Table 3.5 Number of Tube Well Pump by Service Level

Category		Tube Well Numbers		
Service Level	System No.	Submersible	Air-lifting	Total
L-III SW/GW	1	83	21	104
L-III GW	16	22	9	31
L-II GW	2	5	0	5
L-I GW	74	4	70	74
Hydrant	3	3	0	3
YCDC Total		117	100	217

Source; YCDC Township Offices, as of July 2001

According to previous tube wells designed by the YCDC, total length of well screen is 6m or 12m in any case of casing diameter. Gravel placement to annular space at screen portion means that well structure is filtration separator of solid and fluid (in this case soil and water). Therefore, filtration normal velocity (3cm/sec or less) has to be confirmed for final well design with due consideration of filtration thickness and grain size of filtration materials.

3.3 CLASSIFICATION OF EXISTING WATER SUPPLY

3.3.1 General (YCDC and None YCDC)

The existing water supply facilities in Yangon can be classified into two categories, namely "YCDC owned Facilities" and "Privately owned Facilities". Further breakdown is shown below;

Category	Water Source(see Fig. 3.6)	Service Level(see Fig. 3.7)
YCDC owned Facilities	Piped Surface Water (Pipe-SW)	L-II & III
	Piped S/W and G/W	Ditto
	GW with independent network	Ditto
	Tube Well without network (T/W)	L-I
	Boat	Ditto
	Pond	Ditto
Private owned Facilities	Dug/Driven Well	Individual, L-I &II
	Tube Well	Individual, L-I to III
	Pond	L-I
	Rain Collector	Individual

Figure 3.6 is the visual explanation on these categories and water sources.
"Service Level" is the level of accessibility to water.

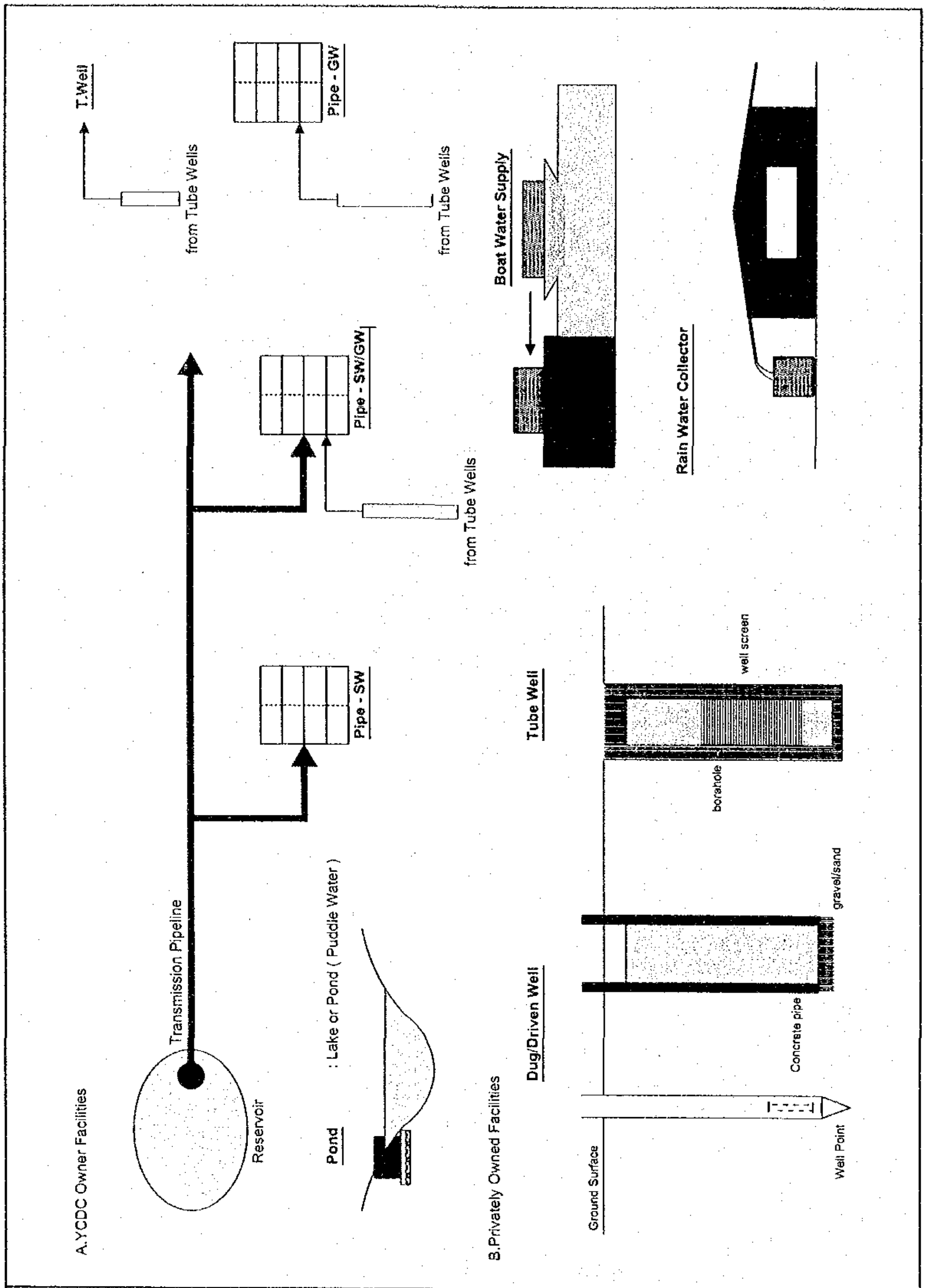
Figure 3.7 shows the explanation of service level, namely individual and Level I to III.

Individual : There is water source without pipeline network supply, only house owner can access to the water source facility.
Level I : There is water source without pipeline network supply, beneficiaries access to the water source facility.
Level II : There is/are water source(s) with pipeline network supply, however beneficiaries access the communal/public faucets.
Level III : There is/are water source(s) with pipeline network supply, beneficiaries can utilize the water from the in-house faucet(house connection).

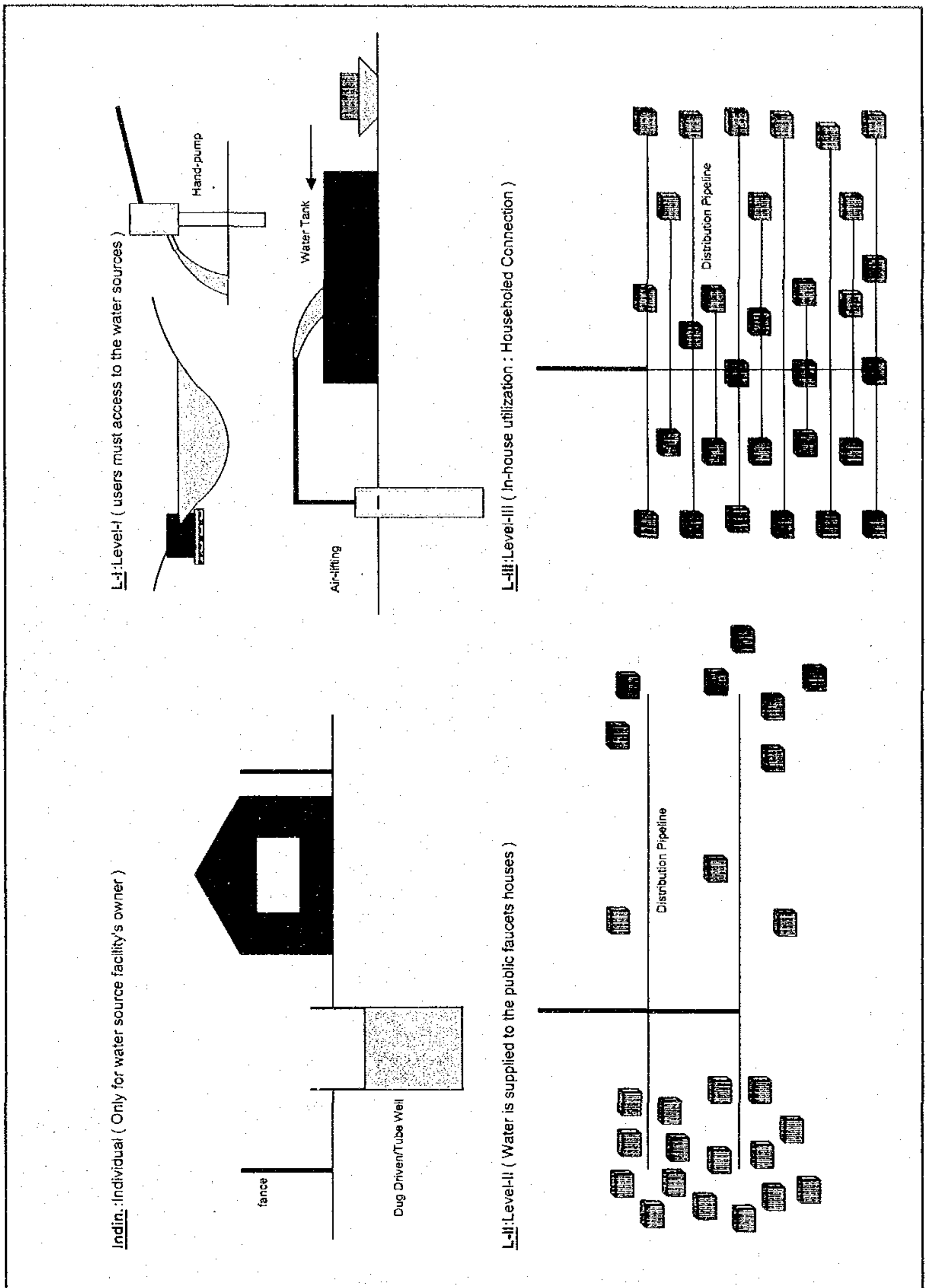
Figure 3.8 shows the service area covered by YCDC owned facilities. Privately owned facilities serve remaining areas.

The YCDC water sources are piped surface water (from 3 reservoirs), tube wells (YCDC owned), Ponds (see section 3.3.4). The total number of YCDC owned Tube wells is 217 respectively (details are in Appendix B) . The location of these wells is shown in Figure 3.9.

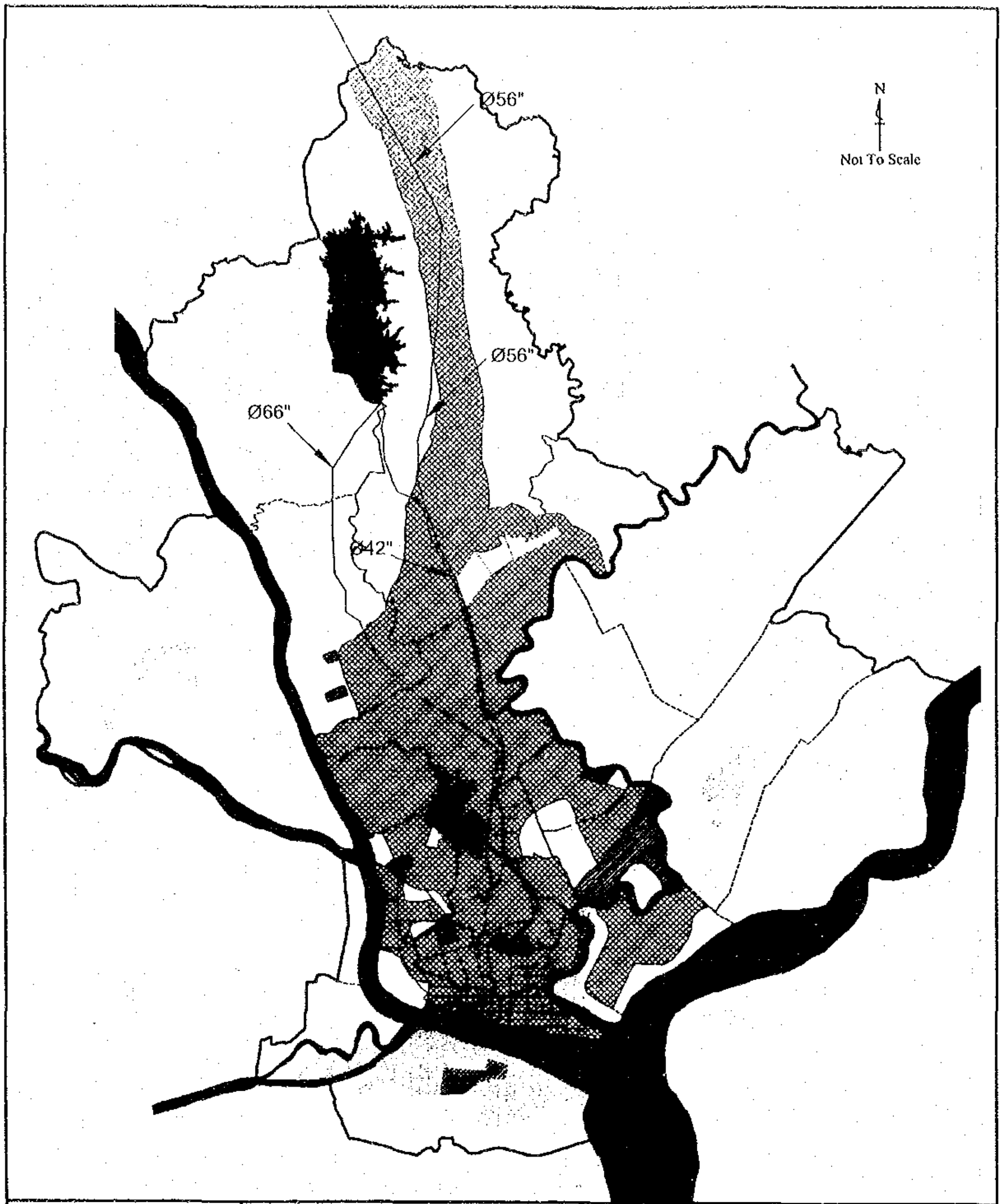
Table 3.6 describes the current service ratio by the said system on a Township basis.
Further breakdown of service level by township is shown in Appendix H.



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.6
	Type of Water Sources	



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.7
	Type of Service Levels	

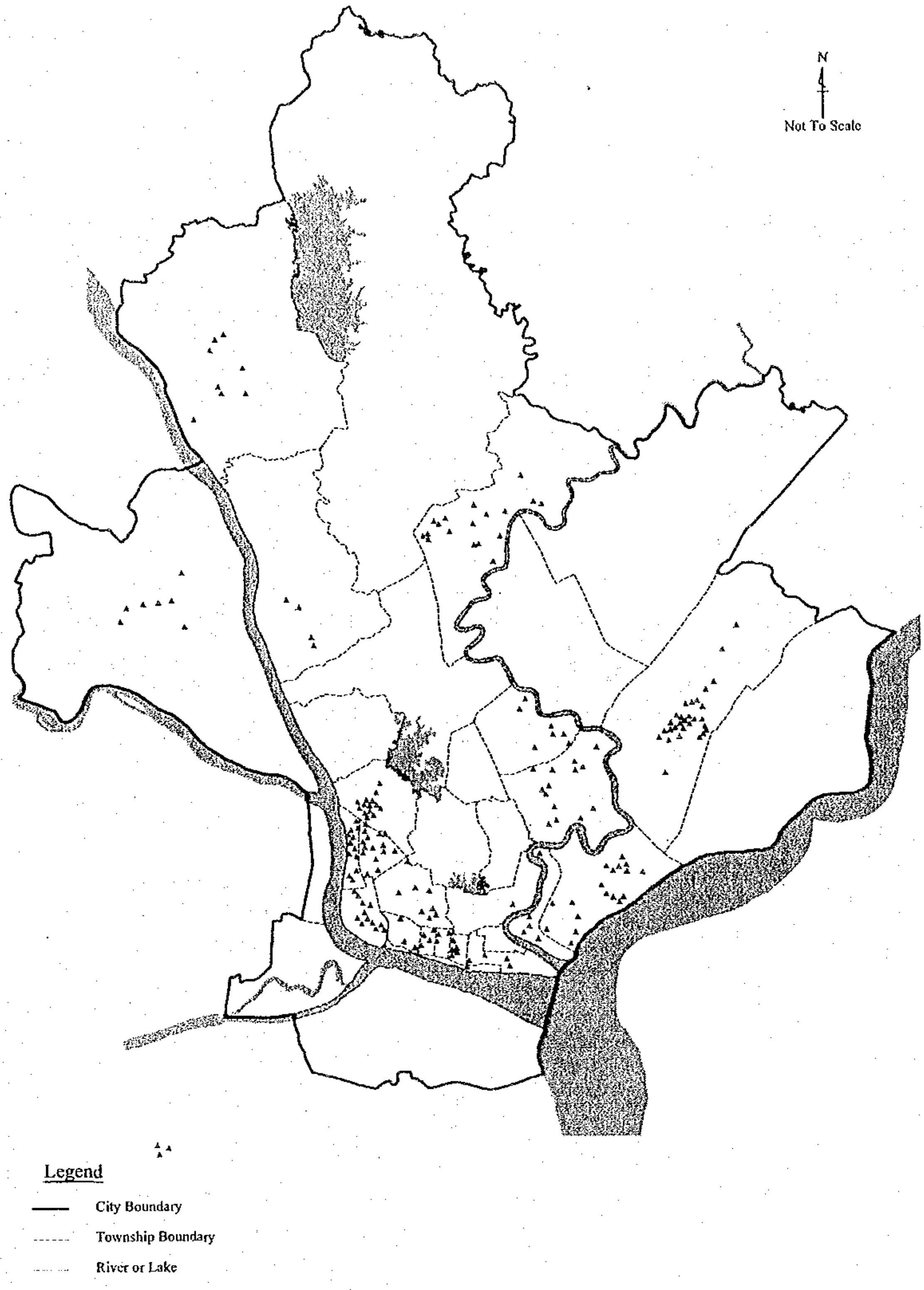


Legend	YCDC owned facilities				Private owned facilities
City Boundary Township Boundary River or Lake Primary Mains	Piped System	Pipe SW Pipe SW/GW	Non piped System	Tube Well Boat Pond	Dug/Driven well Tube well Pond Rain collector
		GW with independent network			

THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FIG 3.8

Existing Service Area



THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FIG 3.9

YCDC Tube Wells Location Map

Table 3.6 Proportion Percentages of Water Supply Service Level by Township

Township Name	Pop.	YCDC Owened Facilities									Privately Owned Facilities									Total
		Pipe-SW		Pipe-SW/GW		Pipe-GW		T/W	Boat	Pond	Dug/Driven Well			Tube Well				Pond	Rain	
		L-II	L-III	L-II	L-III	L-II	L-III	L-I	L-I	L-I	Indiv.	L-I	L-II	Indiv.	L-I	L-II	L-III	L-I	Indiv.	
01. Ahlone	45,870	0%	0%	0%	26%	0%	0%	0%	0%	0%	0%	0%	0%	13%	1%	0%	60%	0%	0%	100%
02. Bahan	100,139	0%	91%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	1%	0%	0%	100%
03. Botataung	55,434	0%	76%	0%	12%	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%	0%	0%	0%	100%
04. Dagon	42,079	0%	0%	0%	97%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	100%
05. Dagon Myothit East	58,108	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	39%	46%	0%	0%	0%	0%	100%
06. Dagon Myothit North	107,045	0%	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	0%	42%	43%	0%	4%	0%	0%	100%
07. Dagon Myothit Seikkan	19,245	0%	0%	0%	0%	0%	0%	0%	0%	53%	0%	0%	0%	1%	22%	0%	23%	0%	0%	100%
08. Dagon Myothit South	147,804	0%	0%	0%	0%	0%	0%	6%	0%	6%	0%	0%	0%	15%	66%	0%	2%	0%	6%	100%
09. Dala	81,317	0%	0%	0%	0%	5%	8%	0%	0%	88%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
10. Dawbon	83,787	0%	2%	0%	0%	0%	0%	14%	0%	70%	0%	0%	0%	12%	1%	0%	0%	0%	0%	100%
11. Hlaing	176,751	0%	10%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	39%	32%	0%	13%	0%	0%	100%
12. Hlaingthaya	209,714	0%	0%	0%	0%	0%	0%	4%	0%	10%	0%	0%	0%	15%	71%	0%	1%	0%	0%	100%
13. Insein	253,421	0%	10%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	13%	76%	0%	0%	0%	0%	100%
14. Kamayut	87,325	0%	0%	0%	24%	0%	23%	0%	0%	0%	0%	0%	0%	53%	0%	0%	0%	0%	0%	100%
15. Kyauktada	46,405	0%	0%	11%	89%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
16. Kyeemyindaing	92,113	0%	0%	0%	20%	0%	0%	0%	17%	0%	0%	0%	0%	33%	4%	0%	9%	0%	17%	100%
17. Lanmadaw	42,742	0%	9%	0%	87%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	100%
18. Latha	34,254	0%	24%	0%	76%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
19. Mayangone	192,694	0%	67%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	100%
20. Mingalardon	179,982	0%	19%	0%	0%	0%	0%	3%	0%	0%	3%	0%	0%	40%	34%	0%	0%	0%	0%	100%
21. Mingalartaungnyunt	115,597	0%	99%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	100%
22. North Okkalapa	304,339	34%	25%	4%	3%	0%	0%	6%	0%	6%	2%	4%	0%	4%	11%	0%	0%	0%	0%	100%
23. Pabedan	49,969	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
24. Pazundaung	40,390	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
25. Sanchaung	82,951	0%	0%	0%	40%	0%	0%	0%	0%	0%	0%	0%	0%	38%	19%	0%	3%	0%	0%	100%
26. Seikan Port	1,452	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	40%	40%	0%	0%	0%	0%	100%
27. Seikkyi Kanaungto	26,938	0%	0%	0%	0%	0%	0%	0%	43%	57%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
28. Shwepyitha	181,484	0%	0%	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	64%	32%	0%	0%	0%	0%	100%
29. South Okkalapa	231,849	0%	54%	0%	13%	0%	1%	0%	0%	0%	0%	0%	0%	22%	11%	0%	0%	0%	0%	100%
30. Tamwe	135,242	0%	92%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	100%
31. Thaketa	294,582	5%	2%	6%	2%	0%	0%	0%	0%	17%	0%	0%	0%	54%	15%	0%	0%	0%	0%	100%
32. Thingangyun	253,119	0%	0%	0%	0%	1%	6%	3%	0%	1%	0%	0%	0%	20%	38%	0%	30%	0%	0%	100%
33. Yankin	112,859	0%	59%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	41%	0%	0%	0%	0%	0%	100%
City Total	3,887,000	3.1%	23.3%	0.9%	8.5%	0.2%	1.2%	1.7%	0.7%	7.1%	0.8%	0.3%	0.0%	24.2%	23.4%	0.0%	4.0%	0.0%	0.6%	100%

Individual There is water source without pipeline network supply. Only house owner can access to the water source facility for fetching water.
Service Level-I There is water source without pipeline network supply. Beneficiaries access to the water source facility for fetching water.
Level-II There is/are water source(s) with pipeline network supply. However, beneficiaries access to the communal/public faucets for fetching water.
Level-III There is/are water source(s) with pipeline network supply. Beneficiaries can utilize the water fron the in-house faucet (house connection).

From Table 3.6 the followings can be seen,

- YCDC piped supply (SW, GW) is 37 % of total population
- YCDC Tube well Level I is 2 %
- YCDC Pond and Boat Supply is 8 %
- Total of YCDC supply is about 46 % (piped supply is only 36%)
- Non YCDC supply is 53%

3.3.2 Communal Tanks

YCDC and its predecessors have initiated a system of water supply to poor communities via communal tanks. In this case, a masonry tank is built and is connected to the YCDC supply network. The tank size *depends on the number of* customers asking for water from the tank. The capacity of existing tanks ranges from 400 gallons to 20,000 gallons. The customers collect water through taps fixed to the tank.

Records on the number of communal tanks and the customers who benefit from this facility are not available. It appears that no one in the department is responsible for the communal tanks. A lot of effort was required to identify the number of communal tanks and where this facility is located.

Table 3.7 provides data on the number of communal tanks in use as well as the estimated number of customers using this facility at present (information is collected through interviews of 33 townships).

Based on the above data, the households which depend on communal tanks as their main water source can be estimated as follows,

Households benefiting from communal tanks	19,890
Total households in study area	540,378
Households depending on communal tanks	3.7%

The communal tanks are in 13 townships. The majority of communal tank users do not pay for water. However, users in two townships are reported to be paying 3.25% of their property tax as water charges. The share of water charge comes to about Ks.11 per quarter.

This system of water supply is particularly suitable for economically disadvantaged communities.

Table 3.7 Distribution of Communal Tanks and Customers in the Study Area

Townships	No. Tanks in Use	Households (NO.)	Water Charges
Bahan	2	10	free
Botahtaung	5 (19)	130 *	free
Dagon South	32	832 *	3.25% property tax
Dawbon	2	100	free
Hlangthayar	8	260 *	free
Insein	2	52 *	free
Kamayut	1	20	free
North Okklapa	317	8242 *	free
Mingalardon	6 (8)	156 *	free
Shwepyitha	8	208 *	free
South Okklapa	50 (62)	1300 *	free
Thaketa	230 (240)	5980 *	free
Thingangyun	100 (196)	2600 *	3.25% property tax
Total Townships =13	763	19,890	

Source: Township Survey By JICA Study Team
* Denotes estimates by JICA Study Team
Figures within parentheses indicate the total number of tanks

The communal tanks are maintained and are cleaned by the staff of WSS. It is to be noted that those customers who obtain their water free of charge are not involved in cleaning and maintenance of this facility. It would be prudent to develop strategies to secure participation of users of this facility for cleaning and maintenance in lieu of free water provided to them. Such a strategy will have to be based on the creation of awareness of the usefulness of this facility to the community and the cost incurred by the department to provide water to them.

Although YCDC (and its predecessors) willingly built communal tanks in the past, the current policy appears to phase them out. Such a decision is unlikely to be in the best interest of economically vulnerable communities in particular.

3.3.3 Standpipes

Standpipes have been provided for the use of pedestrians in the past. For example, the Myanmar General Consultants (1993) report the presence of 2,500 standpipes in 1980 which had later declined to 825 in 1993. The current policy appears to be to get rid of them gradually.

Data on the number and location of standpipes are not available. In-depth discussions with township staff were needed to identify information relating to this facility.

It was revealed that there are 245 standpipes in four townships at present (Table 3.8). The users of standpipes do not pay any water charge. Similar to communal tanks, this facility is suitable for low-income families.

Table 3.8 Distribution of Standpipes in the Study Area

Township	Standpipes (No.)
Dala	7
Kyeemindaing	3
Thaketa	230
Thinganchaung	5
Total	245

Source: Township Survey by JICA Study Team,

3.3.4 Lakes and Ponds

City population relying on lakes and ponds for their water supply was another area where information was lacking. It revealed that township staff had no information covering this area.

Focussed discussions with township staff revealed that lakes and ponds are the main water supply source for people in 12 townships (Table 3.9). Of the 261 lakes and ponds in the 12 townships, only 118 are used as a source of drinking water. The other lakes/ponds serve several functions among which providing water for other domestic purposes (non-drinking), fire control and runoff storage are of significant importance.

Table 3.9 Distribution of Drinking Water Lakes and Households

Township	Total Lakes (No.)	Drinking Water Lakes (No.)	Households (No.)
Dagon East	5	2	530
Dagon North	30	4	1060
Dagon Seikkan	3	3	1200
Dagon South	6	6	1500
Dala	102	12	3100
Dawbon	14	14	3500
Hlangthayar	20	10	6000
Kyeemyindaing	17	7	1600
North Okklapa	22	10	1,000
Seikky Kanantungy	31	31	8200
Thaketa	10	8	24,000
Thingangyun	1	1	265
Total	261	108	51955

Source: Township Survey by JICA Study Team

Using the above data, the number of households which depend on lakes/ponds as their main source of water is about 9 % in Households number..

Water is abstracted from lakes by means of hand-operated pumps and/or is drawn using individual buckets. The importance of this source of water particularly to the poorest of the poor who cannot bear the cost of pipe-borne water is to be highlighted.

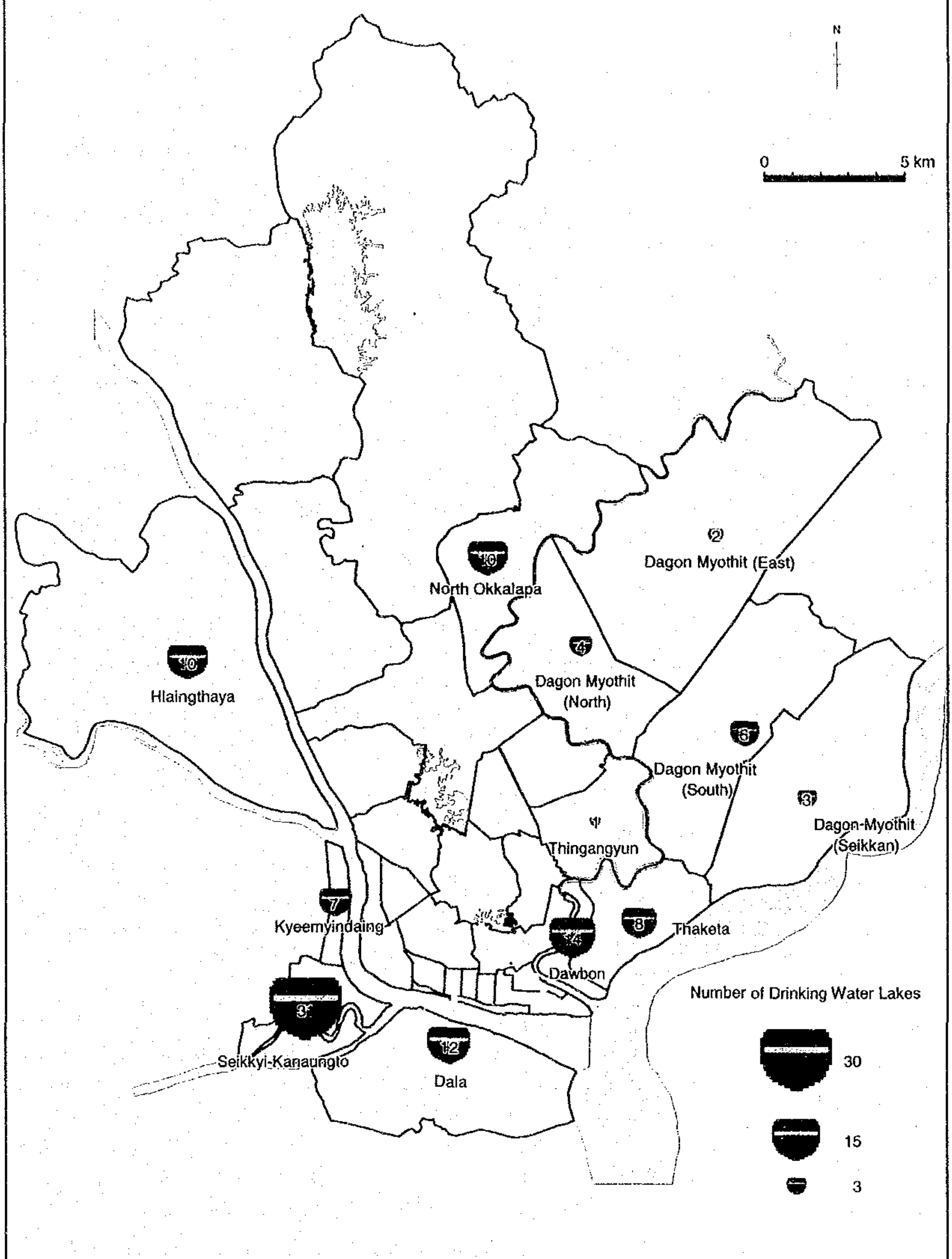
WSS staff clean lakes annually. Occasionally the relevant community participates in lakes cleaning work. Sometimes chlorine is used to purify pond water while alum is added to facilitate cleaning the water during dry months. All these operations are undertaken at the cost of the department. Lake is the main source of water during prolonged periods of power failure and/or during periods of droughts when water from other source is not available. All lakes and ponds are owned by YCDC.

Because of the above reasons, it is to be highlighted that the utilization of this source of water, with appropriate technologies to improve water quality as well as to facilitate water abstraction could be given due consideration.

3.3.5 Other Arrangements

Still there is a practice of water delivery to Seikky Kanantungy township via a tanker. Water is collected from a borehole in Ahlone to be shipped away to the township across the river. The township is a water deficit area especially in the dry season. The well water is salty which is unfit for consumption.

At present, 4,480,000 gallons are provided to the people in this township over a period of 3 months beginning March, 2001.



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.10
	YCDC Ponds Location	

3.4 WATER SUPPLY SERVICE CONDITION

3.4.1 Water Connection

Water connection refers to a pipe providing water from the main supply line of WSS either right into the house or to the compound. In the former case, customer has to have the internal connection approved by the department before connecting to the WSS network. If the connection ends in the compound, customer has no access to water inside the dwelling.

(1) Types of connections

There are four main types of customer connections namely, domestic, commercial, governmental and foreign (Table 3.10).

Table 3.10 Type of Water Connections and Main Characteristics

Connection Type	Description	% of total connections
Domestic	Residential units such as houses, apartments and housing estates.	93
Commercial	Hotels, restaurants, shops, factories, industries and other establishments involved in carrying out commercial activities	6
Government	All government ministries, departments and defence establishments	1
Foreign	Any organization or residence registered under the foreign registration Act. Examples are foreign companies	0.03
Free	Religious organizations (eg. Temple, pagoda, monastery, church, mosque) and diplomatic establishments (eg. Embassies)	n.a.

Source: JICA Study Team using YCDC data

The majority of present connections are domestic while commercial connections are only 6% of the total. Connections given to government departments are just 1% while the lowest is for foreign customers. It is to be noted that there is no record of free connections. Each of the above connection types have different water tariffs except for the free connections. These rates are discussed in section 3.6.8.

The status of connections numbers in the study area as of 2000 is presented in Table 3.11. According to this Table, connections are given only in 26 townships. Again, the variation in terms of the number of metered and non-metered connections vary widely among townships. The above data show that townships such as Ahlone, Kyeemindaing and Sanchaung have more unmetered connections while others such as Dala, Insein and Swhepyitha have more metered connections out of the total connections in their respective townships.

Total number of metered connection is 25,692 (22 %), while un-metered connection is 86,663 (78 %).

Table 3.11 Connection Numbers by Township

Township	Number of metered connection					Number of unmetered connection					Total connection					% of metered
	Dmstic	Dptmnt.	Com&Ind.	Foreign	Total	Dmstic	Dptmnt.	Com&Ind.	Foreign	Total	Dmstic	Dptmnt.	Com&Ind.	Foreign	Total	Domestic
1 Ahlone	109		2		111	2,112	38	50		2,200	2,221	38	52		2,311	4.9
2 Bahan	1,226		105	17	1,348	4,154	85	80		4,319	5,380	85	185	17	5,667	22.8
3 Botataung	755	5	118		878	3,927	100	132		4,159	4,682	105	250		5,037	16.1
4 Dagon	207		9	2	218	1,667	40	53		1,760	1,874	40	62	2	1,978	11.0
5 Dagon Myothit (East)					-										-	
6 Dagon Myothit (North)					-										-	
7 Dagon Myothit (Seikka)					-										-	
8 Dagon Myothit (South)					-										-	
9 Dala	408	8	56		472						408	8	56		472	100.0
10 Dawbon	40	1	9		50	78	2	17		97	118	3	26		147	33.9
11 Hlaing	1,075	5	27		1,107	1,202	1	2		1,205	2,277	6	29		2,312	47.2
12 Hlaingthaya					-										-	
13 Insein	2,123	18	1,165		3,306	204	7	10		221	2,327	25	1,175		3,527	91.2
14 Kamayut	445	1	21	3	470	1,048	19	40		1,107	1,493	20	61	3	1,577	29.8
15 Kyauktada	373	11	172	1	557	5,679	96	212		5,987	6,052	107	384	1	6,544	6.2
16 Kyeemyindaing	59				59	1,865	30	24		1,919	1,924	30	24		1,978	3.1
17 Lanmadaw	1,055	7	115		1,177	4,835	46	249		5,130	5,890	53	364		6,307	17.9
18 Latha	795	1	36		832	3,924	38	235		4,197	4,719	39	271		5,029	16.8
19 Mayangone	1,496	1	144	3	1,644	1,966	40	1		2,007	3,462	41	145	3	3,651	43.2
20 Migalardon	797	4	125		926	164	9	11		184	961	13	136		1,110	82.9
21 Mingalartaungnyunt	2,908	5	214	1	3,128	8,434	74	198		8,706	11,342	79	412	1	11,834	25.6
22 North Okkalapa	1,556		148		1,704	5,474	72	1,717		5,716	7,030	72	318		7,420	22.1
23 Pabedan	637	6	95	1	739	5,521	60	1,174		6,755	6,158	66	1,269	1	7,494	10.3
24 Pazundaung	1,452	15	52		1,519	4,411	48	87		4,546	5,863	63	139		6,065	24.8
25 Sanchaung	138		11		149	3,175	40	156		3,371	3,313	40	167		3,520	4.2
26 Seikan (port)					-											
27 Seikkyi Kanaungto					-											
28 Shwepyitha	1	2			3						1	2			3	100.0
29 South Okkalapa	440	4	76		520	4,113	97	121		4,331	4,553	101	197		4,851	9.7
30 Tamwe	3,062	1	58	1	3,122	11,377	78	107		11,562	14,439	79	165	1	14,683	21.2
31 Thaketa	227	1	20		248	2,025	61	202		2,288	2,252	62	222		2,536	10.1
32 Thingahgyun	78		8		86	85	24	107		1,018	963	24	117		1,104	8.1
33 Yankin	1,150	5	153	11	1,319	3,780	66	32		3,878	4,930	71	185	11	5,186	23.3
Total	22,612	101	2,939	40	25,692	82,020	1,171	3,472		86,663	104,632	1,272	6,411	40	112,355	22.9

Note:26 townships have water connection.
Source: YCDC Head Quarter

(2) Connection policy

The current policy with regard to house connection is not clear. Discussions with the senior staff appear to indicate that the request from all applicants for water connections are granted provided the premises where water connection is requested is located in an area where there is already a network and water is adequate for the existing customers.

There was no data on waiting applications for house connections to establish the current practice and the capacity of the organization to cope with the demand.

The connection rate could not be analyzed due to absence of accurate data, although, in total, 112,315 connections are registered in YCDC.

(3) Connection procedure

The procedure for obtaining YCDC water connection involves three distinct steps as listed below:

- Obtaining an approval for the use of water for construction of a building
- Approval for the internal house connection (plumbing)
- House connection to YCDC supply network.

Customers are allowed to use YCDC water for construction work on payment of a fee of Ks.9,720 for every 1,250 sq.ft. of the building. This is a once-only payment. However, if the customer wishes to remain as a non-YCDC water user for the rest of life of the new building, then this approval is not required. On the other hand, after using water from own source for construction and the customer subsequently decides to obtain water from YCDC for household consumption, then the connection is provided only after the payment of the construction fee mentioned above.

Before connecting to YCDC supply, it is mandatory that the relevant customer should get internal plumbing done by a licensed plumber and apply for the department's approval. On payment of a fee of Ks.1,000, approval is granted subject to a satisfactory inspection. The internal connection approval is necessary even if the customer plans to obtain water from a private source.

Once the internal connection is approved the applicant may apply for YCDC connection by completing and submitting the prescribed application form to the township where the house / building is located. Should the connection be approved, and upon the payment of a connection fee of Ks. 1,900, an individual connection is provided. If the applicant so desires, both types of applications could be made simultaneously making a total payment of Ks.2,900.

The authority for the approval for such applications is vested with the head of water distribution division. In the case of apartment buildings, the procedure is similar to what was outlined above except for the approval by Chief Engineer (CE) in person.

Departmental customers obtain the prescribed form from township office but the application is submitted direct to the CE for approval.

The house connection is made available within 2 days to 2 weeks from the time the application is approved.

(4) Disconnection

Once a connection is provided, the department may disconnect the supply due to three main reasons listed below:

- change of status of water use from one type to another. In this case the already installed connection will be changed to a new type of connection.
- non-payment of water bill within the stipulated period.
- removal of the dwelling and at the request of the customer to do so following change of supply from YCDC to a private source.

Data on disconnections were very hard to collect either from townships or from the headoffice. Most of the townships indicated as not having any records in this area. Many indicated that disconnections were very rare as such the existence of data does not arise. Only one township reported data on disconnections which were found to be far from accurate. It was noted from various discussions that disconnections due to non-payment of water bills are sanctioned only rarely.

3.4.2 Duration of Supply

Duration of water supply means supply hours per day. Due to low water pressure, lack of adequate water, pumping hours if water is drawn from a borehole and other reasons, supply duration varies considerably among townships. Many townships have only a couple of hours of water in the pipe network. Many customers have attempted to overcome this problem by installing electric water pumps fitted to the supply pipe and pumping water into a house tank whenever water is found in pipes. In general, the townships located near the main distribution line get 24-hours water supply while those far away may have their supply lasting only for a short duration.

It was observed that the staff do not have a proper knowledge about supply hours in their townships. As expected, the information provided was found to be inaccurate and in consistent as well. Several focussed discussions were held with township professional staff in order to establish water supply hours for the 28 townships (Table3.12). According to the data in Table 3.12, only 8 townships have 24-hours of water supply. The supply duration for many other townships including some of those in the CBD is very low. The dwellers in the CBD have adapted themselves to low-supply duration by installing water pumps (see Appendix E Consumer survey).

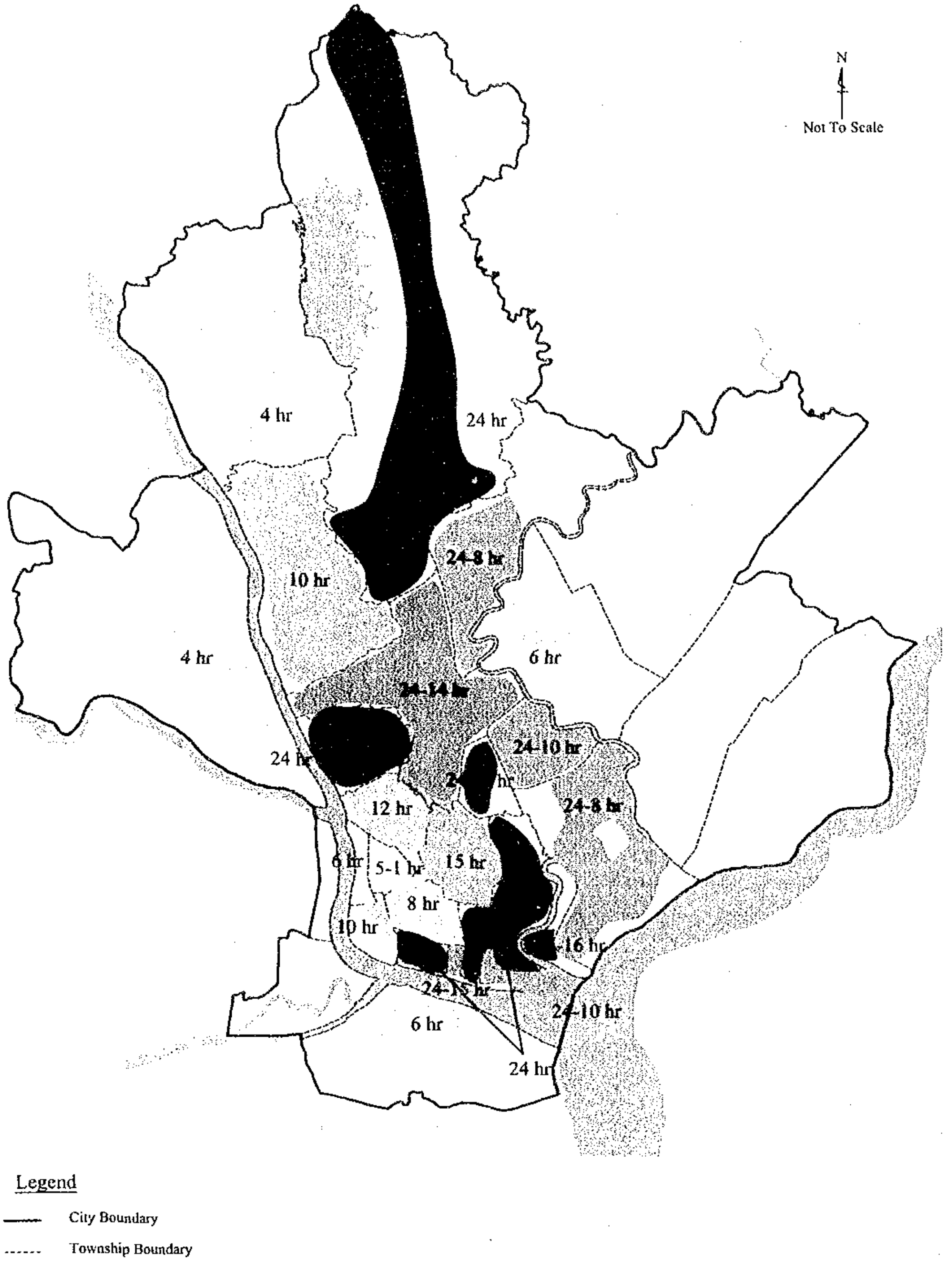
Table 3.12 Distribution of Water Supply Duration and Coverage by Township

Township	Supply Duration (Hours per day)	Number of Wards with Water Supply to Total Wards Number
Ahlone	10	10:11
Bahan	15	21:22
Botataung	24-10	10:10
Dagon	8	5:5
Dagon Myothit (East)	No pipe water supply system	0:54
Dagon Myothit (North)	No pipe water supply system	0:25
Dagon Myothit (Seikan)	No pipe water supply system	0:39
Dagon Myothit (South)	6	5:33
Dala	6	3:23
Dawbon	24-16	3:14
Hlaing	24	12:16
Hlaingthayar	4	7:29
Insein	24-2	4:21
Kamayut	12	10:10
Kyauktada	24	9:9
Kyeemyindaing	6	18:21
Lanmadaw	24	11:12
Latha	24	10:10
Mayangone	24-14	8:10
Mingalardon	24	18:31
Mingalartaungnyunt	24	20:20
North Okklapa	24-8	18:19
Pabedan	24-15	11:11
Pazundaung	24	10:10
Sanchaung	5-1	18:18
Seikkan (Port)	No pipe water supply system	0:3
Seikkyi Kanaungto	No pipe water supply system	0:8
Shwepyitha	4	13:21
South Okklapa	24-10	13:13
Tamwe	24	17:20
Thaketa	24-8	17:19
Thinganchaung	24-8	24:38
Yankin	24-18	15:16

Source: JICA Study Team

It is to be noted that 24-hours supply duration does not mean that every customer in the township gets water throughout the day. The number of customers connected to the network in each township varies over a wide range (Table 3.12). Some wards have just a few customers connected to the network. Hence, in a township of 24-hour supply, only a few customers may in fact benefit by having water throughout the day.

As revealed by above data, supply hours fluctuate remarkably across townships. Townships where many customers enjoy 24-hour supply are Kyauktada, Lanmadaw, Latha, Mingalartaunnyunt, Pazundaung and Tamwe not only because these townships enjoy a 24-hour supply, but also because a higher proportion of wards in these six townships have water from the City network.



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.11
Map of Supply Duration		

3.4.3 Water Pressure

(1) Pressure Measurement

The Study Team conducted 50 points pressure measurement from May 18, 2001 to May 24, 2001, among the following 21 townships.

Ahlone, Bahan, Botataung, Dagon, Dawbon, Hlaing, Insein, Kamayut, Kyauktada, Kyee-myindaing, Lanmadaw, Latha, Mayangone, Mingalartaungnyunt, North Okkalapa, Pazun-daung, Sanchaung, South Okkalapa, Tamwe, Thingangyun, Yankin

The water sources of the area are surface reservoirs and tube wells, however tube wells in downtown were not operated due to power failure on the measurement day.

(2) Measurement Results

Table3.13 shows the measurement results.

The relatively high pressure areas are Bahan, Hlaing, Insein, Mayangone, Tamwe and Yankin. The north of Bahan areas have reasonable pressure, especially near transmission main. Yegu P/S and near Shwe Dagon Service Reservoir areas have relatively high pressure(1.0,1.5, 3.0 kg/cm2).

The other areas such as Ahlone, Botataung, Dagon, Dawbon, Kamayut, Kyauktada, Kyee-myindaing, Lanmadaw, Latha, Mingalartaungnyunt, North Okkalapa, Pazundaung, San-chaung, South Okkalapa, and Thingangyun have low pressure.

Table 3.14 describes estimated pressure condition by township.

By utilizing the measured data, a pressure contour map is created (Figure 3.12, which seems to represent the supply condition to some extent. However overall measured pressure is not so high and only limited areas have enough pressure.

Note) High pressure is a relative term. Typical minimum service levels in many countries are 2 kg/cm^2 and almost all the Yangon Supply area is below this pressure.

(3) Water Pressure in Downtown

The Study Team reinvestigated pressure measurement in downtown area on 4 Sep. As a result, the supplied water conditions in the following township were poor, even the pump of YCDC's tube well was being operated, – Kyeemyindaing, Ahlone, Lanmadaw, Latha, Pabedan, and Kyauktada

Pressure water did not exist in the existing pipe network. Each house is provided with the sucking pump, and the consumer can get water for 24 hours by operating the suck pump. Therefore, the result of water pressure measurement was 0 or negative in downtown area.

Table 3.13 Water Pressure Condition

(million persons)

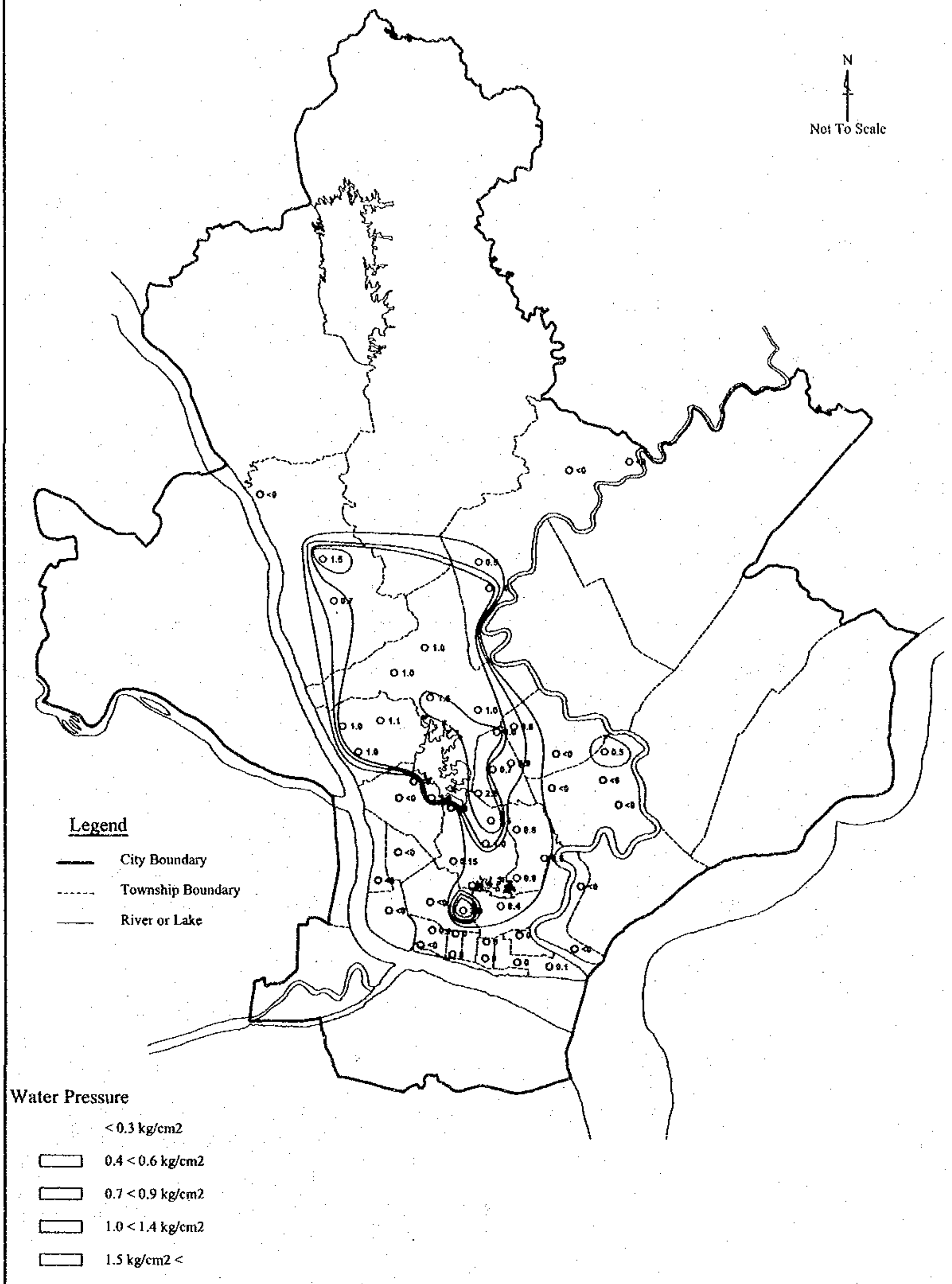
No.	Address		Source of water	Water supply hours	Water Pressure (kg/cm^2)
	Township	Street			
1	Insein	Thazin st	P	24	1.5
2	Insein	Thukhita st	P	24	0.7
3	Mayangone	Kyauk Wai Pagoda st	P	12	1.0
4	Mayangone	Pyee Rd	P	24	1.0
5	Mayangone	Myaing Hai Win st	P	12	1.5
6	Hlaing	Insein Rd	P	24	1.1
7	Hlaing	Yedaner Mon3 Rd	P	24	1.0
9	North Okkalapa		W	24	0.5
10	North Okkalapa	Thudama st	W	24	1.0
11	Mayangone	Ta Yoke Kyaung st	P	24	1.0
12	North Okkalapa	Parami st	P	24	0.8
13	South Okkalapa				very low
14	Thingangyun	Yadanar Theik Pan st	P	24	0.5
17	Yankin		P	24	3.0
18	Yankin		P	24	0.9
19	Yankin		P	24	0.7
20	Yankin		P	24	2.0
21	Tamwe		P	24	0.6
22	Tamwe		P	24	0.5
23	Tamwe		P	24	0.6
24	Thingangyun				low
26	Kamayut		P	24	1.0
28	Bahan		P	24	1.5
29	Bahan				0.2
30	Bahan				0.5
33	Dawbon				low
36	Dagon		P,W		low
37	Dagon		P	24	3.0
38	Mingalartaungnyunt		P	24	0.4
39	Botataung		P	24	0.1
40	Pazundaung			24	0.0
41	Botataung				0.0
42	Kyauktada				0.0
43	Kyauktada				0.0
44	Latha				0.0
45	Latha				0.0
46	Lanmadaw		P,W	12	0.1
47	Lanmadaw		P,W, rationing		low
48	Bahan		P	24	1.0
50	Hlaing		P	24	1.0

Note:pipeline (P) or well (W)

Table 3.14 Water Pressure Condition by Township

No	Township	Water Pressure Measure-ment	Water Pressure Condition*
1	Ahlone	O	x
2	Bahan	O	o
3	Botataung	O	x
4	Dagon	O	x
5	Dagon Myothit (East)		-
6	Dagon Myothit (North)		-
7	Dagon Myothit (Seikkan)		-
8	Dagon Myothit (South)		-
9	Dala		-
10	Dawbon	O	X
11	Hlaing	O	O
12	Hlaingthaya		-
13	Insein	O	O
14	Kamaryut	O	X
15	Kyauktada	O	X
16	Kyeemyindaing	O	X
17	Lanmadaw	O	X
18	Latha	O	X
19	Mayangone	O	O
20	Migalardon		-
21	Mingalartaungnyunt	O	X
22	North Okkalapa	O	X
23	Pabedan		-
24	Pazundaung	O	X
25	Sanchaung	O	X
26	Seikkan (port)		-
27	Seikgyikhanaungto		-
28	Shwepyitha		-
29	South Okkalapa	O	X
30	Tamwe	O	O
31	Thaketa		-
32	Thingahgyun	O	X
33	Yankin	O	O

*: o;Appropriate water supply pressure area
x;Low or negative water suppply pressure area
-;No measurment or no water supply system



THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FIG 3.12

Estimated Pressure Contour Map

3.4.4 Water Quality

(1) General

Periodical water sampling was conducted to examine the current status of the existing water sources. Water sampling was carried out every month starting from May 2001 to March 2002. Sampling was performed by YCDC and Myanmar Science Technological Research Department (MSTRD) executed water quality analysis.

Based on the results of water quality analysis, which was continued almost a year, water treatment method and prospected new water source was proposed.

(2) Examination Parameters

Water quality examination parameters were selected to improve the water quality in the system and to determine the proposed water treatment process. The followings are the selected parameters;

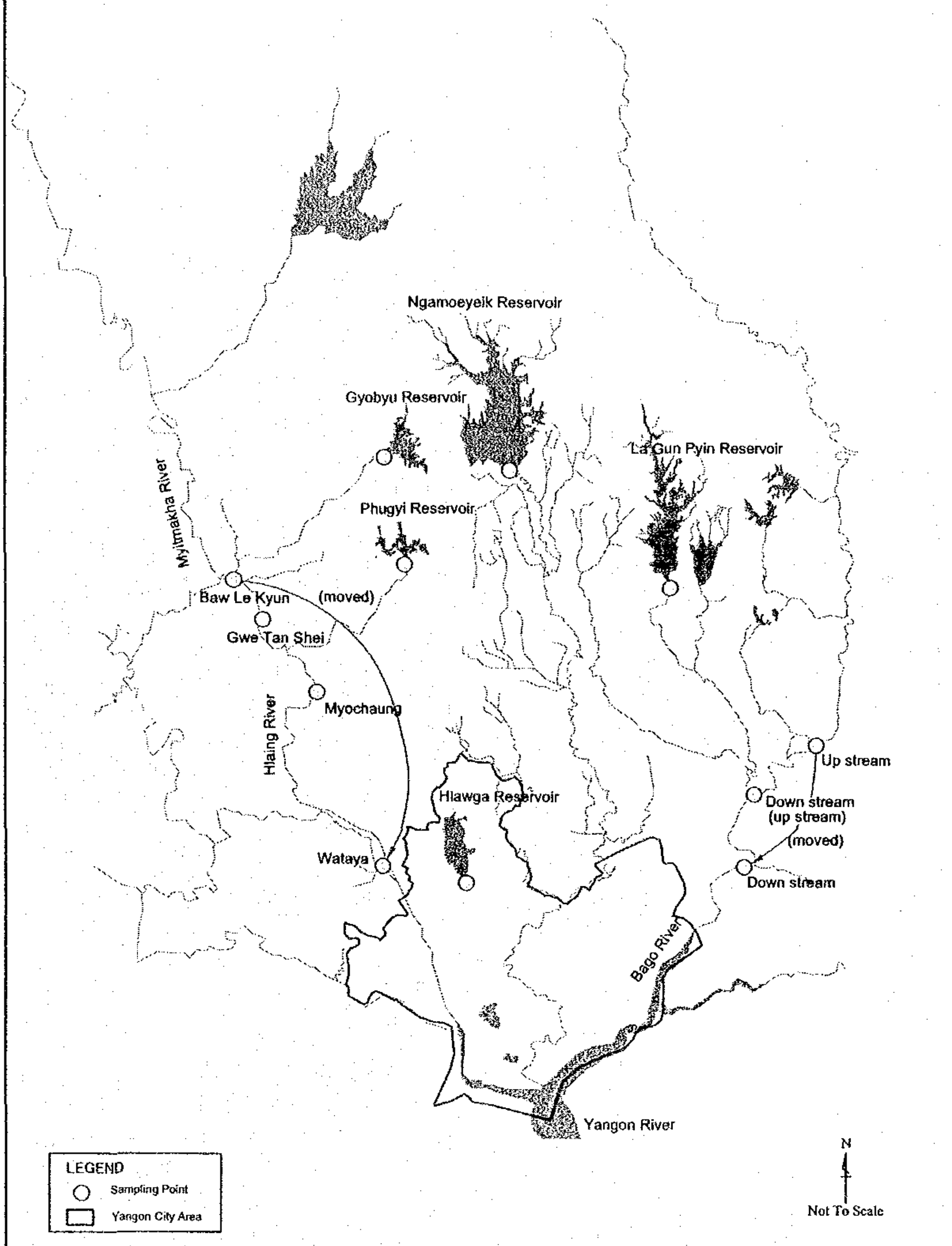
Bacteriological	BOD, Dissolved Oxygen,
Physical	Temperature, Color, Turbidity,
Chemical	Hardness, Alkalinity, pH, COD, Arsenic, Cadmium,
Cations	Calcium, Magnesium, Potassium, Sodium,
Anions	Chloride, Sulfide, Cyanide, Nitrate, Nitrogen-Ammonia,
Trace Elements	Iron, Manganese, Zinc, Copper, Lead,

(3) Sampling Points

Forty sampling points were selected as shown in Figure 3.13, 3.14 and table below;

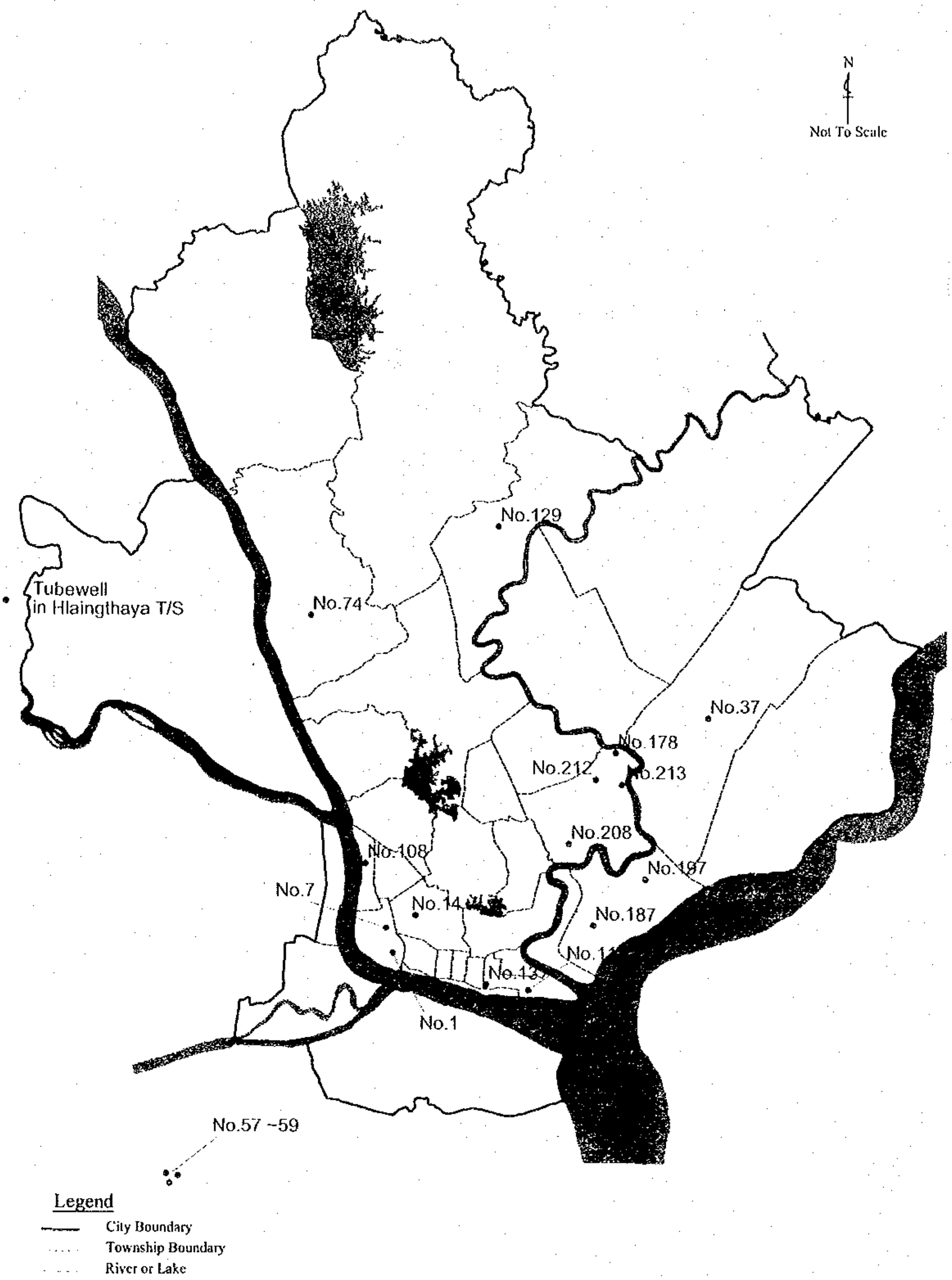
Table 3.15 Original Water Sampling Points

Sampling Points		Sampling Number	Remarks
Existing Reservoirs	Gyobyu Reservoir	1	
	Phugyi Reservoir	1	
	Hlawga Reservoir	1	
Planned Reservoirs	Ngamoeyeik Reservoir	1	
	La Gun Pyin Reservoir	1	
Rivers	Hlaing River	12	High and low tide, 2 points 3 depth (upper, middle, lower)
	Bago River	12	Ditto
Tube Wells		11	
	Total	40	



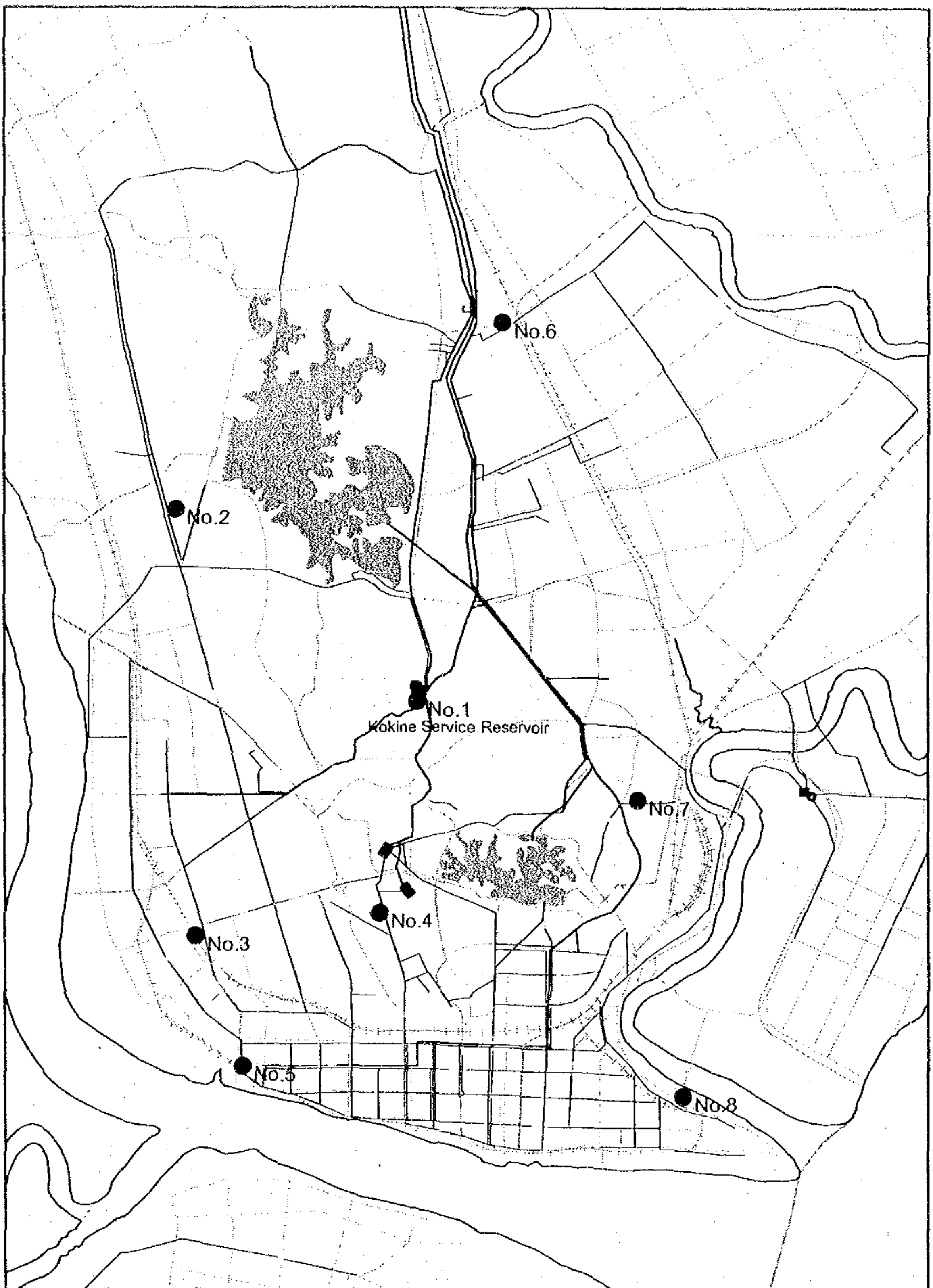
Note) Sampling points of Hlaing and Bago River were moved to down stream in September 2001.

JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.13
	Location Map of Sampling Points	



Note) 8 wells (No.37, 57 to 59, 129, 178, 213, HT) were added in September 2001.

JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.14
	Location Map of YCDC Tube Wells for Water Sampling	



THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FIG 3.15

Location Map of Sampling Points from Water Supply System

(4) Saline Water Intrusion Survey

1) Rainy Season

Saline water intrusion survey was conducted at Bago and Hlaing River on 23 and 24 August 2001. Sampling points are shown in Figure 3.16 and the results are described in Table 3.16 to 3.17 and Figure 3.17 to 3.18, showing no trance of saline water.

2) Dry Season

Saline water intrusion survey was conducted again Hlaing River on 23 to 24 January 2002. Sampling points are shown in Figure 3.19 starting from Thilawa port to Wataya. Electric conductivity was measured during this survey and results are described in Table 3.18. Excluding three points, namely Thilawa, Yangon Port and Wataya, samples were taken in three depths, upper, middle and lower layer.

Table 3.18 E.C. Value Measured in Hlaing River (Dry Season)

No.	Sampling Points	Sampling Time	Distance from Andaman Sea (km)	E.C.(μ S/cm)		
				Upper	Middle	Lower
				0.5 m	10 m	20 m
1	Thilawa	23 Jan, 10:30	24.5	11,700		
2	Yangon Port	23 Jan, 9:30	34.5	2,982		
3	Sinmin	24 Jan, 10:50	43.0	1,711	2,010	2,010
4	Bargayar	24 Jan, 10:10	45.0	942	988	1,051
5	Bayint Naung Bridge	24 Jan, 12:00	51.0	973	936	1,001
6	Aungzaya Bridge	24 Jan, 12:30	54.0	856	887	874
7	Shwepitha Bridge	24 Jan, 13:00	59.5	275	284	304
8	Wataya	24 Jan, 13:35	65.0	258		

Based on the results and location of sampling points, distance from Andaman Sea, the following correlation formula was figured out;

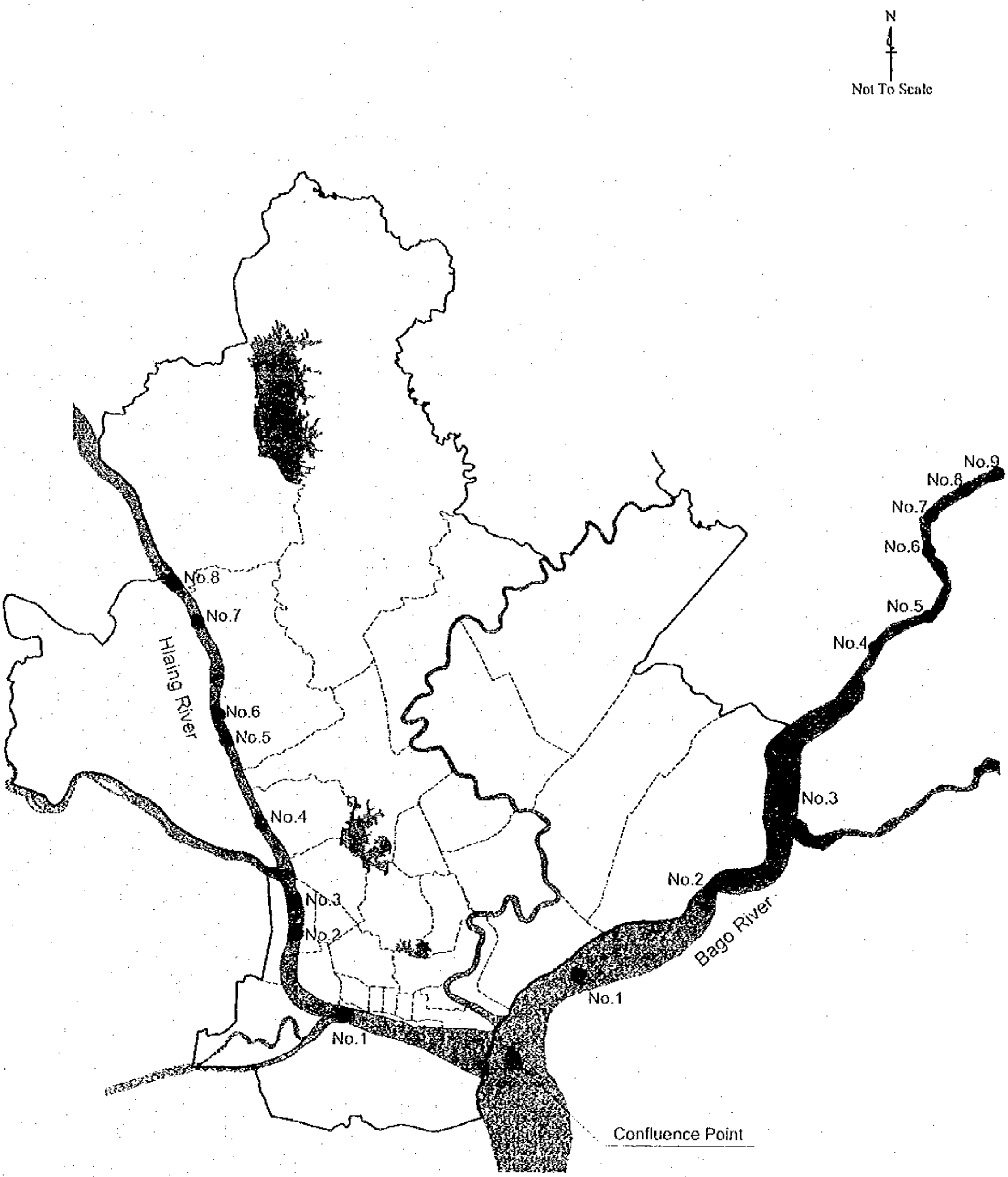
$$E.C. = 3 \times 10^{9} \times X^{-3.8421}$$

Where, X : Distance from Andaman Sea (km), Correlation rate was 0.9554

Figure 3.20 shows the said correlation between E.C. value and sampling points' distance from Andaman Sea. The followings are the conclusion of this saline intrusion survey;

No.	E.C. value (μ S/cm)	Comments
1	11,700	Brackish water
2	2,982	Brackish water (lower limit)
3 to 6	1,711 to 856	Slightly affected by brackish water
7 to 8	304 to 258	Fresh water

Because the proposed intake site, Gwedanshe, is located 15 km upstream of Wataya (No.8), target river water was determined as free from saline water intrusion.



Legend

—— City Boundary

Township Boundary

River or Lake

● Sampling Points

Note) Conflunce point is about 34.5km upstrean of river mouth flowing into Audaman Sea

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THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

Location Map of Saline Water Intrusion Survery Sampling Points (Rainy Season)

FIG 3.16

Table 3.16 Hlaing River Saline Water Intrusion Survey (Rainy Season)

Date : 24 August 2001

No.	Sampling Time	Water Depth (m)	Sampling Depth (m)	E.C.	Cl^-	pH	ORP	Remarks
				μ S/cm	mg/L	-	mV	
1-L	AM 7:25	10	10	12,700	3,316	7.5	315	Turbidity = 180, T = 29.7℃
1-M	7.26	10	5	12,600	3,289	7.5	316	Turbidity = 140, T = 29.8℃
1-U	7:28	10	0.5	12,500	3,262	7.5	316	Turbidity = 140, T = 29.8℃
2-L	7:45	10	10	12,600	3,289	7.5	298	Turbidity = 170, T = 29.8℃
2-M	7:46	10	5	12,600	3,289	7.5	299	Turbidity = 140, T = 29.8℃
2-U	7:47	10	0.5	12,600	3,289	7.5	300	Turbidity = 140, T = 29.8℃
3-L	8:20	10	10	12,900	3,369	7.5	276	T = 29.8℃
3-M	8:21	10	5	12,800	3,342	7.5	279	T = 29.8℃
3-U	8:22	10	0.5	12,800	3,342	7.5	278	T = 29.8℃
4-L	8:35	4.5	4.5	12,900	3,369	7.5	277	T = 29.8℃
4-M	8:36	4.5	2.5	12,800	3,342	7.5	279	T = 29.8℃
4-U	8:37	4.5	0.5	12,800	3,342	7.5	279	T = 29.8℃
5-L	9:20	10	10	13,100	3,422	7.5	258	T = 29.7℃
5-M	9:21	10	5	13,100	3,422	7.6	262	T = 29.8℃
5-U	9:22	10	0.5	13,100	3,422	7.6	263	T = 29.8℃
6-L	10:40	10	10	13,600	3,556	7.6	246	T = 29.7℃
6-M	10:41	10	5	13,500	3,529	7.6	248	T = 29.8℃
6-U	10:42	10	0.5	13,400	3,502	7.5	252	T = 29.8℃
7-L	10:55	10	10	13,500	3,529	7.6	259	T = 29.7℃
7-M	10:56	10	5	13,500	3,529	7.5	265	T = 29.7℃
7-U	10:57	10	0.5	13,500	3,529	7.6	261	T = 29.8℃
8-L	11:10	10	10	13,500	3,529	7.5	267	T = 29.7℃
8-M	11:11	10	5	13,500	3,529	7.5	268	T = 29.7℃
8-U	11:12	10	0.5	13,500	3,529	7.5	266	T = 29.6℃

U = Upper, M = Middle, L = Lower Layer

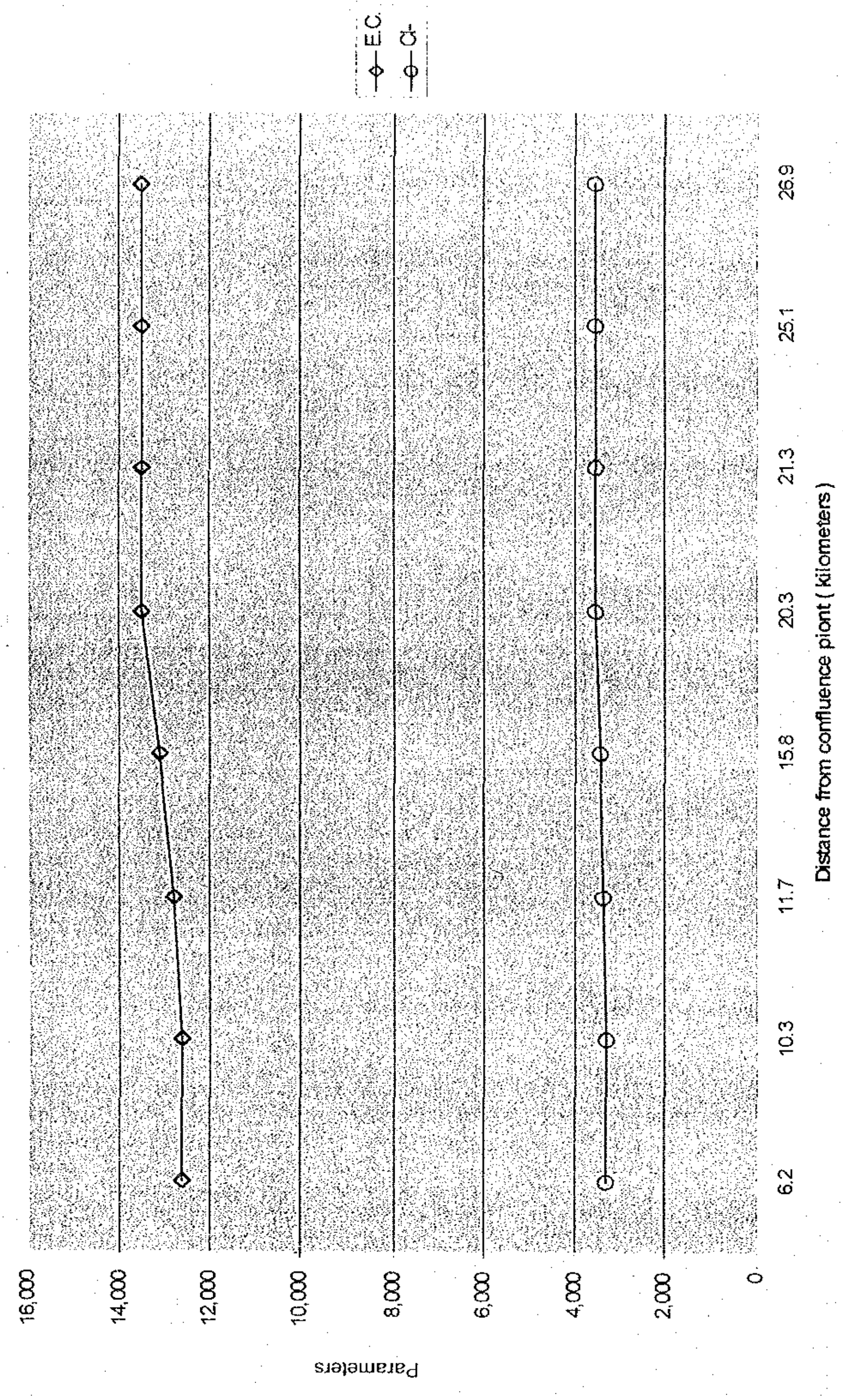
Table 3.17 Bago River Saline Water Intrusion Survey (Rainy Season)

Date : 23 August 2001

No.	Sampling Time	Water Depth (m)	Sampling Depth (m)	E.C.	Cl⁻	pH	ORP	Remarks
				μ S/cm	mg/L	-	mV	
1	AM 4:43	0.5	0.5	11,800	3,076	7.6	350	
2	5:10	0.5	0.5	10,800	2,809	7.36	290	
3	5:12	3.0	3.0	10,600	2,755	7.26	293	
4-L	6:40	4.6	4.6	7,800	2,009	7.3	289	Turbidity = 140, T = 29℃
4-M	6:42	4.6	2.6	7,900	2,035	7.2	293	Air = 27.5℃
4-U	6:43	4.6	0.5	8,000	2,062	7.1	298	
5	7:20	—	—	8,000	2,062	6.9	295	
6-L	7:55	7.0	7.0	9,200	2,382	7.1	283	Turbidity = 400, T = 29℃
6-M	7:56	7.0	3.5	9,200	2,382	7.1	283	
6-U	7:57	7.0	0.5	9,200	2,382	7.1	285	
7-L	8:20	4.8	4.8	9,800	2,542	7.2	275	Turbidity = 300, T = 29.6℃
7-M	8:21	4.8	2.8	9,800	2,542	7.1	279	
7-U	8:22	4.8	0.5	9,700	2,515	7.1	279	8:45 trace back was stopped at No.7
8-L	8:45	4.9	4.9	10,000	2,595	7.1	285	Turbidity = 300, T = 29℃
8-M	8:46	4.9	2.9	9,900	2,569	7.1	287	
8-U	8:47	4.9	0.5	9,900	2,569	7.1	286	
9-L	9:05	3.7	3.7	10,500	2,729	7.3	286	Turbidity = 400, T = 29℃
9-M	9:06	3.7	1.7	10,400	2,702	7.2	288	
9-U	9:07	3.7	0.5	10,100	2,622	7.2	286	
10-L	9:45	5.9	5.9	11,300	2,942	7.2	264	Turbidity = 500, T = 29.3℃, Flow down
10-M	9:46	5.9	3.9	11,300	2,942	7.2	264	Turbidity = 400, T = 29.3℃
10-U	9:47	5.9	0.5	11,200	2,916	7.2	270	Turbidity = 400, T = 29.3℃
11-L	10:50	6.7	6.7	12,300	3,209	7.2	255	Turbidity = 1000, T = 29.3℃
11-M	10:54	6.7	5.7	12,200	3,182	7.1	264	Turbidity = 700, T = 29.4℃
11-U	10:55	6.7	0.5	12,300	3,209	7.2	262	Turbidity = 400, T = 29.5℃

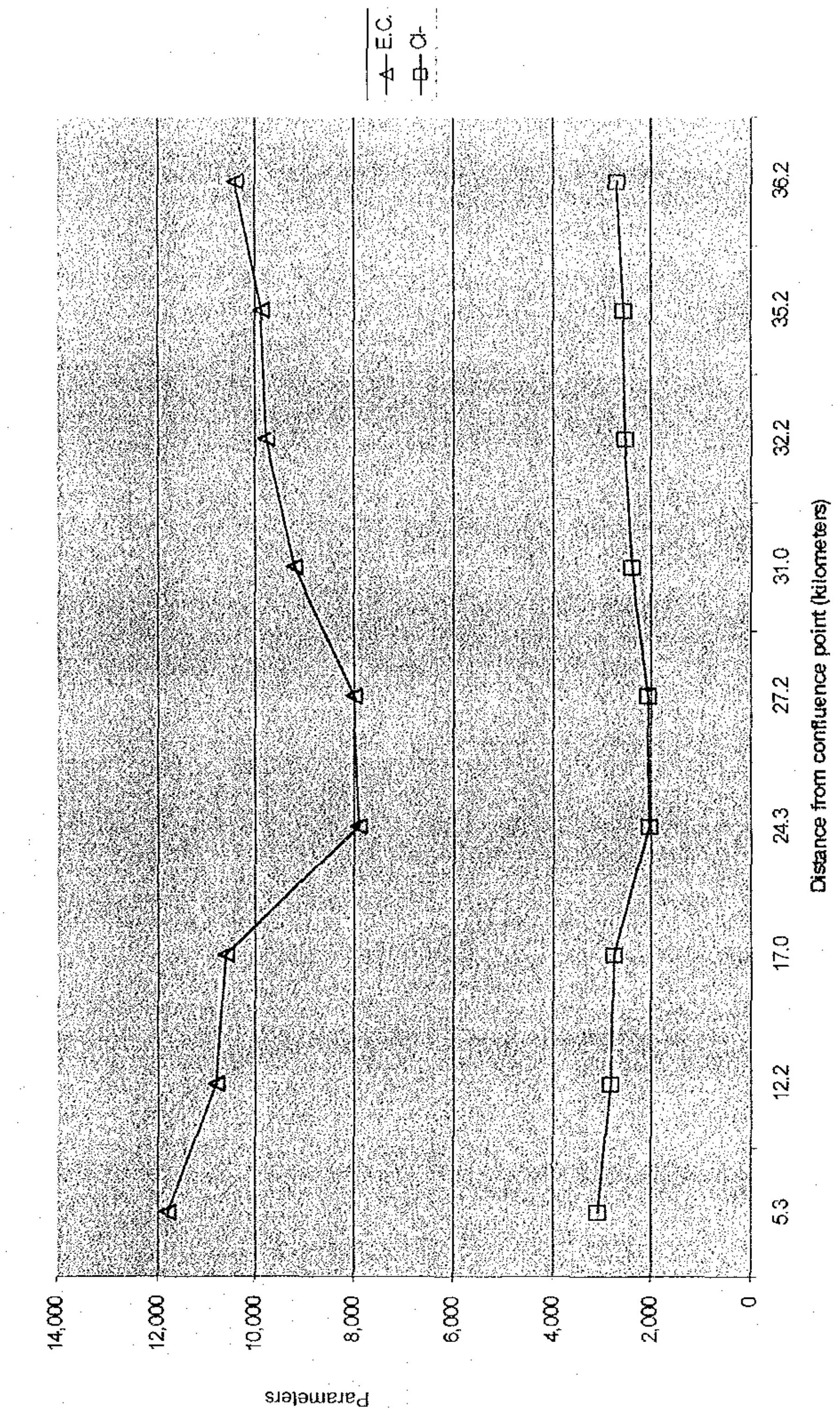
U = Upper, M = Middle, L = Lower Layer

Figure 3.17 Parameters Fluctuation (Hlaing River in Rainy Season)

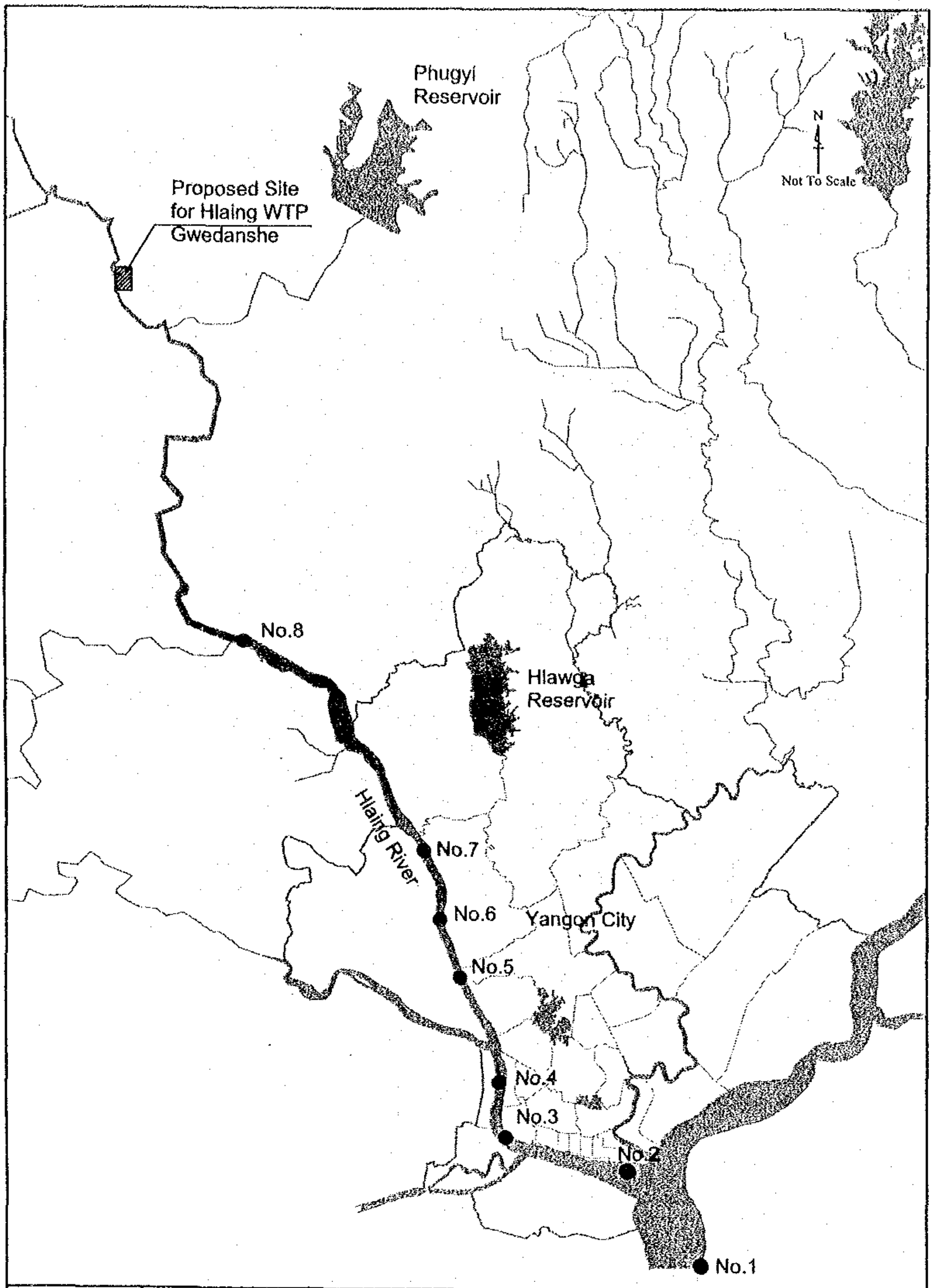


THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.17
Parameter Fluctuation (Hlaing River)	

Figure 3. 18 Parameters Fluctuation (Bago River in Rainy Season)



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.18
	Parameter Fluctuation (Bago River)	



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THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

Location Map of Saline Water Intrusion Survey Sampling Points (Dry Season)

FIG 3.19

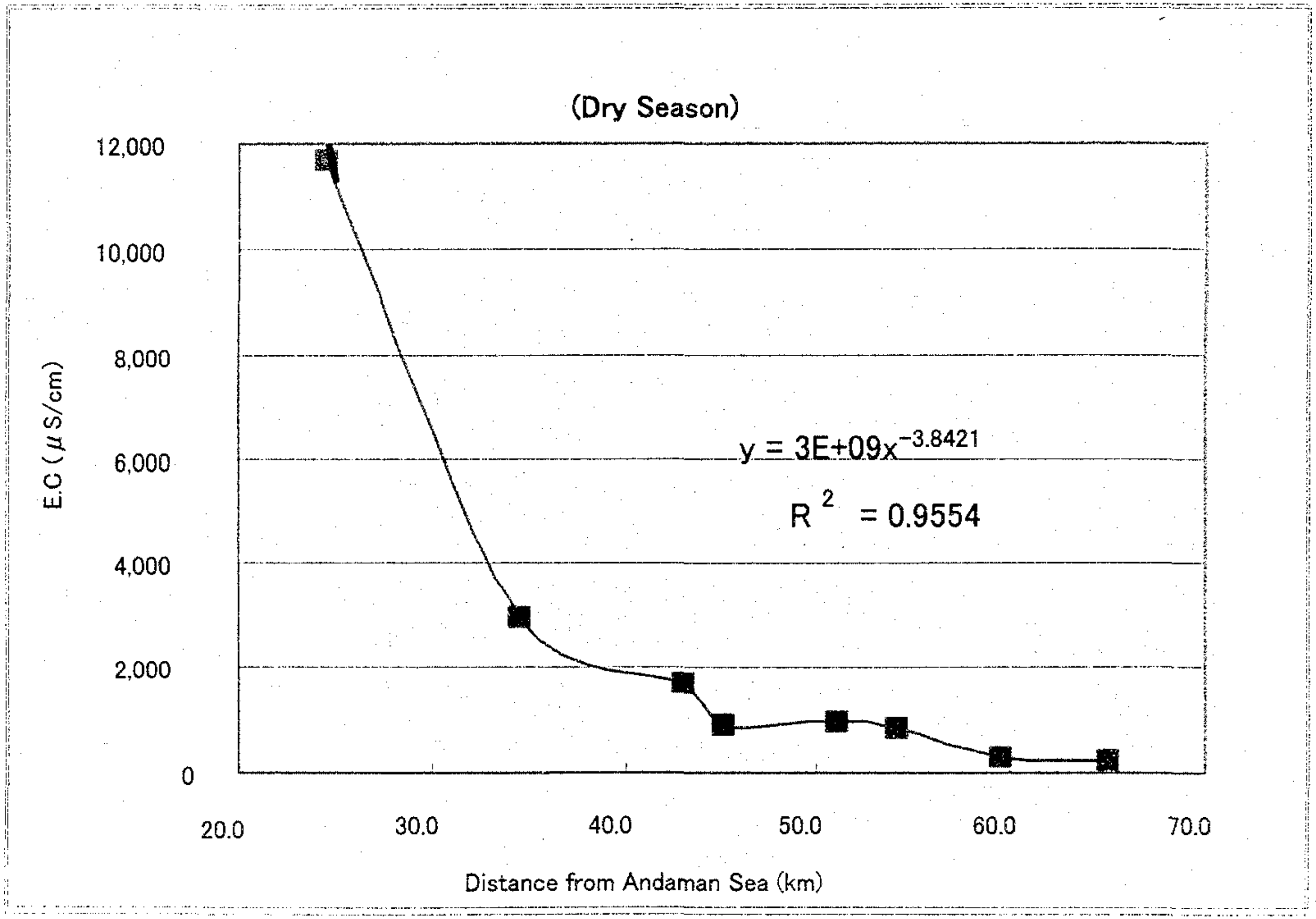


Figure 3.20 Correlation Between E.C. Value and Distance from Andaman

(5) Drinking Water Standard

Table 3.19 is showing the proposed National Drinking Water Standard in Myanmar, which was established in 1990 and drinking water guideline of WHO.

Table 3.19 Drinking Water Standard

Parameters	Unit	Myanmar Standard	WHO Standard
Faecal Coliform	No./100 ml	0	0
Coliform Organisms	No./100 ml	0	0
Arsenic	mg/l	0.05	0.01
Cadmium	mg/l	0.005	0.003
Chromium	mg/l	0.05	0.05
Cyanide	mg/l	0.05	0.07
Flouride	mg/l	1.5	1.5
Lead	mg/l	0.05	0.01
Mercury	mg/l	0.001	0.001
Nitrate (as N)	mg/l	10.0	50.0
Nitrite (as N)	mg/l	0.5	3.0
Selenium	mg/l	0.01	0.01
Aluminium	mg/l	0.2	0.2
Chloride	mg/l	200 – 600	250
Colour	TCU	5 – 50	15
Copper	mg/l	1.0	2.0
Hardness (as $CaCo_3$)	mg/l	500	-
Iron	mg/l	0.5 – 1.5	0.3
Manganese	mg/l	0.3	0.5
pH	mg/l	6.5 – 9.2	Preferably < 8.0
Sodium	mg/l	200	200
Sulphates	mg/l	400	250
Taste & Odour	mg/l	inoffensive	No objection
Solids	mg/l	1,000	1,000
Turbidity	NTU	20	5
Zinc	mg/l	5 - 15	3
Calcium	mg/l	75 – 200	-
Magnesium	mg/l	30 – 150	-
Electrical Conductivity	μ S/cm	1,500	-

As shown in the table, WHO standard is stricter than the proposed national standard of Myanmar in most water quality indices.

Water supply issues in Yangon City can be classified into "distributed water amount" and "distributed water quality". These issues shall be overcome as soon as possible but due to the scale of target area, they cannot be solved at once. Phased improvement in terms of water amount and water quality is realistic and is applicable for the system development in Yangon City. At present, the most serious issue is water shortage and thus, water source development will be given higher priority. Reservoir water shall be distributed with proper disinfection, namely chlorination.

However, all available water must be properly treated by water treatment facility eventually. Therefore, it can be said that implementation period of this project is "Transitional Period" alternating from current system to advanced system. WHO standard shall be considered as ultimate goal but since there are some indices lacking, proposed Myanmar National Drinking Water Quality Standard stated above shall be adopted as target water quality standard for the transitional period. After the completion of water treatment facilities proposed in this study, all water will be appropriately treated and then further effort shall be made to realize treated water quality consistent with WHO standard.

(6) Examination on Analysis Results

1) Reservoirs

There are five existing reservoirs and water quality in these reservoirs was similar, low turbidity and low contents of dissolved matters. The following table shows the summary of water quality analysis from May to October 2001, which was conducted in Gyobyu reservoir.

Table 3.20 Analysis Results of Reservoir (Gyobyu Reservoir)

Parameters	Unit	Myanmar Standard	2001					
			May	June	July	Aug.	Sept.	Oct.
Turbidity	NTU	20	3	2	N.D.	N.D.	N.D.	N.D.
Color	TCU	5 -50	7.5	N.D.	N.D.	N.D.	N.D.	N.D.
pH		6.5 – 9.2	7.65	7.80	7.50	7.65	6.9	7.0
Alkalinity	$CaCO_3$ mg/L	-	58	52	36	42	46	44
Parameters	Unit	Myanmar Standard	2001		2002			
			Nov.	Dec.	Jan	Feb	Mar.	
Turbidity	NTU	20	N.D.	N.D.	8	N.D.	N.D.	
Color	TCU	5 -50	N.D.	N.D.	N.D.	N.D.	N.D.	
pH		6.5 – 9.2	6.7	6.8	6.6	6.7	7.6	
Alkalinity	$CaCO_3$ mg/L	-	40	50	56	56	64	

As shown in the table, water quality in reservoir is good and all detected 26 water parameters were within the proposed Myanmar standard.

2) Rivers

There are two rivers flowing into the city boundary, namely Hlaing and Bago River. However, as examined in the previous section, Hlaing River is further prospective future water source compared with Bago River, because river discharge of Bago River during dry season is almost 0 m^3/sec.

The following table shows the summary of water quality analysis conducted at Hlaing River. Theses results were acquire from water samples taken at Gwedanshe, the proposed water intake point. Sampled in middle layer, during high tide period.

Table 3.21 Analysis Results of River (Hlaing River)

Parameters	Unit	Myanmar Standard	2001					
			May	June	July	Aug.	Sept.	Oct.
Turbidity	NTU	20	800	600	263	232	275	220
Color	TCU	5 – 50	17.5	50	575	235	160	320
pH		6.5 – 9.2	8.1	7.6	7.3	7.7	7.2	7.4
Alkalinity	$CaCO_3$ mg/L	-	125	40	44	50	56	60
Parameters	Unit	Myanmar Standard	2001		2002			
			Nov.	Dec.	Jan	Feb	Mar.	
Turbidity	NTU	20	237	90	45	80	190	
Color	TCU	5 – 50	250	63	80	37	18	
pH		6.5 – 9.2	7.5	7.5	7.2	7.3	8.3	
Alkalinity	$CaCO_3$ mg/L	-	74	90	122	138	140	

Since the river bank erosion during rainy season is regarded as main cause of this high turbidity, turbidity in dry season is much lower. Turbidity and color is exceeding the standard and therefore, proper turbidity removal procedure must be introduced upon utilization of Hlaing river water as drinking water.

The study team also conducted water quality analysis on samples taken at the downstream of agricultural outlet channel discharging into Hlaing River. Said outlet channel is located about 1 km upstream of Gwedanshe. The objective of this survey is to examine the existence of agricultural chemicals, which have been applied in paddy field and might have been discharged into Hlaing River. Two samples were taken in middle layer at 1) Outlet Channel and 2) Gwedanshe. The following chemicals, which are commonly used in Myanmar were analyzed;

Myanmar Name	Common Name
Myanmar-zion	Diazinon
Myanmar-phentho	Phenthoate
Myanmar-endo	Endosulfan
Myanmar-cyper	Cypermethrin

Although there was equipment can analyze such chemicals in Plant Protection Division of Myanmar Agriculture Service, it was malfunctioning. Therefore, samples were sent to Japanese laboratory and analyzed. The followings are the results and no trace of abovementioned chemicals was detected.

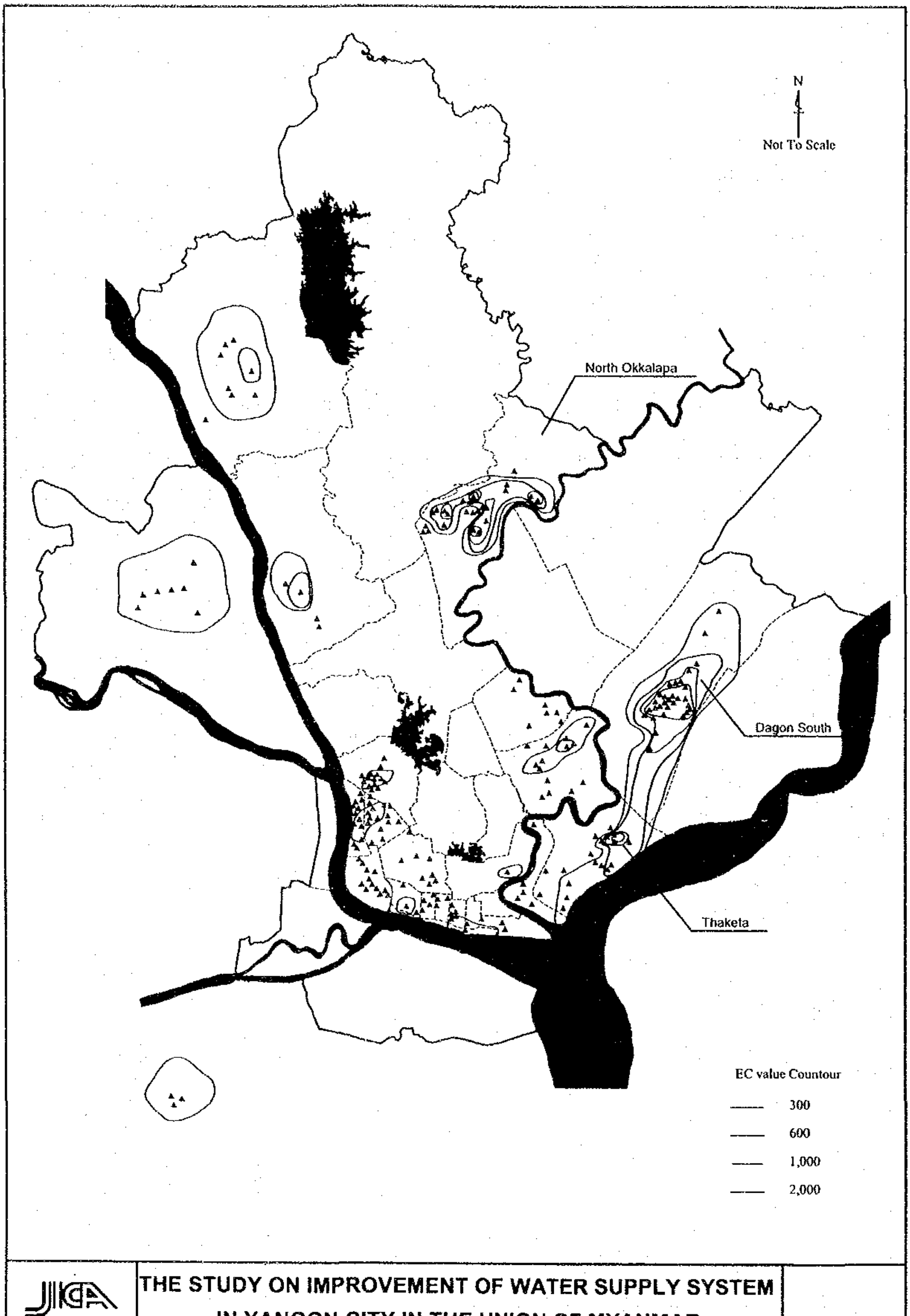
Chemical Name	Analysis Results
Diazinon	Less than 0.0001 mg/L
Phenthoate	Less than 0.001 mg/L
Endosulfan	Less than 0.001 mg/L
Cypermethrin	Less than 0.001 mg/L

However, since this survey was conducted during "dry season", same survey shall be carried out again in "rainy season" with larger possibility of chemical discharge into the River.

3) Tube Wells

11 wells were examined from May to August and 8 wells were added and in total, 19 wells were analyzed from September 2001. The following table shows the results of No.197 well in Thaketa T/S, as representative. As shown in Table 3.22, values higher than the standard was recorded in parameter of Iron, Manganese, Color and Turbidity.

Along with water quality analysis, EC measurement survey was conducted on 217 YCDC wells to grasp the overall water quality. Survey was executed from the end of August up to the middle of September. Figure 3.21 is EC value contour map summarized the measurement results. As shown in the map, wells in eastern, northern areas and T/S in the right bank of Hlaing River have high EC values, showing high contents of dissolved matters. Detailed results are shown in Appendix C.



THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FIG 3.21

EC value Countour Map of YCDC Tube well

Table 3.22 Analysis Results of Tube Well (No.197)

Parameters	Unit	Myanmar Standard	2001					
			May	June	July	Aug.	Sept.	Oct.
Turbidity	NTU	20	12	2	65	43	35	48
Color	TCU	5 – 50	15	15	80	170	50	50
pH		6.5 – 9.2	8.7	6.97	7.8	7.1	7.0	7.1
Iron	ppm	0.5 – 1.5	0.3	1.05	3.56	3.34	3.06	2.93
Manganese	ppm	0.3	0.7	0.15	N.D.	N.D.	N.D.	N.D.
Electric Conductivity	μS/cm	1,500	2,300	1,800	2,900	2,200	2,500	3,400
Parameters	Unit	Myanmar Standard	2001		2002			
			Nov.	Dec.	Jan	Feb	Mar.	
Turbidity	NTU	20	15	28	30	45	55	
Color	TCU	5 – 50	60	90	35	38	90	
pH		6.5 – 9.2	7.1	7.6	7.0	7.0	8.1	
Iron	ppm	0.5 – 1.5	3.34	2.53	1.68		2.53	
Manganese	ppm	0.3	N.D.	N.D.	0.008	N.D.	0.1	
Electric Conductivity	μS/cm	1,500						

According to the EC measurement results and water quality analysis results, it was suggested "groundwater use in the following T/S shall transfer to surface water in the future". The said T/S are;

- Dagon South T/S
- North Okkalapa T/S
- Thaketa T/S

This suggestion must be reflected on the subsequent surface water transmission pipe and distribution network development plan.

4) Water Supply System

Kokine Service Reservoir and seven private faucets were selected as sampling points of distributed water through the existing water supply system. Locations of seven private faucets were selected from upstream to downstream of the distribution network. Seven faucets are in the following T/S;

- Ahlone T/S
- Botataung T/S
- Dagon T/S
- Kamayut T/S
- Lanmadaw T/S
- Tamwe
- Yankin

The following table shows the results of Botataung T/S, located at the downstream of distribution network.

E-Coliform and SPCB was also detected in other six samples only excluding sample taken in Ahlone T/S. This is due to the water contamination in reservoir in upstream. Presence of E-Coliform shows fecal contamination of reservoir water due to the urbanization in surrounding areas. Appropriate disinfection shall be conducted in full-time scale throughout a year.

Table 3.23 Analysis Results of Faucet (Botataung T/S)

Parameters	Unit	Myanmar Standard	2001			
			Sept.	Oct.	Nov.	Dec.
Turbidity	NTU	20	N.D.	3.0	2.0	N.D.
Color	TCU	5 – 50	N.D.	N.D.	N.D.	4
pH		6.5 – 9.2	6.2	6.7	7.0	6.7
Iron	ppm	0.5 – 1.5	0.33	3.20	0.39	0.37
E-Coliform	No./100 ml	0	detected	detected	detected	detected
SPCB	No./100 ml	-	detected	detected	detected	detected
Parameters	Unit	Myanmar Standard	2002			
			Jan.	Feb.	Mar.	
Turbidity	NTU	20	N.D.	2.0	N.D.	
Color	TCU	5 – 50	N.D.	9.0	N.D.	
pH		6.5 – 9.2	6.7	7.4	6.9	
Iron	ppm	0.5 – 1.5	0.27	0.43	0.02	
E-Coliform	No./100 ml	0	detected	detected	detected	
SPCB	No./100 ml	-	detected	detected	detected	

Note) SPCB : Standard Plate Count Bacteria

(6) Proposed Countermeasures

1) Reservoir

As aforementioned, turbidity of raw water in the existing reservoirs are low (average turbidity = 3 NTU). Turbidity must be removed nevertheless but coagulated sedimentation is not applicable for such low turbidity. Flocculation is very slow in such low turbidity and sedimentation velocity is also low. It means that sedimentation effect is inferior and longer sedimentation time or installation of auxiliary sedimentation facility such as tube/plate settler is needed.

Plankton mainly causes turbidity in reservoir water and coagulation process for such water needs high operation technology and monitoring system. Considering the present technical level of YCDC, coagulation process should not be employed for reservoir water treatment. Therefore, the following two treatment processes were proposed;

- Slow Sand Filter
- Biological Contact Aeration Process

Optimum chlorine dosing rate was confirmed by "chlorine requirement test" in laboratory. Chlorine requirement was below 1 mg/l. Considering the seasonal water quality fluctuation, capacity of chlorination equipment was proposed as follows;

Item	Chlorinator Capacity
Duty	1 mg/L
Maximum	5 mg/L

2) Rivers

On the contrary to reservoir water, turbidity of river water is high and coagulation is indispensable. The following is the results of the jar test on Hlaing river water conducted in the YCDC laboratory. Supernatant was extracted for analyze after dosing of Alum and sedimentation.

Table 3.24 Analysis Results of Supernatant after Coagulation and Sedimentation

Alum Dosing Rate (mg/L)	Turbidity	EC	pH	Chloride	Nitrogen-Ammonia	ORP	Iron
0	200	107	7.60	0.4	0.13	277	1.03
10	114	108	7.56	0.3	0.07	286	0.46
20	30	110	7.41	0.3	0.08	295	0.09
30	15	112	7.32	0.3	0.06	303	0.04
40	1.2	115	7.20	0.3	0.06	312	0.01
50	3.8	116	7.02	0.3	0.08	329	0.03
60	7.4	117	6.87	0.3	0.06	336	0.04

40 mg/L was determined as optimum Alum dosing ratio. Remaining concentration of Iron and manganese in supernatant was 0.01 mg/L and 0.001 mg/L, respectively.

Since favorable flocculation and sedimentation effect on Hlaing River water was confirmed by this jar test, the following treatment process was proposed for river water treatment;

- Coagulated Sedimentation and Rapid Sand Filter

Optimum chlorine dosing rate was confirmed by "chlorine requirement test" in laboratory. Test was conducted to supernatant of river water after coagulation and sedimentation. Chlorine requirement was below 1 mg/l. Considering the seasonal water quality fluctuation, capacity of chlorination equipment was proposed as follows;

Item	Chlorinator Capacity
Duty	1 mg/L
Maximum	5 mg/L

3) Groundwater

a) *Hlaing River Left Bank*

As aforementioned in the previous section, groundwater use in the following T/S should transfer to surface water due to inferior groundwater quality;

- Dagon South T/S
- North Okkalapa T/S
- Thaketa T/S

b) Hlaing River Right Bank

The following table shows the results of water quality analysis conducted on 3rd September on four completed tube wells in outside of Hlaingthaya T/S. These wells were constructed to serve groundwater to township. However, since submersible pumps were not yet installed, stagnant groundwater was taken in the depth of around 15 m from the water surface;

Parameter	Unit	No.1	No.2	No.3	No.4
Chloride	ppm	2.6	2.1	4.1	26.1
Total Hardness	ppm	102	112	98.8	128
Iron	ppm	0.11	1.19	0.75	0.45
Manganese	ppm	0.66	1.07	1.2	0.99
E Conductivity	m.mho/cm	277	309	290	403
Nitrogen-Ammonia	ppm	N.D.	N.D.	N.D.	N.D.

High concentration iron and manganese was confirmed. The following day, water analysis was performed again to examine whether high concentration of iron and manganese attributes to "No pump operation". Sample was taken from elevated tank of site office. Water was pumped from well located near by the said four wells. Air-lift Pump was installed.

Parameters	Unit	Results
Iron	ppm	0.07
Manganese	ppm	0.63

Although parameters were affected by air-lifting, manganese concentration was still high.

The table in below shows the water quality analysis results in the same well. Submersible pump was installed in the well in a day before the water sampling and pump was operated in 12 hours continuously to introduce fresh groundwater into the well.

Parameters	Unit	2001	
		Sept.	Oct.
Turbidity	NTU	N.D.	N.D.
Color	TCU	N.D.	N.D.
pH		6.7	6.6
Iron	ppm	0.18	0.59
Manganese	ppm		
Electric Conductivity	micro s/cm	340	352

So far, the results of manganese are still not available.

100 % water supply by treated surface water must be the ultimate goal of Yangon City water supply, but during transition period, transferring to surface water from current water sources, available sources must be optimized.

However, as shown in tables above, there is high possibility that groundwater produced by the existing wells and/or newly drilled wells might have high manganese concentration. Installation of Manganese Removal Facility in Hlaingthaya should be taken into account from viewpoint of "Safe Water Supply".