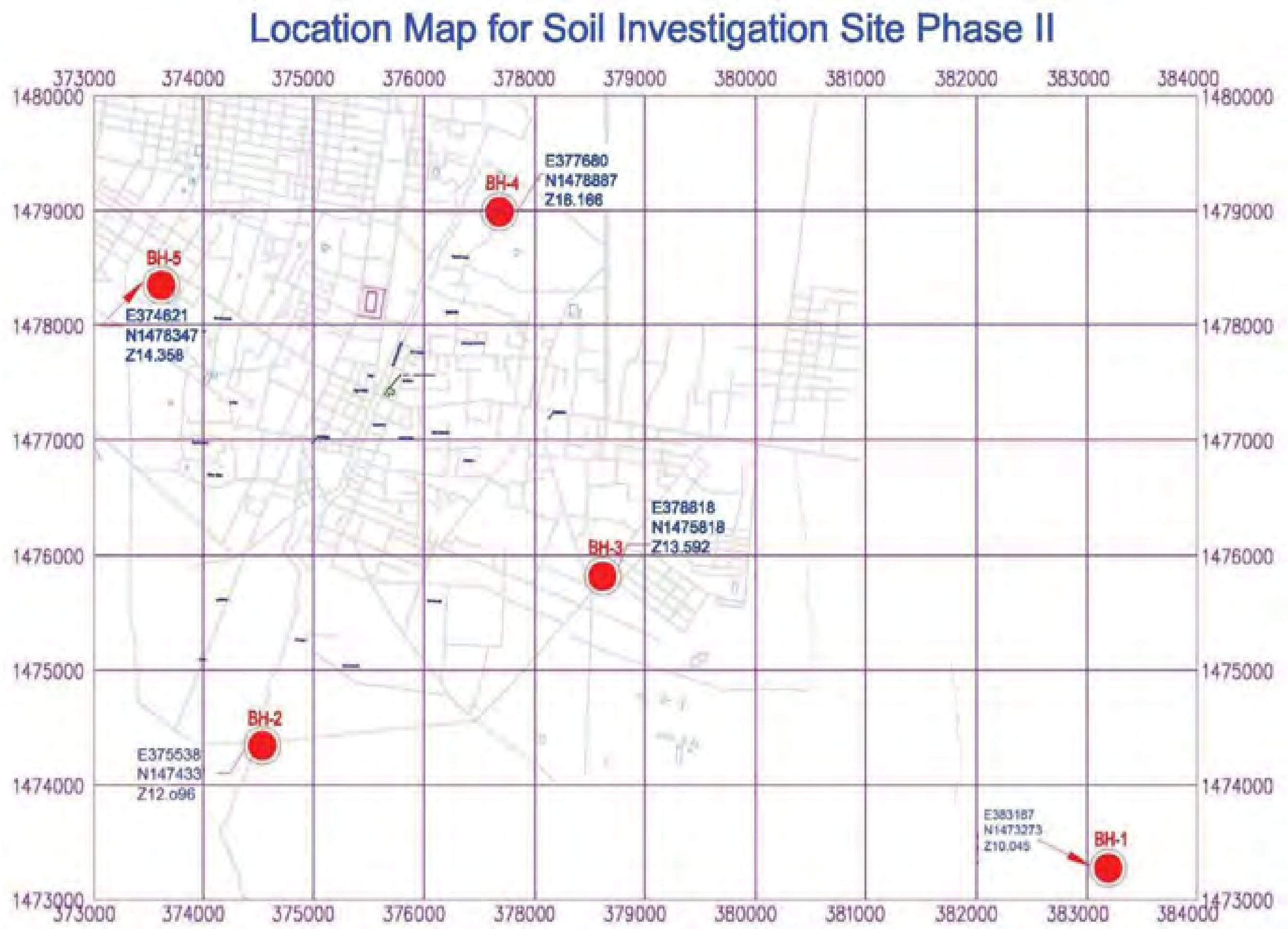
5 Borehole Location

For Phase 1 Contract : (BH 6, 7, 8, 11, 12, 13, 14, and 15)
For Phase 2 Contract : (BH 9 and 10)

LOCATION MAP FOR TOPOGRAPHIC SURVEY AND SOIL INVESTIGATION SITE FOR PHASE I



For Phase 2 Contract: (BH 1, 2, 3, 4, and 5)



6 Bore Holes' Data

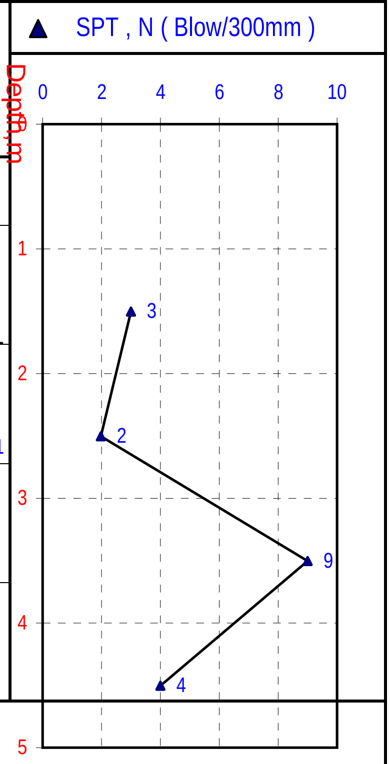
Partner of Construction and Development Services Inc. Soil Quality Analysis Office

BORE HOLE LOG BH1

Owner :	NJS CONSULTANTS CO.,LTD	Method :Rotary Auger	Date started : 18/02/2010
Contractor:	Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 18/02/2010
		Elevation:10.045m	N: 1473273.113, E: 383187.981
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia			LOCATION : Pipeline

Depth to water flow: 2.15 m
Depth to water level: 2.05 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	1.50		Soft yellow, light-gray low plasticity Clay	2	2	1	3
D2: 1.75 -	2.50	SPT	3.00		Loose light-gray, red ,yellow clayey	2	1	0.981	1.981
D3: 2.75 -	3.50	SPT			Sand mixtures	2	3	6	9
D4: 3.75 -	4.50	SPT				2	2	2	4
					END OF SPT TEST 4.50m Depth				



Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

Stiff to hard sandy clay, low plasticity Clay

Firm to stiff silty clay, medium plasticity Clay

Very stiff to hard clay , high plasticity Clay

Clayey sand,Silty Sand

V. Soft to soft clay, organic clay

Fill/topsoil

Gravelly Sand, Clean Sand

Clayey sand with gravel

Fine Sand

Weather Rock

Standard Penetration Test (SPT)

U & SPT

SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia
LOCATION : Pipeline N: 1473273.113, E: 383187.981 Elevation:10.045m

Date started : 18/02/2010
Date finished : 18/02/2010
Depth to water flow: 2.15 m
Depth to water level: 2.05 m

BORE HOLE LOG BH1

SUMMARY LABORATORY TEST

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm^3)	Dry density γ_d (g/cm^3)	Specific Gravity Gs (g/cm^3)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (º)
U1					0.75	1.05			16.49	1.924	1.652	2.656							30.180	15.09	
D1	2	2	1	3	1.05	1.50	Soft yellow, light-gray low plasticity Clay	CL	17.75				31.00	12.25	18.75	41.96	57.90	0.14			
U2					1.75	2.05			23.14	2.105	1.709	2.632							18.443		
D2	2	1	0.981	1.981	2.05	2.50	Loose light-gray, red ,yellow clayey		16.71				22.10	11.28	10.82	48.61	51.39	0.00			28
U3					2.75	3.05	Sand mixtures		22.49	2.216	1.809	2.719							21.640		
D3	2	3	6	9	3.05	3.50		SC	15.23				27.80	10.62	17.18	44.98	55.02	0.00			30
U4					3.75	4.05			18.32	2.135	1.804	2.642							35.290		
D4	2	2	2	4	4.05	4.50			16.35				30.40	9.91	20.49	35.82	64.18	0.00			28
U5					4.75	5.05			15.65	2.305	1.993	2.646							50.026		
D5																					
							END OF SPT TEST 5.50m depth														

Partner of Construction and Development Services Inc. Soil Quality Analysis Office

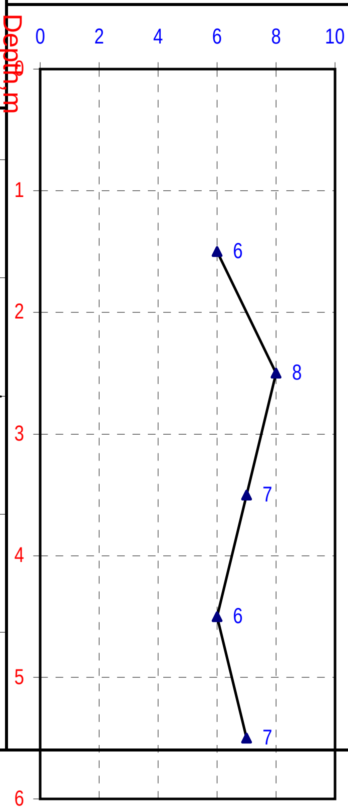
BORE HOLE LOG BH2

Owner : NJS CONSULTANTS CO.,LTD	Method :Rotary Auger	Date started : 17/02/2010
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 17/02/2010
	Elevation:12.096m	N: 1474337.493, E: 375538.993
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Pipeline

Depth to water flow: 2.50 m

Depth to water level: 1.95 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	2.50		Loose yellow, gray silty Sand	3	3	3	6
D2: 1.75 -	2.50	SPT			(SM) 2.50m	3	4	4	8
D3: 2.75 -	3.50	SPT	3.00		Firm brown , gray low plasticity Clay	2	3	4	7
D4: 3.75 -	4.50	SPT			(CL)	2	3	3	6
D5: 4.75 -	5.50	SPT				2	3	4	7
					END OF SPT TEST 5.50m Depth				



Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

- Stiff to hard sandy clay, low plasticity Clay
- Firm to stiff silty clay, medium plasticity Clay
- Very stiff to hard clay , high plasticity Clay
- Clayey sand,Silty Sand
- V. Soft to soft clay, organic clay
- Fill/topsoil
- Gravelly Sand, Clean Sand
- Clayey sand with gravel
- Fine Sand
- Weather Rock

Standard Penetration Test (SPT)

SPT

SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia

LOCATION : Pipeline N: 1474337.493, E: 375538.993 Elevation:12.096m

Date started : 17/02/2010
Date finished : 17/02/2010
Depth to water flow: 2.50 m
Depth to water level: 1.95 m

BORE HOLE LOG BH2

SUMMARY LABORATORY TEST

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm³)	Dry density γ_d (g/cm³)	Specific Gravity Gs (g/cm³)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (º)
U1					0.75	1.05	Loose yellow, gray silty Sand	SM	18.71	2.114	1.781	2.633	-	-	-				46.920		
D1	3	3	3	6	1.05	1.50			17.51				-	-	-	19.90	80.10	0.00			29
U2					1.75	2.05						2.644	-	-	-						
D2	3	4	4	8	2.05	2.50	2.50m		17.88				-	-	-	10.40	88.77	0.83			30
U3					2.75	3.05	Firm brown , gray low plasticity Clay	CL				2.668									
D3	2	3	4	7	3.05	3.50			15.72				35.80	8.15	27.65	56.89	43.11	0.00			
U4					3.75	4.05			16.11	2.171	1.870	2.715							83.119	41.56	
D4	2	3	3	6	4.05	4.50			15.48				31.00	12.09	18.91	52.38	47.62	0.00			
U5					4.75	5.05			11.25	2.263	2.034	2.643							44.003	22.00	
D5	2	3	4	7	5.05	5.50			16.30				27.80	11.15	16.65	52.65	47.35	0.00			
							END OF SPT TEST 5.50m depth														

Partner of Construction and Development Services Inc. Soil Quality Analysis Office

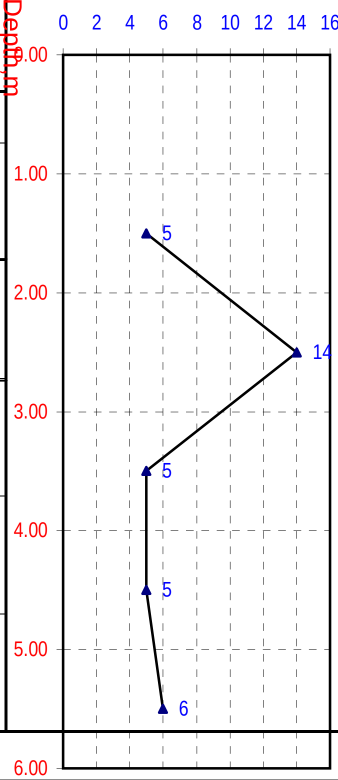
BORE HOLE LOG BH3

Owner : NJS CONSULTANTS CO.,LTD	Method :Rotary Auger	Date started : 17/02/2010
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 17/02/2010
	Elevation:13.592m	N: 1475818.739, E: 378619.044
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Pipeline

Depth to water flow: 2.00 m
Depth to water level: 2.04 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	1.50		Loose gray clayey Sand (SC) 1.50m	3	3	2	5
D2: 1.75 -	2.50	SPT	1.00		Mediun dense red, gray clayey Sand	3	8	6	14
D3: 2.75 -	3.50	SPT	2.55		Loose gray clayey Sand	3	2	3	5
D4: 3.75 -	4.50	SPT			5.05m	2	3	2	5
D5: 4.75 -	5.50	SPT	0.45		Firm yellow, gray medium plasticity Clay	2	3	3	6
					END OF SPT TEST 5.50m Depth				

SPT , N (Blow/300mm)



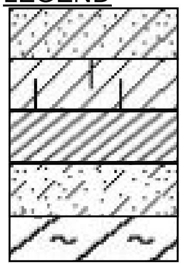
Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

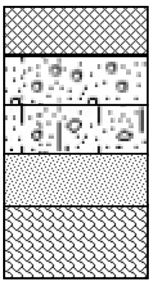
Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND



Stiff to hard sandy clay, low plasticity Clay
Firm to stiff silty clay, medium plasticity Clay
Very stiff to hard clay , fat Clay
Clayey sand,Silty Sand
V. Soft to soft clay, organic clay



Fill/topsoil
Gravelly Sand, Clean Sand
Clayey sand with gravel
Fine Sand
Weather Rock

Standard Penetration Test (SPT)
U & SPT
SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia

LOCATION : Pipeline N: 1475818.739, E: 378619.044 Elevation:13.592m

BORE HOLE LOG BH3

SUMMARY LABORATORY TEST

Date started : 17/02/2010
Date finished : 17/02/2010
Depth to water flow: 2.00 m
Depth to water level: 2.04 m

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm^3)	Dry density γ_d (g/cm^3)	Specific Gravity Gs (g/cm^3)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (°)
U1					0.75	1.05			11.43	2.215	1.988	2.617							74.644	37.32	
D1	3	3	2	5	1.05	1.50	Loose gray clayey Sand 1.50m	SC	10.48							30.04	69.96	0.00			29
U2					1.75	2.05			13.14	2.313	2.044	2.652							62.490	31.25	
D2	3	8	6	14	2.05	2.50	Mediun dense red, gray clayey Sand	SC	12.67							32.84	67.16	0.00			32
U3					2.75	3.05			9.58	2.348	2.143	2.673							73.521	36.76	
D3	3	2	3	5	3.05	3.50	Loose gray clayey Sand	SC	11.60				22.20	13.61	8.59	36.85	63.15	0.00			
U4					3.75	4.05			17.66	2.159	1.856	2.655							47.870	23.94	
D4	2	3	2	5	4.05	4.50			16.31				19.60	9.61	9.99	48.4	51.60	0.00			
U5					4.75	5.05	5.05m		13.24	2.359	2.083	2.667							47.950	23.98	
D5	2	3	3	6	5.05	5.50	Firm yellow, gray medium plasticity Clay	CI	15.28				40.80	13.85	26.95	43.73	56.27	0.00			
							END OF SPT TEST 5.50m depth														

Partner of Construction and Development Services Inc. Soil Quality Analysis Office

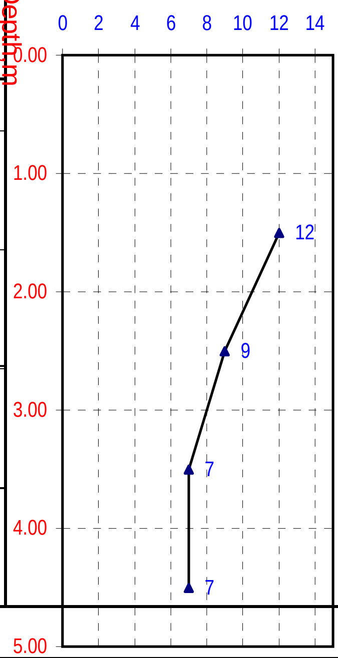
BORE HOLE LOG BH4

Owner : NJS CONSULTANTS CO.,LTD	Method :Rotary Auger	Date started : 18/02/2010
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 18/02/2010
	Elevation:16.166m	N: 1478987.86, E: 377680.013
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Pipeline

Depth to water flow: No m
Depth to water level: No m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	2.50		Medium to loose reddish, gray clayey	4	4	8	12
D2: 1.75 -	2.50	SPT			Sand (SC) 2.50m	3	3	6	9
D3: 2.75 -	3.50	SPT	1.00		Firm gray yellow medium plasticity	3	3	4	7
D4: 3.75 -	4.50	SPT	1.55		Loose yellow, gray Sandy Silt (SM)	2	3	4	7
					END OF SPT TEST 4.50m Depth				

▲ SPT , N (Blow/300mm)



Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

- Stiff to hard sandy clay, low plasticity Clay
- Firm to stiff silty clay, medium plasticity Clay
- Very stiff to hard clay , fat Clay
- Clayey sand,Silty Sand
- V. Soft to soft clay, organic clay
- Fill/topsoil
- Gravelly Sand, Clean Sand
- Clayey sand with gravel
- Fine Sand
- Weather Rock

Standard Penetration Test (SPT)

SPT

▲ SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia

LOCATION : Pipeline N: 1478987.86, E: 377680.013 Elevation:16.166m

Date started : 18/02/2010
Date finished : 18/02/2010
Depth to water flow: No m
Depth to water level: No m

BORE HOLE LOG BH4

SUMMARY LABORATORY TEST

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm³)	Dry density γ_d (g/cm³)	Specific Gravity Gs (g/cm³)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (º)
U1					0.75	1.05	Medium to loose reddish, gray clayey		6.16	2.406	2.266	2.616							195.200	97.60	
D1	4	4	8	12	1.05	1.50	Sand	CL	3.55				22.30	13.57	8.73	32.34	67.66	0.00			31
U2					1.75	2.05						2.614									
D2	3	3	6	9	2.05	2.50	2.50m		10.56				20.10	12.32	7.78	34.86	64.99	0.15			30
U3					2.75	3.05	Firm gray yellow medium plasticity	CI	20.20	2.425	2.017	2.627							163.360	81.68	
D3	3	3	4	7	3.05	3.50	Clay (CI) 3.50m		18.31				39.20	11.25	27.95	71.81	28.19	0.00			
U4					3.75	4.05			20.55	2.174	1.803	2.632							82.430	41.22	
D4	2	3	4	7	4.05	4.50	Loose yellow, gray Sandy Silt	SM	16.32				27.50	10.92	16.58	52.24	47.76	0.00			30
U5					4.75	5.05			18.28	2.075	1.754	2.618							57.074	28.54	
							END OF SPT TEST 5.05m depth														

Partner of Construction and Development Services Inc. Soil Quality Analysis Office

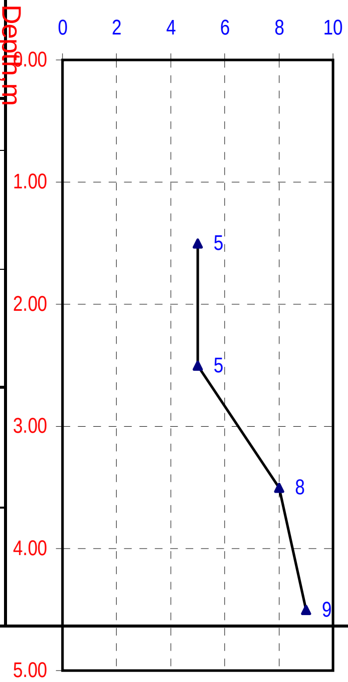
BORE HOLE LOG BH5

Owner : NJS CONSULTANTS CO.,LTD	Method :Rotary Auger
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm
	Elevation:14.358m
Date started : 17/02/2010	Date finished : 17/02/2010
N: 1478347.450, E: 374621.470	LOCATION : Water Treament Plant

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia

Depth to water flow: 3.00 m
Depth to water level: 2.55 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	2.50		Firm light-gray low plasticity Clay	2	2	3	5
D2: 1.75 -	2.50	SPT			(CL) 2.50m	1	2	3	5
D3: 2.75 -	3.50	SPT	1.00		Loose yellow, gray clayey sand	3	4	4	8
D4: 3.75 -	4.50	SPT	1.00		Stiff yellow, gray medium plasticity	3	4	5	9
					END OF SPT TEST 4.50m Depth				



Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

Stiff to hard sandy clay, low plasticity Clay
Firm to stiff silty clay, medium plasticity Clay
Very stiff to hard clay , fat Clay
Clayey sand,Silty Sand
V. Soft to soft clay, organic clay

Fill/topsoil
Gravelly Sand, Clean Sand
Clayey sand with gravel
Fine Sand
Weather Rock

Standard Penetration Test (SPT)
SPT
SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia

LOCATION : Water Treament Plant N: 1478347.450, E: 374621.470 Elevation:14.358m

BORE HOLE LOG BH5

SUMMARY LABORATORY TEST

Date started : 17/02/2010
Date finished : 17/02/2010
Depth to water flow: 3.00 m
Depth to water level: 2.55 m

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm^3)	Dry density γ_d (g/cm^3)	Specific Gravity Gs (g/cm^3)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (º)
U1					0.75	1.05						2.621									
D1	2	2	3	5	1.05	1.50	Firm light-gray low plasticity Clay	CL-CI	15.29				29.60	12.41	17.19	48.90	51.10	0.00			
U2					1.75	2.05			17.48	2.212	1.883	2.658							75.720	37.86	
D2	1	2	3	5	2.05	2.50	2.50m		13.64				34.70	12.95	21.75	42.96	57.04	0.00			
U3					2.75	3.05	Loose yellow, gray clayey sand	SC	20.27	2.093	1.740	2.615							47.720	23.86	
D3	3	4	4	8	3.05	3.50	3.50m		14.49				27.10	12.62	14.48	49.32	50.68	0.00			30
U4					3.75	4.05			24.15	2.238	1.803	2.606							69.941	34.97	
D4	3	4	5	9	4.05	4.50	Stiff yellow, gray medium plasticity	CI	14.89				36.50	14.16	22.34	49.48	50.32	0.20			
U5					4.75	5.05	Clay		17.48	2.212	1.883	2.608							170.105	85.05	
							END OF SPT TEST 5.05m depth														

BORE HOLE LOG BH6

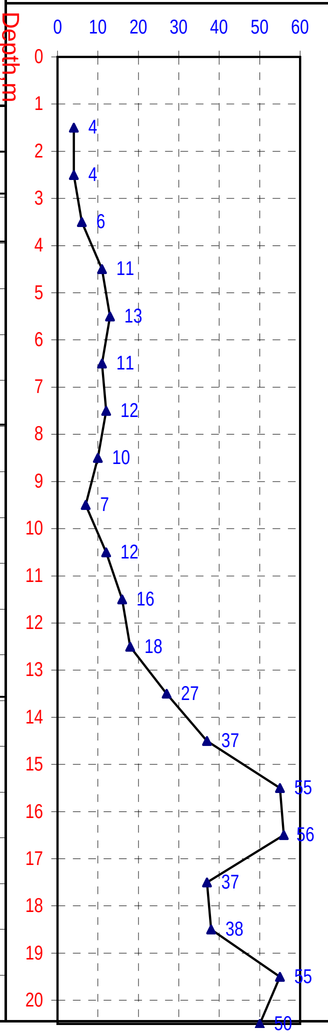
Owner : NJS CONSULTANTS CO.,LTD Contractor: Partner of Construction and Development Services Inc.	Method :Rotary Auger Casing Size : 180 mm Elevation:7.14m	Date started : 21/02/2010 Date finished : 22/02/2010 N: 1469942.129, E:378328.091
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Intake pump Station along option A

Depth to water flow: 0.40 m
Depth to water level: 0.15 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	1.50		Loose yellowish, gray clayey Sand 1.50m	1	1	3	4
D2: 1.75 -	2.50	SPT	1.00		Soft yellowish medium plasticity Clay 2.50m	3	2	2	4
D3: 2.75 -	3.50	SPT	1.55		Loose yellowish fine Sand (SC) 4.05m	2	3	3	6
D4: 3.75 -	4.50	SPT	3.00		Stiff yellow, gray low to medium	2	3	8	11
D5: 4.75 -	5.50	SPT			Plasticity Clay	2	6	7	13
D6: 5.75 -	6.50	SPT			(CL-CI)	3	5	6	11
D7: 6.75-	7.50	SPT			7.05m	5	6	6	12
D8:7.75-	8.50	SPT	6.45		Medium dense yellow,gray clayey	3	4	6	10
D9:8.75 -	9.50	SPT			Sand with a little gravel	4	3	4	7
D10:9.75-	10.50	SPT				4	5	7	12
D11:10.75-	11.50	SPT			(SC)	2	8	8	16
D12:11.75-	12.50	SPT				6	6	12	18
D13:12.75-	13.50	SPT			13.50m	7	12	15	27
D14:13.75-	14.50	SPT	7.00		Hard brown, grayish medium plasticity	8	17	20	37
D15:14.75-	15.50	SPT			Clay	15	26	29	55
D16:15.75-	16.50	SPT				10	23	33	56
D17:16.75-	17.50	SPT				11	17	20	37
D18:17.75-	18.50	SPT				13	18	20	38
D19:18.75-	19.50	SPT				9	25	30	55
D20:19.75-	20.50	SPT				17	31	19	50
					END OF SPT TEST 20.50m Depth				

SPT - N Value Blow/300mm

▲ SPT , N (Blow/300mm)



Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

- Stiff to hard sandy clay, low plasticity Clay
- Soft to stiff medium plasticity clay
- Very stiff to hard clay , high plasticity Clay
- Clayey sand,Silty Sand
- V. Soft to soft clay, organic clay
- Fill/topsoil
- Gravelly Sand, Clean Sand
- Clayey sand with gravel
- Fine Sand
- Weather Rock

Standard Penetration Test (SPT)

U & SPT

▲ SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia
LOCATION : Intake pump Station along option N: 1469942.129, E:378328.091 Elevation:7.14m

Date started : 14/02/2010
Date finished : 15/02/2010
Depth to water flow: 0.45 m
Depth to water level: 0.32 m

BORE HOLE LOG BH6

SUMMARY LABORATORY TEST

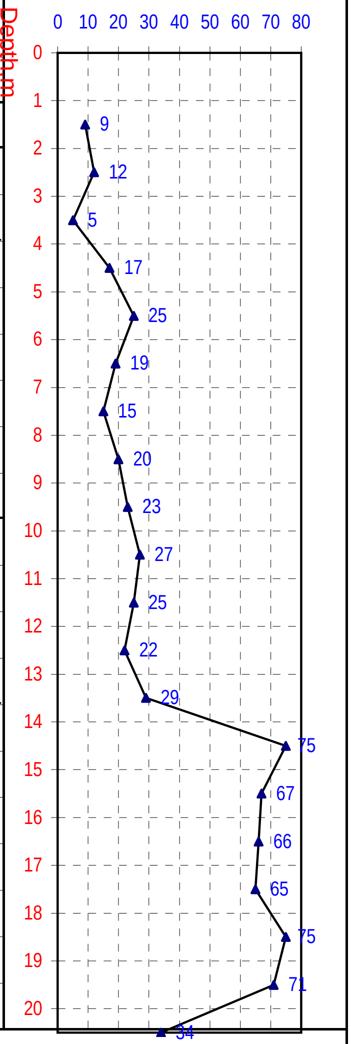
Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm³)	Dry density γ_d (g/cm³)	Specific Gravity Gs (g/cm³)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (°)
U1					0.75	1.05	Loose yellowish, gray clayey Sand	SC	17.08	2.114	1.806	2.618							62.540	31.27	
D1	1	1	3	4	1.05	1.50	1.50m		14.39		0.000		25.00	14.05	10.95	33.68	58.33	7.99			28
U2					1.75	2.05	Soft yellowish medium plasticity Clay	CI	17.02	2.093	1.789	2.675							37.670	18.84	
D2	3	2	2	4	2.05	2.50	2.50m		15.91		0.000		40.30	13.80	26.50	38.90	61.10	0.00			
U3					2.75	3.05	Loose yellowish fine Sand		16.20	2.140	1.842	2.638							13.714	6.86	
D3	2	3	3	6	3.05	3.50		SC	15.55		0.000		11.70	7.73	3.97	9.64	90.36	0.00			29
U4					3.75	4.05	4.05m				0.000	2.685								0.00	
D4	2	3	8	11	4.05	4.50	Stiff yellow, gray low to medium	CL	16.27		0.000		33.80	11.50	22.30	45.31	54.38	0.31			
U5					4.75	5.05	Plasticity Clay		17.66	2.170	1.844	2.669							68.570	34.29	
D5	2	6	7	13	5.05	5.50		CI	15.82		0.000		46.40	13.90	32.50	46.10	39.01	14.89			
U6					5.75	6.05			15.53	2.141	1.853	2.768							126.175	63.09	
D6	3	5	6	11	6.05	6.50		CI	15.03		0.000		35.40	13.96	21.44	50.20	49.80	0.00			
U7					6.75	7.05			14.67	2.211	1.928	2.759							71.785	35.89	
D7	5	6	6	12	7.05	7.50	7.50m	CI	12.88		0.000		35.50	13.80	21.70	45.83	54.17	0.00			
U8					7.75	8.05			15.42	2.087	1.808	2.721							70.519	35.26	
D8	3	4	6	10	8.05	8.50	Medium dense yellow,gray clayey	SC	14.22		0.000		29.00	10.31	18.69	38.94	61.06	0.00			31
U9					8.75	9.05	Sand with a little gravel		15.37	2.197	1.904	2.639							37.393	18.70	
D9	4	3	4	7	9.05	9.50		SC	13.92		0.000		26.20	11.13	15.07	46.33	53.67	0.00			30
U10					9.75	10.05			16.23	2.200	1.893	2.735							32.676	16.34	
D10	4	5	7	12	10.05	10.50		SC	12.77		0.000		28.40	12.20	16.20	41.76	58.24	0.00			31
U11					10.75	11.05			12.19	2.667	2.377	2.685							81.904	40.95	
D11	2	8	8	16	11.05	11.50		SC	12.16		0.000		24.60	14.25	10.35	36.89	63.11	0.00			33
U12					11.75	12.05			12.49	2.294	2.039	2.654							57.456	28.73	
D12	6	6	12	18	12.05	12.50		SC	10.23		0.000		24.40	10.03	14.37	31.43	64.34	4.23			33
U13					12.75	13.05			13.35	2.265	1.998	2.649							69.700	34.85	
D13	7	12	15	27	13.05	13.50	13.50m	SC	10.83		0.000		29.50	13.03	16.47	23.12	76.88	0.00			37
U14					13.75	14.05	Hard brown, grayish medium plasticity		14.10	2.205	1.933	2.734							189.280	94.64	
D14	8	17	20	37	14.05	14.50	Clay	CI	13.83		0.000		41.20	14.91	26.29	54.98	45.02	0.00			40
U15					14.75	15.05			14.03	2.387	2.093	2.741							301.550	150.78	
D15	15	26	29	55	15.05	15.50		CI	15.13		0.000		42.40	14.26	28.14	69.61	29.71	0.68			47
U16					15.75	16.05			17.13	2.24	1.914	2.738							231.590	115.80	
D16	10	23	33	56	16.05	16.50		CI	14.98		0.000		39.20	11.28	27.92	75.44	24.56	0.00			47
U17					16.50	16.95			15.18	2.168	1.882	2.696							252.591	126.30	
D17	13	18	20	37	16.95	17.40		CI	14.84		0.000		43.300	17.130	26.170	58.610	31.350	10.040			40
U18					17.40	17.85			14.46	2.282	1.994	2.684							181.782	90.89	
D18	17	31	19	38	17.85	18.30		CI	13.54		0.000		36.200	11.510	24.690	69.990	30.010	0.000			41
U19					18.30	18.75	Hard brown, grayish medium plasticity		15.95	2.166	1.868	2.681							234.612	117.31	
D19	9	25	30	55	18.75	19.20	Clay	CI	12.00		0.000		37.800	9.100	28.700	56.520	39.260	4.220			47
U20					19.20	19.65			15.66	2.255	1.950	2.766							281.067	140.53	
D20	17	31	19	50	19.65	20.10		CI	11.85		0.000		37.700	13.140	24.560	64.000	32.900	3.100			45
							END OF SPT TEST 20.50m depth														

BORE HOLE LOG BH7

Owner : NJS CONSULTANTS CO.,LTD Contractor: Partner of Construction and Development Services Inc.	Method :Rotary Auger Casing Size : 180 mm Elevation:7.09m	Date started : 23/02/2010 Date finished : 24/02/2010 N: 1469935.795, E:378377.686
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Intake pump Station along option A

Depth to water flow: 0.30 m
Depth to water level: 0.10 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	1.50		Stiff brown low plasticity Clay (CL) 1.50m	3	4	5	9
D2: 1.75 -	2.50	SPT			Stiff to firm yellow, brown medium	4	5	7	12
D3: 2.75 -	3.50	SPT	2.00		Plasticity Clay (CI) 3.50m	2	2	3	5
D4: 3.75 -	4.50	SPT			Very stiff yellow, light-gray medium	5	7	10	17
D5: 4.75 -	5.50	SPT			Plastcity Clay	7	10	15	25
D6: 5.75 -	6.50	SPT	6.00			5	9	10	19
D7: 6.75-	7.50	SPT			(CI)	4	7	8	15
D8:7.75-	8.50	SPT				5	9	11	20
D9:8.75 -	9.50	SPT			9.50m	6	8	15	23
D10:9.75-	10.50	SPT			Very stiff yellow, light-gray low	8	11	16	27
D11:10.75-	11.50	SPT			Plasticity Clay	9	11	14	25
D12:11.75-	12.50	SPT				16	12	10	22
D13:12.75-	13.50	SPT	4.00		13.50m	9	12	17	29
D14:13.75-	14.50	SPT			Hard yellow, light-gray medium	19	33	42	75
D15:14.75-	15.50	SPT			Plasticity Clay	14	35	32	67
D16:15.75-	16.50	SPT				16	31	35	66
D17:16.75-	17.50	SPT	7.00			13	28	37	65
D18:17.75-	18.50	SPT				17	34	41	75
D19:18.75-	19.50	SPT				16	46	25	71
D20:19.75-	20.50	SPT				7	14	20	34



END OF SPT TEST 20.50m Depth

Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

Stiff to hard sandy clay, low plasticity Clay
Soft to stiff medium plasticity clay
Very stiff to hard clay , high plasticity Clay
Clayey sand,Silty Sand
V. Soft to soft clay, organic clay

Fill/topsoil
Gravelly Sand, Clean Sand
Clayey sand with gravel
Fine Sand
Weather Rock

Standard Penetration Test (SPT)
U & SPT
SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia
LOCATION : Intake pump Station along option N: 1469935.795, E:378377.686 Elevation:7.09m

BORE HOLE LOG BH7

SUMMARY LABORATORY TEST

Date started : 23/02/2010
Date finished : 24/02/2010
Depth to water flow: 0.30 m
Depth to water level: 0.10 m

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm³)	Dry density γ_d (g/cm³)	Specific Gravity Gs (g/cm³)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (°)
U1					0.75	1.05	Stiff brown low plasticity Clay		21.41	2.262	1.863	2.670							57.570	28.79	
D1	3	4	5	9	1.05	1.50	1.50m	CL	10.66		0.000		28.30	14.91	13.39	40.98	59.02	0.00			
U2					1.75	2.05			14.14	2.253	1.974	2.657							24.220	12.11	
D2	4	5	7	12	2.05	2.50	Stiff to firm yellow, brown medium	CI	18.03		0.000		36.50	16.18	20.32	58.9	41.10	0.00			
U3					2.75	3.05	Plasticity Clay		19.98	2.071	1.726	2.698							64.017	32.01	
D3	2	2	3	5	3.05	3.50	3.50m	CI	16.65		0.000		36.00	11.70	24.30	44.82	36.33	18.85			
U4					3.75	4.05			14.52	2.186	1.909	2.675							66.740	33.37	
D4	5	7	10	17	4.05	4.50	Very stiff yellow, light-gray medium	CI	13.32		0.000		39.60	14.88	24.72	61.13	38.17	0.70			
U5					4.75	5.05	Plastcity Clay		15.10	2.178	1.892	2.676							239.419	119.71	
D5	7	10	15	25	5.05	5.50		CI	13.79		0.000		45.10	14.35	30.75	72.74	27.26	0.00			
U6					5.75	6.05			16.62	2.188	1.876	2.679							166.510	83.26	
D6	5	9	10	19	6.05	6.50		CI	13.81		0.000		41.00	14.05	26.95	67.65	32.35	0.00			
U7					6.75	7.05			16.16	2.159	1.859	2.662							118.550	59.28	
D7	4	7	8	15	7.05	7.50		CL	15.47		0.000		33.80	12.32	21.48	54.94	44.34	0.72			
U8					7.75	8.05			17.10	2.128	1.817	2.664							102.220	51.11	
D8	5	9	11	20	8.05	8.50		CI	14.97		0.000		40.10	14.25	25.85	49.05	50.95	0.00			
U9					8.75	9.05			17.90	2.085	1.768	2.704							88.770	44.39	
D9	6	8	15	23	9.05	9.50	9.50m	CI	15.65		0.000		38.40	12.65	25.75	56.11	43.89	0.00			
U10					9.75	10.05			14.95	2.176	1.893	2.674							85.480	42.74	
D10	8	11	16	27	10.05	10.50	Very stiff yellow, light-gray low	CL	13.11		0.000		29.10	10.51	18.59	63.75	36.25	0.00			
U11					10.75	11.05	Plasticity Clay		11.75	2.257	2.020	2.658							233.309	116.65	
D11	9	11	14	25	11.05	11.50		CL	11.49		0.000		30.20	14.43	15.77	46.41	53.29	0.30			
U12					11.75	12.05			13.73	2.222	1.954	2.649							146.290	73.15	
D12	16	12	10	22	12.05	12.50		CL	10.75		0.000		28.70	16.45	12.25	46.39	53.61	0.00			
U13					12.75	13.05			13.01	2.226	1.970	2.666							120.365	60.18	
D13	9	12	17	29	13.05	13.50	13.50m	CL	12.14		0.000		24.70	10.65	14.05	40.99	59.01	0.00			
U14					13.75	14.05			16.13	2.141	1.844	2.653							105.510	52.76	
D14	19	33	42	75	14.05	14.50	Hard yellow, light-gray medium	CI	14.72		0.000		41.60	15.11	26.49	63.68	36.32	0.00			
U15					14.75	15.05	Plasticity Clay		13.45	2.185	1.926	2.708							215.790	107.90	
D15	14	35	32	67	15.05	15.50		CI	16.51		0.000		44.70	15.20	29.50	69.07	30.93	0.00			
U16					15.75	16.05			14.04	2.234	1.959	2.729							306.354	153.18	
D16	16	31	35	66	16.05	16.50		CI	16.29		0.000		37.60	12.27	25.33	64.00	36.00	0.00			
U17					16.50	16.95			14.61	2.185	1.906	2.673							306.354	153.18	
D17	13	28	37	65	16.95	17.40		CI	15.10		0.000		41.00	11.92	29.08	81.83	17.43	0.74			
U18					17.40	17.85			13.12	2.213	1.956	2.713							280.612	140.31	
D18	17	34	41	75	17.85	18.30		CL	11.88		0.000		34.30	10.81	23.49	50.88	31.94	17.18			
U19					18.30	18.75			14.77	2.159	1.881	2.654							253.570	126.79	
D19	16	46	25	71	18.75	19.20		CI	12.95		0.000		40.70	12.92	27.78	73.95	26.05	0.00			
U20					19.20	19.65			14.50	2.152	1.879	2.695							250.520	125.26	
D20	7	14	20	34	19.65	20.10		CI	12.63		0.000		41.70	14.82	26.88	71.49	28.51	0.00			
							END OF SPT TEST 20.50m depth														

Prepared by : Chea Serey Vuth

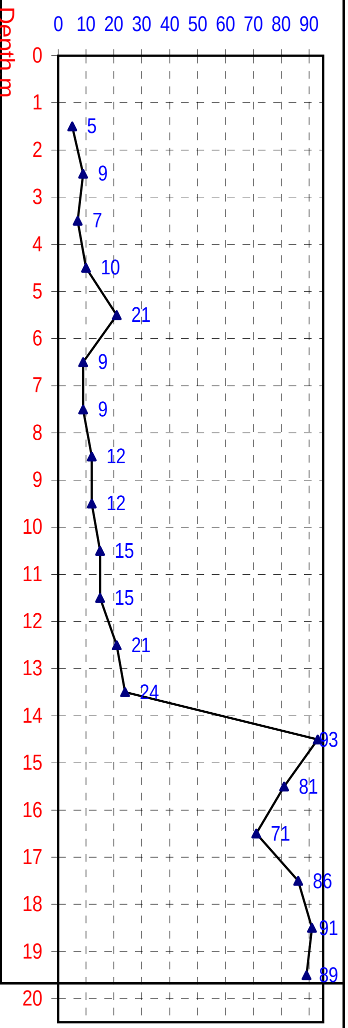
BORE HOLE LOG BH8

Owner : NJS CONSULTANTS CO.,LTD	Method :Rotary Auger	Date started : 14/02/2010	
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 15/02/2010	
	Elevation:6.23m	N: 1468478.700, E:378225.444	
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Distribution Chamber along line option A	

Depth to water flow: 0.45 m
Depth to water level: 0.32 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT			Firm to stiff reddish,gray clay,Sand	2	2	3	5
D2: 1.75 -	2.50	SPT	3.05		low plasticity Clay (CL) 3.05m	2	3	6	9
D3: 2.75 -	3.50	SPT			Firm to stiff reddish, gray medium	2	3	4	7
D4: 3.75 -	4.50	SPT			Plasticity clay	2	4	6	10
D5: 4.75 -	5.50	SPT			(CI-CL)	5	8	13	21
D6: 5.75 -	6.50	SPT	4.00		7.05m	2	3	6	9
D7: 6.75-	7.50	SPT	0.45		Loose yellowish, gray clayey Sand	2	3	6	9
D8:7.75-	8.50	SPT			Stiff yellow, gray,low to medium plasticity	3	5	7	12
D9:8.75 -	9.50	SPT			CL to CI)	2	5	7	12
D10:9.75-	10.50	SPT	3.00		10.50m	4	6	9	15
D11:10.75-	11.50	SPT			Medium dense yellowish,light-gray	3	6	9	15
D12:11.75-	12.50	SPT	2.00		clayey Sand (SC) 12.50m	2	9	12	21
D13:12.75-	13.50	SPT				6	9	15	24
D14:13.75-	14.50	SPT			Very stiff to Hard yellow, red,gray	15	28	65	93
D15:14.75-	15.50	SPT			Clay	17	38	43	81
D16:15.75-	16.50	SPT			(CI)	15	30	41	71
D17:16.75-	17.50	SPT				16	40	46	86
D18:17.75-	18.50	SPT			19.05m	16	44	47	91
D19:18.75-	19.50	SPT			Very dense reddish,gray clayey Sand	39	40	49	89
					END OF SPT TEST 19.50m Depth				

SPT , N (Blow/300mm)



Consistency: N-Value for Clay Blows/30Cm
Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm
Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

Stiff to hard sandy clay, low plasticity clay
Soft to stiff medium plasticity clay
Very stiff to hard clay , high plasticity Clay
Clayey sand,Silty Sand
V. Soft to soft clay, organic clay

Fill/topsoil
Gravelly Sand, Clean Sand
Clayey sand with gravel
Fine Sand
Weather Rock

Standard Penetration Test (SPT)
U & SPT
SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia
LOCATION : Distribution Chamber along line option A — N: 1468478.700, E:378225.444 — Elevation:6.23m
BORE HOLE LOG BH8 — SUMMARY LABORATORY TEST

Date started : 14/02/2010
Date finished : 15/02/2010
Depth to water flow: 0.45 m
Depth to water level: 0.32 m

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm³)	Dry density γ_d (g/cm³)	Specific Gravity Gs (g/cm³)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
		N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (°)
U1					0.75	1.05					0.000	2.572								0.00	
D1	2	2	3	5	1.05	1.50	Firm to stiff reddish, gray clay, Sand	CL	17.43	1.850	1.575		23.30	9.55	13.75	42.89	49.34	7.77			
U2					1.75	2.05	mixtures, low plasticity Clay				0.000	2.623								0.00	
D2	2	3	6	9	2.05	2.50		CL	18.07		0.000		26.30	12.90	13.40	47.11	52.89	0.00			
U3					2.75	3.05	3.05m		27.02	2.028	1.597	2.665							73.920	36.96	
D3	2	3	4	7	3.05	3.50		CI	20.73		0.000		37.70	13.13	24.57	48.83	50.94	0.23			
U4					3.75	4.05	Firm to stiff yellowish, reddish, gray		15.23	2.138	1.855	2.753							83.407	41.70	
D4	2	4	6	10	4.05	4.50	medium to low plasticity Clay	CI	13.93		0.000		40.00	10.02	29.98	38.18	57.65	4.17			
U5					4.75	5.05			13.18	2.225	1.966	2.692							283.508	141.75	
D5	5	8	13	21	5.05	5.50		CI	16.21		0.000		42.40	10.85	31.55	59.81	40.19	0.00			
U6					5.75	6.05			15.75	2.207	1.907	2.656							128.516	64.26	
D6	2	3	6	9	6.05	6.50		CL	15.90		0.000		30.00	8.50	21.50	43.24	55.25	1.51			
U7					6.75	7.05	7.05m		14.41	2.210	1.932	2.682							51.762	25.88	
D7	2	3	6	9	7.05	7.50	Loose yellowish, gray clayey sand	SC	14.77		0.000		19.20	11.16	8.04	33.24	66.76	0.00			30
U8					7.75	8.05			13.62	2.278	2.005	2.687							61.310	30.66	
D8	3	5	7	12	8.05	8.50	Stiff yellow, gray low to medium	CL	13.68		0.000		30.00	9.06	20.94	41.19	58.81	0.00			
U9					8.75	9.05	Plasticity Clay		13.98	2.227	1.954	2.639							71.278	35.64	
D9	2	5	7	12	9.05	9.50		CL	13.55		0.000		25.30	10.89	14.41	45.05	54.95	0.00			
U10					9.75	10.05			17.84	2.161	1.834	2.720							28.900	14.45	
D10	4	6	9	15	10.05	10.50	10.50m	CI	15.49		0.000		42.30	12.08	30.22	47.5	52.50	0.00			
U11					10.75	11.05	Medium dense yellowish, light-gray		14.00	2.151	1.887	2.685							20.410	10.21	
D11	3	6	9	15	11.05	11.50	clayey Sand	SC	12.50		0.000		21.20	10.62	10.58	34.83	65.17	0.00			32
U12					11.75	12.05					0.000	2.661								0.00	
D12	2	9	12	21	12.05	12.50	12.50m	SC	11.75		0.000		21.40	13.83	7.57	32.86	67.05	0.09			35
U13					12.75	13.05			12.81	2.174	1.927	2.708							96.107	48.05	
D13	6	9	15	24	13.05	13.50	Hard yellow, red, gray medium	CL	13.34		0.000		34.80	11.41	23.39	55.14	44.86	0.00			
U14					13.75	14.05	Plasticity Clay		15.52	2.088	1.807	2.725							245.542	122.77	
D14	15	28	65	93	14.05	14.50		CI	16.45		0.000		48.80	10.92	37.88	66.33	32.94	0.73			
U15					14.75	15.05			16.33	2.251	1.935	2.646							237.500	118.75	
D15	17	38	43	81	15.05	15.50		CI	16.25		0.000		47.20	13.88	33.32	76.10	23.23	0.67			
U16					15.75	16.05			20.98	2.068	1.709	2.666							97.552	48.78	
D16	15	30	41	71	16.05	16.50		CI	14.89		0.000		39.90	14.63	25.27	85.67	14.33	0.00			
U17					16.75	17.05			15.53	2.200	1.904	2.674							217.733	108.87	
D17	16	44	47	86	17.05	17.50		CI	13.50		0.000		48.10	16.50	31.60	80.77	15.60	3.63			
U18					17.75	18.05			14.90	2.064	1.796	2.787							134.308	67.15	
D18	39	40	49	91	18.05	18.50		CI	12.61		0.000		43.00	16.95	26.05	63.50	23.95	12.55			
U19					18.75	19.05	19.05m		16.97	2.08	1.777	2.696			0.00			100.00	132.64		
D19	39	40	49	89	19.05	19.50	Very dense reddish,gray clayey Sand	SC	15.60		0.000				0.00	35.28	63.25	1.47			50
							END OF SPT TEST 19.50m depth														

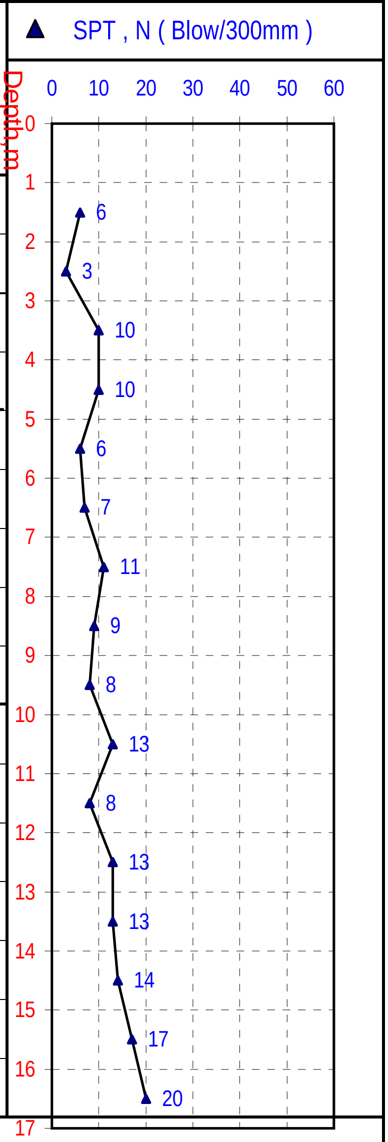
Partner of Construction and Development Services Inc. Soil Quality Analysis Office

BORE HOLE LOG BH9

Owner : NJS CONSULTANTS CO.,LTD	Method :Rotary Auger	Date started : 13/02/2010
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 13/02/2010
	Elevation:8.21m	N: 1470994.422, E: 382167.847
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Water Treament Plant

Depth to water flow: 2.25 m
Depth to water level: 0.45 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	3.05		Loose red, gray clayey Sand with alitle	2	2	4	6
D2: 1.75 -	2.50	SPT			gravel (SC) 3.05m	1	1	2	3
D3: 2.75 -	3.50	SPT	1.45		Stiff yellow, gray medium plasticity	2	4	6	10
D4: 3.75 -	4.50	SPT			Clay (CI) 4.50m	2	4	6	10
D5: 4.75 -	5.50	SPT	7.55		Loose yellowish, red, gray clayey	2	2	4	6
D6: 5.75 -	6.50	SPT			Sand with alitle gravel	3	3	4	7
D7: 6.75-	7.50	SPT				3	5	6	11
D8:7.75-	8.50	SPT			(SC)	3	4	5	9
D9:8.75 -	9.50	SPT			12.05m	2	3	5	8
D10:9.75-	10.50	SPT	4.45		Medium dense light-gray clayey Sand	4	5	8	13
D11:10.75-	11.50	SPT				2	3	5	8
D12:11.75-	12.50	SPT				4	5	8	13
D13:12.75-	13.50	SPT				5	6	7	13
D14:13.75-	14.50	SPT				6	6	8	14
D15:14.75-	15.50	SPT				3	8	9	17
D16:15.75-	16.50	SPT				5	8	12	20



END OF SPT TEST 16.50m Depth

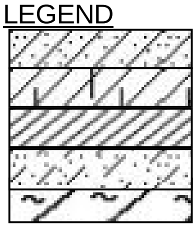
Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

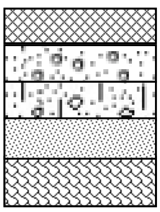
Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND



Stiff to hard sandy clay, low plasticity Clay
Firm to stiff medium plasticity Clay
Very stiff to hard clay , high plasticity Clay
Clayey sand,Silty Sand
V. Soft to soft clay, organic clay



Fill/topsoil
Gravelly Sand, Clean Sand
Clayey sand with gravel
Fine Sand
Weather Rock

Standard Penetration Test (SPT)
SPT
SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia
LOCATION : Water Treament Plant   N: 1470994.422, E: 382167.847   Elevation:8.21m
BORE HOLE LOG BH9   SUMMARY LABORATORY TEST

Date started : 13/02/2010
Date finished : 13/02/2010
Depth to water flow: 2.25 m
Depth to water level: 0.45 m

	N1	N2	N3	N=N2+N3	From	To															
U1					0.75	1.05			10.48	2.306	2.087	2.645							80.395	40.20	
D1	2	2	4	6	1.05	1.50			18.29		0.000		31.80	12.85	18.95	44.47	55.53	0.00			29
U2					1.75	2.05			16.71	2.096	1.796	2.623							38.284	19.14	
D2	1	1	2	3	2.05	2.50			16.86		0.000		25.80	11.11	14.69	39.71	56.53	3.76			28
U3					2.75	3.05			13.94	2.105	1.847	2.655							74.850	37.43	
D3	2	4	6	10	3.05	3.50			19.17		0.000		40.50	15.24	25.26	53.05	46.95	0.00			
U4					3.75	4.05			17.43	2.219	1.890	2.625							139.480	69.74	
D4	2	4	6	10	4.05	4.50			16.00		0.000		38.50	13.07	25.43	43.22	37.84	18.94			
U5					4.75	5.05			17.99	2.041	1.730	2.607							106.178	53.09	
D5	2	2	4	6	5.05	5.50			16.71		0.000		26.40	10.97	15.43	44.07	55.93	0.00			29
U6					5.75	6.05			19.85	1.983	1.655	2.637							27.401	13.70	
D6	3	3	4	7	6.05	6.50			16.52		0.000		22.70	12.79	9.91	40.39	59.61	0.00			30
U7					6.75	7.05			18.95	2.220	1.866	2.599							34.600	17.30	
D7	3	5	6	11	7.05	7.50			13.72		0.000		29.80	10.44	19.36	32.61	34.18	33.21			31
U8					7.75	8.05			14.90	2.161	1.881	2.617							34.048	17.02	
D8	3	4	5	9	8.05	8.50			14.74		0.000		23.00	10.92	12.08	36.46	63.13	0.41			30
U9					8.75	9.05			14.13	2.155	1.888	2.602							60.577	30.29	
D9	2	3	5	8	9.05	9.50			14.68		0.000		26.10	10.09	16.01	41.65	58.35	0.00			30
U10					9.75	10.05			18.23	2.310	1.954	2.620							46.256	23.13	
D10	4	5	8	13	10.05	10.50			13.38		0.000		22.60	10.59	12.01	38.15	61.85	0.00			32
U11					10.75	11.05			14.57	2.194	1.915	2.615							35.652	17.83	
D11	2	3	5	8	11.05	11.50			13.46		0.000		23.80	11.98	11.82	33.00	65.41	1.59			30
U12					11.75	12.05			15.29	2.096	1.818	2.614							25.023	12.51	
D12	4	5	8	13	12.05	12.50			13.43		0.000		24.70	12.15	12.55	42.80	57.20	0.00			
U13					12.75	13.05			13.96	2.307	2.024	2.629							106.500	53.25	
D13	5	6	7	13	13.05	13.50			9.63		0.000		22.80	10.04	12.76	41.88	58.12	0.00			32
U14					13.75	14.05			13.44	2.184	1.925	2.611							98.017	49.01	
D14	6	6	8	14	14.05	14.50			12.77		0.000		26.40	13.30	13.10	44.0	55.9	0.14			32
U15					14.75	15.05			18.58	2.190	1.847	2.619							24.623	12.31	
D15	3	8	9	17	15.05	15.50			23.26		0.000		19.80	14.41	5.39	29.51	70.5	0.00			33
U16					15.75	16.05			18.08	2.10	1.775	2.630							23.597	11.80	
D16	5	8	12	20	16.05	16.50			14.88		0.000		25.00	10.7	14.3	30.57	69.4	0.00			34

Partner of Construction and Development Services Inc. — Soil Quality Analysis Office

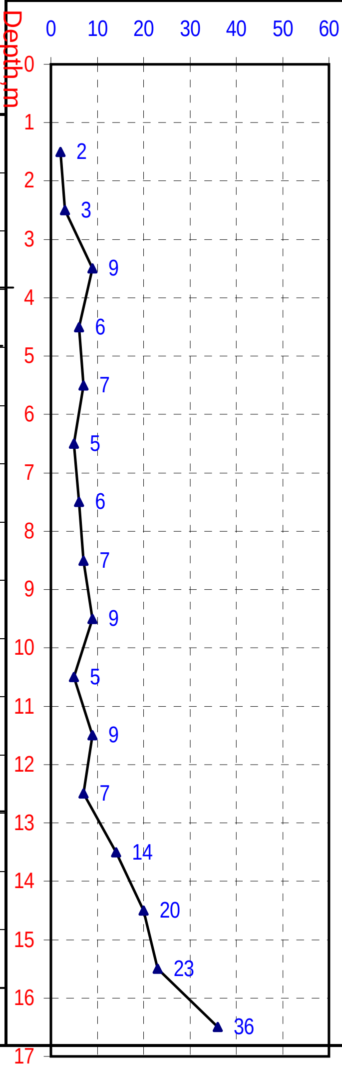
BORE HOLE LOG BH10

Owner :	NJS CONSULTANTS CO.,LTD	Method :Rotary Auger	Date started : 12/02/2010
Contractor:	Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 12/02/2010
		Elevation:8.12m	N: 1470879.937, E: 382175.821
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia			LOCATION : Water Treament Plant

Depth to water flow: 2.25 m
Depth to water level: 0.45 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	4.05		Loose red, gray clayey Sand with alitle	1	1	1	2
D2: 1.75 -	2.50	SPT			gravel (SC)	1	1	2	3
D3: 2.75 -	3.50	SPT			4.05m	2	4	5	9
D4: 3.75 -	4.50	SPT	1.25		Stiff yellow, gray medium plasticity	2	2	4	6
D5: 4.75 -	5.50	SPT	11.80		Loose yellowish, red, gray clayey	2	3	4	7
D6: 5.75 -	6.50	SPT			Sand with alitle gravel	1	2	3	5
D7: 6.75-	7.50	SPT				2	2	4	6
D8:7.75-	8.50	SPT			(SC)	3	3	4	7
D9:8.75 -	9.50	SPT				2	4	5	9
D10:9.75-	10.50	SPT				2	2	3	5
D11:10.75-	11.50	SPT				3	3	6	9
D12:11.75-	12.50	SPT			13.50m	3	3	4	7
D13:12.75-	13.50	SPT	2.95		Medium dense light-gray clayey Sand	4	6	8	14
D14:13.75-	14.50	SPT				5	8	12	20
D15:14.75-	15.50	SPT			16.00m	5	10	13	23
D16:15.75-	16.50	SPT			Dense brown clayey Sand	9	16	20	36

SPT , N (Blow/300mm)



END OF SPT TEST 16.50m Depth

Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

- Stiff to hard sandy clay, low plasticity Clay
- Firm to stiff medium plasticity Clay
- Very stiff to hard clay , high plasticity Clay
- Clayey sand,Silty Sand
- V. Soft to soft clay, organic clay
- Fill/topsoil
- Gravelly Sand, Clean Sand
- Clayey sand with gravel
- Fine Sand
- Weather Rock
- Standard Penetration Test (SPT)
- SPT
- SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion

Project in The Kingdom of Cambodia

LOCATION : Water Treament Plant N: 1470879.937, E: 382175.821 Elevation:8.21m

BORE HOLE LOG BH10

SUMMARY LABORATORY TEST

Date started : 12/02/2010

Date finished : 12/02/2010

Depth to water flow: 2.25 m

Depth to water level: 0.45 m

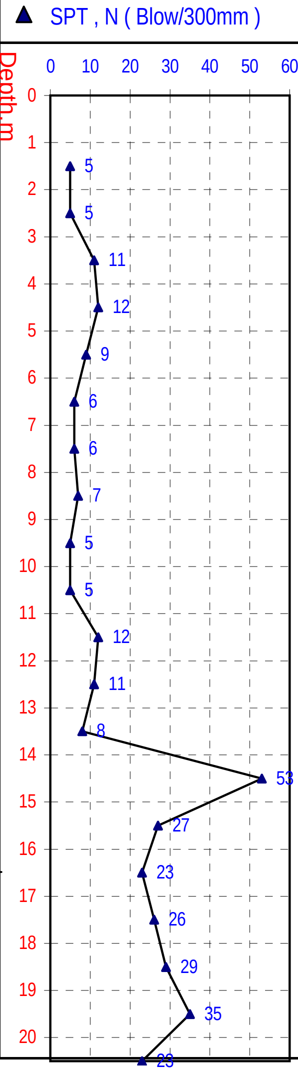
Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm³)	Dry density γ_d (g/cm³)	Specific Gravity Gs (g/cm³)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (°)
U1					0.75	1.05	Loose yellowish clayey sand with a little		17.84	2.113	1.793	2.599							40.717	20.36	
D1	1	1	1	2	1.05	1.50	gravel		18.61		0.000		25.10	9.89	15.21	38.57	59.42	2.01			28
U2					1.75	2.05			15.96	1.998	1.723	2.596							44.746	22.37	
D2	1	1	2	3	2.05	2.50		SC	16.76		0.000		17.10	10.56	6.54	25.32	74.68	0.00			28
U3					2.75	3.05			20.70	2.264	1.876	2.665							60.821	30.41	
D3	2	4	5	9	3.05	3.50			20.64		0.000		29.10	9.11	19.99	50.04	48.30	1.66			
U4					3.75	4.05	4.05m		21.80	2.191	1.799	2.632							65.370	32.69	
D4	2	2	4	6	4.05	4.50	Firm yellow, gray medium plasticity Clay	CI	20.18		0.000		39.60	11.66	27.94	54.8	41.87	3.33			
U5					4.75	5.05	5.30m		19.25	2.062	1.729	2.684							48.830	24.42	
D5	2	3	4	7	5.05	5.50	Loose gray clayey Sand with alittle gravel		19.25		0.000		34.20	12.60	21.60	47.32	52.68	0.00			30
U6					5.75	6.05			15.67	2.283	1.974	2.652							81.453	40.73	
D6	1	2	3	5	6.05	6.50			16.13		0.000		30.10	11.57	18.53	39.59	60.41	0.00			29
U7					6.75	7.05			13.80	2.077	1.825	2.636							38.920	19.46	
D7	2	2	4	6	7.05	7.50			15.52		0.000		28.70	11.71	16.99	40.51	59.17	0.32			29
U8					7.75	8.05			15.80	2.178	1.881	2.644							38.325	19.16	
D8	3	3	4	7	8.05	8.50			15.30		0.000		24.90	9.39	15.51	42.52	47.66	9.82			30
U9					8.75	9.05		SC	17.83	2.080	1.765	2.651							25.208	12.60	
D9	2	4	5	9	9.05	9.50			14.84		0.000		26.80	8.50	18.30	39.65	60.00	0.35			30
U10					9.75	10.05			16.80	2.285	1.956	2.666							46.042	23.02	
D10	2	2	3	5	10.05	10.50			15.06		0.000		22.80	14.24	8.56	35.29	64.71	0.00			29
U11					10.75	11.05			13.78	2.279	2.003	2.666							38.820	19.41	
D11	3	3	6	9	11.05	11.50			13.49		0.000		24.10	10.85	13.25	39.93	60.07	0.00			30
U12					11.75	12.05			15.28	2.262	1.962	2.646							26.340	13.17	
D12	3	3	4	13	12.05	12.50			14.10		0.000		22.80	11.45	11.35	31.40	68.60	0.00			
U13					12.75	13.05	13.05m		16.87	2.175	1.861	2.655							28.120	14.06	
D13	4	6	8	14	13.05	13.50	Medium dense light-gray clayey Sand		12.72		0.000		23.30	13.90	9.40	40.11	59.89	0.00			32
U14					13.75	14.05			19.52	2.271	1.900	2.614							18.336	9.17	
D14	5	8	12	20	14.05	14.50		SC	13.21		0.000		29.30	11.85	17.45	45.9	54.1	0.00			34
U15					14.75	15.05			18.37	2.280	1.926	2.626							83.834	41.92	
D15	5	10	13	23	15.05	15.50	16.00m		12.96		0.000		19.70	8.85	10.85	36.67	61.7	1.63			35
U16					15.75	16.05	Dense gray brown clayey Sand	SC	13.92	2.230	1.958	2.644		10.3					119.871	59.94	
D16	9	16	20	36	16.05	16.50			12.06		0.000		27.60	10.7	16.9	39.97	60.0	0.03			40
							END OF SPT TEST 16.50m depth														

BORE HOLE LOG BH11

Owner : NJS CONSULTANTS CO.,LT	Method :Rotary Auger	Date started : 17/02/2010
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 18/02/2010
	Elevation:7.07m	N: 1469615.175, E:382925.686
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Intake pump Station a lond line option B

Depth to water flow: 1.50 m
Depth to water level: 0.45 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	1.50	Firm yellow,brown medium olasticity Clay 1.50m	3	2	3	5
D2: 1.75 -	2.50	SPT	1.00	Loose gray, brown clayey Sand 2.50m	1	2	3	5
D3: 2.75 -	3.50	SPT	3.00	Stiff yellow, red, gray medium plasticity Clay	4	5	6	11
D4: 3.75 -	4.50	SPT		(CI)	4	5	7	12
D5: 4.75 -	5.50	SPT		5.50m	3	4	5	9
D6: 5.75 -	6.50	SPT	3.00	Loose gray Clayey Sand	2	2	4	6
D7: 6.75-	7.50	SPT		(SC)	2	3	3	6
D8:7.75-	8.50	SPT		8.50m	2	3	4	7
D9:8.75 -	9.50	SPT	3.00	Firm to stiff gray low plasticity Clay	2	3	2	5
D10:9.75-	10.50	SPT		(CL)	2	2	3	5
D11:10.75-	11.50	SPT		11.50m	2	6	6	12
D12:11.75-	12.50	SPT	2.00	Medium to loose yellowish, gray Clayey Sand	3	5	6	11
D13:12.75-	13.50	SPT		(SC) 13.50m	3	3	5	8
D14:13.75-	14.50	SPT	2.00	Very dense to medium dense yellowish	3	18	35	53
D15:14.75-	15.50	SPT		Clayey Sand (SC) 15.50m	6	16	11	27
D16:15.75-	16.50	SPT	1.45	Very stiff yellow low plasticity Clay (CL) 16.95m	5	8	15	23
D17:16.75-	17.50	SPT	0.90	Medium dense yellow, gray clayey Sand (SC) 17.85m	7	12	14	26
D18:17.75-	18.50	SPT	0.65	Very stiff yellow, gray medium plasticity Clay 18.50m	8	12	17	29
D19:18.75-	19.50	SPT	2.00	Hard gray medium to low plasticity Clay	12	16	19	35
D20:19.75-	20.50	SPT			6	10	13	23



END OF SPT TEST 20.50m Depth

Consistency: N-Value for Clay Blows/30Cm
Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm
Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

Stiff to hard sandy clay, low plasticity Clay
Firm to stiff medium plasticity Clay
Very stiff to hard clay , high plasticity Clay
Clayey sand,Silty Sand
V. Soft to soft clay, organic clay

Fill/topsoil
Gravelly Sand, Clean Sand
Clayey sand with gravel
Fine Sand
Weather Rock

Standard Penetration Test (SPT)
SPT
SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia
LOCATION : Intake pump Station a lond line or N: 1469615.175, E:382925.686 Elevation:7.07m

BORE HOLE LOG BH11

SUMMARY LABORATORY TEST

Date started : 17/02/2010
Date finished : 18/02/2010
Depth to water flow: 1.50 m
Depth to water level: 0.45 m

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm³)	Dry density γ_d (g/cm³)	Specific Gravity Gs (g/cm³)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (º)
U1					0.75	1.05	Firm yellow,brown medium Clay	CI			0.000	2.602								0.00	
D1	3	2	3	5	1.05	1.50	1.50m		20.85	2.050	1.696		40.00	14.78	25.22	59.21	40.47	0.32			
U2					1.75	2.05	Loose gray, brown clayey Sand	SC			0.000	2.613								0.00	
D2	1	2	3	5	2.05	2.50	2.50m		13.52	2.050	1.806		20.10	10.80	9.30	37.68	62.32	0.00			29
U3					2.75	3.05	Stiff yellow, red, gray medium plasticity		18.98	2.082	1.750	2.728							66.637	33.32	
D3	4	5	6	11	3.05	3.50	Clay		21.26		0.000		46.00	11.82	34.18	64.12	35.88	0.00			
U4					3.75	4.05		CI	17.34	2.123	1.809	2.598							64.386	32.19	
D4	4	5	7	12	4.05	4.50			18.94		0.000		49.00	14.43	34.57	59.65	38.73	1.62			
U5					4.75	5.05			20.14	2.086	1.736	2.617							112.867	56.43	
D5	3	4	5	9	5.05	5.50	5.50m		15.32		0.000		38.20	16.97	21.23	48.91	51.09	0.00			
U6					5.75	6.05	Loose gray Clayey Sand				0.000	2.618								0.00	
D6	2	2	4	6	6.05	6.50			16.73		0.000		26.30	12.00	14.30	41.08	58.92	0.00			29
U7					6.75	7.05		SC	14.93	2.115	1.840	2.652							79.300	39.65	
D7	2	3	3	6	7.05	7.50			14.96		0.000		28.20	11.09	17.11	35.74	64.26	0.00			29
U8					7.75	8.05			15.01	2.254	1.960	2.585							82.460	41.23	
D8	2	3	4	7	8.05	8.50	8.50m		14.85		0.000		27.90	13.28	14.62	37.59	62.41	0.00			30
U9					8.75	9.05			15.30	2.203	1.911	2.666							66.160	33.08	
D9	2	3	2	5	9.05	9.50	Firm to stiff gray low plasticity Clay		15.73		0.000		31.70	11.29	20.41	36.09	63.74	0.17			
U10					9.75	10.05		CL	13.96	2.246	1.971	2.590							75.280	37.64	
D10	2	2	3	5	10.05	10.50			15.25		0.000		32.50	11.15	21.35	42.14	57.86	0.00			
U11					10.75	11.05			13.58	2.199	1.936	2.735							73.600	36.80	
D11	2	6	6	12	11.05	11.50	11.50m		12.16		0.000		34.80	10.87	23.93	35.93	63.62	0.45			
U12					11.75	12.05	Medium to loose yellowish, gray		14.79	2.069	1.802	2.646							82.550	41.28	
D12	3	5	6	11	12.05	12.50	Clayey Sand	SC	14.38		0.000		29.20	13.70	15.50	46.36	53.64	0.00			31
U13					12.75	13.05			13.74	2.039	1.793	2.615							68.500	34.25	
D13	3	3	5	8	13.05	13.50	13.50m		14.85		0.000		28.00	12.63	15.37	34.01	65.99	0.00			30
U14					13.75	14.05	Very dense to medium dense yellowish		14.74	2.173	1.894	2.591							68.651	34.33	
D14	3	18	35	53	14.05	14.50	Clayey Sand		12.24		0.000		28.40	10.81	17.59	29.26	70.74	0.00			46
U15					14.75	15.05		SC	14.60	2.226	1.942	2.62							96.540	48.27	
D15	6	16	11	27	15.05	15.50	15.50m		11.92		0.000		29.20	14.58	14.62	41.81	58.19	0.00			37
U16					15.75	16.05	Very stiff yellow low plasticity Clay		14.60	2.217	1.935	2.693							157.270	78.64	
D16	5	8	15	23	16.05	16.50		CL	12.85		0.000		33.40	13.01	20.39	49.18	50.82	0.00			
U17					16.50	16.95	16.95m		12.58	2.465	2.190	2.592							152.930	76.47	
D17	8	12	17	29	16.95	17.40	Medium dense yellow, gray clayey Sand		13.27		0.000		27.30	13.50	13.80	36.70	62.96	0.34			37
U18					17.40	17.85	17.85m	SC	9.55	2.311	2.110	2.606							169.530	84.77	
D18	6	10	13	23	17.85	18.30	Very stiff yellow, gray medium plasticity Clay	CI	11.93		0.000		35.70	12.59	23.11	42.53	57.47	0.00			
U19					18.30	18.75	Hard gray medium to low plasticity		13.22	2.088	1.844	2.617							172.445	86.22	
D19	12	16	19	35	18.75	19.20	Clay	CI-CL	12.53		0.000		41.60	12.45	29.15	54.84	45.16	0.00			
U20					19.20	19.65			15.58	2.101	1.818	2.623							141.882	70.94	
D20	6	10	13	23	19.65	20.10			12.58		0.000		32.00	12.28	19.72	43.15	56.85	0.00			

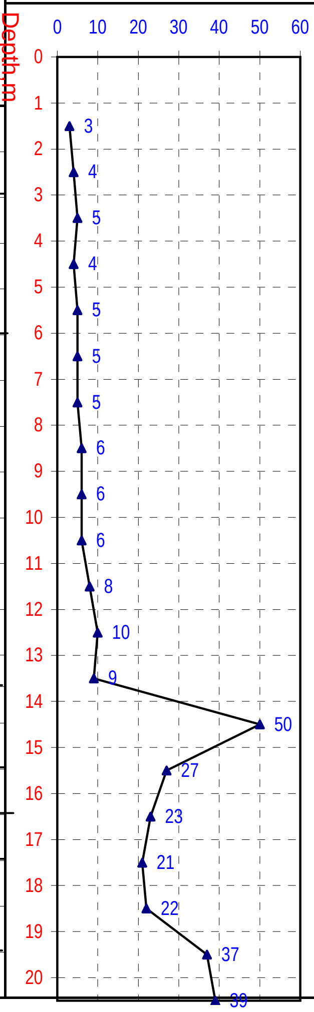
BORE HOLE LOG BH12

Owner : NJS CONSULTANTS CO.,LTD	Method :Rotary Auger	Date started : 18/02/2010
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 19/02/2010
	Elevation:7.09m	N: 1469615.142, E:382975.637
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Intake pump Station

Depth to water flow: 1.30 m
Depth to water level: 0.40 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	2.50		Loose dark-gray brown clayey Sand	1	1	2	3
D2: 1.75 -	2.50	SPT			(SC) 2.50m	1	2	2	4
D3: 2.75 -	3.50	SPT	3.00		Firm yellow-gray medium plasticity	2	2	3	5
D4: 3.75 -	4.50	SPT			Clay with gravel (CI)	2	1	3	4
D5: 4.75 -	5.50	SPT			5.50m	2	2	3	5
D6: 5.75 -	6.50	SPT	8.00		Loose yellowish, gray clayey Sand	1	2	3	5
D7: 6.75-	7.50	SPT				2	2	3	5
D8:7.75-	8.50	SPT				2	2	4	6
D9:8.75 -	9.50	SPT				2	3	3	6
D10:9.75-	10.50	SPT			(SC)	2	3	3	6
D11:10.75-	11.50	SPT				2	3	5	8
D12:11.75-	12.50	SPT				4	4	6	10
D13:12.75-	13.50	SPT			13.50m	2	4	5	9
D14:13.75-	14.50	SPT	2.00		Very dense to medium dense	2	24	26	50
D15:14.75-	15.50	SPT			yellowish, gray clayey Sand 15.50m	12	12	15	27
D16:15.75-	16.50	SPT	1.00		Very stiff brown, gray low plasticity	9	11	12	23
D17:16.75-	17.50	SPT	1.00		Medium dense gray clayey Sand	6	9	12	21
D18:17.75-	18.50	SPT	2.15		Hard gray low to medium plasticity Clay	6	10	12	22
D19:18.75-	19.50	SPT			(CI) 19.65m	9	16	21	37
D20:19.75-	20.50	SPT	1.00		Dense gray clayey Sand	10	14	25	39

END OF SPT TEST 20.50m Depth



Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

- Stiff to hard sandy clay, low plasticity Clay
- Firm to stiff medium plasticity Clay
- Very stiff to hard clay , high plasticity Clay
- Clayey sand,Silty Sand
- V. Soft to soft clay, organic clay
- Fill/topsoil
- Gravelly Sand, Clean Sand
- Clayey sand with gravel
- Fine Sand
- Weather Rock
- Standard Penetration Test (SPT) SPT
- SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia
LOCATION : Intake pump Station a lond line of N: 1469615.142, E:382975.637 Elevation:7.09m

BORE HOLE LOG BH12

SUMMARY LABORATORY TEST

Date started : 18/02/2010
Date finished : 19/02/2010
Depth to water flow: 1.30 m
Depth to water level: 0.40 m

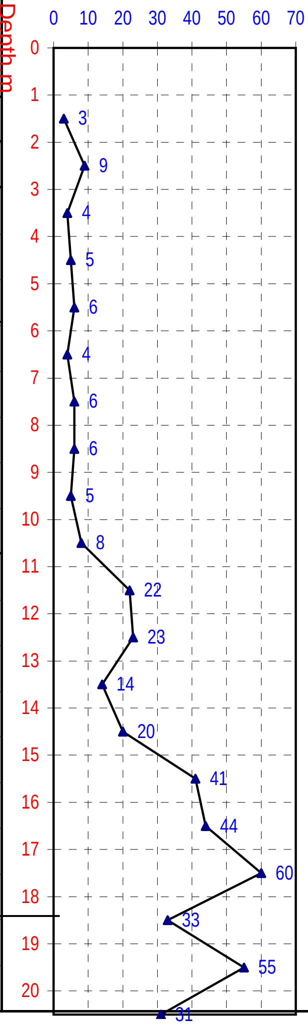
Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm³)	Dry density γ_d (g/cm³)	Specific Gravity Gs (g/cm³)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (°)
U1					0.75	1.05	Loose dark-gray brown clayey Sand		19.60	2.100	1.756	2.701							48.477	24.24	
D1	1	1	2	3	1.05	1.50		SC	17.59		0.000		28.00	12.14	15.86	35.86	59.66	4.48			28
U2					1.75	2.05			17.50	2.087	1.776	2.650							34.720	17.36	
D2	1	2	2	4	2.05	2.50	2.50m		16.96		0.000		21.20	10.29	10.91	39.5	60.50	0.00			28
U3					2.75	3.05	Firm yellow-gray medium plasticity		19.80	2.173	1.814	2.623							20.165	10.08	
D3	2	2	3	5	3.05	3.50	Clay with gravel		20.52		0.000		39.90	11.10	28.80	48.22	51.52	0.26			
U4					3.75	4.05		CI-CL	17.76	2.166	1.839	2.649							49.742	24.87	
D4	2	1	3	4	4.05	4.50			18.64		0.000		36.50	14.23	22.27	44.74	48.30	6.96			
U5					4.75	5.05			19.53	2.083	1.743	2.605							39.000	19.50	
D5	2	2	3	5	5.05	5.50	5.50m		16.50		0.000		31.70	11.83	19.87	41.49	58.51	0.00			29
U6					5.75	6.05	Loose yellowish, gray clayey Sand		16.71	2.438	2.089	2.644							68.800	34.40	
D6	1	2	3	5	6.05	6.50			16.64		0.000		29.40	13.02	16.38	37.87	62.13	0.00			29
U7					6.75	7.05			16.12	2.382	2.051	2.654							52.741	26.37	
D7	2	2	3	5	7.05	7.50			17.49		0.000		28.80	12.90	15.90	36.08	63.92	0.00			29
U8					7.75	8.05			15.23	2.214	1.921	2.606							73.248	36.62	
D8	2	2	4	6	8.05	8.50			14.74		0.000		26.80	13.30	13.50	37.44	62.56	0.00			29
U9					8.75	9.05			13.30	2.255	1.990	2.636							79.380	39.69	
D9	2	3	3	6	9.05	9.50		SC	15.29		0.000		23.70	10.57	13.13	35.01	64.99	0.00			29
U10					9.75	10.05			14.41	2.493	2.179	2.732							67.254	33.63	
D10	2	3	3	6	10.05	10.50			13.51		0.000		26.50	12.78	13.72	36.69	63.31	0.00			29
U11					10.75	11.05			13.39	2.315	2.042	2.710							84.930	42.47	
D11	2	3	5	8	11.05	11.50			14.48		0.000		23.60	11.03	12.57	38.22	61.78	0.00			30
U12					11.75	12.05			12.20	2.239	1.996	2.629							65.907	32.95	
D12	4	4	6	10	12.05	12.50			13.67		0.000		27.30	10.12	17.18	35.44	64.56	0.00			
U13					12.75	13.05			13.10	2.231	1.973	2.625							74.560	37.28	
D13	2	4	5	9	13.05	13.50	13.50m		14.15		0.000		23.80	12.18	11.62	28.14	71.71	0.15			30
U14					13.75	14.05			13.25	2.275	2.009	2.666							35.112	17.56	
D14	2	24	26	50	14.05	14.50	Very dense to medium dense	SC	12.72		0.000		21.90	12.28	9.62	29.04	70.96	0.00			45
U15					14.75	15.05	yellowish, gray clayey Sand		14.11	2.316	2.030	2.691							49.907	24.95	
D15	12	12	15	27	15.05	15.50	15.50m		12.70		0.000		25.20	12.75	12.45	34.66	64.78	0.56			37
U16					15.75	16.05	Very stiff brown, gray low plasticity	CL	16.49	2.444	2.098	2.738							103.834	51.92	
D16	9	11	12	23	16.05	16.50	Clay 16.50m		13.20		0.000		30.10	12.01	18.09	41.26	57.97	0.77			35
U17					16.50	16.95	Medium dense gray clayey Sand	SC	15.20	2.236	1.941	2.641							35.540	17.77	
D17	6	10	12	22	16.95	17.40	17.40m		13.68		0.000		25.50	13.81	11.69	32.67	67.33	0.00			35
U18					17.40	17.85	Hard gray low to medium plasticity Clay		14.05	2.215	1.942	2.666							149.940	74.97	
D18	10	14	25	39	17.85	18.30			13.50		0.000		30.00	11.71	18.29	39.97	60.03	0.00			41
U19					18.30	18.75		CL-CI	14.41	2.263	1.978	2.634							236.490	118.25	
D19	9	16	21	37	18.75	19.20			12.68		0.000		36.10	11.94	24.16	40.93	59.07	0.00			40
U20					19.20	19.65	19.65m		14.08	2.275	1.994	2.625							238.950	119.48	
D20	10	14	25	39	19.65	20.10	Dense gray clayey Sand	SC	12.46		0.000		26.50	11.93	14.57	39.71	60.29	0.00			41

BORE HOLE LOG BH13

Owner : NJS CONSULTANTS CO.,LTD	Method :Rotary Auger	Date started : 14/02/2010
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 16/02/2010
	Elevation:6.32m	N: 1468699.450, E:382834.053
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Raw Water along line option B

Depth to water flow: 0.80 m
Depth to water level: 0.40 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	1.50		Soft gray low plasticity Clay (CL) 1.50m	2	1	2	3
D2: 1.75 -	2.50	SPT	1.00		Loose brown clayey Sand (SC) 2.50m	2	4	5	9
D3: 2.75 -	3.50	SPT			Soft to firm brown, gray medium to low	1	2	2	4
D4: 3.75 -	4.50	SPT			Plasticity City Clay (CI-CL)	2	2	3	5
D5: 4.75 -	5.50	SPT	3.00		5.50m	2	3	3	6
D6: 5.75 -	6.50	SPT			Loose gray clayey Sand	2	2	2	4
D7: 6.75-	7.50	SPT				1	2	4	6
D8:7.75-	8.50	SPT			(SC)	2	3	3	6
D9:8.75 -	9.50	SPT				2	3	2	5
D10:9.75-	10.50	SPT	5.00		10.50m	3	3	5	8
D11:10.75-	11.50	SPT			Stiff to very Stiff brown, gray low plasticity	6	10	12	22
D12:11.75-	12.50	SPT	2.50		Clay (CL) 12.50m	7	10	13	23
D13:12.75-	13.50	SPT			Medium dense brown, gray clayey Sand	4	5	9	14
D14:13.75-	14.50	SPT	2.00		(SC) 14.50m	6	9	11	20
D15:14.75-	15.50	SPT			Hard yellow, gray medium to low plasticity	13	18	23	41
D16:15.75-	16.50	SPT			Clay	16	20	24	44
D17:16.75-	17.50	SPT			(CI-CL)	17	48	12	60
D18:17.75-	18.50	SPT	4.00		18.50m	8	13	20	33
D19:18.75-	19.50	SPT			Very dense to dense yellow, brown	24	40	15	55
D20:19.75-	20.50	SPT	2.00		Clayey Sand (SC)	8	13	18	31



END OF SPT TEST 20.50m Depth

Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

Stiff to hard sandy clay, low plasticity Clay	Fill/topsoil		Standard Penetration
Firm to stiff medium plasticity Clay	Gravelly Sand, Clean Sand		Test (SPT)
Very stiff to hard clay , high plasticity Clay	Clayey sand with gravel		SPT
Clayey sand,Silty Sand	Fine Sand		SPT - N Value
V. Soft to soft clay, organic clay	Weather Rock		

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia
LOCATION : Raw Water along line option B N: 1468699.450, E:382834.053 Elevation:6.32m

BORE HOLE LOG BH13

SUMMARY LABORATORY TEST

Date started : 14/02/2010
Date finished : 16/02/2010
Depth to water flow: 0.80 m
Depth to water level: 0.40 m

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm³)	Dry density γ_d (g/cm³)	Specific Gravity Gs (g/cm³)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (°)
U1					0.75	1.05	Soft gray low plasticity Clay	CL			0.000	2.700								0.00	
D1	2	1	2	3	1.05	1.50	1.50m		18.50	1.850	1.561		32.80	11.95	20.85	47.24	49.11	3.65			28
U2					1.75	2.05	Loose brown clayey Sand	SC	14.68	2.226	1.941	2.636							58.911	29.46	
D2	2	4	5	9	2.05	2.50	2.50m		13.54		0.000		21.90	10.06	11.84	35.53	64.47	0.00			30
U3					2.75	3.05					0.000	2.649								0.00	
D3	1	2	2	4	3.05	3.50	Soft to firm brown, gray medium to low		19.62		0.000		36.40	13.28	23.12	43.1	56.90	0.00			
U4					3.75	4.05	Plasticity City Clay		17.30	1.768	1.507	2.672							37.228	18.61	
D4	2	2	3	5	4.05	4.50		CI-CL	16.89		0.000		36.40	12.10	24.30	41.57	52.89	5.54			
U5					4.75	5.05			17.78	2.200	1.868	2.660							69.470	34.74	
D5	2	3	3	6	5.05	5.50	5.50m		16.96		0.000		31.70	12.11	19.59	42.45	57.55	0.00			
U6					5.75	6.05	Loose gray clayey Sand		15.68	2.133	1.844	2.662							50.093	25.05	
D6	2	2	2	4	6.05	6.50			15.73		0.000		24.90	11.83	13.07	31.03	68.97	0.00			28
U7					6.75	7.05			15.14	2.070	1.798	2.622							40.756	20.38	
D7	1	2	4	6	7.05	7.50			16.06		0.000		25.50	11.59	13.91	33.75	66.25	0.00			29
U8					7.75	8.05		SC	14.55	2.124	1.854	2.677							40.372	20.19	
D8	2	3	3	6	8.05	8.50			14.86		0.000		21.60	12.23	9.37	34.40	65.60	0.00			29
U9					8.75	9.05					0.000	2.690								0.00	
D9	2	3	2	5	9.05	9.50			16.02		0.000		30.90	10.93	19.97	39.84	60.10	0.06			29
U10					9.75	10.05	10.50m		16.97	2.124	1.816	2.660							42.270	21.14	
D10	3	3	5	8	10.05	10.50	Stiff to very Stiff brown, gray low plasticity		14.83		0.000		32.80	12.62	20.18	50.71	49.29	0.00			
U11					10.75	11.05	Clay	CL	15.70	2.165	1.871	2.646							35.878	17.94	
D11	6	10	12	22	11.05	11.50			13.04		0.000		32.90	10.87	22.03	55.06	44.94	0.00			
U12					11.75	12.05	12.05m		15.91	2.154	1.858	2.648							89.270	44.64	
D12	7	10	13	23	12.05	12.50	Medium dense brown, gray clayey Sand		12.75		0.000		28.80	9.64	19.16	45.97	54.03	0.00			
U13					12.75	13.05			14.79	2.286	1.991	2.670							84.034	42.02	
D13	4	5	9	14	13.05	13.50		SC	14.02		0.000		29.20	11.48	17.72	38.84	61.16	0.00			32
U14					13.75	14.05					0.000									0.00	
D14	6	9	11	20	14.05	14.50	14.50m		13.47		0.000		26.70	11.10	15.60	44.85	54.92	0.23			34
U15					14.75	15.05	Hard yellow, gray medium to low plasticity		17.38	2.092	1.782	2.702							139.817	69.91	
D15	13	18	23	41	15.05	15.50	Clay		15.43		0.000		42.20	11.26	30.94	63.65	36.35	0.00			42
U16					15.75	16.05			18.32	2.104	1.778	2.630							181.662	90.83	
D16	16	20	24	44	16.05	16.50			13.95		0.000		32.80	12.72	20.08	66.84	22.58	10.58			43
U17					16.50	16.95		CI-CL	15.51	2.245	1.944	2.678							159.863	79.93	
D17	17	48	12	60	16.95	17.40			13.41		0.000		33.10	10.27	22.83	49.25	40.31	10.44			49
U18					17.40	17.85			17.50	2.148	1.828	2.731							43.143	21.57	
D18	8	13	20	33	17.85	18.30			12.84		0.000		33.20	13.20	20.00	58.62	41.38	0.00			39
U19					18.30	18.75	18.75m		14.98	2.245	1.953	2.723							213.165	106.58	
D19	24	40	15	55	18.75	19.20	Very dense to dense yellow, brown		12.20		0.000		25.40	10.37	15.03	37.16	45.13	17.71			47
U20					19.20	19.65	Clayey Sand	SC	13.12	2.331	2.061	2.681							240.131	120.07	
D20	8	13	18	31	19.65	20.10			12.97		0.000		26.60	10.91	15.69	38.39	61.61	0.00			38

BORE HOLE LOG BH14

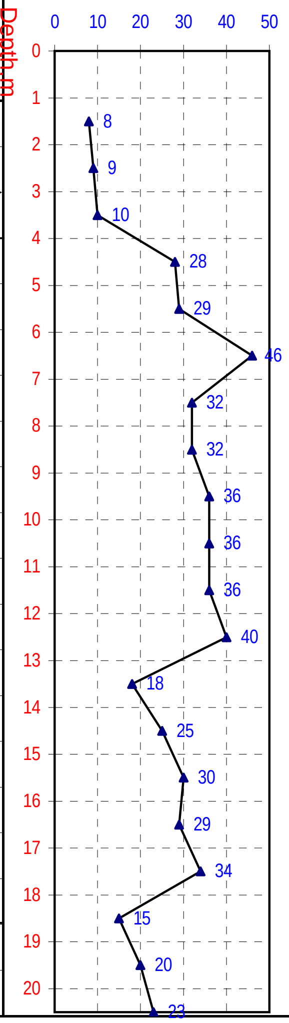
Owner : NJS CONSULTANTS CO.,LTD	Method :Rotary Auger	Date started : 23/02/2010
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm	Date finished : 23/02/2010
	Elevation:1.12m	N:1462006, E: 378209
PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia		LOCATION : Intake Chamber

Depth to water flow: + 1.60 m
Depth to water level: +1.60 m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT			Stiff red, gray high plasticity Clay,	2	3	5	8
D2: 1.75 -	2.50	SPT	3.00		Fat Clay (CH) 3.00m	2	4	5	9
D3: 2.75 -	3.50	SPT	0.50		Medium dense yellow, gray Clayey Sand	2	5	5	10
D4: 3.75 -	4.50	SPT				5	11	17	28
D5: 4.75 -	5.50	SPT			Very stiff to hard yellow, red,gray	6	12	17	29
D6: 5.75 -	6.50	SPT			medium to high plasticity Clay	10	18	28	46
D7: 6.75-	7.50	SPT				8	14	18	32
D8:7.75-	8.50	SPT				6	14	18	32
D9:8.75 -	9.50	SPT				8	18	18	36
D10:9.75-	10.50	SPT			(CH-CI)	9	14	22	36
D11:10.75-	11.50	SPT	17.80			7	16	20	36
D12:11.75-	12.50	SPT				9	18	22	40
D13:12.75-	13.50	SPT				4	8	10	18
D14:13.75-	14.50	SPT				11	13	12	25
D15:14.75-	15.50	SPT				7	13	17	30
D16:15.75-	16.50	SPT				6	13	16	29
D17:16.75-	17.50	SPT				6	14	20	34
D18:17.75-	18.50	SPT			18.30m	5	6	9	15
D19:18.75-	19.50	SPT			Medium dense yellow, gray Clayey	7	8	12	20
D20:19.75-	20.50	SPT			Sand (SC) 20.50m	6	9	14	23
					END OF SPT TEST 20.50m Depth				

SPT - N Value Blow/300mm

▲ SPT , N (Blow/300mm)



Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

Stiff to hard sandy clay, low plasticity clay
Soft to stiff medium plasticity clay
Very stiff to hard clay , high plasticity Clay
Clayey sand,Silty Sand
V. Soft to soft clay, organic clay

Fill/topsoil
Gravelly Sand, Clean Sand
Clayey sand with gravel
Fine Sand
Weather Rock

Standard Penetration Test (SPT)
U & SPT
▲ SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia

LOCATION : Intake Chamber N:1462006, E: 378209 Elevation:1.12m

BORE HOLE LOG BH14

SUMMARY LABORATORY TEST

Date tested: 01-March-2010
Depth to water flow: + 1.60
Depth to water level: +1.60

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm^3)	Dry density γ_d (g/cm^3)	Specific Gravity Gs (g/cm^3)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (°)
U1					0.75	1.05	Stiff red, gray high plasticity Clay, fat Clay		37.66	1.866	1.356	2.651							32.850	16.43	
D1	2	3	5	8	1.05	1.50		CH	17.26		0.000		66.50	16.27	50.23	54.7	43.25	2.05			
U2					1.75	2.05			19.98	2.068	1.724	2.613							66.750	33.38	
D2	2	4	5	9	2.05	2.50		CH	16.52		0.000		58.30	15.84	42.46	54.85	45.15	0.00			
U3					2.75	3.05	3.00m		17.69	2.253	1.914	2.666							22.570	11.29	
D3	2	5	5	10	3.05	3.50	Medium dense yellow, gray clayey Sand	SC	15.93		0.000		28.30	12.52	15.78	45.79	54.21	0.00			31
U4					3.75	4.05			19.16	2.138	1.794	2.631							62.330	31.17	
D4	5	11	17	28	4.05	4.50	Very stiff to hard yellow,red, gray	CH	18.38		0.000		64.70	18.98	45.72	62.63	37.37	0.00			
U5					4.75	5.05	medium to high plasticity Clay		28.78	1.988	1.544	2.589							67.701	33.85	
D5	6	12	17	29	5.05	5.50		CH	27.80		0.000		75.10	16.63	58.47	84.44	15.56	0.00			
U6					5.75	6.05			26.72	1.966	1.551	2.565							74.610	37.31	
D6	10	18	28	46	6.05	6.50		CI	22.88		0.000		48.60	16.19	32.41	78.89	21.11	0.00			
U7					6.75	7.05			26.17	1.988	1.576	2.689							228.069	114.03	
D7	8	14	18	32	7.05	7.50		CH	29.49		0.000		59.90	21.28	38.62	83.7	16.30	0.00			
U8					7.75	8.05			30.21	1.891	1.452	2.706							229.650	114.83	
D8	6	14	18	32	8.05	8.50		CH	21.20		0.000		61.80	15.44	46.36	86.08	13.21	0.71			
U9					8.75	9.05			21.48	2.070	1.704	2.591							145.780	72.89	
D9	8	18	18	36	9.05	9.50		CH	20.85		0.000		62.10	13.75	48.35	78.98	20.42	0.60			
U10					9.75	10.05			17.58	2.116	1.800	2.673							153.276	76.64	
D10	9	14	22	36	10.05	10.50		CH	17.78		0.000		51.10	14.05	37.05	62.33	37.67	0.00			
U11					10.75	11.05			18.27	2.081	1.760	2.682							128.700	64.35	
D11	7	16	20	36	11.05	11.50		CI	15.10		0.000		45.60	12.92	32.68	64.56	35.44	0.00			
U12					11.75	12.05			20.93	2.097	1.734	2.685							233.787	116.89	
D12	9	18	22	40	12.05	12.50		CH	16.59		0.000		55.90	15.48	40.42	96.13	3.87	0.00			
U13					12.75	13.05			20.53	2.067	1.715	2.665							226.370	113.19	
D13	4	8	10	18	13.05	13.50		CI	15.01		0.000		36.80	11.27	25.53	65.09	34.91	0.00			
U14					13.75	14.05			16.82	2.128	1.822	2.651							105.510	52.76	
D14	11	13	12	25	14.05	14.50		CI	13.26		0.000		36.60	12.30	24.30	67.15	32.85	0.00			
U15					14.75	15.05			17.22	2.109	1.799	2.728							52.580	26.29	
D15	7	13	17	30	15.05	15.50		CI	14.86		0.000		41.40	13.28	28.12	74.40	25.60	0.00			
U16					15.75	16.05			17.03	2.064	1.764	2.688							153.440	76.72	
D16	6	13	16	29	16.05	16.50		CI	16.93		0.000		45.90	13.39	32.51	97.06	2.94	0.00			
U17					16.50	16.95			20.54	2.118	1.757	2.634							157.390	78.70	
D17	5	6	9	34	16.95	17.40		CI	16.47		0.000		47.10	14.09	33.01	94.79	5.21	0.00			
U18					17.40	17.85			18.80	2.128	1.791	2.648							65.051	32.53	
D18	6	9	14	15	17.85	18.30	18.30m	CI	18.39		0.000		45.50	16.39	29.11	75.53	24.47	0.00			
U19					18.30	18.75	Medium dense yellowish, light-gray		15.89	2.240	1.933	2.677							36.460	18.23	
D19	7	8	12	20	18.75	19.20	Clayey Sand	SC	15.60		0.000		24.00	18.43	5.57	35.28	63.25	1.47			34
U20					19.20	19.65					0.000									0.00	
D20	6	9	14	23	19.65	20.10		SC	13.83	2.250	1.977		27.10	16.57	10.53	39.17	60.83	0.00			35

BORE HOLE LOG BH15

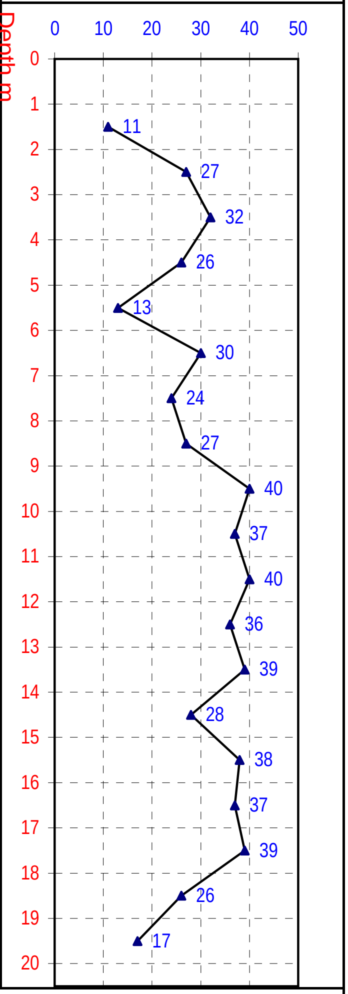
Owner : NJS CONSULTANTS CO.,LTD	Method :Rotary Auger
Contractor: Partner of Construction and Development Services Inc.	Casing Size : 180 mm
	Elevation:1.197m
Date started : 25/02/2010	Date finished : 26/02/2010
N:1460658, E: 382766	LOCATION : Intake Chamber

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion Project in The Kingdom of Cambodia

Depth to water flow: +1.45m

Depth to water level:+1.45m

Sampling Depth, m From	To	Type of Sampling U / SPT	Thickness, (m)	Legend	Description of soil	SPT - N Value Blow/300mm N1=150mm	N2=300mm	N3=450mm	N=N2+N3
D1: 0.75-	1.50	SPT	1.50		Stiff reddish, gray medium plasticity Clay	3	4	7	11
D2: 1.75 -	2.50	SPT	2.50		Very stiff reddish, gray high plasticity	4	10	17	27
D3: 2.75 -	3.50	SPT	3.00		Hard to stiff reddish, gray medium	7	14	18	32
D4: 3.75 -	4.50	SPT			Plasticity Clay (CI)	5	10	16	26
D5: 4.75 -	5.50	SPT			5.50m	5	5	8	13
D6: 5.75 -	6.50	SPT	5.00		Hard yellow, reddish, gray high	6	13	17	30
D7: 6.75-	7.50	SPT			plasticity Clay	6	9	15	24
D8:7.75-	8.50	SPT			(CH)	6	12	15	27
D9:8.75 -	9.50	SPT				7	18	22	40
D10:9.75-	10.50	SPT			10.50m	7	15	22	37
D11:10.75-	11.50	SPT	2.00		Hard yellow-gray medium plasticity	8	18	22	40
D12:11.75-	12.50	SPT			Clay (CI) 12.50m	7	16	20	36
D13:12.75-	13.50	SPT	4.90		Hard yellow-gray high plasticity Clay	6	15	24	39
D14:13.75-	14.50	SPT				8	12	16	28
D15:14.75-	15.50	SPT			(CH)	8	16	22	38
D16:15.75-	16.50	SPT				8	15	22	37
D17:16.75-	17.50	SPT			17.40m	7	16	23	39
D18:17.75-	18.50	SPT	2.10		Very stiff yellow, gray medium plasticity	7	12	14	26
D19:18.75-	19.50	SPT			Clay	4	7	10	17
					END OF SPT TEST 19.50m Depth				



Consistency: N-Value for Clay Blows/30Cm

Very Soft-Less 2blows, Soft-2-4blows, Firm-4-8blows, Stiff-8-15, Very Stiff-15-30blows, Hard >30blows

Relative Density: N-Value for Sand Blows/30cm

Very loose- Less 4blows, Loose- 4-10 blows, Medium dense-10-30 blows, Dense-8-15 blows, Very dense->50 blows

LEGEND

- Stiff to hard sandy clay, low plasticity Clay
- Firm to stiff medium plasticity clay
- Very stiff to hard clay , high plasticity Clay
- Clayey sand,Silty Sand
- V. Soft to soft clay, organic clay
- Fill/topsoil
- Gravelly Sand, Clean Sand
- Clayey sand with gravel
- Fine Sand
- Weather Rock

Standard Penetration Test (SPT)

U & SPT

SPT - N Value

PROJECT : The preparatory Study on the Siem Reap Water Supply Expansion
Project in The Kingdom of Cambodia
LOCATION : Intake Chamber N:1460658, E: 382766 Elevation:1.197m

BORE HOLE LOG BH15

SUMMARY LABORATORY TEST

Date started : 25/02/2010
Date finished : 26/02/2010
Depth to water flow: +1.45m 0.00 m
Depth to water level:+1.45m 0.00 m

Sample	SPT - N Value Blows / 300mm				Depth(m)		Soil description	Unified Clasification	NMC W (%)	Bulk density γ_w (g/cm³)	Dry density γ_d (g/cm³)	Specific Gravity Gs (g/cm³)	Atterberg limit			Grain size			Unconf. Strength q_u (Kpa)	Shear Strength	
	N1	N2	N3	N=N2+N3	From	To							LL (%)	PL (%)	PI (%)	Clay and Silt %	Sand %	Gravel %		Cohesion Kpa	Friction Angle Degree (°)
U1					0.75	1.05	Stiff reddish, gray medium plasticity Clay	CI	35.65	1.890	1.393	2.685							36.123	18.06	
D1	3	4	7	11	1.05	1.50	1.50m		19.79		0.000		41.90	18.46	23.44	89.20	10.80	0.00			
U2					1.75	2.05	Very stiff reddish, gray high plasticity	CH	20.87	2.088	1.727	2.601							189.160	94.58	
D2	4	10	17	27	2.05	2.50	Clay 2.50m		19.82		0.000		51.20	18.04	33.16	83.80	16.20	0.00			
U3					2.75	3.05	Hard to stiff reddish, gray medium		24.41	2.110	1.696	2.656							205.289	102.64	
D3	7	14	18	32	3.05	3.50	Plasticity Clay		18.03		0.000		39.50	14.47	25.03	89.78	10.22	0.00			
U4					3.75	4.05		CI	16.85	2.137	1.829	2.607							152.350	76.18	
D4	5	10	16	26	4.05	4.50			15.76		0.000		43.70	13.28	30.42	95.04	4.96	0.00			
U5					4.75	5.05			20.01	2.196	1.830	2.563							86.000	43.00	
D5	5	5	8	13	5.05	5.50	5.50m		14.46		0.000		40.90	13.60	27.30	46.99	53.01	0.00			
U6					5.75	6.05			22.55	2.066	1.686	2.551							130.173	65.09	
D6	6	13	17	30	6.05	6.50	Hard yellow, reddish, gray high		17.85		0.000		64.90	21.15	43.75	85.07	14.93	0.00			
U7					6.75	7.05	plasticity Clay		28.36	1.948	1.518	2.691							109.810	54.91	
D7	6	9	15	24	7.05	7.50			25.08		0.000		61.70	21.35	40.35	85.71	14.29	0.00			
U8					7.75	8.05		CH	34.50	2.020	1.502	2.659							135.147	67.57	
D8	6	12	15	27	8.05	8.50			26.15		0.000		65.00	16.67	48.33	82.92	17.08	0.00			
U9					8.75	9.05			24.90	2.029	1.624	2.578							232.682	116.34	
D9	7	18	22	40	9.05	9.50			24.85		0.000		69.00	15.34	53.66	84.18	15.82	0.00			
U10					9.75	10.05			21.14	2.028	1.674	2.584							398.440	199.22	
D10	7	15	22	37	10.05	10.50	10.50m		15.94		0.000		56.90	16.09	40.81	46.79	53.21	0.00			
U11					10.75	11.05	Hard yellow-gray medium plasticity		20.45	1.982	1.645	2.704							360.265	180.13	
D11	8	18	22	40	11.05	11.50	Clay	CI	18.12		0.000		34.70	13.36	21.34	55.20	44.80	0.00			
U12					11.75	12.05			20.78	2.014	1.667	2.661							116.537	58.27	
D12	7	16	20	36	12.05	12.50	12.50m		16.43		0.000		46.10	16.35	29.75	69.80	30.20	0.00			
U13					12.75	13.05			19.88	1.843	1.537	2.667							132.244	66.12	
D13	6	15	24	39	13.05	13.50	Hard yellow-gray high plasticity Clay		18.84		0.000		56.90	15.81	41.09	72.06	27.94	0.00			
U14					13.75	14.05			15.63	2.035	1.760	2.638							240.850	120.43	
D14	8	12	16	28	14.05	14.50			15.26		0.000		52.20	17.08	35.12	67.39	32.61	0.00			
U15					14.75	15.05		CH	18.58	2.032	1.714	2.684							221.091	110.55	
D15	8	16	22	38	15.05	15.50			15.33		0.000		49.40	14.03	35.37	77.33	22.67	0.00			
U16					15.75	16.05			21.45	2.09	1.717	2.632							227.808	113.90	
D16	8	15	22	37	16.05	16.50			18.90		0.000		69.20	17.71	51.49	98.91	1.09	0.00			
U17					16.50	16.95			25.29	2.049	1.635	2.617							220.360	110.18	
D17	7	16	23	39	16.95	17.40	17.40m		19.53		0.000		68.80	16.45	52.35	94.56	5.44	0.00			
U18					17.40	17.85	Very stiff yellow, gray medium plasticity		26.40	1.972	1.560	2.658							203.010	101.51	
D18	7	12	14	26	17.85	18.30	Clay		20.90		0.000		46.20	13.90	32.30	92.85	7.15	0.00			
U19					18.30	18.75		CI-CL	22.09	2.054	1.682	2.638							144.311	72.16	
D19	4	7	10	17	18.75	19.20			17.58		0.000		29.40	13.09	16.31	71.06	28.94	0.00			
U20					19.20	19.65			23.46	1.953	1.582	2.636							15.685	7.84	

SR 4.7 Mechanical & Electrical Equipment List for Intake Facilities

SR 4.7.1 Mechanical Equipment List For Intake Facilities

Intake Pump station; Priority Project 33,000m3/day, Future 33,000m3/day, Total 66,000m3/day

Facility/Equipment	Tag No.	Specification	Power (kW)	Q'ty Priority Project Duty	Q'ty Priority Project St'db	Q'ty Future Duty	Q'ty Future St'db	Q'ty Total Duty	Q'ty Total St'db	Q'ty Total Total	Remarks
01. Intake Facility											
Inflow Gate	01HG11/21	Hand operated Sluice Gate 1.2mW x 1.2mH	-	4	0	0	0	4	0	4	Spindle L=15m, include Gate at Intake Chamber
Suction Valve	01HV11 to 21	DN 800 Manually operated Sluice valve	-	2	0	0	0	2	0	2	
Suction Valve	01HV11 to 51	DN 300 Manually operated Sluice valve	-	2	1	2	0	4	1	5	
Raw Water Pump	01RP11 to 31	Horizontal Double Volute Centrifugal (VSD, split casing) 11.5 m3/min x 26m	68	2	1	2	0	4	1	5	
Check Valve	01CV11 to 31	DN 300 Swing check	-	2	1	2	0	4	1	5	
Discharge Valve	01MV11 to 31	Motorized Butterfly Dia.300mm	0.2	2	1	2	0	4	1	5	
Discharge Valve	01MV11 to 31	Manuaaly Butterfly Dia.300mm	-	2	1	2	0	4	1	5	
Isolate Valve	01HV13 to 63	Manuaaly Butterfly Dia.800mm	-	4	0	2	0	6	0	6	
Sump Drainage Pump	01DP11 to 41	Submersible 0.3m3/min x 15m	2.2	2	2	0	0	2	2	4	
Floor Drainage Pump	01DP11 to 21	Submersible 0.3m3/min x 20m	4	1	1	0	0	1	1	2	
Isolate Gate	01HG12	Hand operated Sluice 1.8mW x 1.8mH	-	1	0	0	0	1	0	1	
Monorail Hoist	01MC01	Motorized bridge crane 3ton	-	1	0	0	0	1	0	1	
Overhead Crane(1)	01HC01	Motorized bridge crane 3ton	3	1	0	0	0	1	0	1	

SR 4.7.2 Electrical Equipment List for Intake Facilities

Plant Electrical Works -Intake Pump Station			Priority Project		Future	
	Item	Details	Nr.		Nr.	
1	HV Power Receiving Panel	22kV VCB	2			
2	HV CT, VT Panel	22kV	2			
3	HV Bus-tie Panel	22kV VCB	1			
4	Bus Duct	22kV	1			
5	HV Tr Primary Panel	22kV VCB	1		1	
6	Power Transformer	500kVA Mold	1		1	
7	LV Panel	MCC Type	3		2	
8	Pump Starter Panel	68kW 400V Inverter	3		2	
9	Motor Control Center	400V Form3b	3		1	
10	Local Control Panel	Stand Type	6		2	
11	UPS	1hr 5kVA	1			
12	DC Unit	30min	1			
13	Intake Flow	Electromagnetic Type	1		1	
14	Water Level	Ultrasonic Type	4			
15	Water Quality	Turbidity, pH	2			
16	IP Panel		1			
17	IP Panel	(modification)			1	
18	PLC Panel		1			
19	PLC Panel	(modification)			1	
20	Monitoring Panel		1			
21	Monitoring Panel	(modification)			1	
22	Incoming Cable	Duty, Stand-by 22kV	2			
23	Optic Fiber Cable	with data communication sys.	1			

SR 4.8 Alternative of Raw Water Intake Pump Unit

1. Alternative of Raw Water Pump Unit

A comparison of pump unit for Priority Project is shown below. Total Cost comparison of Case1 and Case2 is almost same. Case 1 has advantage which more than 50% of raw water can be supplied to WTP if two pumps were out of order in the unexpected worst – case condition.

Thus Case 1 is recommended in Intake Pump Station.

(Priority Project)	Case 1	Case 2
Pump units	Duty 2 unit Standby 1unit	Duty 1 unit Standby 1unit
Pump capacity per unit	11.5m3/min x 26m x 68kW	23m3/min x 26m x 140kW
Total Installation Load (not include standby)	136kW	140kW
Operation time	24hr	24hr
Initial Equipment Cost ($)	45,800$/unit x 3units = 137,400 $	63,000$/unit x 2units = 126,000 $
A) Depreciation Cost ($/year)	8,200$/year	7,500$/year
B) Power Cost (Not consider VSD)	136kW x 0.1968$/kwh x 24hr x 365 = 234,400$/yaer	140kW x 0.1968$/kwh x 24hr x 365 = 241,300$/yaer
C) Maintenance Cost (Assump.3%/year of Equipment cost)	4,100$/year	3,700$/year
A)+B)+C) Total Cost Comparison	**246,700$/year (100%)**	**252,500$/year (102%)**
Capacity in case one pump is out of order	100% flow	100% flow
Capacity in case two pumps is out of order	**50% flow good**	**0% flow Not good**
Pump room Area	A little larger area	

A comparison of pump unit for Future is shown below. Total Cost comparison of Case1 and Case2 is almost same. Case 1 has advantage which more than 75% of raw water can be supplied to WTP if two pumps were out of order in the unexpected worst – case condition.

Comprehensively Case 1 is recommended in Intake Pump Station .

(Future)	Case1	Case2
Pump units	Duty 4 unit Standby 1unit	Duty 2 unit Standby 1unit
Pump capacity per unit	11.5m3/min x 26m x 68kW	23m3/min x 26m x 140kW
Total Installation Load (not include standby)	272kW	280kW
Operation time	24hr	24hr

Initial Equipment Cost ($)	45,800$/unit x 5units = 229,000$	63,000$/unit x 3units = 189,000 $
A) Depreciation Cost ($/year)	13,700$/year	11,300$/year
B) Power Cost (Not consider VSD)	272kW x 0.1968$/kwh x 24hr x 365 = 468,800$/yaer	280kW x 0.1968$/kwh x 24hr x 365 = 482,700$/yaer
C) Maintenance Cost (Assump.3%/year of Equipment cost)	6,800$/year	5.700$/year
A)+B)+C) Total Cost Comparison	**489,300$/year (100%)**	**499,700$/year (102%)**
Capacity in case one pump is out of order	100% flow	100% flow
Capacity in case two pumps is out of order	**75% flow better**	**50% flow good**
Pump room Area	A little larger area	

SR 4.9 Pump Calculation Sheet for Intake Facilities

Raw Water Intake Pump (Priority Project; 33,000 m3/day)

				case1	case2		
1	Equip. No.			case1	case2		
	Pump Name						
2	Pump Type			Double suction	Double suction		
3	q : Capacity (m3/min)			11.5	23		
4	N : Operation number			2	1		
	Pump			VSD	VSD		
	Pump Number			2D + 1S	1D + 1S		
	Total Head H=ha+hf1+hf2+hf3+hf4						
5	ha	:Actual head (m)		20.2	20.2		
		=DWL-SWL					
6	DWL	(m) WTP Distribution Chamber		19.500	19.500		
7	SWL	(m)		-0.720	-0.720		
8	hf1	: Straight pipe loss (m) =		3.051	3.051		
		(10.666 x Q^1.85) x L x Cc					
		(C^1.85xD^4.87)					
9	Q	: Flow (m3/sec)		0.383	0.383		
		=q x N/60					
10	C	: Coefficient		110	110		
		LWL: 110					
		HWL: 140					
11	D	: Pipe Dia. (m)		0.8	0.8		
12	L	: Pipe length (m)		3400	3400		
13	Cc	: Correction coefficient		1.0	1.0		
		Water: 1.0					
		Sludge: WT99.2% :					
14	hf2			0.000	0.000		
15	hf3	: Pump around loss (m)		2	2		
		Horizontal type : 2.0m					
		Submersible type : 0.7m					
16	hf4	:Other head		0	0		
17	H'	=ha+hf1+hf2+hf3+hf4 (m)		25.27	25.27		
18	H	: Total head (m)		26.0	26.0		
		Velocity		0.76	0.76		
	Motor Power						
19	BKW	=0.163*SG*q*H/Pe (kW)		58.719	117.439		
20	SG	:Specific gravity		1.0	1.0		
21	Pe	:Pump efficiency		0.83	0.83		
22	kW	=BKW x C		67.527	135.054		
23	C	:Coefficient (1.15)		1.15	1.15		
24	Motor Power (kW)			68	140		

SR 4.10 Capacity Calculation for Water Treatment Plant

Item	Phase I					Phase II				
Production Capacity	Q=	30,000	cu m/day		(Daily Max)	Q=	60,000	cu m/day		
Plant Capacity	=	33,000	cu m/day		(Prod. Cap. +10%)	=	66,000	cu m/day		(Prod. Cap. +10%)
	=	1,375	cu m/hour			=	2,750	cu m/hour		
	=	22.9	cu m/min			=	45.8	cu m/min		
	=	0.382	cu m/sec			=	0.764	cu m/sec		
(1) Receiving Well										
Criteria	Retention Time		T =	1.5	min	Retention Time		T =	1.5	min
	Recirculation		a =	0.0	%	Recirculation		a =	0.0	%
Dimension	Rectangular		1	units		Rectangular		1	units	
	L m x	W m x	D m	x units		L m x	W m x	D m	x units	
	4.4	3.0	4.0	1		4.4	3.0	4.0	2	
	V=	52.8	cu m			V=	105.6	cu m		
Retention Time	T=	2.3	min			T=	2.3	min		
	Overflow weir length:		5.0	m		Overflow weir length:		5.0	m	
	Ovedrflow depth h=		0.169	m	$h=(Q/1.84/B)^{2/}$	Ovedrflow depth h=		0.268	m	$h=(Q/1.84/B)^{2/3}$
(2) Mixing Chamber										
Criteria	Retention Time	T=		1 - 5	min	Retention Time	T=		1 - 5	min
	Recirculation	a =		0.0	%	Recirculation	a =		0.0	%
Dimension	Rectangular		2	units		Rectangular		4	units	
	L m x	W m x	D m	x units		L m x	W m x	D m	x units	
	2.5	2.0	3.86	2		2.5	2.0	3.86	4	
Unit Volume	UV =	19.3	cu m/unit			UV =	19.3	cu m/unit		
Total Volume	V =	39	cu m			V =	77	cu m		
Retention Time	t =	1.7	min			t =	1.7	min		
Mixing	Hydraulic Mixing					Hydraulic Mixing				
						In case inflow be dobled.				
Hydraulic Mixing by Weir	Width =	1.5	m			Width =	1.5	m		$Q=1.84Bh^{3/2}$
Over flow depth	h =	0.172	m (refer to the hydraulic caluculation)			h =	0.129	m		$h=(Q/1.84/B)^{2/3}$
G value	G=	351	s^{-1} > 350							
$G=(H\cdot\rho\cdot Q\cdot g/(V\cdot\mu))^{0.5}$	H=	860	mm							
viscosity	μ =	0.898	kg/m/s x 10-3	(25 degree)			0.000			
s.g. of water	ρ =	997.1	kg/m3							
	g =	9.8	m/s2							

SR 4.10 Capacity Calculation for Water Treatment Plant

Item	Phase I						Phase II				
(3) Flocculator											
Criteria	Retention Time		T =	20 - 40	min		Retention Time		T =	20 - 40	min
	Recirculation		a =	0	%		Recirculation		a =	0	%
	Required Volume		V =	458	cu.m to		Required Volume		V =	917	cu.m to
				917	cu.m					1,833	cu.m
	Required G value		G =	10 - 70	s-1						
		Gt =	15,000 - 112,500								
			55,176								
Unit Flow	q =	11.5	cu m/min/basin				q =	11.5	cu m/min/basin		
Dimension		2	units		G value			4	units		
Step 1	W m	x L m	x D m	x No.of Channel			W m	x L m	x D m	x No.of Channel	
	1.1	8.0	3.6	2		70	1.1	8.0	3.6	2	
Step 2	W m	x L m	x D m	x No.of Channel			W m	x L m	x D m	x No.of Channel	
	1.5	8.0	3.65	2		40	1.5	8.0	3.65	2	
Step 3	W m	x L m	x D m	x No.of Channel			W m	x L m	x D m	x No.of Channel	
	1.9	8.0	3.7	2		10	1.9	8.0	3.7	2	
Volume	Step 1		63.4	cu m/unit			Step 1		63.4	cu m/unit	
	Step 2		87.6	cu m/unit			Step 2		87.6	cu m/unit	47.36
	Step 3		112.5	cu m/unit			Step 3		112.5	cu m/unit	
	Volume / Unit		263.4	cu m/unit			Volume / Unit		263.4	cu m/unit	
Total Volume	V =	527	cu m				V =	1,054	cu m		
Retention Time		23.0	minutes					23.0	minutes		
Overall head loss	H = G2·V·μ/(ρ·Q·g)	G =		40	s-1					14429	380
	=	0.203	m							86573	

SR 4.10 Capacity Calculation for Water Treatment Plant

Item	Phase I				Phase II			
(4) Seddimentation Basin								
Type	Rectangular, Horizontal Flow				Rectangular, Horizontal Flow			
Unit Flow	q =	688	cu m/hr/basin		q =	688	cu m/hr/basin	
Criteria	Retention Time	T =	2.5	hours	Retention Time	T =	2.5	hours
	Surface Load	a =	15 - 30	mm/min	Surface Load	a =	15 - 30	mm/min
	Hor. Flow Velocity	v <	0.40	m/min	Hor. Flow Velocity	v <	0.4	m/min
	L/W Ratio	L/W =	3 - 8	times	L/W Ratio	L/W =	3 - 8	times
	Depth	D =	3 - 4	m	Depth	D =	3 - 4	m
	Depth of 30 cm or more is provided for sludge settlement.				Depth of 30 cm or more is provided for sludge settlement.			
Dimension	No.	2	basins		No.	4	basins	
	W m	x L m	x D m	x N	W m	x L m	x D m	x N
	8.0	60	4.0	2	8.0	60.0	4.0	4
Per Basin								
Volume	V =	1920	cu m/basin		V =	1,920	cu m/basin	
Retention Time	T =	2.8	hours		T =	2.8	hours	
L/W Ratio	L/W =	7.5		In case of 1 train stoped.	L/W =	7.5		
Surface Load	a =	23.9	mm/min	36 mm/min	a =	23.9	mm/min	
Hor. Flow Velocity	v =	0.358	m/min		v =	0.358	m/min	
Overflow Weir	Load =	400	m3/m/day		Load =	400	m3/m/day	
Trough Length	L =	21	m or longer	41	L =	41	m or longer	83
	No.	5	troughs per basin		No.	5	troughs per basin	
	L m	x N			L m	x N		
Per Basin	6.0	4	per basin		6.0	5		
Total per basin	L =	24.0	m	344 m3/m/day	L =	30.0	m	
Sludge Removal	Manual Washing with Pressured Water				Manual Washing with Pressured Water			

SR 4.10 Capacity Calculation for Water Treatment Plant

Item	Phase I	Phase II
(5) Rapid Sand Filter		
Type	Down Flow, Single Media	Down Flow, Single Media
No.	4 units	8 units
Unit Flow	q = 8,250 cu m/day/unit	q = 8,250 cu m/day/unit
Criteria	Filtration Rate Fr = 120 m/day	Filtration Rate Fr = 120 m/day
	= 5.0 m/hour	= 5.0 m/hour
	Filter Area per Unit A < 150 sq m	Filter Area per Unit A < 150 sq m
Dimension	W m x L m x N units	W m x L m x N units
	8.0 x 8.5 x 4	8.0 x 8.5 x 8
Unit Filtration Area	A = 68.0 sq m/unit	A = 68.0 sq m/unit
Filtration Rate	Fr = 121.3 m/day	Fr = 121.3 m/day
Filtration Rate	Fr'= 161.8 m/day 17.000 m3/min	Fr'= 138.7 m/day
during washing	1 unit out of 4 is washing	1 unit out of 6 is washing
Filter Washing		
Frequency	Once a day for each filter	Once a day for each filter
Rate	Air scoring rate = 1.00 m3/m2/min	Air scoring rate = 1.00 m3/m2/min
	duration = 5 min	duration = 5 min
	Backwashing rate = 0.25 m3/m2/min	Backwashing rate = 0.25 m3/m2/min
	duration = 10 min	duration = 10 min
	rate per filter = 17.00 m3/min	rate per filter = 17.00 m3/min
	0.28 m3/sec	0.28 m3/sec
Water Amount	Loss of settled water 0.0 m3	Loss of settled water 0.0 m3
for washing	Backwashing amount Vb = 170 cu m/unit	Backwashing Vb = 170.0 cu m/unit
	Vs + Vb = 170 cu m/unit	Vs + Vb = 170 cu m/unit
for Total Units	Total Amount for Washing Water 680 cu m/day	Total Amount for Washing Water 1,360 cu m/day
	Percentage for Planned Flow 2.1 %	Percentage for Planned Flow 2.1 %
Solid Amount	So = Q*K*(T1-T2)*10^-6	
in Wastewater	where So:Sludge dry weight(ton)	
(ton-DS)	Q :Treated water amount(m3/d)	
	K :Coefficient converting turbidity	
	to SS (0.8-1.5 ->>1.2)	
	T1 :Turbidity before filter (ave= 5)	
	T2 :Turbidity after filter (ave = 0)	
	So = 0.20 ton-DS/day	So = 0.40 ton-DS/day
SS Contents	s = 291 mg/l	s = 291 mg/l

SR 4.10 Capacity Calculation for Water Treatment Plant

Item	Phase I	Phase II
(6) Backwash Water Tank	(will be constrcuted besides the filter tanks.)	
Required Bacakwash	Backwashing amount Vb = 170 cu m/unit	*Backwash tank is continuously replenished by fitered water.
	adding 20% allowance= vb120% = 204 cu m/unit	*Computation is only for reference.
Dimensions	W m x L m x D m No. of tank	
	6.5 15.5 2.10 1	
Volume	V= 212 m3	
Refill time after washing	t= 7.4 min*	
	Inflow (filtered) amount= 22.92 cu m/min	
(7) Air Scoring Blower		
No. of Pump	N= 2 units + 1 for stand-by	N= 2 units + 1 for stand-by
Required Capacity	TQ = 68.0 cu m/min	TQ = 68.0 cu m/min
Capacity per Unit	Q = 34.0 cu m/min/unit	Q = 34.0 cu m/min/unit
Specification	Capacity Q = 34.0 cu m/min	Capacity Q = 34.0 cu m/min
	Diameter D = 490 mm	Diameter D = 500 mm
	Head H = 30 m	Head H = 30 m
(8) Backwash Water Recycle Pump		
No. of Pump	N= 2 units + 1 for stand-by	N= 2 units + 0 for stand-by
Required Amount	TQ = 170 m3 (for 10min backwash)	TQ = 170.0 cu m (for 10min backwash)
Tranmission period	T= 4.0 hrs	T= 4.0 hrs
Capacity per Unit	Q = 0.78 cu m/min/unit (10% allowance)	Q = 0.78 cu m/min/unit (10% allowance)
Specification	Capacity Q = 0.78 cu m/min	Capacity Q = 0.78 cu m/min
	Diameter (assumption) D = 100 mm	Diameter D = 100 mm
	Head (assumption) H = 12 m	Head H = 12 m
	Motor Output P = 2.0 KW	Motor Output P = 2.0 KW
(9) Clear Water Reservoir		
Criteria	Retention Time T > 8.0 hours	Retention Time T > 8.0 hours
Required Volume	V = 11,000 cu m	V = 22,000 cu m
Washwater	170 cu m	
TTL volume	V = 11,170 cu m	
Dimension	No. 4 units	No. 8 units
	L m x W m x D m m x N units	L m x W m x D m m x N units
	12.0 48.0 5.0 4	12.0 48.0 5.0 8
Total Volume	V = 11,520 cu m	V = 23,040 cu m
Retention Time	T = 8.38 hours	T = 8.38 hours

SR 4.10 Capacity Calculation for Water Treatment Plant

Item	Phase I	Phase II
(10) Elevated Water Tank		
Criteria	Retention Time T > 1.5 hours	Retention Time T > 1.5 hours
Required Volume	V = 2,100 cu m	V = 4,100 cu m
Washwater	170 cu m	
TTL volume	V = 2,270 cu m	V = 4,100 cu m
Dimension	No. 1 units	No. 2 units
	Dia H m x Dia L m x High m m x N units	L m x W m x D m m x N units
Dia. for H.W.L	25.6 7.0 1 514	26.0 12.5 2
Dia. for L.W.L	9.5 71	9.5 3.5
Space for Staircase	2.4 7.0 5	2.0 9.5 9.0
Total Volume	V = 2,002 cu m	V = 4,311 cu m
Retention Time	T = 1.50 hours	T = 1.57 hours
(11) Alum Dissolving Tank	Chemical Building wll be sized to cater for the future chemical requirements of Phase 1, Stage2.	
Coagulant	Solid Aluminum Sulphate (Al2(SO4)3)	Solid Aluminum Sulphate (Al2(SO4)3)
	containing 15 % Al2-O3	containing 15 % Al2-O3
	Dosage Rate :	Dosage Rate :
Criteria	Max. 60 mg-solid alum/l	Max. 60 mg-solid alum/l
	Ave. 15 mg/l	Ave. 15 mg/l
	Min. 10	Min. 10
	Coagulant Solution : 10 % sg = 1.0525	Coagulant Solution : 10 % sg = 1.0525
	Retention Time 24 hours (Max dosage)	Retention Time 24 hours
	Dissolving Time 2 hours	Dissolving Time 2 hours
Dosage Amount	Wt = 1,980 kg-Alum/day (Max dosage)	Wt = 3,960 kg-Alum/day (Max dosage)
Coagulant Solution	V = 18.8 cu m/day (Max dosage)	V = 37.6 cu m/day (Max dosage)
Solution Tank	Square 2 units (alternative use for Stage 1)	Square 4 units 26.128 l/min
Dimension	L m x W m x D m x units	L m x W m x D m x units
	2.0 2.0 2.5 2	2.0 2.0 2.5 4
Total Volume	V = 20.0 cu m	V = 40.0 cu m
Retention Time	T = 25.5 hours (for max. dosage)	T = 25.5 hours (for max. dosage)
Storage Volume	Period 30 days (for average dosage)	Period 30 days (for average dosage)

SR 4.10 Capacity Calculation for Water Treatment Plant

Item	Phase I				Phase II			
	Bulk s. g.	0.60			Bulk s. g.	0.60		
Storage Area	A =	12	m2 at	2.0 m height	A =	25	m2 at	2.0 m height
Construction scheme	4 tanks will be constructed while 2 sets of equipment will be installed in Phase I.							
(12) Lime Dissolving Tank	Chemical Building wll be sized to cater for the future chemical requirements of Phase 1, Stage2.							
pH Control Chemical	Hydrated Lime ($Ca(OH)_2$)				Hydrated Lime ($Ca(OH)_2$)			
1) Pre-pH Control	containing 72 % CaO				containing 72 % CaO			
Dosage Criteria	Max.	30	mg-solid Lime/l		Max.	30	mg-solid Lime/l	
	Ave.	10	mg/l		Ave.	10	mg/l	
	Min.	5			Min.	5		
	Lime Solution	10	% sg =	1.0607	Lime Solution	10	% sg =	1.0607
	Retention Time	24	hours	(Max dosage)	Retention Time	24	hours	(Max dosage)
	Dissolving Time	2	hours		Dissolving Time	2	hours	
Dosage Amount	Wtpre =	990	kg-lime/day	(Max dosage)	Wtpre =	1,980	kg-lime/day	(Max dosage)

SR 4.10 Capacity Calculation for Water Treatment Plant

Item	Phase I					Phase II				
Lime Solution	Vpre =	9.3	cu m/day	(Max dosage)		Vpre =	18.7	cu m/day	(Max dosage)	
2) Post pH Conrol										
Dosage Criteria	Max.	30	mg-solid Lime/l			Max.	30	mg-solid Lime/l		
	Ave.	5	mg/l			Ave.	5	mg/l		
	Min.	5				Min.	5			
	Lime Solution	10	%	sg =	1.0607	Lime Solution	10	%	sg =	1.0607
	Retention Time	24	hours		(Max dosage)	Retention Time	24	hours		(Max dosage)
	Dissolving Time	2	hours			Dissolving Time	2	hours		
	Storage period	30	days (for average dosage)			Storage period	30	days (for average dosage)		
Dosage Amount	Wtpost =	990	kg-lime/day	(Max dosage)		Wtpost =	1,980	kg-lime/day	(Max dosage)	
Lime Solution	Vpost =	9.3	cu m/day	(Max dosage)		Vpost =	18.7	cu m/day	(Max dosage)	
3) Pre+Post TTL										
Dosage Amount	Wt =	1,980	kg-lime/day	(Max dosage)		Wt =	3,960	kg-lime/day	(Max dosage)	
	V =	19	cu m/day	(Max dosage)		V =	37	cu m/day	(Max dosage)	
	Square	2	units	(alternative use for Stage 1)		Square	4	units	25.9	l/min
Dimension	L m x W	m x D m	x units			L m x W	m x D m	x units		
	2.0	2.0	2.5	2		2.0	2.0	2.5	4	
Total Volume	V =	20.0	cu m			V =	40.0	cu m		
Retention Time	T =	25.7	hours			T =	25.7	hours		9.47
	Bulk s. g.	0.40				Bulk s. g.	0.40			
Storage Area	A =	19	m2 at	2.0	m height	A =	37	m2 at	2.0	m height
Construction scheme	4 tanks will be constructed while 2 sets of equipment will be installed in Stage 1.									
(11) Chlorination Equipment	Chlorine Building will be sized to cater for the future chemical requirements of Phase II.									
Injection Point	at the Distribution Chamber					at the Distribution Chamber				
	and Inlet of Clearwater Reservoir					and iInlet of Clearwater Reservoir				
Type	Liquid Chlorine (900 kg-cylinder)					Liquid Chlorine (900 kg-cylinder)				
Criteria	Prechlorine	Max.	5.0	mg/l		Prechlorine	Max.	5.0	mg/l	
		Ave.	2.0	mg/l			Ave.	2.0	mg/l	
		Min.	1.0	mg/l			Min.	1.0	mg/l	
	Postchlorine	Max.	2.0	mg/l		Postchlorine	Max.	2.0	mg/l	
		Ave.	1.0	mg/l			Ave.	1.0	mg/l	
		Min.	1.0	mg/l			Min.	1.0	mg/l	
Dosage Amount	Prechlorine			Max		Prechlorine				
in average	Wt =	66	kg- Cl gas/day	1980	kg- Cl gas/mon	Wt =	132	kg- Cl gas/day	3960	kg- Cl gas/mon
	or	2.8	kg- Cl gas/hour			or	5.5	kg- Cl gas/hour		
	Postchlorine					Postchlorine				
	Wt =	33	kg- Cl gas/day	990	kg- Cl gas/mon	Wt =	66	kg- Cl gas/day	1980	kg- Cl gas/mon
	or	1.4	kg- Cl gas/hour			or	2.8	kg- Cl gas/hour		

SR 4.10 Capacity Calculation for Water Treatment Plant

Item	**Phase I**					**Phase II**				
Chlorinator	Vacuum Type		Prechlorine		Postchlorine	Vacuum Type		Prechlorine		Postchlorine
No. of unit		1	units	1	units		2	units	2	units
		(+ 1 units stand-by)		(+ 1 unit stand-by)			(+ 2 units stand-by)		(+ 2 units stand-by)	
Rate		2.75	kg/hour/unit	1.38	kg/hour/unit		2.75	kg/hour/unit	1.38	kg/hour/unit
Operation Rate		80	percent	80	percent		80	percent	80	percent
Capacity		4	kg/hour/unit	2	kg/hour/unit		4	kg/hour/unit	2	kg/hour/unit
Storage	Period	30	days			Period	30	days		
Storage Area	A pre =	5	m2 as	2.0	m2/container	A =	10	m2 as	2.0	m2/container
	A post =	3	m2 as	2970.0	kg- Cl gas/mon		5	m2 as	5940.0	kg- Cl gas/month
		8	m2				15	m2		
Max. Dosage(prechlorine)	2 units of chlorinators with 7kg/h will be operated simultaneously to attain the Max dosage of 13.25kg/h.					4 units of chlorinators with 7kg/h will be operated simultaneously to attain the Max dosage of 26.25kg/h.				
Max. Dosage(postchlorine)	2 units of chlorinators with 4kg/h will be operated simultaneously to attain the Max dosage of 5.3kg/h.					4 units of chlorinators with 4kg/h will be operated simultaneously to attain the Max dosage of 10.5kg/h.				

(12) Backwash Water Receiving Tank

Backwash Water	Vs + Vb =	170	cu.m/filter unit			Vs + Vb =	170	cu.m/filter unit		
Return pump		1	unit (+1 standby)				2	units (+0 stand by)		
Return time		4	hours	(=4 hours x 4 filters)			4	hours	(= 4 hours x 8 filters)	
Required pump cap		0.708	m3/min				0.71	m3/min		
Tank No.	N =	2	units	(1 tank for standby)		N =	2	units	(0 tank for standby)	
Dimension	L m	x W m	x D m	m x N	units	L m	x W m	x D m	m x N	units
	7.5	5.0	2.0	2		7.5	5.0	2.0	2	
Total Volume	v =	150	cu m			v =	150	cu m		
Frequency of Wash	Once a day = 4 filters/day					Once a day = 8 filters/day				

(12) Sludge Discharge Tank

Sludge Discharge	V_1 =	142	cu.m/filter unit			Vs + Vb =	0	cu.m/filter unit		
Discherge allowance	V_2 =	57	cu.m/filter unit (40 %)			Vs + Vb =	0	cu.m/filter unit		
Total Discharge	$V_1 + V_2$ =	199	cu.m/filter unit			Vs + Vb =	0	cu.m/filter unit		
Discharge pump		1	unit (+1 standby)				2	units (+0 stand by)		
Discharge time		4	hours	(=4 hours x 1 baisin)			4	hours	(= 4 hours x 8 filters)	
Discharge pump cap		0.828	m3/min				0.00	m3/min		
Tank No.	N =	2	units			N =	2	units	(0 tank for standby)	
Dimension	L m	x W m	x D m	m x N	units	L m	x W m	x D m	m x N	units
	10.0	5.0	2.1	2		10.0	5.0	2.1	2	
Total Volume	v =	210	cu m			v =	210	cu m		
Frequency of Wash	Once a month = 1 baisin/time					Once a day = 8 filters/day				

SR 4.10 Capacity Calculation for Water Treatment Plant

Item	Phase I	Phase II
(13) Sludge Drying Bed		
Sludge Removal	Mechanical Sludge Withdrawal	Mechanical Sludge Withdrawal
	Max. Withdrawal Valume : 35.5 cu m/time	
Sludge Amount	So = Q * (K*(T1-T2)+B*156/666)*10^-6	
	where So:Sludge dry weight(ton)	
	Q :Treated water amount(m3/d)	
	K :Coefficient converting turbidity to SS (0.8-1.5 ->>1.2)	
	T1 :Turbidity in raw water (ave= 20 during rainy season)	
	Turbidity is expected to reduce to this level in Raw Water Reservoir	
	T2 :Turbidity after Sedimentation(ave= 5 during rainy season)	
TTL Dry Solid Amount	B :Alum dosage rate (ave.= 15 mg/l)	
per day	So = 0.71 ton-DS/day	So = 1.42 ton-DS/day
per month	= 21.3 ton-DS/month	= 42.6 ton-DS/month
per year	= 256 ton-DS/year	= 511 ton-DS/year
Solid content of sludge	w = 15.0 %	w = 15.0 %
Total Sludge Volume	Total v = 142 cu.m/month 1,065	v = 284 cu.m/month
	v = 1,704 cu.m/year	v = 3,408 cu.m/year
Drying Period	for 2 month	for 2 month
Required Volume	v = 142 cu m	v = 284 cu m
Dimension	Rectangular 5 units	Rectangular 10 units
	L m x W m x D m x units m	L m x W m x D m x units m
	25.0 23.0 0.6 5	25.0 23.0 0.6 10
Volume	v = 1,725 cu m	v = 3,450 cu m
Side Slope	s = 1 : 2.0	s = 1 : 2.0

Note : Small pumps such as utility water pumps are not shown in this calculation.

Alum - Specific Gravity (% as Al2(SO4)3-18H2O)		Lime - Specific Gravity (% as Ca (OH)2)		Vitrioric Acid - Specific Gravity (% as H2SO4)	
5	1.0254	5	1.0308	5	1.0360
10	1.0525	10	1.0607	10	1.0660
15	1.0804	15	1.0923	15	1.0978

SR 4.11 Hydraulic Calculation for Water Treatment Plant

No.	Item		For Phase I				
	Production rate	Total Q =	30,000	cu.m/day			
	Production loss		10	%			
	Planned Flow Rate	=	33,000				
		=	1,375	cu.m/hour			
		=	22.9	cu.m/min			
		=	0.382	cu.m/sec			
A.	Receiving Well	WL0 = +	19.500	m	(+	64.0 feet)	
	Overflow Weir Crest	Hw1 = +	19.550	m	(+	64.1 feet)	
	Overflow Level in Phase I	Hover = +	19.669	m	(+	64.5 feet)	
B.	D-Chamber	WL1 = +	19.458	m	(+	63.8 feet)	
	Distribution Weir Crest	Hw2 = +	19.286	m	(+	63.3 feet)	
C.	Mixing Chamber	WL2 = +	18.879	m	(+	61.9 feet)	
D.	Inlet Chamber for Floc. Basin	WL3 = +	18.629	m	(+	61.1 feet)	
E.	Flocculation Channel						
	Start	WL4 = +	18.474	m	(+	60.6 feet)	
	End	WL5 = +	18.394	m	(+	60.3 feet)	
F.	Sedimentation Basin						
	in Basin	WL6 = +	18.394	m	(+	60.3 feet)	
	Overflow Trough Crest	Ht = +	18.464	m	(+	60.6 feet)	
	Outlet Channel	WL7 = +	17.954	m	(+	58.9 feet)	
	Overflow Weir Crest	Hw3= +	13.650	m	(+	44.8 feet)	
G.	Sand Filter						
	Inflow Conduit	WL8 = +	17.750	m	(+	58.2 feet)	
	Weir Crest	Hw4 = +	13.250	m	(+	43.5 feet)	
	Filter Basin : HWL	WL9 = +	17.400	m	(+	57.1 feet)	
	Filter Basin : LWL	WL10 = +	15.400	m	(+	50.5 feet)	
	Effluent Conduit	WL11 = +	15.482	m	(+	50.8 feet)	ordinal operation
			15.499	m	(+	50.9 feet)	during backwashing
	Effluent Weir Crest	Hw5 = +	15.400	m	(+	50.5 feet)	
H.	Backwash Water Tank	WL12 = +	14.891	m	(+	48.9 feet)	Satge I
		WL12 = +	14.949	m	(+	49.0 feet)	Phase II

SR 4.11 Hydraulic Calculation for Water Treatment Plant

Effluent Weir Crest for Clear Well :	Hw6 = +	14.790 m	(+ 48.5 feet)	
Effluent Water Level :	WL13 = +	14.490 m	(+ 47.5 feet)	Phase I
				Phase II
I. Clear Water Reservoir				
Reservoir : HWL :	WL14 = +	14.450 m	(+ 47.4 feet)	Phase I
		14.360 m	(+ 47.1 feet)	Phase II
Reservoir : LWL :	WL15 = +	9.450 m	(+ 31.0 feet)	Phase I
		9.360 m	(+ 30.7 feet)	Phase II

Initial Water Level in Receiving Well : WL0 = + 19.500 m AMSL
(+ 64.0 feet AMSL)

1. Receiving Well

	No. of Unit =	1	
Perfolated Buffle :	Wall	Width = 2.00	m
		Depth = 4.00	m
		Area = 8.00	m2
	Holes	Diameter = 0.10	m
		No. = 89	No.
		Area = 0.70	m2
		Pitch = 0.30	m
Open Ratio :		8.73	%
	Velocity in Hole: v =	0.55	m/sec
Overflow Discharge Weir :	Overflow depth h over =	0.119	m
(full width) :	say =	0.119	m
	Width of wall B =	5.000	m
	Hight of crest W =	4.650	m
	W<=1 m	e=0	
	W>1m	e=0.55*(W-1)= 2.008	

Water Level in the Receiving Well Chamber
WL0 = + 19.500 m

(1) Head Loss through baffle wall
h = (1/c^2)*(v^2/(2*g))
where, c = 0.600
= 0.042 m
say = 0.042 m
=========

Water Level in the Distribution Channel
WL1 = + 19.458 m
=========

h over =(Q/C/B)^(2/3)
C = 1.785+(0.00295/h+0.287*h/W)*(1+e)
= 1.867 m^0.5/s
h = 0.183 m (trial)

Overflow Weir Crest Level
Hw1 = 19.550 m

Overflow Level
H over= 19.669 m

SR 4.11 Hydraulic Calculation for Water Treatment Plant

2. Mixing Well Outlet

	No. =	2	outlet	
	Unit q =	0.191	cu.m/sec	
Overflow Weir	Overflow depth hw =	0.172	m	
	Discharge Q =	0.191	m3/s	
	Width of channel B =	2.500	m	
	Width of weir b =	1.500	m	
	Hight of crest W =	3.970	m	
Effluent Water Level	(= Hw -	0.579	m)	
		(for hydraulic mixing)		

(1) Weir Loss

hw = (q/(C*b))^(2/3)

where,C = 1.785+0.00295/h

+0.237*h/W-0.428{(B-b)*h/(W*B)}^0.5

+0.034(B/W)^0.5

C = 1.777 m^0.5/s

h = 0.203 m (trial)

Weir Crest Level (= WL1-hw)

Hw2 = 19.286 m

Water Level at Mixing Well Outlet

WL2 = + 18.879 m

=========

Outlet Pipe from Mixing Well to Flocculation Chamber

No. =		2	lines	
Unit q =		0.191	cu.m/sec	
	Pipe Size D =	0.50	m	
(assumption)	Length: L =	40.0	m	
	Section =	0.196	m2	
	Velocity v =	0.973	m/sec	
	90 deg. Bend =	4	(f = 0.17)	
	45 deg. Bend =	2	(f = 0.12)	

(1) Friction Loss (pipe)

hf = f*(L/D)*(v^2/(2*g))

where, f = (20+(1/(2*D)))*1.5/1000

= 0.032

= 0.124 m

(2) In-Out Loss

ho = f*(v^2/(2*g))

where, f = 1.50 =(0.5 + 1.0)

= 0.072

(3) Bend Loss

hb = f*(v^2/(2*g))

where, f = 0.17 * 4 + 0.12 * 2

= 0.92

= 0.044 m

(4) Valve Loss (Butterfly valve usually open)

hv = f*(v^2/(2*g))

where, f = 0.1

= 0.005 m

Total Loss

hf +ho+hb+hv = 0.245 m

say = 0.250 m

Inflow Water Level at Flocculation Chamber

WL3 = + 18.629 m

=========

SR 4.11 Hydraulic Calculation for Water Treatment Plant

3. Connection Channel	No. =	2	lines	(1) Friction Loss (open channel)
(Mixing Well to	Unit q =	0.191	cu.m/sec	hf = n^2*v^2*L/R^(4/3)
Flocculation Channel)				where, n = 0.015
Channel(Open Box)	Channel Section W =	1.500	m	R = W*D/(2*(D+W))
	D =	5.57	m	= 0.59 m
	Velocity in Channel: v =	0.023	m/sec	= 0.000 m
N/A	90 deg. Bend =	0	(f = 0.17)	(2) Bend Loss (N/A)
	45 deg. Bend =	0	(f = 0.12)	hb = f*(v^2/(2*g))
				where, f = 0.17 * 1 + 0.12 * 4
				= 0
Perfolated Buffle	Wall Width =	1.500	m	= 0.000 m
	Depth =	5.570	m	(3) In-Out Loss (N/A)
	Dead Depth =	1.000	m	hio = f*(v^2/(2*g))
	Area =	6.855	m2	where, f = 1.500 =(0.5 + 1)
	Holes Diameter =	0.100	m	= 0.000 m
	No. =	76.167	No.	(4) Head Loss through baffle wall
	Area =	0.598	m2	hbw = (1/c^2)*(v^2/(2*g)
	Pitch =	0.300	m	where, c = 0.600
	Open Ratio =	8.727	%	= 0.014 m
	Velocity in Hole: v =	0.319	m/sec	Total Loss : hf + hb + hio + fbw
				= 0.014 m
				say = 0.150 m
Outlet to flocculation basin (Orifice)	No. =	2	trains	(1) Head Loss
	Unit q =	0.191	cu.m/sec	h = f*(v^2/(2*g))
				where, f = 3.00 = (1.5 * 2)
	Oriffice Width =	1.500	m	= 0.005 m
	Height =	0.70	m	
	Area =	1.05	m2	
	Velocity in Gate: v =	0.18	m/sec	Water Level at the start of Flocculation Channel
				WL4 = + 18.474 m

SR 4.11 Hydraulic Calculation for Water Treatment Plant

4 Flocculation Channel				
Total Loss	Refer to the detailed computation for baffled flocculation			
Inlet Baffle wall	Wall	Width =	8.00	m
to Sedimentation Basin		Depth =	4.00	m(approx)
		Area =	32.00	m2
	Holes	Diameter =	0.10	m
Baffle/diffuser location		Pitch =	0.30	m
2 to 2.5m down stream of inlet		No. =	356	Nos.
		Area =	2.79	m2
approx. 6%	Open Ratio =		8.7	%
0.23m/sec >	Velocity in Hole: v =		0.07	m/sec
Loss of head	for floc protection		<10	mm

(1) H = h1+h2+h3 = 0.079 m

say = 0.080 m

Water Level at the End of Flocculation Channel

WL5 = + 18.394 m

=========

(2) Head Loss at the Inlet difuser wall before sedimentation basin

h = (1/c^2)*(v^2/(2*g))

where, c = 0.600

= 0.0007 m OK

0.0000 m negregible

5 Sedimentation Basin	No. =	2	trains	0.30
	Unit q =	0.191	cu.m/sec/train	
Trough				
	No. : n =	4	No./train	
	Length : L =	6.0	m	
	Width : B =	300	mm	
	Depth : h =	350	mm	
	Orifice size d=	30	mm	
	Pitch of orifice	100	mm	
	Clearance from WL	0.07	m	
	Nos of orrifice	120	per trough	
	TTL Nos of orifice	480	per basin	
	TTL area of orifice	0.339	m2	
Trough Flow	Passing velocity of orifice	0.563	m/sec	
	Unit Flow : per trough q =	0.048	cu.m/sec	
	Total Trough Length: L=	48	m/train	
	Overflow Load : FL =	343.8	m3/m/day	

Water Level in Sedimentation Basin

WL6 = + 18.394 m

=========

(1) Trough Loss

ht = v^2/(2*9.8*C^2)

= 0.045 m

C = 0.60

Trough Top Level (= WL6-ht)

Ht = 18.464 m

=========

Critical Depth at the Trough End: hc

hc = (1.1*q^2/(g*B^2))^(1/3)

= 0.142 m

Depth at the Beggining of Trough: ho

ho = 3^(1/2)*hc

= 0.204 m

Trough Bottom Level : Htb

Htb = 18.114 m

Sedimentation Effluent Channel Water Level

SR 4.11 Hydraulic Calculation for Water Treatment Plant

	(Trough Bottom - 0.160 m below)	WL7 = + 17.954 m
	(baffle wall loss will be absorbed with this allowances.)	=========
6 Overflow weir at the end of Sedimentation Basin	Discharge q= 0.382 cu.m/sec	(1) hw = (q/(C*b))^(2/3)
	Width of weir b = 2.000 m	= 0.219 m
(overflow weir at sedimentation)	Hight of crest W = 2.000 m	
	where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e)	weir crest should be =
	= 1.860	Hw3 = 13.650 m
	W<=1 m e= 1	(Top level of sed. Tank is
	W>1m e=0.55*(W-1)= 0.550	14.600 m)
	h = 0.337 m (trial)	
	(2) Friction Loss by 1000 DI Over low Pipe (refer to the following calculation)	
	40 m -1000 pipe + In-Out Loss=0.031+0.066 m	0.165 m
7 Sedmentation Basin Outlet to Filter Distribution Channel	No.= 1 pipe	(3) Valve Loss(butterfly valve usually open)
	Size = 700 mm	h = f*(v^2/(2*g)) (N/A)
(by pipe)	Discharge q= 0.382 m3/s	where, f = 0.1
	Verocity v= 0.993 m/sec	= 0.000 m
assumption	Inflow pipe length L= 40 m	(4) In-Out Loss
		hio = f*(v^2/(2*g))
	90 deg. Bend = 3 (f = 0.17)	where, f = 1.5 =(0.5 + 1)
	45 deg. Bend = 2 (f = 0.12)	= 0.075 m
	(1) Friction Loss	TTL Loss from Sedimentation Effluent Channel to
	hf = f*(L/D)*(v^2/(2*g))	Filter Distribution Channel
	where, f = (20+(1/(2*D)))*1.5/1000	= 0.203 m
	= 0.031	
	= 0.089 m	
	(2) Pipe Bend Loss	
	hb = f*(v^2/(2*g))	Water level at the inlet channel of filter
	where, f = 0.17 * 5 + 0.12 *2	WL8= + 17.750 m
	= 0.75	=========

SR 4.11 Hydraulic Calculation for Water Treatment Plant

		= 0.038 m	
8	Sedimentation Outlet Channel to Sand Filter Filter Inflow Box	During wash / Ordinal	Water level at the distribution channel of filter
		No. Filter = 3 / 4	WL8= + 17.750 m
		Unit q = (cu.m/sec) 0.127 / 0.095 (per filter)	
	Inflow Channel	Width of inflow channel W= 1.50 m	(1) Friction Loss (open channel)
		D = 1.65 m	hf = n^2*v^2*L/R^(4/3)
		L = 25 m	where, n = 0.015
		Discharge q = 0.191 m3/s	R = W*D/(2*D+W)
		Velocity in Channel : v = 0.05 m/sec	= 0.516 m
			= 0.000 m negregible
	Inflow Weir loss	Width of weir b = 3.500 m	(2) Weir Loss (overflow depth)
		Hight of crest W = 1.650 m	hw = (q/(C*b))^(2/3)
	during backwash	where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e)	hw(3)= 0.073 m
	3	= 1.843	hw(4)= 0.060 m
	filters	W<=1 m e= 0	
		W>1m e=0.55*(W-1)= 0.358	Inflow Weir Crest Level:
		h = 0.112 m (trial)	Hw4 = + 13.250 m
			Allowance between WL8 and Weir Crest:
	ordinal operation	C= 1.785+(0.00295/h+0.237*h/W)*(1+e)	4.500 m >
	4	= 1.846	0.073 m
	fiters	h= 0.093 m (trial)	(= hw(3) or hw(4))
	Inflow gate	Inflow gate d= 500 mm	(3) Gate Orifice Loss
	Inflow gate velocity;	Inflow velocity v(3)= 0.509 m/sec	ht = v^2/(2*9.8*C^2)
		Inflow velocity v(4)= 0.382 m/sec	C = 0.60
		<1.0 m/sec	ht(3)= 0.037 m 0.350
			ht(4)= 0.021 m
9	Sludge Drain Pipe		(3) Bend Loss

SR 4.11 Hydraulic Calculation for Water Treatment Plant

Nos of train		2	trains	
TTL Dry soild amount per day		0.710	ton-DS/day	
Dry soid amount per train per day	per train	0.355	ton-DS/day	
Water Contents of Drawn Sludge		1	%	
Sludge amount per train per day	per train	35.5	m3/day	
Withdrawal time		10	min	
Sludge withdrawal amount	per train	3.550	m3/min	
Nos of sludge withdraw pipes		4	pipes	
Indivisual withdrawl pipe		0.887	m3/min	
		0.015	m3/sec	

Indivisual pipe spec. : Pipe Size:

Dia : D =	150	mm
Length: L =	5	m
Area : a =	0.018	m2
Velocity : v =	0.837	m/sec

(1) Friction Loss (pipe)

hf = f*(L/D)*(v^2/(2*g))

where, f = (20+(1/(2*D)))*1.5/1000

= 0.035

= 0.042 m

(2) In-Out, Valve Loss

Ho1 = f*(V^2)/2g

= 0.118 m

Ho1: Head Loss (m)

f : Coefficient(= 0.1+1.0+0.2+2.0)

including in, out, valve, contrl valve

Hb = f*(V^2)/2g

= 0.071 m

Hb: Head Loss (m)

f : Coefficient(= 0.2 x 10, for safe)

(4) Friction Loss after combined

hf = f*(L/D)*(v^2/(2*g))

where, f = (20+(1/(2*D)))*1.5/1000

= 0.033

= 0.825 m

Combined

Dia : D=	250	mm
Length: L=	150	m
Area :A=	0.049	m2
Velocity :V =	0.904	m/sec

(5) Out Loss

Ho = f*(V^2)/2g

= 0.042 m

(6) Bend Loss (10 places)

Hb2= f*(V^2)/2g

= 0.083 m

(v) Total Loss

H = Hf1 + Hb1 + Ho1+Hf2+Ho2+Hb2

= 1.182 m

say 1.200 m

High Water Level of Sedimentation Basins

WL6 = + 18.394 m

High Water Level of Sludge D Tank should be not higher than

17.194 m

=========

10 Sand Filter

(1) Required Backwash Head

High Water Level of Filter Tank:

Allowance between WL8 and HWL of Filter:

0.350 m

WL9 = 17.400 m

SR 4.11 Hydraulic Calculation for Water Treatment Plant

(preliminary)	Effective Filter Head:				2.000 m
	Low Water Level of Filter Tank:				WL10 = 15.400 m
Trough	Nos of trough n =	2		Nos	(1) Weir (trough) Loss
Backwash amount per filter	Q =	20.4		m3/min	hw = (q/(C*b))^(2/3)
including 20%+0.25m3/m2/min	Width of weir b =	8.500		m	= 0.077 m
'+settled water	Wash amount per trough q =	0.170		m3/s	where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e)
Backwash pipe;	d=	500		mm	= 1.860
					Hight of crest W = 0.500 m
					W<=1 m e= 0
1.5 to 3.0 m/s	Backwash amount =	17.0		m3/min	W>1m e=0.55*(W-1)
2 m/s is preferable	=	0.283		m3/sec	h = 0.072 m (trial)
Backwash Drain	actual v=	1.44		m/s	(2) Friction Loss after combined
	Pipe length L=	50		m	hf = f*(L/D)*(v^2/(2*g))
	(assumption)				where, f = (20+(1/(2*D)))*1.5/1000
					= 0.032
					= 0.335 m
					(3) Pipe Bend Loss
	90 deg. Bend =	6		(f = 0.17)	hb = f*(v^2/(2*g))
	45 deg. Bend =	5		(f = 0.12)	where, f = 0.17 * 3 + 0.12 *2
					= 1.62
Filter Madia :		Effective Size		Thickness	= 0.172 m
		(mm)	(D : m)	(Lo : m)	(4) Valve Loss(butterfly valve usually open)
					h = f*(v^2/(2*g))
	Sand	1.20	0.00120	1.200	where, f = 1.6 (=0.1 +1.5)
N/A	Gravel-1	2.75	0.00000	0.000	= 0.170 m
N/A	Gravel-2	5.25	0.00000	0.000	(5) Loss of head through filter media (Leva)
N/A	Gravel-3	10.00	0.00000	0.000	h1= 200*Lo*u*v*(1-e)^2/(pf*g*f^2*D^2)
N/A	Gravel-4	16.50	0.00000	0.000	/(eo^3)
					where, u (viscosity) = 0.898 kg/m/s x 10-3
Note:	for (5), Leva's formula will be applied due to fixed layer.				pf (s.g. of water) = 997.1 at 25 deg.C
	v (backwash rate) =	0.0042		m/s	eo (void ratio) = 0.450
	f (shape coefficient) =	0.7			ps (density of media) = 2630 kg/m3
					= 0.432 m

SR 4.11 Hydraulic Calculation for Water Treatment Plant

				(6) Loss of supporting gravel (Leva's formula)
				hg= 0 m (N/A)
Underdrain System :	Strainer K- type			(7) Loss of under drain
	b= opening ratio of strainer			hu = 1/(2*g)*(u/a/b)^2
	assumption	1.00	%	where, u = backwash rate
	a = disharge coefficient			= 0.004 m3/s
	assumption =	0.62		= 0.023 m
				Required Backwash Head
				TTL head loss h =(1)+(2)+(3)+(4)+(5)+(6)+(7)
				= 1.3 m + actual lifting head
				Details shall be referred to the mechanical design
				for backwash pump.
(2) Loss of head between filter	4filters q (per filter) =	0.095	m3/s	(1) Friction loss of effluent pipe
and Effluent Pipe	d=	400	mm	hf (4)= f*(L/D)*(v^2/(2*g))
	actual v=	0.760	m/s	where, f = (20+(1/(2*D)))*1.5/1000
	3filters q (per filter) =	0.127	m3/s	= 0.032
	d=	400	mm	= 0.004 m
	actual v=	1.014	m/s	hf(3)= f*(L/D)*(v^2/(2*g))
	pipe length L=	1.500	m	= 0.006 m
				(2) In-Out Loss
				ho = f*(v^2/(2*g)) use bell mouse
				where, f = 1.500 (=0.5+1)
				ho(4)= 0.044 m
				ho(3)= 0.079 m
				(3) Valve Loss(butterfly valve)
	0.764			h = f*(v^2/(2*g))
	1.04			where, f = 0.1
				h(4)= 0.003 m
				h(3)= 0.005 m
Initial Loss of Head				(4) Fair Hatch Formula:
through Filter	Media size D=	1.2	mm	Re= pF*D*v/m
	Thickness of media L=	1200	mm	= 1.877 >1

SR 4.11 Hydraulic Calculation for Water Treatment Plant

	Void ratio e= 0.45	Cd= 24/Re+3/Re^0.5+0.34
	Filtration rate v (4) = 121.3 m/d	= 15.3
	1.404E-03 m/sec	h(4) = (0.178*24)/Re*L*v^2/g/e^4/D*a/b
	Viscosity m= at 25 degree 8.950E-04 kg/m/sec	= 0.220 m
	Density of water at 25 deg.= 997.1 kg/m3	h(3) =
	Coefficient of figure a/b= 5.5	====================
	v (3) = 161.8 m/d	TTL head loss h =(1)+(2)+(3)
	1.872E-03 m/sec	h4= 0.051 m
		h3= 0.090 m
(3) Effluent Weir to Backwash	Weir Crest Level of Each Filter Effluent	Hw5 = 15.400 m
Tank	During Filtration 4 filters	(1) Weir Loss durinf ordinal filtration
	Flow rate Q = 30,000 cu.m/day	hw(4) = (q/(C*b))^(2/3)
0.347	per basin q= 0.087 m3/sec	= 0.082 m
	Width of weir b = 2.000 m	
	Hight of crest W = 2.400 m	where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e)
	W<=1 m e= 0	= 1.848
	W>1m e=0.55*(W-1)= 0.770	(2) Weir loss during washing
	h = 0.130 m (trial)	hw (3)= (q/(C*b))^(2/3)
	During Washing 3.000 filters	= 0.099 m
	per basin q= 0.116 m3/sec	
	h = 0.158 m (trial)	where, C = 1.785+(0.00295/h+0.237*h/W)*(1+e)
		= 1.846
		WL11 = 15.482 m (during ordinal opertioin)
		15.499 m (during backwashing)
		====================
	Weir Crest Level of Wahswaer Tank Outlet to Clear Well	Hw6 = 14.790 m
(4) Effluent Weir to Clear Well	For Phase I q = 0.382 m3/sec	
	22.917 m3/min	For Stgage I:
	Weir Width B= 6.500 m	Loss of head by effluent weir
	Weir hight W= 2.100 m	hw = (q/(C*B))^(2/3)
	W<=1 m e= 0	where, C = 1.785+(0.00295/h

SR 4.11 Hydraulic Calculation for Water Treatment Plant

W>1m e=0.55*(W-1)= 0.605
h = 0.155 m (trial)

For Phase II c q for Phase II= 0.764 m3/sec
45.833 m3/min
h= 0.245 m (trial)

Water Level of Backwash Water Tank — Phase I: WL 12= 14.891 m
Phase II: WL 12= 14.949 m

Effluent Water Level to Cleae Well — 0.3m below of Weir Crest Level of Backwash Effluent Tank — WL 13 = 14.490 m

+0.237*h/W)*(1+e)
= 1.844
= 0.101 m

For Phase II:
Loss of head by effluent weir
hw = (q/(C*B))^(2/3)
where, C = 1.785+(0.00295/h
+0.237*h/W)*(1+e)
= 1.849
= 0.159 m

---

11 Effluent Channel to Clear Water Reservoir

No. = 1 lines
Unit Q = 0.382 cu.m/sec

Pipe 1400

Dia : D =	1.40	m
Length: L =	200.0	m
Area : A =	1.54	m2
Velocity in Pipe : V =	0.25	m/sec
90 deg. Bend =	3	(f = 0.17)
45 deg. Bend =	0	(f = 0.12)

Pipe 1000 (in the pipe gallerly of clear water reservoir)

Dia : D =	1.00	1.00
Q : =	0.382	0.191
Length: L =	10.0	10
Area : A =	0.785	0.785
Velocity : V =	0.49	0.24

(1) Friction Loss (pipe)
hf = f*(L/D)*(v^2/(2*g))
= 0.014 m
where, f = (20+(1/(2*D)))*1.5/1000
= 0.031 m

(2) Friction Loss (1m pipe)
hf = f*(L/D)*(v^2/(2*g))
= 0.005 m
where, f = (20+(1/(2*D)))*1.5/1000
= 0.031 m

(3) Bend Loss
hb = f*(v^2/(2*g))
where, f = 0.17 *3 + 0.12 * 0
= 0.510
= 0.002 m

SR 4.11 Hydraulic Calculation for Water Treatment Plant

		(4) In-Out Loss
	(6) Reducing loss from 1.4m to 1.0m	hio = f*(v^2/(2*g))
	hr= fgc*v^2/(2g) where, fgc= 0.01	where, f = 1.500 = (0.5 + 1)
	= 0.000 m neglectable	= 0.005 m
	(7) Branching loss:	(5) Valves
	hdb(1)= fdb*v^2/(2g) where, fdb= 0.70	hv= fv(v^2/(2*g))
	= 0.008 m	where, fv= 0.100
	hdr(2)= fdr*v^2/(2g) where, fdr= 0.05	0.000 m
	= 0.001 m	
		Total Loss : hf + hb + hio +hv +hr +hdb
		= 0.034 m
		say 0.040 m
		WL 14 = 14.450 m
12 Clear Water Reservoir	HWL =WL13	WL 14 = 14.450 m
	LWL = WL14 = WL 13-5.0	WL 15 = 9.450 m
Overflow Pipe		(2) In-Out, Valve Loss
	Bellmouth overflow pipe is provided for flowing 20 percent	Ho1 = f*(V^2)/2g
	of full flow.	= 0.002 m
	Flow Rate = 0.076 cu m/sec	Ho1: Head Loss (m)
	Diameter of overflow pipe = 800 mm	f : Coefficient(= 0.5+1.0)
	Overflow Head = 1.00 m	including in, out, valve, contrl valve
	Pipe length= 100 m	(3) Bend Loss
	Velocity= 0.152 m/sec	Hb = f*(V^2)/2g
	(1) Friction Loss (pipe)	= 0.002 m
	hf = f*(L/D)*(v^2/(2*g))	Hb: Head Loss (m)
	where, f = (20+(1/(2*D)))*1.5/1000	f : Coefficient(= 0.2 x 10, for safe)
	= 0.031	
	= 0.005 m	TTL head loss:Hf = 0.009 m
		WL16 = + 14.459 m< 10.42m

SR 4.11 Hydraulic Calculation for Water Treatment Plant

13 Filter Wash Water Drainage	(backwash water drainage will be commonly used during	
Rate of backwash water	Phase I and Phase II = assuming 2 filters be washed at onc	(1) Friction Loss (pipe)
per filter x 1.2	12.00 min	hf = f*(L/D)*(v^2/(2*g))
(for 2 filters)	34.00 m3/min	where, f = (20+(1/(2*D)))*1.5/1000
Amount of backwash water	per filter 170 cu m/unit	= 0.031
(for 2 filters)	Flow Rate = 0.567 cu m/sec	= 0.075 m
Diameter of backwash drainage pipe =	800 mm	(2) In-Out, Valve Loss
	Pipe length= 30 m	Ho1 = f*(V^2)/2g
	Velocity= 1.127 m/sec	= 0.097 m
		Ho1: Head Loss (m)
Filter drainage	Gate Orifice Loss	f : Coefficient(= 0.5+1.0)
	Gate size 600 mm sq.	including in, out, valve, contrl valve
	Velocity= 1.574 m/sec	(3) Bend Loss
	ht = v^2/(2*9.8*C^2)	Hb = f*(V^2)/2g
	C = 0.60	= 0.130 m
	= 0.351 m	Hb: Head Loss (m)
	For safety HWL of Filter Drainage Channel is assumed	f : Coefficient(= 0.2 x 10, for safe)
	to be 14.000	(4) Valves
	= 14.000 m	hv= fv(v^2/(2*g))
	Loss of head (1)+(2)+(3)+(4)= 0.318 m	where, fv= 0.250
	HWL of Backwash Water 13.682 m	0.016 m
	Receiving Tank	WL17= + 13.600 m
		WL18= + 11.600 m
14 Sludge Lagoon	Highest High Water Level of Laggon	
	(see item 9) 17.194 m	WL19=+ 15.800 m
Estimated High Water Level	Tr=10 11.600 m	WL20= + m
	Tr=25 12.200 m	

The Preparatory Study on The Siem Reap Water Supply Expansion Project

Simulation for Clear Water Reservoir Fill & Draw System

Scenario: Clear Water Reservoir will receive water from the WTP at constant rate, and discharge by pump to ELT.

cu m/d	cu m/hr	cu m/min	litter/sec
30,000	1,250	21	347
48,000	2,000	33	556

Day Demand = 30,000 cu m/day = 347 l/sec
Demand increase ratio= 3.60

Peak Factor = 1.6 (as shown below)

Storage Volume of Sump = 5000 m3
Detention time 4.00 hrs

Initial Storage = 30% Max. Storage = 97%
Final Storage = 30% Min. Storage = 21%

Time	Peak Factor for Inflow	Ave. Inflow (cu m/hr)	Total Inflow (cu m/hr)	Peak Factor for Disch.	Ave. Disch. (cu m/hr)	Total Disch. (cu m/hr)	Storage (start)		Storage (end)	
							(m3)	(%)	(m3)	(%)
0:00	1.00	1,250.00	1,250	0.58	1,250.00	725.00	1,500	30%	2,025	41%
1:00	1.00	1,250.00	1,250	0.50	1,250.00	625.00	2025	41%	2,650	53%
2:00	1.00	1,250.00	1,250	0.47	1,250.00	587.50	2650	53%	3,313	66%
3:00	1.00	1,250.00	1,250	0.45	1,250.00	562.50	3313	66%	4,000	80%
4:00	1.00	1,250.00	1,250	0.50	1,250.00	625.00	4000	80%	4,625	93%
5:00	1.00	1,250.00	1,250	0.81	1,250.00	1,012.50	4625	93%	4,863	97%
6:00	1.00	1,250.00	1,250	1.26	1,250.00	1,575.00	4863	97%	4,538	91%
7:00	1.00	1,250.00	1,250	1.60	1,250.00	2,000.00	4538	91%	3,788	76%
8:00	1.00	1,250.00	1,250	1.44	1,250.00	1,800.00	3788	76%	3,238	65%
9:00	1.00	1,250.00	1,250	1.33	1,250.00	1,662.50	3238	65%	2825	57%
10:00	1.00	1,250.00	1,250	1.25	1,250.00	1,562.50	2825	57%	2513	50%
11:00	1.00	1,250.00	1,250	1.17	1,250.00	1,462.50	2513	50%	2300	46%
12:00	1.00	1,250.00	1,250	1.14	1,250.00	1,425.00	2300	46%	2125	43%
13:00	1.00	1,250.00	1,250	1.13	1,250.00	1,412.50	2125	43%	1963	39%
14:00	1.00	1,250.00	1,250	1.09	1,250.00	1,362.50	1963	39%	1850	37%
15:00	1.00	1,250.00	1,250	1.06	1,250.00	1,325.00	1850	37%	1775	36%
16:00	1.00	1,250.00	1,250	1.11	1,250.00	1,387.50	1775	36%	1638	33%
17:00	1.00	1,250.00	1,250	1.16	1,250.00	1,450.00	1638	33%	1438	29%
18:00	1.00	1,250.00	1,250	1.13	1,250.00	1,412.50	1438	29%	1275	26%
19:00	1.00	1,250.00	1,250	1.10	1,250.00	1,375.00	1275	26%	1150	23%
20:00	1.00	1,250.00	1,250	1.07	1,250.00	1,337.50	1150	23%	1063	21%
21:00	1.00	1,250.00	1,250	1.01	1,250.00	1,262.50	1063	21%	1050	21%
22:00	1.00	1,250.00	1,250	0.89	1,250.00	1,112.50	1050	21%	1188	24%
23:00	1.00	1,250.00	1,250	0.76	1,250.00	950.00	1188	24%	1488	30%
0:00	1.00	347.22	1,250.00	0.58	1,250.00	950.00	1488	30%	4738	95%

SR 4.12 Mechanical& Electrical Equipment List for Water Treatment Plant

SR 4.12.1 Mechanical Equipment List for Water Treatment Plant

Water Treatment Plant; Priority Project 30,000m3/day, Future 30,000m3/day, Total 60,000m3/day (Product water)

Facility/Equipment	Tag No.	Specification	Power (kW)	Q'ty							Remarks
				Priority Project		Future		Total			
				Duty	St'db	Duty	St'db	Duty	St'db	Total	
01. Distribution Chamber											
Distribution Gate	02HG11 to 41	Hand Operated Sluice Gate Dia.500mm	-	2	0	2	0	4	0	4	Spindle L=5m
Drain Gate	02HG01	Hand operated Sluice Gate W300mmxH300mm	-	1	0	0	0	1	0	1	Spindle L=5m
02. Flocculation / Sedimentation Basin											
De-sludge Valve.1	03MV11 to 43	Electrically operated , Eccentric DN 150mm	0.08	6	0	6	0	12	0	12	
De-sludge Valve.2	03HV11 to 43	Manually operated gate valve, DN 150mm	-	6	0	6	0	12	0	12	
Sump Drainage Pump	03DP11 to 41	Submersible 0.2m3/min x 15m	1.5	1	1	1	1	2	2	4	
Sampling Pump	03SP11 to 21	Self-priming Centrifugal 0.06m3/min x 12 m	0.4	1	1	0	0	1	1	2	
03. Filters											
Filter Inflow Gate	04MV11 to 81	Motorized Sluice Gate with head stock 400mmW x 400Hmm	0.4	4	0	4	0	8	0	8	Spindle L=1.5m
Backwash Water Discharge Gate	04MV12 to 82	Motorized Sluice Gate with head stock 700mmW x 700mmH	0.75	4	0	4	0	8	0	8	Spindle L=3m
Stop log	04SL11 to 81	Manual, Stainless Steel W1000xW2000H	-	4	0	4	0	8	0	8	
Backwash Valve	04MV14 to 84	Motorized Butterfly Dia.500mm	0.4	4	0	4	0	8	0	8	
Air Scour Valve	04MV15 to 85	Motorized Butterfly Dia.400mm	0.2	4	0	4	0	8	0	8	
Effluent Valve	04MV17 to 87	Motorized Butterfly Dia.400mm	0.2	4	0	4	0	8	0	8	
Drain Valve	04HV11to 81	Manual Operated Gate valve with Headstock Dia.150mm	-	4	0	4	0	8	0	8	Spindle L=5m
Backwash Pump	04BP11 to 31	Horizontal Centrifugal 17m3/min x 8m	37	1	1	1	0	2	1	3	
Backwash Line Valve	04HV12/22	Manually operated Butterfly Valve, DN500	-	1	0	1	0	2	0	2	
Air Blower	04AB 11 to 31	Roots Blower 68Nm3/min x 3500mmAq	75	1	1	1	0	2	1	3	
Sump Drainage Pump	04DP01/02	Submersible 0.3m3/min x 15m	2.2	1	1	0	0	1	1	2	
Sampling Pump	04SP01/02	Self-priming Centrifugal 0.06m3/min x 12 m	0.125	1	1	0	0	1	1	2	
Air Blower check valve	04CV 11 to 31	Swing check valve, DN250	-	2	1	0	0	2	1	3	
Air Blower Isolate valve	04MV 13 to 2	Manual Operated Gate valve DN 400	-	1	1	0	0	1	1	2	
Air Blower Butterfly valve	04MV 16 to 3	Manually operated Butterfly Valve DN 250	-	2	1	0	0	2	1	3	
Back wash Pump check Valve	04HV 13 to 3	Swing check Valve DN 300	-	1	1	1	0	2	1	3	
Back wash Pump Suction Valve	04CV 13 to 3	Manually operated Gate Valve DN 300	-	1	2	0	0	1	2	3	
Back wash Pump Valve	04HV14 to 34	Manually operated Butterfly Valve DN 300	-	1	2	0	0	1	2	3	
Sand	04SD	Total 272m3/ 4units	-	1	0	1	0	2	0	2	

04. Clear Water Reservoir and High Lift Pump Station										
High Lift Pump	05HP11 to 51	Horizontal Double VoluteCentrifugal 17m3/min x 48m (split casing)	200	2	1	1	1	3	2	5	Future pump; 7.8m3/min x 27kW
Suction Header Valve	05HV11 to 81	Manuaaly Butterfly Valve 1000mmdia	-	4	0	4	0	8	0	8	Future; 400mmdia
Inlet Valve	05HV12 to 82	Manually Butterfly Valve 1000mmdia	-	4	0	4	0	8	0	8	Future; 400mmdia
Suction Valve	05HV16 to 56	Manually Gate Valve Dia.400mm	-	2	1	1	1	3	2	5	Future; 250mmdia
Check Valve	05CV11 to 51	Swing check Valve DN 400	-	2	1	1	1	3	2	5	Future; 250mmdia
Discharge Valve	05MV11 to 51	Motorized Butterfly Dia.400mm	0.2	2	1	1	1	3	2	5	Future; 250mmdia
Discharge Valve	05HV13 to 53	Manually Gate Valve Dia.400mm	-	2	1	1	1	3	2	5	Future; 250mmdia
Sump Drainage Pump	05DP01/02	Submersible 0.1m3/min x 12m	2	1	1	0	0	1	1	2	
Plant Water Supply Unit	05PU01	Horizontal Centrifugal Pumps with Pressure tank 1.5m3/min x 35m	9	1	0	0	0	1	0	1	with control panel, two pumps/ unit
Chlorination Booster Pump	05BP11 to 31	Horizontal Centrifugal 0.4m3/min x 52m	7.5	1	1	1	0	2	1	3	
Overhead Crane	05HC01	Motorized bridge crane 3Ton	3	1	0	1	0	2	0	2	
Isolation Valve	05HV14	Manually Butterfly Valve Dia.1000	-	2	0	2	0	4	0	4	For Flow Meter Future; 400mmdia
05.Chemical Building											
Alum Dosing System											
Alum Mixer	06ALM11 to 41	Vertical (2.8m x 2.3m x 3.5mH,	4	1	1	0	0	1	1	2	Tank (civil work)
Alum Pump	06ALP11 to 31	Diaphgram Pump (Manually stroke control type) 70-790L/h x 20m	2.2	1	1	1	0	2	1	3	
Alum Dust Collector	06ADC11 to 41	Filter Type, Approx.9.0m2, Filtreration Air 10m3/min	1.5	1	1	0	0	1	1	2	Stainless Steel / Non Corrosive Material
Portable Belt Conveyor	06BC11	Portable Belt Conveyer W350 x 5m	1	1	0	0	0	1	0	1	
Sump Drainage Pump	06DP11/21	Stainless Steel Submersible 0.24m3/min x 15m	2	1	1	1	0	2	1	3	
Lime Dosing System											
Lime Mixer	06LM11 to 41	Vertical (2.8m x 2.3m x 3.5mH, W.D. 2.5m)	4	1	1	0	0	1	1	2	Tank (civil work)
Lime Pump	06LP11 to 61	Diaphgram Pump (Manually stroke control type) 39-390L/h x 20m	2.2	2	2	2	0	4	2	6	
Lime Dust Collector	06LDC11 to 41	Filter Type, Approx.9.0m2, Filtreration Air 10m3/min	1.5	1	1	0	0	1	1	2	New, Mild Steel
Chemical Crane	06MC01	Motorized with Trolley 2.0 Ton	0.75 +0.4	1	0	0	0	1	0	1	For Alum and Lime
Sump Drainage Pump	06DP13/23	Stainless Steel Submersible 0.24m3/min x 15m	2	1	1	1	0	2	1	3	
Chlorination System											
Chlorine Containaer	06CC01 to 10	Steel Container 1.0t gas Cylinder	-	4	6	0	0	4	6	10	Approx. Dia. 770mm, 2,200mmL
Weighing Scale	06WS11 /21	hydraulic load cell type 2.0Ton	-	1	1	0	0	1	1	2	with one dial at the scale for two, 1 tonne chlorine cylinders
Chlorinator-Pre	06CL11 to 13	Auto Vacuum solution feed type (include ejector) 10kg/hr	0.025	1	1	1	0	2	1	3	Floor mounted
Chlorinator-Post	06CL21 to 23	Auto Vacuum solution feed type (include ejector) 10kg/hr	0.025	1	1	1	0	2	1	3	Floor mounted
Chlorine Crane	06MC02	Motorized with Trolley 2.0 Ton	0.75 +0.4	1	0	0	0	1	0	1	

06.Backwash Recovery Tank											
Backwash Inlet Gate	07HG11/21	Hand operated Sluice Gate ϕ 800mm	-	2	0	0	0	2	0	2	Spindle L=2m
Backwash Recovery Pump	07WP11/31	Centrifugal Pump 0.78m3/min x 15m	4	1	1	1	0	2	1	3	
Suction Valve	07 HV 11 to 51	Manually Sluice Gate Valve DN 150	-	5	0	0	0	5	0	5	
Check Valve	07 CV 11 to 31	Swing Check Valve DN 150	-	3	0	0	0	3	0	3	
Sump Drainage Pump	07DP01/02	Submersible 0.3m3/min x 15m	2.2	1	1	0	0	1	1	2	
Discharge Valve	07 HV 12 to 52	Manually Sluice Gate Valve DN 150	-	3	2	0	0	3	2	5	
Isolate Valve	07 HV 13 to 33	Manually Sluice Gate Valve DN 150	-	2	0	0	0	2	0	2	For Flow Meter
07.Sludge Discharge Tank											
Sludge Inlet Gate	08HG11/21	Hand operated Sluice Gate ϕ 400mm	-	2	0	0	0	2	0	2	Spindle L=2m
Sludge Discharge Pump	08WP11/31	Centrifugal Pump 1m3/min x 15m	5.5	1	1	1	0	2	1	3	
Suction Valve	08 HV 11 to 51	Manually Sluice Gate Valve DN 150	-	5	0	0	0	5	0	5	
Check Valve	08 CV 11 to 31	Swing Check Valve DN 150	-	3	0	0	0	3	0	3	
Sump Drainage Pump	08DP01/02	Submersible 0.3m3/min x 15m	2.2	1	1	0	0	1	1	2	
Discharge Valve	08 HV 12 to 52	Manually Sluice Gate Valve DN 150	-	3	2	0	0	3	2	5	
08. Sludge Dring Bed											
Sludge Drying Bed Inlet Valve	09MV01 to 24	Manual Sluice gate valve Dia.150	-	5	0	5	0	10	0	10	
Stop Log	09 SL 01 do 24	650 x 200 Aluminium	-	20	0	20	0	40	0	40	
09. Elevated Water Tank											
Outlet Valve	10HV 11 to 31	Manually Butterfly DN 1000	-	2	1	0	0	2	1	3	For Flow Meter
drain Valve	10HV 11	Manual Gate Valve DN150	-	1	0	0	0	1	0	1	

SR 4.12.2 Electrical Equipment List for Water Treatment Plant

Plant Electrical Works - Water Treatment Plant			Priority Project		Future	
	Item	Details	Nr.		Nr.	
1	Incoming Pole	with LA, Cut-out, PH	1		1	
2	HV Power Receiving Panel	22kV VCB	1		1	
3	HV CT, VT Panel	22kV	1		1	
4	HV Bus-tie Panel	22kV VCB	1			
5	Bus Duct	22kV			1	
6	HV Tr Primary Panel	22kV VCB	1		1	
7	Power Transformer	2000kVA Mold	1		1	
8	Standby Generator Set	2000kVA	1		1	
9	LV Panel	MCC Type	7		3	
10	Pump Starter Panel	300kW 400V Soft-starter	3		2	
11	Motor Control Center	400V Form3b	20		16	
12	Local Control Panel	Stand Type	30		20	
13	UPS	1hr 20kVA	1		1	
14	DC Unit	30min	1		1	
15	Water Flow	Electromagnetic Type	4		1	
16	Water Level	Ultrasonic Type	10		6	
17	Water Quality	Turbidity, pH, RCl	3		3	
18	IP Panel		4		2	
19	PLC Panel		4		2	
20	SCADA System		1			
21	SCADA System	(modification)			1	

SR 4.13 Pump Calculation Sheet for Water Treatment Plant

Clear Water Pump for Service Area (Priority Project; 30,000 m3/day)

1	Equip. No.			case1	case2		
	Pump Name						
2	Pump Type			Double suction	Double suction		
3	**q : Capacity (m3/min)**			**17**	**34**		
	Consider peak factor above		**factor value**	1.6	1.6		
4	**N : Operation number**			2	1		
	Pump				VSD		
	Pump Number			2D + 1S	1D + 1S		
	Total Head H=ha+hf1+hf2+hf3+hf4						
5	ha	:Actual head (m)		45.8	45.8		
		=DWL−SWL					
6	DWL	(m)		55.250	55.250		
7	SWL	(m)		9.450	9.450		
8	hf1	: Straight pipe loss (m) =		0.063	0.063		
		(10.666 x Q^1.85) x L x Cc					
		(C^1.85xD^4.87)					
9	Q	: Flow (m3/sec)		0.567	0.567		
		=q x N/60					
10	C	: Coefficient		**110**	**110**		
		LWL: 110					
		HWL: 140					
11	D	: Pipe Dia. (m)		0.9	0.9		
12	L	: Pipe length (m)		60	60		
13	Cc	: Correction coefficient		1.0	1.0		
		Water: 1.0					
		Sludge: WT99.2% :					
14	hf2			0.000	0.000		
15	hf3	: Pump around loss (m)		2	2		
		Horizontal type : 2.0m					
		Submersible type : 0.7m					
16	hf4	:Other head		0	0		
17	H'	=ha+hf1+hf2+hf3+hf4 (m)		47.86	47.86		
18	**H**	**: Total head (m)**		**48.0**	**48.0**		
		Velocity		0.89	0.89		
	Motor Power						
19	BKW	=0.163*SG*q*H/Pe (kW)		166.260	332.520		
20	SG	:Specific gravity		1.0	1.0		
21	Pe	:Pump efficiency		0.8	0.8		
22	kW	=BKW x C		191.199	382.398		
23	C	:Coefficient (1.15)		1.15	1.15		
24	**Motor Power (kW)**			**200**	**400**		

SR4.14 WTP Construction Cost Comparison

1. Introduction and Objectives

In this section construction cost comparison on four Options of WTP in addition to the original plan presented in the Draft Final Report is studied to justify a plan with the least construction cost. The site of the water treatment is located near the north end of Tonle Sap Lake. The existing areas are possible to be submerged when water level becomes high during rainy season. The WTP facilities shall be safe and maintained stable in operation during the rainy season. This study is made taking into consideration of buoyancy effect to the facility structures caused by the high water, which is one of the important factors in analyzing the foundations and configurations and elevations of facilities.

2. Applied Conditions

The following conditions are applied :

Table A.1 Applied Conditions

Item	Condition
Elevation of Existing Ground Level of the Tentatively Proposed Plant Site	+8.0 A.M.S.L.
Proposed Elevation of Embankment at the Proposed Plant Area	+12.0 A.M.S.L.
High Water Level	+11.0 A.M.S.L.
Other condition	The study is based on Soil Investigation Report conducted in the vicinity of the **Tentatively Proposed Plant Site** for the Study.(attached in SR4.6)

3. WTP Facilities

The following Water Treatment Facilities are considered in the study which are to be largely affected by the buoyancy effect and would result in variations in construction costs depending on their elevations to be constructed.

Table A.2 Facilities Considered

Item	Facilities
114-1	Distribution Chamber
114-2	Flocculation and Sedimentation Basin
114-3	Filter Units
114-4	Clear Water Reservoir
114-5	Sludge Discharge Tank
114-6	Sludge Drying Bed
114-8	Back Wash Recovery Tank
121-1	Elevated Water Tank

4. Options of Case Study

In addition to the study made in the Final Draft Report, the following four (4) options are studied with different types of pile foundation and the elevations of the facilities as follows.

Draft Final Report Plan :

Pile material 300x300 and/or 400x400, L=10m, allocated 0.5 piles per square meter. Structures are so shaped to resist the buoyancy effect with their dead weights. The dead weight of piles is not considered as for buoyancy resistance but taken as allowance as safety side.

Option A :

Pile material 300x300, L=10m. The dead weight of piles is considered as for buoyancy resistance to reduce structural concrete volume. Elevations of the Facilities are the same as those shown in the Draft Final Report. Bearing capacity of the pile 300x300 is estimated accordingly based on the soil investigation report, The number of piles are calculated based on the estimated bearing capacity. Elevations of the Facilities are the same as those shown in the Draft Final Report.

Option B :

Pile material 400x400, Length of pile for individual structure is calculated assuming the bearing strata of soil be -8.0m. The dead weight of piles is considered as for buoyancy resistance to reduce structural concrete volume. Bearing capacity of the pile 400x400 is estimated accordingly based on the soil investigation report, resulting in reduction of number of piles. Elevations of the Facilities are the same as those shown in the Draft Final Report.

Option C:

Pile material 400x400. The Facilities are raised by **2.0m** from the plan of the Draft Final Report to reduce buoyancy effect at the time of high water. By raising the facilities following work volumes are reduced; structural concrete and related work, steel sheet piles for shoring, excavation volume, backfilling volume. Less number of piles is required for some facilities as the dead weight of structures became smaller.

Option D:

Pile material 400x400. The Facilities are raised by **4.0m** from the plan of the Draft Final Report to minimize buoyancy effect at the time of high water.. By raising the facilities following work volumes are reduced to a maximum extent; structural concrete and related work, steel sheet piles for shoring, excavation volume, backfilling volume. Less number of piles is required for some facilities as the dead weight of structures became smaller.

5. Results of the Study

As shown in the following table, the Option D appeared to have the least cost among the options.

Table A.3 Summary Table Unit : 1,000xUS$

Option	Cost Estimate	Difference from Draft Final
Draft Final	8,415	-
A	6,199	-2,216
B	5,495	-2,920
C	5,415	-3,000
D	5,043	-3,372

6. Conclusion and Recommendations

The study presents that the Option D is recommendable, showing the least construction cost among the options.

However, in the detailed design stage, it is recommended that further study be performed based on the finally arranged proposed site of the plant. By obtaining more information in depth on soil conditions with standard penetration tests (SPTs), foundation types and configuration of structures of Water Treatment Facilities should be optimized. As has mentioned the area for planned area is located under water level during the rainy season, elaborate analysis and study are indispensable in designing and in considering of construction procedures.

7. Attachments

- WTP cost comparison of options (DF/R. A, B, C, and D)
- Cost Comparison of Options, Draft Final Report , A, B, C, and D

WTP Cost Compariosn of Options (DF/R, A, B, C, and D)

No.	Facilities	Draft Final		Option A		Option B		Option C		Option D		Remarks
		FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	
114-1	Distribution Chamber	20,330.64	32,656.95	20,330.64	40,992.71	20,330.64	28,791.96	20,330.64	101,893.96	20,330.64	159,073.96	Unit : US$
114-2	Floc. Sedimentation Basi	882,059.04	1,107,204.96	301,428.00	706,305.40	301,760.64	497,312.36	298,128.64	524,456.86	272,780.64	485,413.46	
114-3	Filter	277,702.00	539,977.46	277,702.00	507,999.30	277,725.76	421,024.94	273,655.76	437,420.14	236,831.76	433,900.64	
114-4	Clear Water Resev.	1,733,776.24	2,133,509.38	951,898.00	1,748,343.20	998,237.92	1,290,890.08	938,276.48	1,180,453.72	746,775.44	1,016,905.16	
114-5	Backwash Recovery Tank	85,536.00	230,118.88	61,776.00	223,225.00	81,726.48	204,693.72	62,069.04	167,333.96	62,069.04	99,496.36	
114-6	Sludge Drying Bed	142,560.00	212,746.80	155,232.00	213,906.00	155,374.56	245,551.84	155,374.56	342,884.84	155,374.56	554,565.84	
114-8	Sludge Discharge Tank	105,722.40	185,749.98	83,982.00	180,514.90	99,528.96	162,208.34	80,464.00	133,163.30	57,222.00	92,547.70	
121-1	Elevated Water Tank	180,495.84	544,855.89	180,495.84	544,855.89	180,495.84	529,297.28	177,275.84	521,642.71	155,643.84	493,764.71	
	Sub total	3,428,182.16	4,986,820.30	2,032,844.48	4,166,142.40	2,115,180.80	3,379,770.52	2,005,574.96	3,409,249.49	1,707,027.92	3,335,667.83	
	Total		8,415,002.46		6,198,986.88		5,494,951.32		5,414,824.45		5,042,695.75	
	Cost reduction			1,395,337.68	820,677.90	1,313,001.36	1,607,049.78	1,422,607.20	1,577,570.81	1,721,154.24	1,651,152.47	
	Total of cost reduction				**2,216,015.58**		**2,920,051.14**		**3,000,178.01**		**3,372,306.71**	

Cost Comparison of Options, Draft Final Report , A, B, C, and D

114-1 Distribution Chamber

Items	Option A	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	44	14.50	0.00	0.00	14.50	638.00	
Pile Driving Work	300×300, L = 10m	m	625	16.00	0.00	0.00	16.00	10,000.00	Increased by buoyancy control
Pile Material	300×300, L = 10m	m^3	56	88.00	0.00	0.00	88.00	4,928.00	Increased by buoyancy control
Pile Head Treatment	300×300	pcs	62	16.00	0.00	0.00	16.00	992.00	Increased by buoyancy control
Gravel		m^3	9	19.00	0.00	0.00	19.00	171.00	
Reinforced Concrete		m^3	151	88.00	0.00	0.00	88.00	13,288.00	
Formwork		m^2	504	12.00	0.00	0.00	12.00	6,048.00	
Supporting Works for Formwork		m^3	155	11.00	0.00	0.00	11.00	1,705.00	
Rebar Fabrication and Assembly		t	26	880.00	792.00	20,330.64	88.00	2,258.96	R-bar/Concrete = 170kg/m3
Excavation		m^3	386	2.50	0.00	0.00	2.50	963.75	
Total Cost						**20,330.64**		**40,992.71**	
Total Cost (FC+LC)					**62,000**				1000 US$ roundup

Items	Draft Final Report	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	44	14.50	0.00	0.00	14.50	638.00	
Pile Driving Work	300×300, L = 10m	m	297	16.00	0.00	0.00	16.00	4,752.00	
Pile Material	300×300, L = 10m	m^3	27	88.00	0.00	0.00	88.00	2,352.24	
Pile Head Treatment	300×300	pcs	30	16.00	0.00	0.00	16.00	480.00	
Gravel		m^3	9	19.00	0.00	0.00	19.00	171.00	
Reinforced Concrete		m^3	151	88.00	0.00	0.00	88.00	13,288.00	
Formwork		m^2	504	12.00	0.00	0.00	12.00	6,048.00	
Supporting Works for Formwork		m^3	155	11.00	0.00	0.00	11.00	1,705.00	
Rebar Fabrication and Assembly		t	26	880.00	792.00	20,330.64	88.00	2,258.96	R-bar/Concrete = 170kg/m3
Excavation		m^3	386	2.50	0.00	0.00	2.50	963.75	
Total Cost						**20,330.64**		**32,656.95**	
Total Cost (FC+LC)					**53,000**				1000 US$ roundup

Items	Option B	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	44	14.50	0.00	0.00	14.50	638.00	
Pile Driving Work	400×400	m	133	20.00	0.00	0.00	20.00	2,660.00	Decreased by pile review
Pile Material	400×400	m^3	21	88.00	0.00	0.00	88.00	1,848.00	Decreased by pile review
Pile Head Treatment	400×400	pcs	7	25.00	0.00	0.00	25.00	175.00	Decreased by pile review
Gravel		m^3	9	19.00	0.00	0.00	19.00	171.00	
Reinforced Concrete		m^3	151	88.00	0.00	0.00	88.00	13,288.00	
Formwork		m^2	504	12.00	0.00	0.00	12.00	6,048.00	
Supporting Works for Formwork		m^3	155	11.00	0.00	0.00	11.00	1,705.00	
Rebar Fabrication and Assembly		t	26	880.00	792.00	20,330.64	88.00	2,258.96	R-bar/Concrete = 170kg/m3
Excavation		m^3	0	2.50	0.00	0.00	2.50	0.00	
Total Cost						**20,330.64**		**28,791.96**	
Total Cost (FC+LC)					**50,000**				1000 US$ roundup

Items	Option C	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
	Embankment	m^3	5,048	14.50	0.00	0.00	14.50	73,196.00	Increased by +2m liftup
	400×400	m	147	20.00	0.00	0.00	20.00	2,940.00	Longer pile length by +2m liftup
	400×400	m^3	24	88.00	0.00	0.00	88.00	2,112.00	Longer pile length by +2m liftup
	400×400	pcs	7	25.00	0.00	0.00	25.00	175.00	
		m^3	9	19.00	0.00	0.00	19.00	171.00	
		m^3	151	88.00	0.00	0.00	88.00	13,288.00	
		m^2	504	12.00	0.00	0.00	12.00	6,048.00	
		m^3	155	11.00	0.00	0.00	11.00	1,705.00	
		t	26	880.00	792.00	20,330.64	88.00	2,258.96	R-bar/Concrete = 170kg/m3
		m^3	0	2.50	0.00	0.00	2.50	0.00	
						20,330.64		**101,893.96**	
					123,000				1000 US$ roundup

Option A Pile 300×300×L 10m	Draft Final
Option B Pile 400×400×L	Option C +2m liftup Pile 400×400×L
	Option D +4m liftup Pile 400×400×L

Items	Option D	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	8,960	14.50	0.00	0.00	14.50	129,920.00	Increased by +4m liftup
Pile Driving Work	400×400	m	161	20.00	0.00	0.00	20.00	3,220.00	Longer pile length by +4m liftup
Pile Material	400×400	m^3	26	88.00	0.00	0.00	88.00	2,288.00	Longer pile length by +4m liftup
Pile Head Treatment	400×400	pcs	7	25.00	0.00	0.00	25.00	175.00	
Gravel		m^3	9	19.00	0.00	0.00	19.00	171.00	
Reinforced Concrete		m^3	151	88.00	0.00	0.00	88.00	13,288.00	
Formwork		m^2	504	12.00	0.00	0.00	12.00	6,048.00	
Supporting Works for Formwork		m^3	155	11.00	0.00	0.00	11.00	1,705.00	
Rebar Fabrication and Assembly		t	26	880.00	792.00	20,330.64	88.00	2,258.96	R-bar/Concrete = 170kg/m3
Excavation		m^3	0	2.50	0.00	0.00	2.50	0.00	
Total Cost						**20,330.64**		**159,073.96**	
Total Cost (FC+LC)					**180,000**				1000 US$ roundup

Cost Comparison of Options, Draft Final Report , A, B, C, and D

114-2 Floccuration and Sedimentation Basin

Items	Option A	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	300×300, L = 10m	m	11,090	16.00	0.00	0.00	16.00	177,440.00	Increased by buoyancy control
Pile Material	300×300, L = 10m	m^3	998	88.00	0.00	0.00	88.00	87,824.00	Increased by buoyancy control
Pile Head Treatment	300×300	pcs	1,109	16.00	0.00	0.00	16.00	17,744.00	Increased by buoyancy control
Sheet Pile Driving Work	Type III, L = 15m	m^2	1,493	22.00	0.00	0.00	22.00	32,846.00	
Sheet Pile	Type III, L = 15m, Remain	t	90	206.00	206.00	18,540.00	0.00	0.00	
Supporting Works		t	36	260.00	0.00	0.00	260.00	9,360.00	
Support		t	36	290.00	290.00	10,440.00	0.00	0.00	
Embankment		m^3	3,246	14.50	0.00	0.00	14.50	47,067.00	
Excavation		m^3	2,032	2.50	0.00	0.00	2.50	5,080.00	
Backfilling		m^3	1,734	5.10	0.00	0.00	5.10	8,843.40	
Surplus Soil Transport		m^3	1,734	4.50	0.00	0.00	4.50	7,803.00	
Gravel		m^3	275	19.00	0.00	0.00	19.00	5,225.00	
Concrete		m^3	92	82.50	0.00	0.00	82.50	7,590.00	
Reinforced Concrete		m^3	2,026	88.00	0.00	0.00	88.00	178,288.00	Structural volume decreased by pile review
Formwork		m^2	5,739	12.00	0.00	0.00	12.00	68,868.00	
Supporting Works for Formwork		m^3	2,005	11.00	0.00	0.00	11.00	22,055.00	
Rebar Fabrication and Assembly		t	344	880.00	792.00	272,448.00	88.00	30,272.00	R-bar/Concrete = 170kg/m3
Total Cost						301,428.00		706,305.40	
Total Cost (FC+LC)					1,008,000				1000 US$ roundup

Items	Draft Final Report	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	300×300, L = 10m	m	9,200	16.00	0.00	0.00	16.00	147,200.00	
Pile Material	300×300, L = 10m	m^3	828	88.00	0.00	0.00	88.00	72,864.00	
Pile Head Treatment	300×300	pcs	920	16.00	0.00	0.00	16.00	14,720.00	
Sheet Pile Driving Work	Type III, L = 15m	m^2	1,493	22.00	0.00	0.00	22.00	32,846.00	
Sheet Pile	Type III, L = 15m, Remain	t	90	206.00	206.00	18,540.00	0.00	0.00	
Supporting Works		t	36	260.00	0.00	0.00	260.00	9,360.00	
Support		t	36	290.00	290.00	10,440.00	0.00	0.00	
Embankment		m^3	3,246	14.50	0.00	0.00	14.50	47,067.00	
Excavation		m^3	2,032	2.50	0.00	0.00	2.50	5,080.00	
Backfilling		m^3	1,734	5.10	0.00	0.00	5.10	8,843.40	
Surplus Soil Transport		m^3	1,734	4.50	0.00	0.00	4.50	7,803.00	
Gravel		m^3	275	19.00	0.00	0.00	19.00	5,225.00	
Concrete		m^3	92	82.50	0.00	0.00	82.50	7,590.00	
Reinforced Concrete		m^3	6,336	88.00	0.00	0.00	88.00	557,568.00	
Formwork		m^2	6,008	12.00	0.00	0.00	12.00	72,096.00	
Supporting Works for Formwork		m^3	2,196	11.00	0.00	0.00	11.00	24,156.00	
Rebar Fabrication and Assembly		t	1,077	880.00	792.00	853,079.04	88.00	94,786.56	R-bar/Concrete = 170kg/m3
Total Cost						882,059.04		1,107,204.96	
Total Cost (FC+LC)					1,990,000				1000 US$ roundup

Items	Option B	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	2,070	20.00	0.00	0.00	20.00	41,400.00	Decreased by pile review
Pile Material	400×400	m^3	331	88.00	0.00	0.00	88.00	29,128.00	Decreased by pile review
Pile Head Treatment	400×400	pcs	138	25.00	0.00	0.00	25.00	3,450.00	Decreased by pile review
Sheet Pile Driving Work	Type III, L = 15m	m^2	1,493	22.00	0.00	0.00	22.00	32,846.00	
Sheet Pile	Type III, L = 15m, Remain	t	90	206.00	206.00	18,540.00	0.00	0.00	
Supporting Works		t	36	260.00	0.00	0.00	260.00	9,360.00	
Support		t	36	290.00	290.00	10,440.00	0.00	0.00	
Embankment		m^3	3,246	14.50	0.00	0.00	14.50	47,067.00	
Excavation		m^3	2,032	2.50	0.00	0.00	2.50	5,080.00	
Backfilling		m^3	1,734	5.10	0.00	0.00	5.10	8,843.40	
Surplus Soil Transport		m^3	1,734	4.50	0.00	0.00	4.50	7,803.00	
Gravel		m^3	275	19.00	0.00	0.00	19.00	5,225.00	
Concrete		m^3	92	82.50	0.00	0.00	82.50	7,590.00	
Reinforced Concrete		m^3	2,026	88.00	0.00	0.00	88.00	178,288.00	
Formwork		m^2	5,739	12.00	0.00	0.00	12.00	68,868.00	
Supporting Works for Formwork		m^3	2,005	11.00	0.00	0.00	11.00	22,055.00	
Rebar Fabrication and Assembly		t	344	880.00	792.00	272,780.64	88.00	30,308.96	R-bar/Concrete = 170kg/m3
Total Cost						301,760.64		497,312.36	
Total Cost (FC+LC)					800,000				1000 US$ roundup

Items	Option C	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	2,346	20.00	0.00	0.00	20.00	46,920.00	Longer pile length by +2m liftup
Pile Material	400×400	m^3	375	88.00	0.00	0.00	88.00	33,000.00	Longer pile length by +2m liftup
Pile Head Treatment	400×400	pcs	138	25.00	0.00	0.00	25.00	3,450.00	
Sheet Pile Driving Work	Type III, L = 13m	m^2	1,294	22.00	0.00	0.00	22.00	28,468.00	Decreased by +2m liftup
Sheet Pile	Type III, L = 13m, Remain	t	78	206.00	206.00	16,068.00	0.00	0.00	Decreased by +2m liftup
Supporting Works		t	32	260.00	0.00	0.00	260.00	8,320.00	Decreased by +2m liftup
Support		t	32	290.00	290.00	9,280.00	0.00	0.00	Decreased by +2m liftup
Embankment		m^3	3,246	14.50	0.00	0.00	14.50	47,067.00	
Excavation		m^3	858	2.50	0.00	0.00	2.50	2,145.00	Decreased by +2m liftup
Backfilling		m^3	999	5.10	0.00	0.00	5.10	5,094.90	Decreased by +2m liftup
Surplus Soil Transport		m^3	999	4.50	0.00	0.00	4.50	4,495.50	Decreased by +2m liftup
Gravel		m^3	275	19.00	0.00	0.00	19.00	5,225.00	
Concrete		m^3	92	82.50	0.00	0.00	82.50	7,590.00	
Reinforced Concrete		m^3	2,026	88.00	0.00	0.00	88.00	178,288.00	
Formwork		m^2	5,739	12.00	0.00	0.00	12.00	68,868.00	
Supporting Works for Formwork		m^3	2,005	11.00	0.00	0.00	11.00	22,055.00	
Rebar Fabrication and Assembly		t	344	880.00	792.00	272,780.64	88.00	30,308.96	R-bar/Concrete = 170kg/m3
	Embankment	m^3	2,287	14.50	0.00	0.00	14.50	33,161.50	reviewed
Total Cost						298,128.64		524,456.86	
Total Cost (FC+LC)					823,000				1000 US$ roundup

Option A Pile 300×300×L 10m	Draft Final
Option B Pile 400×400×L	Option C +2m liftup Pile 400×400×L
	Option D +4m liftup Pile 400×400×L

Items	Option D	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	2,622	20.00	0.00	0.00	20.00	52,440.00	Longer pipe length by +4m liftup
Pile Material	400×400	m^3	420	88.00	0.00	0.00	88.00	36,960.00	Longer pipe length by +4m liftup
Pile Head Treatment	400×400	pcs	138	25.00	0.00	0.00	25.00	3,450.00	
Sheet Pile Driving Work		m^2	0	22.00	0.00	0.00	22.00	0.00	Deleted by +4m liftup
Sheet Pile		t	0	206.00	206.00	0.00	0.00	0.00	Deleted by +4m liftup
Supporting Works		t	0	260.00	0.00	0.00	260.00	0.00	Deleted by +4m liftup
Support		t	0	290.00	290.00	0.00	0.00	0.00	Deleted by +4m liftup
Embankment		m^3	3,246	14.50	0.00	0.00	14.50	47,067.00	
Excavation		m^3	0	2.50	0.00	0.00	2.50	0.00	Deleted by +4m liftup
Backfilling		m^3	0	5.10	0.00	0.00	5.10	0.00	Deleted by +4m liftup
Surplus Soil		m^3	0	4.50	0.00	0.00	4.50	0.00	Deleted by +4m liftup
Gravel		m^3	275	19.00	0.00	0.00	19.00	5,225.00	
Concrete		m^3	92	82.50	0.00	0.00	82.50	7,590.00	
Reinforced Concrete		m^3	2,026	88.00	0.00	0.00	88.00	178,288.00	
Formwork		m^2	5,739	12.00	0.00	0.00	12.00	68,868.00	
Supporting Works for Formwork		m^3	2,005	11.00	0.00	0.00	11.00	22,055.00	
Rebar Fabrication and Assembly		t	344	880.00	792.00	272,780.64	88.00	30,308.96	R-bar/Concrete = 170kg/m3
Embankment		m^3	2,287	14.50	0.00	0.00	14.50	33,161.50	
Total Cost						272,780.64		485,413.46	
Total Cost (FC+LC)					759,000				1000 US$ roundup

Cost Comparison of Options, Draft Final Report , A, B, C, and D

114-3 Rapid Sand Filter

Items	Option A	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	300×300, L=10m	m	5,306	16.00	0.00	0.00	16.00	84,896.00	Increased by buoyancy control
Pile Material	300×300, L=10m	m^3	478	88.00	0.00	0.00	88.00	42,064.00	Decreased by structure review
Pile Head Treatment	300×300	pcs	531	16.00	0.00	0.00	16.00	8,496.00	Increased by buoyancy control
Sheet Pile Driving Work	Type III, L = 20m	m^2	2,108	22.00	0.00	0.00	22.00	46,376.00	
Sheet Pile	Type III, L = 20m, Remain	t	127	206.00	206.00	26,162.00	0.00	0.00	
Supporting Works		t	51	260.00	0.00	0.00	260.00	13,208.00	
Support		t	51	290.00	290.00	14,732.00	0.00	0.00	
Excavation		m^3	121	2.50	0.00	0.00	2.50	302.50	
Backfilling		m^3	103	5.10	0.00	0.00	5.10	525.30	
Surplus Soil Transport		m^3	17	4.50	0.00	0.00	4.50	76.50	
Gravel		m^3	138	19.00	0.00	0.00	19.00	2,622.00	
Concrete		m^3	46	82.50	0.00	0.00	82.50	3,795.00	
Reinforced Concrete		m^3	1,759	88.00	0.00	0.00	88.00	154,792.00	
Formwork		m^2	5,394	12.00	0.00	0.00	12.00	64,728.00	
Supporting Works for Formwork		m^3	2,546	11.00	0.00	0.00	11.00	28,006.00	
Rebar Fabrication and Assembly		t	299	880.00	792.00	236,808.00	88.00	26,312.00	R-bar/Concrete = 170kg/m3
Filter Operation Gallery		m^2	318	100.00	0.00	0.00	100.00	31,800.00	
Total Cost						277,702.00		507,999.30	
Total Cost (FC+LC)					786,000				1000 US$ roundup

Items	Draft Final Report	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400, L = 10m	m	4,577	20.00	0.00	0.00	20.00	91,540.00	
Pile Material	400×400, L = 10m	m^3	732	88.00	0.00	0.00	88.00	64,444.16	
Pile Head Treatment	400×400	pcs	458	25.00	0.00	0.00	25.00	11,450.00	
Sheet Pile Driving Work	Type III, L = 20m	m^2	2,108	22.00	0.00	0.00	22.00	46,376.00	
Sheet Pile	Type III, L = 20m, Remain	t	127	206.00	206.00	26,162.00	0.00	0.00	
Supporting Works		t	51	260.00	0.00	0.00	260.00	13,208.00	
Support		t	51	290.00	290.00	14,732.00	0.00	0.00	
Excavation		m^3	121	2.50	0.00	0.00	2.50	302.50	
Backfilling		m^3	103	5.10	0.00	0.00	5.10	525.30	
Surplus Soil Transport		m^3	17	4.50	0.00	0.00	4.50	76.50	
Gravel		m^3	138	19.00	0.00	0.00	19.00	2,622.00	
Concrete		m^3	46	82.50	0.00	0.00	82.50	3,795.00	
Reinforced Concrete		m^3	1,759	88.00	0.00	0.00	88.00	154,792.00	
Formwork		m^2	5,394	12.00	0.00	0.00	12.00	64,728.00	
Supporting Works for Formwork		m^3	2,546	11.00	0.00	0.00	11.00	28,006.00	
Rebar Fabrication and Assembly		t	299	880.00	792.00	236,808.00	88.00	26,312.00	R-bar/Concrete = 170kg/m3
Filter Operation Gallery		m^2	318	100.00	0.00	0.00	100.00	31,800.00	
Total Cost						277,702.00		539,977.46	
Total Cost (FC+LC)					818,000				1000 US$ roundup

Items	Option B	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	1,361	20.00	0.00	0.00	20.00	27,220.00	Decreased by pile review
Pile Material	400×400	m^3	218	88.00	0.00	0.00	88.00	19,184.00	Decreased by pile review
Pile Head Treatment	400×400	pcs	83	25.00	0.00	0.00	25.00	2,075.00	Decreased by pile review
Sheet Pile Driving Work	Type III, L = 20m	m^2	2,108	22.00	0.00	0.00	22.00	46,376.00	
Sheet Pile	Type III, L = 20m, Remain	t	127	206.00	206.00	26,162.00	0.00	0.00	
Supporting Works		t	51	260.00	0.00	0.00	260.00	13,208.00	
Support		t	51	290.00	290.00	14,732.00	0.00	0.00	
Excavation		m^3	121	2.50	0.00	0.00	2.50	302.50	
Backfilling		m^3	103	5.10	0.00	0.00	5.10	525.30	
Surplus Soil Transport		m^3	17	4.50	0.00	0.00	4.50	76.50	
Gravel		m^3	138	19.00	0.00	0.00	19.00	2,622.00	
Concrete		m^3	46	82.50	0.00	0.00	82.50	3,795.00	
Reinforced Concrete		m^3	1,759	88.00	0.00	0.00	88.00	154,792.00	
Formwork		m^2	5,394	12.00	0.00	0.00	12.00	64,728.00	
Supporting Works for Formwork		m^3	2,546	11.00	0.00	0.00	11.00	28,006.00	
Rebar Fabrication and Assembly		t	299	880.00	792.00	236,831.76	88.00	26,314.64	R-bar/Concrete = 170kg/m3
Filter Operation Gallery		m^2	318	100.00	0.00	0.00	100.00	31,800.00	
Total Cost						277,725.76		421,024.94	
Total Cost (FC+LC)					699,000				1000 US$ roundup

Items	Option C	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	1,527	20.00	0.00	0.00	20.00	30,540.00	Longer pile length by +2m liftup
Pile Material	400×400	m^3	244	88.00	0.00	0.00	88.00	21,472.00	Longer pile length by +2m liftup
Pile Head Treatment	400×400	pcs	83	25.00	0.00	0.00	25.00	2,075.00	
Sheet Pile Driving Work	Type III, L = 18m	m^2	1,898	22.00	0.00	0.00	22.00	41,756.00	Decreased by +2m liftup
Sheet Pile	Type III, L = 18m, Remain	t	114	206.00	206.00	23,484.00	0.00	0.00	Decreased by +2m liftup
Supporting Works		t	46	260.00	0.00	0.00	260.00	11,960.00	Decreased by +2m liftup
Support		t	46	290.00	290.00	13,340.00	0.00	0.00	Decreased by +2m liftup
Excavation		m^3	0	2.50	0.00	0.00	2.50	0.00	Decreased by +2m liftup
Backfilling		m^3	0	5.10	0.00	0.00	5.10	0.00	Decreased by +2m liftup
Surplus Soil Transport		m^3	0	4.50	0.00	0.00	4.50	0.00	Decreased by +2m liftup
Gravel		m^3	138	19.00	0.00	0.00	19.00	2,622.00	
Concrete		m^3	46	82.50	0.00	0.00	82.50	3,795.00	
Reinforced Concrete		m^3	1,759	88.00	0.00	0.00	88.00	154,792.00	
Formwork		m^2	5,394	12.00	0.00	0.00	12.00	64,728.00	
Supporting Works for Formwork		m^3	2,546	11.00	0.00	0.00	11.00	28,006.00	
Rebar Fabrication and Assembly		t	299	880.00	792.00	236,831.76	88.00	26,314.64	R-bar/Concrete = 170kg/m3
Filter Operation Gallery		m^2	318	100.00	0.00	0.00	100.00	31,800.00	
	Embankment	m^3	1,211	14.50	0.00	0.00	14.50	17,559.50	reviewed
Total Cost						273,655.76		437,420.14	
Total Cost (FC+LC)					712,000				1000 US$ roundup

Option A **Pile 300×300×L 10m**	**Draft Final**
Option B Pile **400×400×L**	**Option C** **+2m liftup** **Pile 400×400×L**
	Option D **+4m liftup** **Pile 400×400×L**

Items	Option D	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	1,693	20.00	0.00	0.00	20.00	33,860.00	Longer pipe length by +4m liftup
Pile Material	400×400	m^3	271	88.00	0.00	0.00	88.00	23,848.00	Longer pipe length by +4m liftup
Pile Head Treatment	400×400	pcs	83	25.00	0.00	0.00	25.00	2,075.00	
Sheet Pile Driving Work		m^2	0	22.00	0.00	0.00	22.00	0.00	Deleted by +4m liftup
Sheet Pile		t	0	206.00	206.00	0.00	0.00	0.00	Deleted by +4m liftup
Supporting Works		t	0	260.00	0.00	0.00	260.00	0.00	Deleted by +4m liftup
Support		t	0	290.00	290.00	0.00	0.00	0.00	Deleted by +4m liftup
Excavation		m^3	0	2.50	0.00	0.00	2.50	0.00	
Backfilling		m^3	0	5.10	0.00	0.00	5.10	0.00	
Surplus Soil		m^3	0	4.50	0.00	0.00	4.50	0.00	
Gravel		m^3	138	19.00	0.00	0.00	19.00	2,622.00	
Concrete		m^3	46	82.50	0.00	0.00	82.50	3,795.00	
Reinforced Concrete		m^3	1,759	88.00	0.00	0.00	88.00	154,792.00	
Formwork		m^2	5,394	12.00	0.00	0.00	12.00	64,728.00	
Supporting Works for Formwork		m^3	2,546	11.00	0.00	0.00	11.00	28,006.00	
Rebar Fabrication and Assembly		t	299	880.00	792.00	236,831.76	88.00	26,314.64	R-bar/Concrete = 170kg/m3
Filter Operation Gallery		m^2	318	100.00	0.00	0.00	100.00	31,800.00	
Embankment		m^3	4,280	14.50	0.00	0.00	14.50	62,060.00	reviewed
Total Cost						236,831.76		433,900.64	
Total Cost (FC+LC)					671,000				1000 US$ roundup

Cost Comparison of Options, Draft Final Report , A, B, C, and D

114-4 Clear Water Reservoir and High Lift Pump Station

Items	Option A	Unit	Qty	Unit Cost	FC Portion (US%)		LC Portion (US$)		Reference
					Unit Price	Amount	Unit Price	Amount	
Pile Driving Work	300×300, L=10m	m	23,593	16.00	0.00	0.00	16.00	377,488.00	Increased by buoyancy control
Pile Material	300×300, L=10m	m^3	2,123	88.00	0.00	0.00	88.00	186,824.00	Increased by structure review
Pile Head Treatment	300×300	pcs	2,359	16.00	0.00	0.00	16.00	37,744.00	Increased by buoyancy control
Sheet Pile Driving Work	III型, L = 15m	m^2	3,540	22.00	0.00	0.00	22.00	77,880.00	
Sheet Pile	Type III, L = 15m, Removal	t	213	206.00	206.00	43,878.00	0.00	0.00	
Supporting Works		t	86	260.00	0.00	0.00	260.00	22,360.00	
Support		t	86	290.00	290.00	24,940.00	0.00	0.00	
Excavation		m^3	23,787	2.50	0.00	0.00	2.50	59,467.50	
Backfilling		m^3	12,377	5.10	0.00	0.00	5.10	63,122.70	
Surplus Soil Transport		m^3	11,410	4.50	0.00	0.00	4.50	51,345.00	
Gravel		m^3	317	19.00	0.00	0.00	19.00	6,023.00	
Concrete		m^3	106	82.50	0.00	0.00	82.50	8,745.00	
Reinforced Concrete		m^3	6,557	88.00	0.00	0.00	88.00	577,016.00	
Formwork		m^2	8,848	12.00	0.00	0.00	12.00	106,176.00	Volume decreased by piles' weight
Supporting Works for Formwork		m^3	6,912	11.00	0.00	0.00	11.00	76,032.00	
Rebar Fabrication and Assembly		t	1,115	880.00	792.00	883,080.00	88.00	98,120.00	ditto
									R-bar/Concrete = 170kg/m3
Total Cost						**951,898.00**		**1,748,343.20**	
Total Cost (FC+LC)					**2,701,000**				1000 US$ roundup

Items	Draft Final Report	Unit	Qty	Unit Cost	FC Portion (US%)		LC Portion (US$)		Reference
					Unit Price	Amount	Unit Price	Amount	
Pile Driving Work	400×400, L = 10m	m	10,543	20.00	0.00	0.00	20.00	210,860.00	
Pile Material	400×400, L = 10m	m^3	1,687	88.00	0.00	0.00	88.00	148,445.44	
Pile Head Treatment	400×400	pcs	1,054	25.00	0.00	0.00	25.00	26,357.38	
Sheet Pile Driving Work	III型, L = 15m	m^2	3,540	22.00	0.00	0.00	22.00	77,880.00	
Sheet Pile	Type III, L = 15m, Removal	t	213	206.00	206.00	43,878.00	0.00	0.00	
Supporting Works		t	86	260.00	0.00	0.00	260.00	22,360.00	
Support		t	86	290.00	290.00	24,940.00	0.00	0.00	
Excavation		m^3	23,787	2.50	0.00	0.00	2.50	59,467.50	
Backfilling		m^3	12,377	5.10	0.00	0.00	5.10	63,122.70	
Surplus Soil Transport		m^3	11,410	4.50	0.00	0.00	4.50	51,345.00	
Gravel		m^3	317	19.00	0.00	0.00	19.00	6,023.00	
Concrete		m^3	106	82.50	0.00	0.00	82.50	8,745.00	
Reinforced Concrete		m^3	12,366	88.00	0.00	0.00	88.00	1,088,208.00	
Formwork		m^2	9,139	12.00	0.00	0.00	12.00	109,668.00	
Supporting Works for Formwork		m^3	6,912	11.00	0.00	0.00	11.00	76,032.00	
Rebar Fabrication and Assembly		t	2,102	880.00	792.00	1,664,958.24	88.00	184,995.36	R-bar/Concrete = 170kg/m3
Total Cost						**1,733,776.24**		**2,133,509.38**	
Total Cost (FC+LC)					**3,868,000**				1000 US$ roundup

Items	Option B	Unit	Qty	Unit Cost	FC Portion (US%)		LC Portion (US$)		Reference
					Unit Price	Amount	Unit Price	Amount	
Pile Driving Work	400×400	m	2,835	20.00	0.00	0.00	20.00	56,700.00	Decreased by pile review
Pile Material	400×400	m^3	454	88.00	0.00	0.00	88.00	39,952.00	Decreased by pile review
Pile Head Treatment	400×400	pcs	270	25.00	0.00	0.00	25.00	6,750.00	Decreased by pile review
Sheet Pile Driving Work	Type III, L = 15m	m^2	3,540	22.00	0.00	0.00	22.00	77,880.00	
Sheet Pile	Type III, L = 15m, Removal	t	213	206.00	206.00	43,878.00	0.00	0.00	
Supporting Works		t	86	260.00	0.00	0.00	260.00	22,360.00	
Support		t	86	290.00	290.00	24,940.00	0.00	0.00	
Excavation		m^3	23,787	2.50	0.00	0.00	2.50	59,467.50	
Backfilling		m^3	12,377	5.10	0.00	0.00	5.10	63,122.70	
Surplus Soil Transport		m^3	11,410	4.50	0.00	0.00	4.50	51,345.00	
Gravel		m^3	317	19.00	0.00	0.00	19.00	6,023.00	
Concrete		m^3	106	82.50	0.00	0.00	82.50	8,745.00	
Reinforced Concrete		m^3	6,903	88.00	0.00	0.00	88.00	607,464.00	Increased by buoyancy control
Formwork		m^2	9,315	12.00	0.00	0.00	12.00	111,780.00	Increased by buoyancy control
Supporting Works for Formwork		m^3	6,912	11.00	0.00	0.00	11.00	76,032.00	
Rebar Fabrication and Assembly		t	1,174	880.00	792.00	929,419.92	88.00	103,268.88	Increased by buoyancy control
									R-bar/Concrete =
Total Cost						**998,237.92**		**1,290,890.08**	
Total Cost (FC+LC)					**2,290,000**				1000 US$ roundup

Items	Option C	Unit	Qty	Unit Cost	FC Portion (US%)		LC Portion (US$)		Reference
					Unit Price	Amount	Unit Price	Amount	
Pile Driving Work	400×400	m	3,250	20.00	0.00	0.00	20.00	65,000.00	Longer pile length by +2m liftup
Pile Material	400×400	m^3	520	88.00	0.00	0.00	88.00	45,760.00	Longer pile length by +2m liftup
Pile Head Treatment	400×400	pcs	260	25.00	0.00	0.00	25.00	6,500.00	Review of pile numbers
Sheet Pile Driving Work	Type III, L = 13m	m^2	2,860	22.00	0.00	0.00	22.00	62,920.00	Decreased by +2m liftup
Sheet Pile	Type III, L = 13m, Removal	t	172	206.00	206.00	35,432.00	0.00	0.00	Decreased by +2m liftup
Supporting Works		t	69	260.00	0.00	0.00	260.00	17,940.00	Decreased by +2m liftup
Support		t	69	290.00	290.00	20,010.00	0.00	0.00	Decreased by +2m liftup
Excavation		m^3	14,939	2.50	0.00	0.00	2.50	37,347.50	Decreased by +2m liftup
Backfilling		m^3	9,460	5.10	0.00	0.00	5.10	48,246.00	Decreased by +2m liftup
Surplus Soil Transport		m^3	5,479	4.50	0.00	0.00	4.50	24,655.50	Decreased by +2m liftup
Gravel		m^3	317	19.00	0.00	0.00	19.00	6,023.00	
Concrete		m^3	106	82.50	0.00	0.00	82.50	8,745.00	
Reinforced Concrete		m^3	6,557	88.00	0.00	0.00	88.00	577,016.00	Decreased buoyancy by +2m liftup
Formwork		m^2	8,848	12.00	0.00	0.00	12.00	106,176.00	Decreased buoyancy by +2m liftup
Supporting Works for Formwork		m^3	6,912	11.00	0.00	0.00	11.00	76,032.00	
Rebar Fabrication and Assembly		t	1,115	880.00	792.00	882,834.48	88.00	98,092.72	Decreased buoyancy by +2m liftup
									R-bar/Concrete = 170kg/m3
Total Cost						**938,276.48**		**1,180,453.72**	
Total Cost (FC+LC)					**2,119,000**				1000 US$ roundup

Option A **Pile 300×300×L 10m**	**Draft Final**
Option B Pile **400×400×L**	**Option C** **+2m liftup** **Pile 400×400×L**
	Option D **+4m liftup** **Pile 400×400×L**

Items	Option D	Unit	Qty	Unit Cost	FC Portion (US%)		LC Portion (US$)		Reference
					Unit Price	Amount	Unit Price	Amount	
Pile Driving Work	400×400	m	4,108	20.00	0.00	0.00	20.00	82,160.00	Longer pipe length by +4m liftup
Pile Material	400×400	m^3	657	88.00	0.00	0.00	88.00	57,816.00	Longer pipe length by +4m liftup
Pile Head Treatment	400×400	pcs	260	25.00	0.00	0.00	25.00	6,500.00	
Sheet Pile Driving Work	Type III, L = 11m	m^2	2,420	22.00	0.00	0.00	22.00	53,240.00	Decreased by +4m liftup
Sheet Pile	Type III, L = 11m, Removal	t	146	206.00	206.00	30,076.00	0.00	0.00	Decreased by +4m liftup
Supporting Works		t	59	260.00	0.00	0.00	260.00	15,340.00	Decreased by +4m liftup
Support		t	59	290.00	290.00	17,110.00	0.00	0.00	Decreased by +4m liftup
Excavation		m^3	9,467	2.50	0.00	0.00	2.50	23,667.50	Decreased by +4m liftup
Backfilling		m^3	7,460	5.10	0.00	0.00	5.10	38,046.00	Decreased by +4m liftup
Surplus Soil		m^3	2,007	4.50	0.00	0.00	4.50	9,031.50	Decreased by +4m liftup
Gravel		m^3	317	19.00	0.00	0.00	19.00	6,023.00	
Concrete		m^3	106	82.50	0.00	0.00	82.50	8,745.00	
Reinforced Concrete		m^3	5,196	88.00	0.00	0.00	88.00	457,248.00	Decreased buoyancy by +4m liftup
Formwork		m^2	8,777	12.00	0.00	0.00	12.00	105,324.00	Decreased buoyancy by +4m liftup
Supporting Works for Formwork		m^3	6,912	11.00	0.00	0.00	11.00	76,032.00	
Rebar Fabrication and Assembly		t	883	880.00	792.00	699,589.44	88.00	77,732.16	Decreased buoyancy by +4m liftup
									R-bar/Concrete = 170kg/m3
Total Cost						**746,775.44**		**1,016,905.16**	
Total Cost (FC+LC)					**1,764,000**				1000 US$ roundup

Cost Comparison of Options, Draft Final Report , A, B, C, and D

114-5 Backwash Recovery Tank

Items	Option A	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	1,532	14.50	0.00	0.00	14.50	22,214.00	
Pile Driving Work	300×300, L=10m	m	1,848	16.00	0.00	0.00	16.00	29,568.00	Increased by buoyancy control
Pile Material	300×300, L=10m	m^3	166	88.00	0.00	0.00	88.00	14,608.00	Increased by buoyancy control
Pile Head Treatment	300×300	pcs	185	16.00	0.00	0.00	16.00	2,960.00	Increased by buoyancy control
Sheet Pile Driving Work	III型, L = 15m	m^2	1,449	22.00	0.00	0.00	22.00	31,878.00	
Sheet Pile	III型, L = 15m, Remain	t	87	206.00	0.00	0.00	206.00	17,922.00	
Supporting Works		t	35	260.00	0.00	0.00	260.00	9,100.00	
Supporting		t	35	290.00	0.00	0.00	290.00	10,150.00	
Excavation		m^3	2,379	2.50	0.00	0.00	2.50	5,947.50	
Backfilling		m^3	1,570	5.10	0.00	0.00	5.10	8,007.00	
Surplus Soil Transport		m^3	809	4.50	0.00	0.00	4.50	3,640.50	
Gravel		m^3	30	19.00	0.00	0.00	19.00	570.00	
Concrete		m^3	10	82.50	0.00	0.00	82.50	825.00	
Reinforced Concrete		m^3	461	88.00	0.00	0.00	88.00	40,568.00	
Formwork		m^2	1,125	12.00	0.00	0.00	12.00	13,500.00	Volume decreased by piles' weight
Supporting Works for Formwork		m^3	273	11.00	0.00	0.00	11.00	3,003.00	
Rebar Fabrication and Assembly		t	78	880.00	792.00	61,776.00	88.00	6,864.00	ditto
Building Work		m^2	19	100.00	0.00	0.00	100.00	1,900.00	
									R-bar/Concrete = 170kg/m3
Total Cost						61,776.00		223,225.00	
Total Cost (FC+LC)						286,000			1000 US$ roundup

Items	Draft Final Report	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	1,532	14.50	0.00	0.00	14.50	22,214.00	
Pile Driving Work	400×400, L = 10m	m	986	20.00	0.00	0.00	20.00	19,720.00	
Pile Material	400×400, L = 10m	m^3	158	88.00	0.00	0.00	88.00	13,882.88	
Pile Head Treatment	400×400	pcs	99	25.00	0.00	0.00	25.00	2,475.00	
Sheet Pile Driving Work	III型, L = 15m	m^2	1,449	22.00	0.00	0.00	22.00	31,878.00	
Sheet Pile	III型, L = 15m, Remain	t	87	206.00	0.00	0.00	206.00	17,922.00	
Supporting Works		t	35	260.00	0.00	0.00	260.00	9,100.00	
Supporting		t	35	290.00	0.00	0.00	290.00	10,150.00	
Excavation		m^3	2,379	2.50	0.00	0.00	2.50	5,947.50	
Backfilling		m^3	1,570	5.10	0.00	0.00	5.10	8,007.00	
Surplus Soil Transport		m^3	809	4.50	0.00	0.00	4.50	3,640.50	
Gravel		m^3	30	19.00	0.00	0.00	19.00	570.00	
Concrete		m^3	10	82.50	0.00	0.00	82.50	825.00	
Reinforced Concrete		m^3	635	88.00	0.00	0.00	88.00	55,880.00	
Formwork		m^2	1,125	12.00	0.00	0.00	12.00	13,500.00	
Supporting Works for Formwork		m^3	273	11.00	0.00	0.00	11.00	3,003.00	
Rebar Fabrication and Assembly		t	108	880.00	792.00	85,536.00	88.00	9,504.00	R-bar/Concrete = 170kg/m3
Building Work		m^2	19	100.00	0.00	0.00	100.00	1,900.00	
Total Cost						85,536.00		230,118.88	
Total Cost (FC+LC)						316,000			1000 US$ roundup

Items	Option B	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	1,532	14.50	0.00	0.00	14.50	22,214.00	
Pile Driving Work	400×400	m	258	20.00	0.00	0.00	20.00	5,160.00	Decreased by pile review
Pile Material	400×400	m^3	41	88.00	0.00	0.00	88.00	3,608.00	Decreased by pile review
Pile Head Treatment	400×400	pcs	20	25.00	0.00	0.00	25.00	500.00	Decreased by pile review
Sheet Pile Driving Work	III型, L = 15m	m^2	1,449	22.00	0.00	0.00	22.00	31,878.00	
Sheet Pile	III型, L = 15m, Remain	t	87	206.00	0.00	0.00	206.00	17,922.00	
Supporting Works		t	35	260.00	0.00	0.00	260.00	9,100.00	
Supporting		t	35	290.00	0.00	0.00	290.00	10,150.00	
Excavation		m^3	2,379	2.50	0.00	0.00	2.50	5,947.50	
Backfilling		m^3	1,570	5.10	0.00	0.00	5.10	8,007.00	
Surplus Soil Transport		m^3	809	4.50	0.00	0.00	4.50	3,640.50	
Gravel		m^3	30	19.00	0.00	0.00	19.00	570.00	
Concrete		m^3	10	82.50	0.00	0.00	82.50	825.00	
Reinforced Concrete		m^3	607	88.00	0.00	0.00	88.00	53,416.00	Increased by buoyancy control
Formwork		m^2	1,481	12.00	0.00	0.00	12.00	17,772.00	Increased by buoyancy control
Supporting Works for Formwork		m^3	273	11.00	0.00	0.00	11.00	3003.00	
Rebar Fabrication and Assembly		t	103	880.00	792.00	81,726.48	88.00	9,080.72	Increased by buoyancy control
Building Work		m^2	19	100.00	0.00	0.00	100.00	1,900.00	
									R-bar/Concrete = 170kg/m3
Total Cost						81,726.48		204,693.72	
Total Cost (FC+LC)						287,000			1000 US$ roundup

Items	Option C	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	1,532	14.50	0.00	0.00	14.50	22,214.00	
Pile Driving Work	400×400	m	238	20.00	0.00	0.00	20.00	4,760.00	Decreased by deducted pilie number
Pile Material	400×400	m^3	38	88.00	0.00	0.00	88.00	3,344.00	Decreased by deducted pilie number
Pile Head Treatment	400×400	pcs	16	25.00	0.00	0.00	25.00	400.00	Due to deducted buoyancy
Sheet Pile Driving Work	Type III, L = 13m	m^2	1,256	22.00	0.00	0.00	22.00	27,632.00	Decreased by +2m liftup
Sheet Pile	Type III, L = 13m, Remain	t	76	206.00	0.00	0.00	206.00	15,656.00	Decreased by +2m liftup
Supporting Works		t	31	260.00	0.00	0.00	260.00	8,060.00	Decreased by +2m liftup
Supporting		t	31	290.00	0.00	0.00	290.00	8,990.00	Decreased by +2m liftup
Excavation		m^3	1,219	2.50	0.00	0.00	2.50	3,047.50	Decreased by +2m liftup
Backfilling		m^3	804	5.10	0.00	0.00	5.10	4,100.40	Decreased by +2m liftup
Surplus Soil Transport		m^3	415	4.50	0.00	0.00	4.50	1,867.50	Decreased by +2m liftup
Gravel		m^3	30	19.00	0.00	0.00	19.00	570.00	
Concrete		m^3	10	82.50	0.00	0.00	82.50	825.00	
Reinforced Concrete		m^3	461	88.00	0.00	0.00	88.00	40,568.00	Decreased buoyancy by +2m liftup
Formwork		m^2	1,125	12.00	0.00	0.00	12.00	13,500.00	Decreased buoyancy by +2m liftup
Supporting Works for Formwork		m^3	273	11.00	0.00	0.00	11.00	3003.00	
Rebar Fabrication and Assembly		t	78	880.00	792.00	62,069.04	88.00	6,896.56	Decreased buoyancy by +2m liftup
Building Work		m^2	19	100.00	0.00	0.00	100.00	1,900.00	
									R-bar/Concrete = 170kg/m3
Total Cost						62,069.04		167,333.96	
Total Cost (FC+LC)						230,000			1000 US$ roundup

Option A Pile 300×300×L 10m	**Draft Final**
Option B Pile **400×400×L**	**Option C** **+2m liftup** **Pile 400×400×L**
	Option D **+4m liftup** **Pile 400×400×L**

Items	Option D	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	1,532	14.50	0.00	0.00	14.50	22,214.00	
Pile Driving Work	400×400	m	270	20.00	0.00	0.00	20.00	5,400.00	Longer pipe length by +4m liftup
Pile Material	400×400	m^3	43	88.00	0.00	0.00	88.00	3,784.00	Longer pipe length by +4m liftup
Pile Head Treatment	400×400	pcs	16	25.00	0.00	0.00	25.00	400.00	
Sheet Pile Driving Work		m^2	0	22.00	0.00	0.00	22.00	0.00	Deleted by +4m liftup
Sheet Pile		t	0	206.00	0.00	0.00	206.00	0.00	Deleted by +4m liftup
Supporting Works		t	0	260.00	0.00	0.00	260.00	0.00	Deleted by +4m liftup
Supporting		t	0	290.00	0.00	0.00	290.00	0.00	Deleted by +4m liftup
Excavation		m^3	59	2.50	0.00	0.00	2.50	147.50	Decreased by +4m liftup
Backfilling		m^3	38	5.10	0.00	0.00	5.10	193.80	Decreased by +4m liftup
Surplus Soil		m^3	21	4.50	0.00	0.00	4.50	94.50	Decreased by +4m liftup
Gravel		m^3	30	19.00	0.00	0.00	19.00	570.00	
Concrete		m^3	10	82.50	0.00	0.00	82.50	825.00	
Reinforced Concrete		m^3	461	88.00	0.00	0.00	88.00	40,568.00	
Formwork		m^2	1,125	12.00	0.00	0.00	12.00	13,500.00	
Supporting Works for Formwork		m^3	273	11.00	0.00	0.00	11.00	3003.00	
Rebar Fabrication and Assembly		t	78	880.00	792.00	62,069.04	88.00	6,896.56	
Building Work		m^2	19	100.00	0.00	0.00	100.00	1,900.00	
									R-bar/Concrete = 170kg/m3
Total Cost						62,069.04		99,496.36	
Total Cost (FC+LC)						162,000			1000 US$ roundup

Cost Comparison of Options, Draft Final Report , A, B, C, and D

114-6 Sludge Drying Bed

Items	Option A	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	2,994	14.50	0.00	0.00	14.50	43,413.00	
Pile Driving Work	300×300, L=10m	m	530	16.00	0.00	0.00	16.00	8,480.00	Decreased by increased weight of structure
Pile Material	300×300, L=10m	m^3	48	88.00	0.00	0.00	88.00	4,224.00	
Pile Head Treatment	300×300	pcs	53	16.00	0.00	0.00	16.00	848.00	
Gravel		m^3	286	19.00	0.00	0.00	19.00	5,434.00	
Concrete		m^3	96	82.50	0.00	0.00	82.50	7,920.00	
Reinforced Concrete		m^3	1,154	88.00	0.00	0.00	88.00	101,552.00	Increased by buoyancy control
Formwork		m^2	1,863	12.00	0.00	0.00	12.00	22,356.00	Increased by buoyancy control
Supporting Works for Formwork		m^3	221	11.00	0.00	0.00	11.00	2,431.00	
Rebar Fabrication and Assembly		t	196	880.00	792.00	155,232.00	88.00	17,248.00	Increased by buoyancy control
									R-bar/Concrete = 170kg/m3
Total Cost						**155,232.00**		**213,906.00**	
Total Cost (FC+LC)						**370,000**			1000 US$ roundup

Items	Draft Final Report	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	2,994	14.50	0.00	0.00	14.50	43,413.00	
Pile Driving Work	400×400, L = 10m	m	760	20.00	0.00	0.00	20.00	15,200.00	
Pile Material	400×400, L = 10m	m^3	122	88.00	0.00	0.00	88.00	10,700.80	
Pile Head Treatment	400×400	pcs	76	25.00	0.00	0.00	25.00	1,900.00	
Gravel		m^3	286	19.00	0.00	0.00	19.00	5,434.00	
Concrete		m^3	96	82.50	0.00	0.00	82.50	7,920.00	
Reinforced Concrete		m^3	1,059	88.00	0.00	0.00	88.00	93,192.00	
Formwork		m^2	1,393	12.00	0.00	0.00	12.00	16,716.00	
Supporting Works for Formwork		m^3	221	11.00	0.00	0.00	11.00	2,431.00	
Rebar Fabrication and Assembly		t	180	880.00	792.00	142,560.00	88.00	15,840.00	R-bar/Concrete = 170kg/m3
Total Cost						**142,560.00**		**212,746.80**	
Total Cost (FC+LC)						**356,000**			1000 US$ roundup

Items	Option B	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	2,994	14.50	0.00	0.00	14.50	43,413.00	
Pile Driving Work	400×400	m	1,274	20.00	0.00	0.00	20.00	25,480.00	
Pile Material	400×400	m^3	204	88.00	0.00	0.00	88.00	17,952.00	Increased by pile review
Pile Head Treatment	400×400	pcs	70	25.00	0.00	0.00	25.00	1,750.00	
Gravel		m^3	286	19.00	0.00	0.00	19.00	5,434.00	
Concrete		m^3	96	82.50	0.00	0.00	82.50	7,920.00	
Reinforced Concrete		m^3	1,154	88.00	0.00	0.00	88.00	101,552.00	
Formwork		m^2	1,863	12.00	0.00	0.00	12.00	22,356.00	
Supporting Works for Formwork		m^3	221	11.00	0.00	0.00	11.00	2,431.00	
Rebar Fabrication and Assembly		t	196	880.00	792.00	155,374.56	88.00	17,263.84	R-bar/Concrete = 170kg/m3
Total Cost						**155,374.56**		**245,551.84**	
Total Cost (FC+LC)						**401,000**			1000 US$ roundup

Items	Option C	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment	Embankment	m^3	9,380	14.50	0.00	0.00	14.50	136,010.00	Reviewed
Pile Driving Work	400×400	m	1,414	20.00	0.00	0.00	20.00	28,280.00	Longer pile length by +2m liftup
Pile Material	400×400	m^3	226	88.00	0.00	0.00	88.00	19,888.00	Longer pile length by +2m liftup
Pile Head Treatment	400×400	pcs	70	25.00	0.00	0.00	25.00	1,750.00	
Gravel		m^3	286	19.00	0.00	0.00	19.00	5,434.00	
Concrete		m^3	96	82.50	0.00	0.00	82.50	7,920.00	
Reinforced Concrete		m^3	1,154	88.00	0.00	0.00	88.00	101,552.00	
Formwork		m^2	1,863	12.00	0.00	0.00	12.00	22,356.00	
Supporting Works for Formwork		m^3	221	11.00	0.00	0.00	11.00	2,431.00	
Rebar Fabrication and Assembly		t	196	880.00	792.00	155,374.56	88.00	17,263.84	R-bar/Concrete = 170kg/m3
Total Cost						**155,374.56**		**342,884.84**	
Total Cost (FC+LC)						**499,000**			1000 US$ roundup

Option A **Pile 300×300×L 10m**	**Draft Final**
Option B Pile **400×400×L**	**Option C** **+2m liftup** **Pile 400×400×L**
	Option D **+4m liftup** **Pile 400×400×L**

Items	Option D	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Embankment		m^3	23,646	14.50	0.00	0.00	14.50	342,867.00	Reviewed
Pile Driving Work	400×400	m	1,554	20.00	0.00	0.00	20.00	31,080.00	Longer pipe length by +4m liftup
Pile Material	400×400	m^3	249	88.00	0.00	0.00	88.00	21,912.00	Longer pipe length by +4m liftup
Pile Head Treatment	400×400	pcs	70	25.00	0.00	0.00	25.00	1,750.00	
Gravel		m^3	286	19.00	0.00	0.00	19.00	5,434.00	
Concrete		m^3	96	82.50	0.00	0.00	82.50	7,920.00	
Reinforced Concrete		m^3	1,154	88.00	0.00	0.00	88.00	101,552.00	
Formwork		m^2	1,863	12.00	0.00	0.00	12.00	22,356.00	
Supporting Works for Formwork		m^3	221	11.00	0.00	0.00	11.00	2,431.00	
Rebar Fabrication and Assembly		t	196	880.00	792.00	155,374.56	88.00	17,263.84	R-bar/Concrete = 170kg/m3
Total Cost						**155,374.56**		**554,565.84**	
Total Cost (FC+LC)						**710,000**			1000 US$ roundup

Cost Comparison of Options, Draft Final Report , A, B, C, and D

114-8 Sludge Discharge Tank

Items	Option A	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	300×300, L=10m	m	1,632	16.00	0.00	0.00	16.00	26,112.00	Increased by buoyancy control
Pile Material	300×300, L=10m	m^3	147	88.00	0.00	0.00	88.00	12,936.00	Increased by buoyancy control
Pile Head Treatment	300×300	pcs	163	16.00	0.00	0.00	16.00	2,608.00	Increased by buoyancy control
Sheet Pile Driving Work	Type III, L = 15m	m^2	1,374	22.00	0.00	0.00	22.00	30,228.00	
Sheet Pile	Type III, L = 15m, Remain	t	83	206.00	206.00	17,098.00	0.00	0.00	1/5 of Purchase Price
Supporting Works		t	34	260.00	0.00	0.00	260.00	8,840.00	
Support		t	34	290.00	290.00	9,860.00	0.00	0.00	1/5 of Purchase Price
Embankment		m^3	1,432	14.50	0.00	0.00	14.50	20,764.00	
Excavation		m^3	2,254	2.50	0.00	0.00	2.50	5,635.00	
Backfilling		m^3	1,539	5.10	0.00	0.00	5.10	7,848.90	
Surplus Soil Transport		m^3	715	4.50	0.00	0.00	4.50	3,217.50	
Gravel		m^3	25	19.00	0.00	0.00	19.00	475.00	
Concrete		m^3	9	82.50	0.00	0.00	82.50	742.50	
Reinforced Concrete		m^3	425	88.00	0.00	0.00	88.00	37,400.00	Decreased by pile review
Formwork		m^2	1,029	12.00	0.00	0.00	12.00	12,348.00	
Supporting Works for Formwork		m^3	284	11.00	0.00	0.00	11.00	3,124.00	
Rebar Fabrication and Assembly		t	72	880.00	792.00	57,024.00	88.00	6,336.00	ditto
Building Work		m^2	19	100.00	0.00	0.00	100.00	1,900.00	
									R-bar/Concrete = 170kg/m3
Total Cost						83,982.00		180,514.90	
Total Cost (FC+LC)						265,000			1000 US$ roundup

Items	Draft Final Report	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400, L = 10m	m	831	20.00	0.00	0.00	20.00	16,620.00	
Pile Material	400×400, L = 10m	m^3	133	88.00	0.00	0.00	88.00	11,700.48	
Pile Head Treatment	400×400	pcs	83	25.00	0.00	0.00	25.00	2,075.00	
Sheet Pile Driving Work	Type III, L = 15m	m^2	1,374	22.00	0.00	0.00	22.00	30,228.00	
Sheet Pile	Type III, L = 15m, Remain	t	83	206.00	206.00	17,098.00	0.00	0.00	1/5 of Purchase Price
Supporting Works		t	34	260.00	0.00	0.00	260.00	8,840.00	
Support		t	34	290.00	290.00	9,860.00	0.00	0.00	1/5 of Purchase Price
Embankment		m^3	1,432	14.50	0.00	0.00	14.50	20,764.00	
Excavation		m^3	2,254	2.50	0.00	0.00	2.50	5,635.00	
Backfilling		m^3	1,539	5.10	0.00	0.00	5.10	7,848.90	
Surplus Soil Transport		m^3	715	4.50	0.00	0.00	4.50	3,217.50	
Gravel		m^3	25	19.00	0.00	0.00	19.00	475.00	
Concrete		m^3	9	82.50	0.00	0.00	82.50	742.50	
Reinforced Concrete		m^3	585	88.00	0.00	0.00	88.00	51,480.00	
Formwork		m^2	1,029	12.00	0.00	0.00	12.00	12,348.00	
Supporting Works for Formwork		m^3	284	11.00	0.00	0.00	11.00	3,124.00	
Rebar Fabrication and Assembly		t	99	880.00	792.00	78,764.40	88.00	8,751.60	R-bar/Concrete = 170kg/m3
Building Work		m^2	19	100.00	0.00	0.00	100.00	1,900.00	
Total Cost						105,722.40		185,749.98	
Total Cost (FC+LC)						292,000			1000 US$ roundup

Items	Option B	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	229	20.00	0.00	0.00	20.00	4,572.00	Decreased by pile review
Pile Material	400×400	m^3	37	88.00	0.00	0.00	88.00	3,256.00	Decreased by pile review
Pile Head Treatment	400×400	pcs	18	25.00	0.00	0.00	25.00	450.00	Decreased by pile review
Sheet Pile Driving Work	Type III, L = 15m	m^2	1,374	22.00	0.00	0.00	22.00	30,228.00	
Sheet Pile	Type III, L = 15m, Remain	t	83	206.00	206.00	17,098.00	0.00	0.00	1/5 of Purchase Price
Supporting Works		t	34	260.00	0.00	0.00	260.00	8,840.00	
Support		t	34	290.00	290.00	9,860.00	0.00	0.00	1/5 of Purchase Price
Embankment		m^3	1,432	14.50	0.00	0.00	14.50	20,764.00	
Excavation		m^3	2,254	2.50	0.00	0.00	2.50	5,635.00	
Backfilling		m^3	1,539	5.10	0.00	0.00	5.10	7,848.90	
Surplus Soil Transport		m^3	715	4.50	0.00	0.00	4.50	3,217.50	
Gravel		m^3	25	19.00	0.00	0.00	19.00	475.00	
Concrete		m^3	9	82.50	0.00	0.00	82.50	742.50	
Reinforced Concrete		m^3	539	88.00	0.00	0.00	88.00	47,432.00	Increased by buoyancy control
Formwork		m^2	1,305	12.00	0.00	0.00	12.00	15,660.00	Increased by buoyancy control
Supporting Works for Formwork		m^3	284	11.00	0.00	0.00	11.00	3,124.00	
Rebar Fabrication and Assembly		t	92	880.00	792.00	72,570.96	88.00	8,063.44	Increased by buoyancy control
Building Work		m^2	19	100.00	0.00	0.00	100.00	1,900.00	
									R-bar/Concrete = 170kg/m3
Total Cost						99,528.96		162,208.34	
Total Cost (FC+LC)						262,000			1000 US$ roundup

Items	Option C	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	206	20.00	0.00	0.00	20.00	4,120.00	Decreased by pile review
Pile Material	400×400	m^3	33	88.00	0.00	0.00	88.00	2,904.00	Decreased by pile review
Pile Head Treatment	400×400	pcs	14	25.00	0.00	0.00	25.00	350.00	Decreased by buoyancy review
Sheet Pile Driving Work	Type III, L = 13m	m^2	1,191	22.00	0.00	0.00	22.00	26,202.00	Decreased by +2m liftup
Sheet Pile	Type III, L = 13m, Remain	t	72	206.00	206.00	14,832.00	0.00	0.00	Decreased by +2m liftup
Supporting Works		t	29	260.00	0.00	0.00	260.00	7,540.00	Decreased by +2m liftup
Support		t	29	290.00	290.00	8,410.00	0.00	0.00	Decreased by +2m liftup
Embankment		m^3	1,432	14.50	0.00	0.00	14.50	20,764.00	
Excavation		m^3	1,206	2.50	0.00	0.00	2.50	3,015.00	Decreased by +2m liftup
Backfilling		m^3	823	5.10	0.00	0.00	5.10	4,197.30	Decreased by +2m liftup
Surplus Soil Transport		m^3	383	4.50	0.00	0.00	4.50	1,723.50	Decreased by +2m liftup
Gravel		m^3	25	19.00	0.00	0.00	19.00	475.00	
Concrete		m^3	9	82.50	0.00	0.00	82.50	742.50	
Reinforced Concrete		m^3	425	88.00	0.00	0.00	88.00	37,400.00	Decreased buoyancy by +2m liftup
Formwork		m^2	1,029	12.00	0.00	0.00	12.00	12,348.00	Decreased buoyancy by +2m liftup
Supporting Works for Formwork		m^3	284	11.00	0.00	0.00	11.00	3,124.00	
Rebar Fabrication and Assembly		t	72	880.00	792.00	57,222.00	88.00	6,358.00	Decreased buoyancy by +2m liftup
Building Work		m^2	19	100.00	0.00	0.00	100.00	1,900.00	
									R-bar/Concrete = 170kg/m3
Total Cost						80,464.00		133,163.30	
Total Cost (FC+LC)						214,000			1000 US$ roundup

Option A Pile 300×300×L 10m	**Draft Final**
Option B Pile 400×400×L	**Option C** +2m liftup Pile 400×400×L
	Option D **+4m liftup** **Pile 400×400×L**

Items	Option D	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	233	20.00	0.00	0.00	20.00	4,660.00	Longer pipe length by +4m liftup
Pile Material	400×400	m^3	37	88.00	0.00	0.00	88.00	3,256.00	Longer pipe length by +4m liftup
Pile Head Treatment	400×400	pcs	14	25.00	0.00	0.00	25.00	350.00	
Sheet Pile Driving Work		m^2	0	22.00	0.00	0.00	22.00	0.00	Deleted by +4m liftup
Sheet Pile		t	0	206.00	206.00	0.00	0.00	0.00	Deleted by +4m liftup
Supporting Works		t	0	260.00	0.00	0.00	260.00	0.00	Deleted by +4m liftup
Support		t	0	290.00	290.00	0.00	0.00	0.00	Deleted by +4m liftup
Embankment		m^3	1,432	14.50	0.00	0.00	14.50	20,764.00	
Excavation		m^3	158	2.50	0.00	0.00	2.50	395.00	Decreased by +4m liftup
Backfilling		m^3	107	5.10	0.00	0.00	5.10	545.70	Decreased by +4m liftup
Surplus Soil		m^3	51	4.50	0.00	0.00	4.50	229.50	Decreased by +4m liftup
Gravel		m^3	25	19.00	0.00	0.00	19.00	475.00	
Concrete		m^3	9	82.50	0.00	0.00	82.50	742.50	
Reinforced Concrete		m^3	425	88.00	0.00	0.00	88.00	37,400.00	
Formwork		m^2	1,029	12.00	0.00	0.00	12.00	12,348.00	
Supporting Works for Formwork		m^3	284	11.00	0.00	0.00	11.00	3,124.00	
Rebar Fabrication and Assembly		t	72	880.00	792.00	57,222.00	88.00	6,358.00	
Building Work		m^2	19	100.00	0.00	0.00	100.00	1,900.00	
									R-bar/Concrete = 170kg/m3
Total Cost						57,222.00		92,547.70	
Total Cost (FC+LC)						150,000			1000 US$ roundup

Cost Comparison of Options, Draft Final Report , A, B, C, and D

121-1 1,000 cum Elevated Water Tank in WTP - Structure

For V=30,000m3

Items	Option A	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400, L = 10m	m	1,135	20.00	0.00	0.00	20.00	22,700.00	
Pile Material	400×400, L = 10m	m^3	182	88.00	0.00	0.00	88.00	15,980.80	
Pile Head Treatment	400×400	pcs	113	25.00	0.00	0.00	25.00	2,835.81	
Sheet Pile Driving Work	Type III, L = 15m	m^2	1,272	22.00	0.00	0.00	22.00	27,984.00	
Sheet Pile	Type III, L = 15m, Remain	t	77	206.00	206.00	15,862.00	0.00	0.00	
Supporting Works		t	31	260.00	0.00	0.00	260.00	8,060.00	
Support		t	31	290.00	290.00	8,990.00	0.00	0.00	
Excavation		m^3	858	2.50	0.00	0.00	2.50	2,145.99	
Backfilling	Backhoe	m^3	493	5.10	0.00	0.00	5.10	2,514.20	
Embankment		m^3	2,088	14.50	0.00	0.00	14.50	30,277.45	
Surplus Soil Transport		m^3	365	4.50	0.00	0.00	4.50	1,644.38	
Gravel		m^3	35	19.00	0.00	0.00	19.00	665.00	
Concrete		m^3	12	82.50	0.00	0.00	82.50	990.00	
Reinforced Concrete		m^3	1,156	88.00	0.00	0.00	88.00	101,728.00	
Formwork		m^2	2,096	12.00	0.00	0.00	12.00	25,152.00	
Rebar Fabrication and Assembly		t	197	880.00	792.00	155,643.84	88.00	17,293.76	R-bar/Concrete = 170kg/m3
Scaffolding/Supporting		m^3	25,853	11.00	0.00	0.00	11.00	284,384.50	
Building Work		m^2	5	100.00	0.00	0.00	100.00	500.00	
Total Cost						**180,495.84**		**544,855.89**	
Total Cost (FC+LC)						**726,000**			1000 US$ roundup

Items	Draft Final Report	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400, L = 10m	m	1,135	20.00	0.00	0.00	20.00	22,700.00	
Pile Material	400×400, L = 10m	m^3	182	88.00	0.00	0.00	88.00	15,980.80	
Pile Head Treatment	400×400	pcs	113	25.00	0.00	0.00	25.00	2,835.81	
Sheet Pile Driving Work	Type III, L = 15m	m^2	1,272	22.00	0.00	0.00	22.00	27,984.00	
Sheet Pile	Type III, L = 15m, Remain	t	77	206.00	206.00	15,862.00	0.00	0.00	
Supporting Works		t	31	260.00	0.00	0.00	260.00	8,060.00	
Support		t	31	290.00	290.00	8,990.00	0.00	0.00	
Excavation		m^3	858	2.50	0.00	0.00	2.50	2,145.99	
Backfilling	Backhoe	m^3	493	5.10	0.00	0.00	5.10	2,514.20	
Embankment		m^3	2,088	14.50	0.00	0.00	14.50	30,277.45	
Surplus Soil Transport		m^3	365	4.50	0.00	0.00	4.50	1,644.38	
Gravel		m^3	35	19.00	0.00	0.00	19.00	665.00	
Concrete		m^3	12	82.50	0.00	0.00	82.50	990.00	
Reinforced Concrete		m^3	1,156	88.00	0.00	0.00	88.00	101,728.00	
Formwork		m^2	2,096	12.00	0.00	0.00	12.00	25,152.00	
Rebar Fabrication and Assembly		t	197	880.00	792.00	155,643.84	88.00	17,293.76	R-bar/Concrete = 170kg/m3
Scaffolding/Supporting		m^3	25,853	11.00	0.00	0.00	11.00	284,384.50	
Building Work		m^2	5	100.00	0.00	0.00	100.00	500.00	
Total Cost						**180,495.84**		**544,855.89**	
Total Cost (FC+LC)						**726,000**			1000 US$ roundup

Items	Option B	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	725	20.00	0.00	0.00	20.00	14,500.00	Reduced by review of pie
Pile Material	400×400	m^3	116	88.00	0.00	0.00	88.00	10,208.00	Reduced by review of pie
Pile Head Treatment	400×400	pcs	50	25.00	0.00	0.00	25.00	1,250.00	Reduced by review of pie
Sheet Pile Driving Work	Type III, L = 15m	m^2	1,272	22.00	0.00	0.00	22.00	27,984.00	
Sheet Pile	Type III, L = 15m, Remain	t	77	206.00	206.00	15,862.00	0.00	0.00	
Supporting Works		t	31	260.00	0.00	0.00	260.00	8,060.00	
Support		t	31	290.00	290.00	8,990.00	0.00	0.00	
Excavation		m^3	858	2.50	0.00	0.00	2.50	2,145.99	
Backfilling	Backhoe	m^3	493	5.10	0.00	0.00	5.10	2,514.20	
Embankment		m^3	2,088	14.50	0.00	0.00	14.50	30,277.45	
Surplus Soil Transport		m^3	365	4.50	0.00	0.00	4.50	1,644.38	
Gravel		m^3	35	19.00	0.00	0.00	19.00	665.00	
Concrete		m^3	12	82.50	0.00	0.00	82.50	990.00	
Reinforced Concrete		m^3	1,156	88.00	0.00	0.00	88.00	101,728.00	
Formwork		m^2	2,096	12.00	0.00	0.00	12.00	25,152.00	
Rebar Fabrication and Assembly		t	197	880.00	792.00	155,643.84	88.00	17,293.76	R-bar/Concrete = 170kg/m3
Scaffolding/Supporting		m^3	25,853	11.00	0.00	0.00	11.00	284,384.50	
Building Work		m^2	5	100.00	0.00	0.00	100.00	500.00	
Total Cost						**180,495.84**		**529,297.28**	
Total Cost (FC+LC)						**710,000**			1000 US$ roundup

Items	Option C	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	825	20.00	0.00	0.00	20.00	16,500.00	Longer pile length by +2m liftup
Pile Material	400×400	m^3	132	88.00	0.00	0.00	88.00	11,616.00	Longer pile length by +2m liftup
Pile Head Treatment	400×400	pcs	50	25.00	0.00	0.00	25.00	1,250.00	
Sheet Pile Driving Work	Type III, L = 13m	m^2	1,103	22.00	0.00	0.00	22.00	24,266.00	Decreased by +2m liftup
Sheet Pile	Type III, L = 13m, Rema	t	67	206.00	206.00	13,802.00	0.00	0.00	Decreased by +2m liftup
Supporting Works		t	27	260.00	0.00	0.00	260.00	7,020.00	Decreased by +2m liftup
Support		t	27	290.00	290.00	7,830.00	0.00	0.00	Decreased by +2m liftup
Excavation		m^3	0	2.50	0.00	0.00	2.50	0.00	Decreased by +2m liftup
Backfilling	Backhoe	m^3	0	5.10	0.00	0.00	5.10	0.00	Decreased by +2m liftup
Embankment		m^3	2,088	14.50	0.00	0.00	14.50	30,277.45	
Surplus Soil Transport		m^3	0	4.50	0.00	0.00	4.50	0.00	Decreased by +2m liftup
Gravel		m^3	35	19.00	0.00	0.00	19.00	665.00	
Concrete		m^3	12	82.50	0.00	0.00	82.50	990.00	
Reinforced Concrete		m^3	1,156	88.00	0.00	0.00	88.00	101,728.00	
Formwork		m^2	2,096	12.00	0.00	0.00	12.00	25,152.00	
Rebar Fabrication and Assembly		t	197	880.00	792.00	155,643.84	88.00	17,293.76	R-bar/Concrete = 170kg/m3
Scaffolding/Supporting		m^3	25,853	11.00	0.00	0.00	11.00	284,384.50	
Building Work		m^2	5	100.00	0.00	0.00	100.00	500.00	
Total Cost						**177,275.84**		**521,642.71**	
Total Cost (FC+LC)						**699,000**			1000 US$ roundup

Option A **Pile 300×300×L 10m**	**Draft Final**
Option B Pile **400×400×L**	**Option C** **+2m liftup** **Pile 400×400×L**
	Option D **+4m liftup** **Pile 400×400×L**

Items	Option D	Unit	Qty	Unit Cost	FC Portion (US%) Unit Price	FC Portion (US%) Amount	LC Portion (US$) Unit Price	LC Portion (US$) Amount	Reference
Pile Driving Work	400×400	m	925	20.00	0.00	0.00	20.00	18,500.00	Longer pipe length by +4m liftup
Pile Material	400×400	m^3	148	88.00	0.00	0.00	88.00	13,024.00	Longer pipe length by +4m liftup
Pile Head Treatment	400×400	pcs	50	25.00	0.00	0.00	25.00	1,250.00	
Sheet Pile Driving Work		m^2	0	22.00	0.00	0.00	22.00	0.00	Deleted by +4m liftup
Sheet Pile		t	0	206.00	206.00	0.00	0.00	0.00	Deleted by +4m liftup
Supporting Works		t	0	260.00	0.00	0.00	260.00	0.00	Deleted by +4m liftup
Support		t	0	290.00	290.00	0.00	0.00	0.00	Deleted by +4m liftup
Excavation		m^3	0	2.50	0.00	0.00	2.50	0.00	
Backfilling	Backhoe	m^3	0	5.10	0.00	0.00	5.10	0.00	
Embankment		m^3	2,088	14.50	0.00	0.00	14.50	30,277.45	
Surplus Soil		m^3	0	4.50	0.00	0.00	4.50	0.00	
Gravel		m^3	35	19.00	0.00	0.00	19.00	665.00	
Concrete		m^3	12	82.50	0.00	0.00	82.50	990.00	
Reinforced Concrete		m^3	1,156	88.00	0.00	0.00	88.00	101,728.00	
Formwork		m^2	2,096	12.00	0.00	0.00	12.00	25,152.00	
Rebar Fabrication and Assembly		t	197	880.00	792.00	155,643.84	88.00	17,293.76	R-bar/Concrete = 170kg/m3
Scaffolding/Supporting		m^3	25,853	11.00	0.00	0.00	11.00	284,384.50	
Building Work		m^2	5	100.00	0.00	0.00	100.00	500.00	
Total Cost						**155,643.84**		**493,764.71**	
Total Cost (FC+LC)						**650,000**			1000 US$ roundup

SIEM REAP WATER SUPPLY AUTHORITY

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

FEASIBILITY STUDY DRAWINGS

JANUARY 2011

NJS CONSULTANTS CO., LTD

KOKUSAI KOGYO CO., LTD

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

Manner of Drawing Number

Cord	Item
Project Cord	
SR	THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA
Facilities Cord	
00	General
01	Raw Water Intake Chamber
02	Raw Water Intake Pump Station
03	Raw Water Conveyance/Transmission Pipeline
04	Distribution Chamber
05	Flocculation and Sedimentation Basin
06	Sludge Discharge Tank
07	Filtration Units
08	Backwash Recovery Tank
09	Clear Water Reservoir and Clear Water Pump Station
10	Elevated Water Tank
11	Sludge Drying Bed
12	Chemical Building
13	Electrical Building
14	Administration Building
15	Storage Building
16	Guard House
17	Distribution Network
DWG Group Cord	
G	General
C	Civil
MA	Mechanical and Architectural
A	Architectural
S	Standard
DWG Number	In order for DWG group

Drawing

PROJECT: THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

CLIENT: SIEM REAP WATER SUPPLY AUTHORITY; JAPAN INTERNATIONAL COOPERATION AGENCY

CONSULTANTS: NJS CONSULTANTS CO., LTD. - JAPAN; KOKUSAI KOGYO CO., LTD.-JAPAN

REV.	DESCRIPTION	DATE	SIGN.

TITLE: LIST OF DRAWINGS-SHEET 1OF 2

SCALE: NONE | DATE: 30/09/2009 | DRAWING NO.: SR-00-G-02

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

Drawing

PROJECT: THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

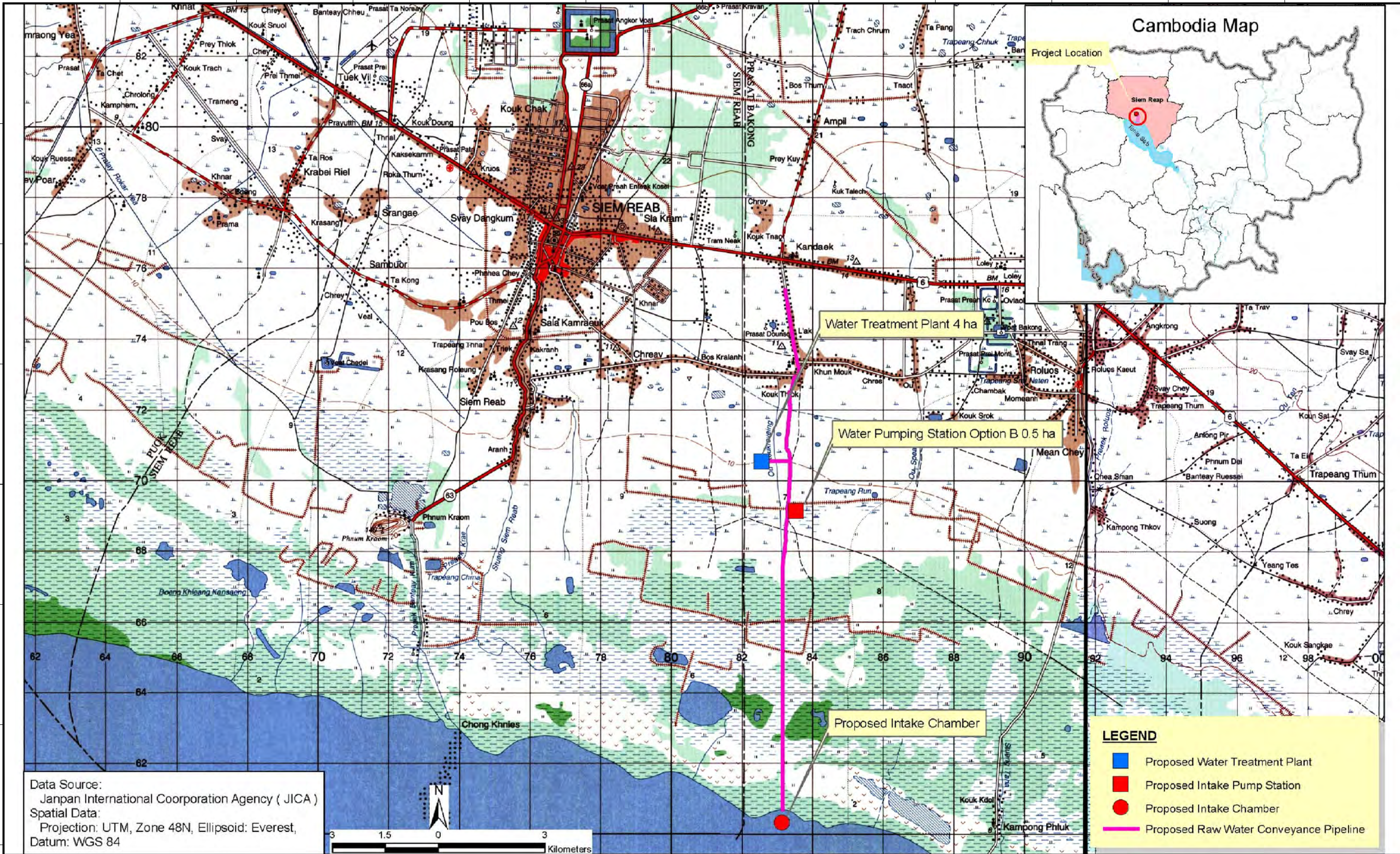
CLIENT: SIEM REAP WATER SUPPLY AUTHORITHY
JAPAN INTERNATIONAL COOPERATION AGENCY

CONSULTANTS : NJS CONSULTANTS CO., LTD. - JAPAN
KOKUSAI KOGYO CO., LTD.-JAPAN

REV.	DESCRIPTION	DATE	SIGN.

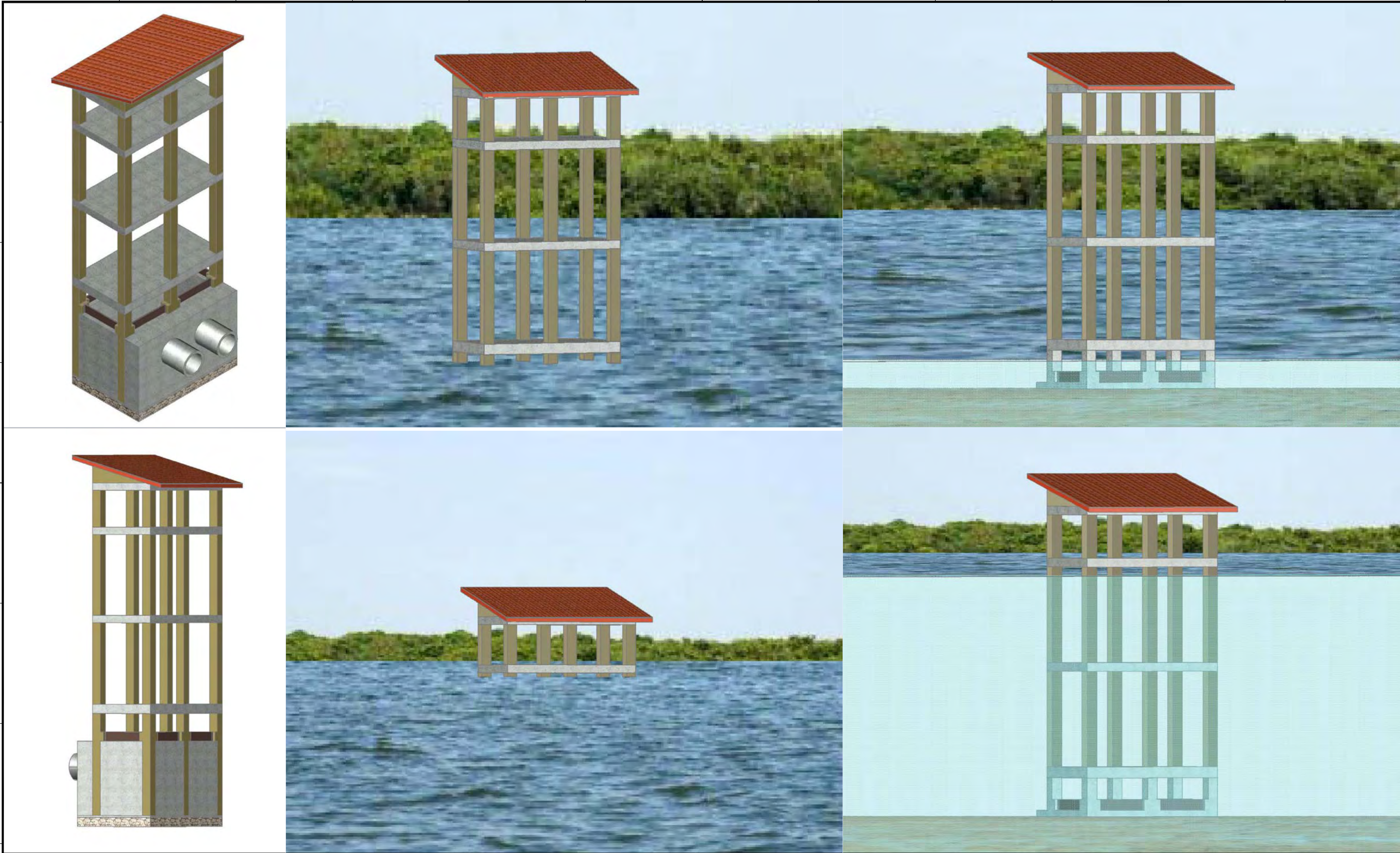
TITLE: LIST OF DRAWINGS-SHEET 2 OF 2

SCALE: NONE | DATE: 30/09/2009 | DRAWING NO.: SR-00-G-03



PROJECT:
THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

CLIENT:	CONSULTANTS :	REV.	DESCRIPTION	DATE	SIGN.	TITLE:
SIEM REAP WATER SUPPLY AUTHORITHY	NJS CONSULTANTS CO., LTD. - JAPAN					LOCATION AND VINICITY MAP
JAPAN INTERNATIONAL COOPERATION AGENCY	KOKUSAI KOGYO CO., LTD.-JAPAN					SCALE: 1/100000 — DATE: 30/09/2009 — DRAWING NO.: SR-00-G-04



PROJECT:

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

CLIENT:

SIAM REAP WATER SUPPLY AUTHORITHY

JAPAN INTERNATIONAL COOPERATION AGENCY

CONSULTANTS :

NJS CONSULTANTS CO., LTD. - JAPAN

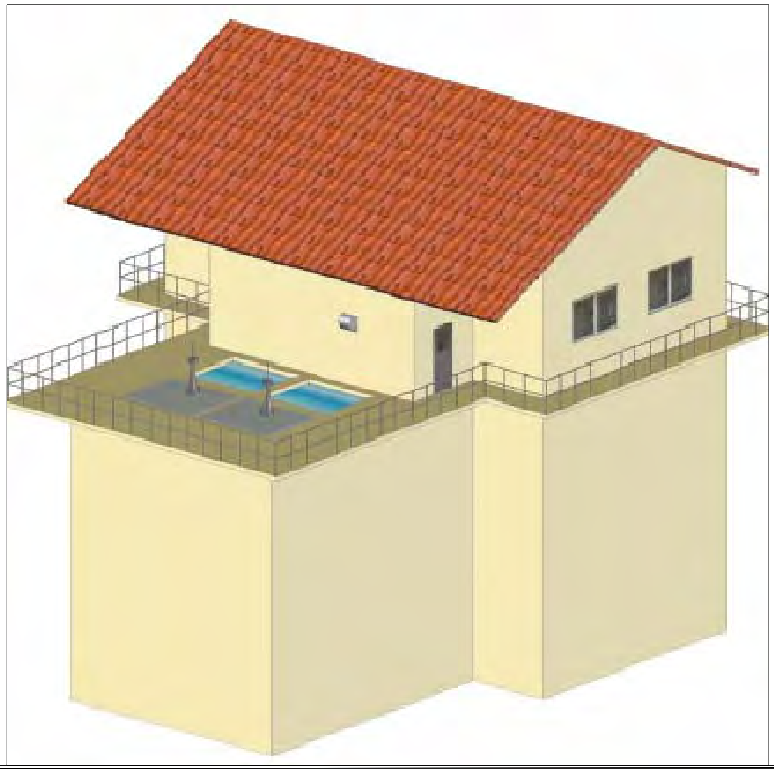
KOKUSAI KOGYO CO., LTD.-JAPAN

REV.	DESCRIPTION	DATE	SIGN.

TITLE:

AIR VIEW OF RAW WATER INTAKE CHAMBER

SCALE:	DATE:	DRAWING NO.:
NONE	30/09/2009	SR-00-G-05



EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

SIAM REAP WATER SUPPLY AUTHORITHY
JAPAN INTERNATIONAL COOPERATION AGENCY

CONSULTANTS :
NJS CONSULTANTS CO., LTD. - JAPAN
KOKUSAI KOGYO CO., LTD.-JAPAN

REV.	DESCRIPTION	DATE	SIGN.

TITLE: AIR VIEW OF RAW WATER INTAKE PUMP STATION

SCALE:	DATE:	DRAWING NO.:
NONE	30/09/2009	SR-00-G-06

PROJECT:

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

CLIENT:

SIAM REAP WATER SUPPLY AUTHORITHY

JAPAN INTERNATIONAL COOPERATION AGENCY

CONSULTANTS :

NJS CONSULTANTS CO., LTD. - JAPAN

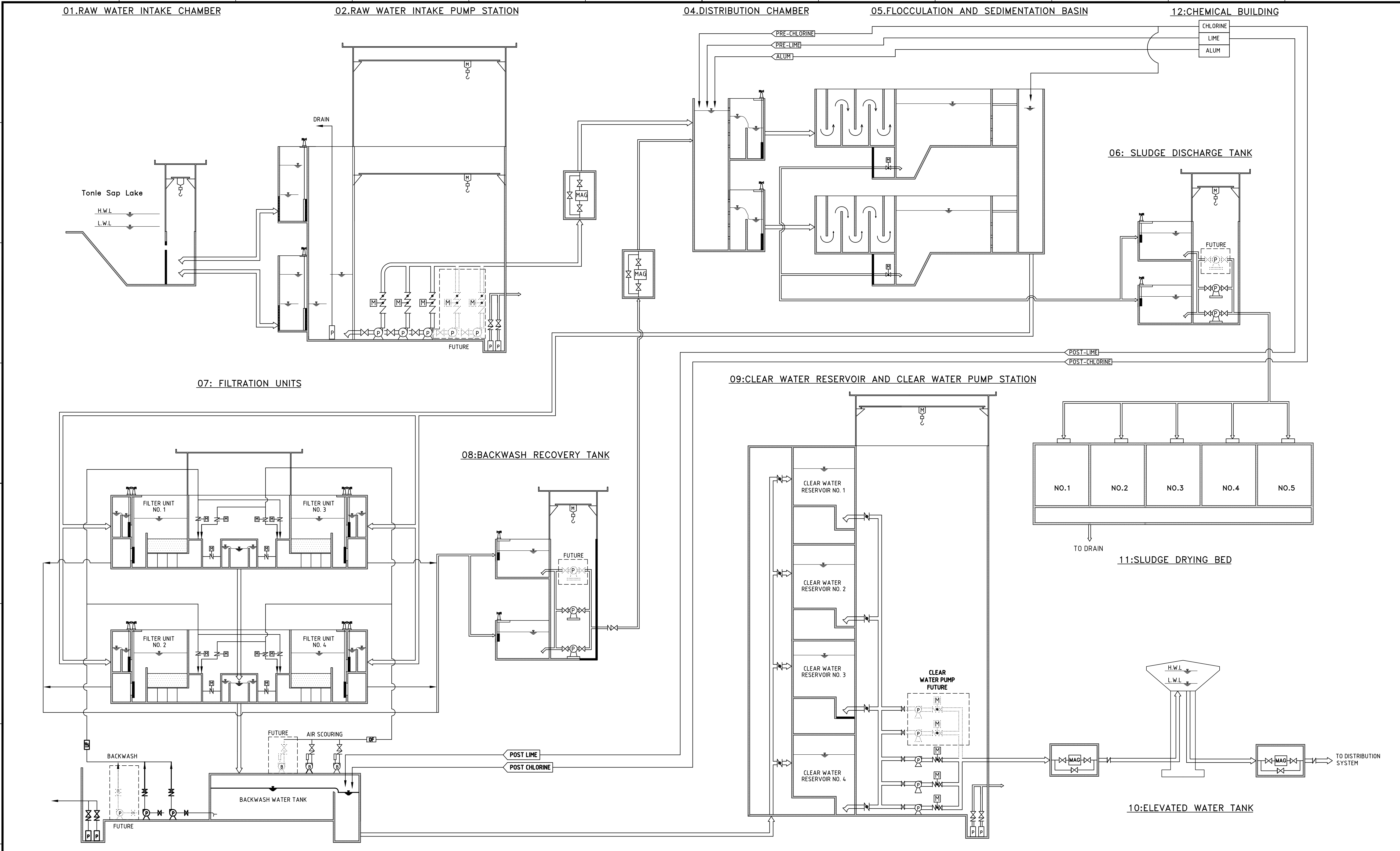
KOKUSAI KOGYO CO., LTD.-JAPAN

REV.	DESCRIPTION	DATE	SIGN.

TITLE:

AIR VIEW OF WATER TREATMENT PLANT

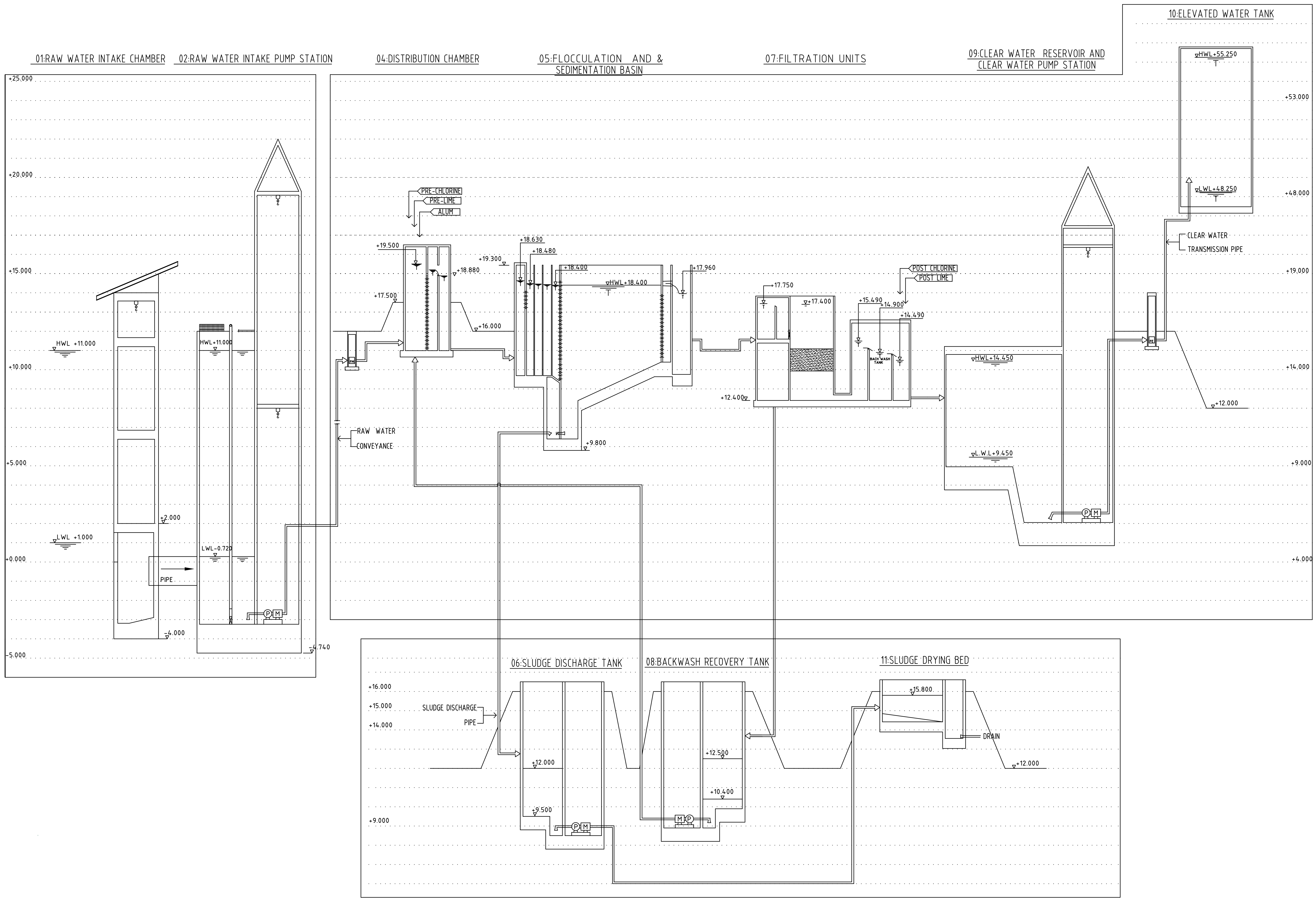
SCALE:	DATE:	DRAWING NO.:
NONE	30/09/2009	SR-00-G-07



PROJECT:

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

CLIENT:	CONSULTANTS :	REV.	DESCRIPTION	DATE	SIGN.	TITLE:
SIEM REAP WATER SUPPLY AUTHORITHY	NJS CONSULTANTS CO., LTD. - JAPAN					PROCESS SCHEMATIC AND FLOW DIAGRAM
JAPAN INTERNATIONAL COOPERATION AGENCY	KOKUSAI KOGYO CO., LTD.-JAPAN					SCALE: NONE / DATE: 30/09/2009 / DRAWING NO.: SR-00-G-08



PROJECT:

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

CLIENT:

SIEM REAP WATER SUPPLY AUTHORITHY

JAPAN INTERNATIONAL COOPERATION AGENCY

CONSULTANTS :

NJS CONSULTANTS CO., LTD. - JAPAN

KOKUSAI KOGYO CO., LTD.-JAPAN

REV.	DESCRIPTION	DATE	SIGN.

TITLE: HYDRAULIC PROFILE

SCALE: NONE

DATE: 30/09/2009

DRAWING NO.: SR-00-G-09