CHAPTER 3

CHAPTER 3 STUDY OF FUNDAMENTALS FOR DESIGN OF THE SEWAGE TREATMENT PLANT

3-1 The Present and Future Land Use in Baguio City

Baguio City is situated in mountainous area. The land is nevertheless made full use of, with houses skillfully built on the slopes, resulting in a high population density in this climatically-favored region of the Philippines. High buildings are limited to hotels, schools and public facilities, and one- or two-storied houses and apartments are dominant in the city. The existing road network has a high ratio of surfaced roads and most of the streets are sinuous with steep slopes. Land use status both in the entire city and in the area served by the existing sewerage system is given in Table 3-1. The present land use pattern of Baguio City, shown in Figure 3-1, characterizes it as a developing resort city.

Table 3-1 Present Land Use in Baguio City

Land Use	Percentage of the Total Area	
	Baguio city	Area served by the existing sewerage system
1. Residential	13.0	45
2. Institutional	17.25	20
3. Parks	18.25	20
4. Commercial/ Industrial	1.5	5
5. Open Space	50.0	20

The construction of roads on the periphery of the city and several parks is planned for the immediate development of the city. In addition, development of open space will be accelerated to meet the requirements of the city. Although an authorized plan for development of such areas has not been prepared yet by the city, an effective use of open space is expected in line with the increase in population as reported by the city staff members concerned and as observed by the team members.

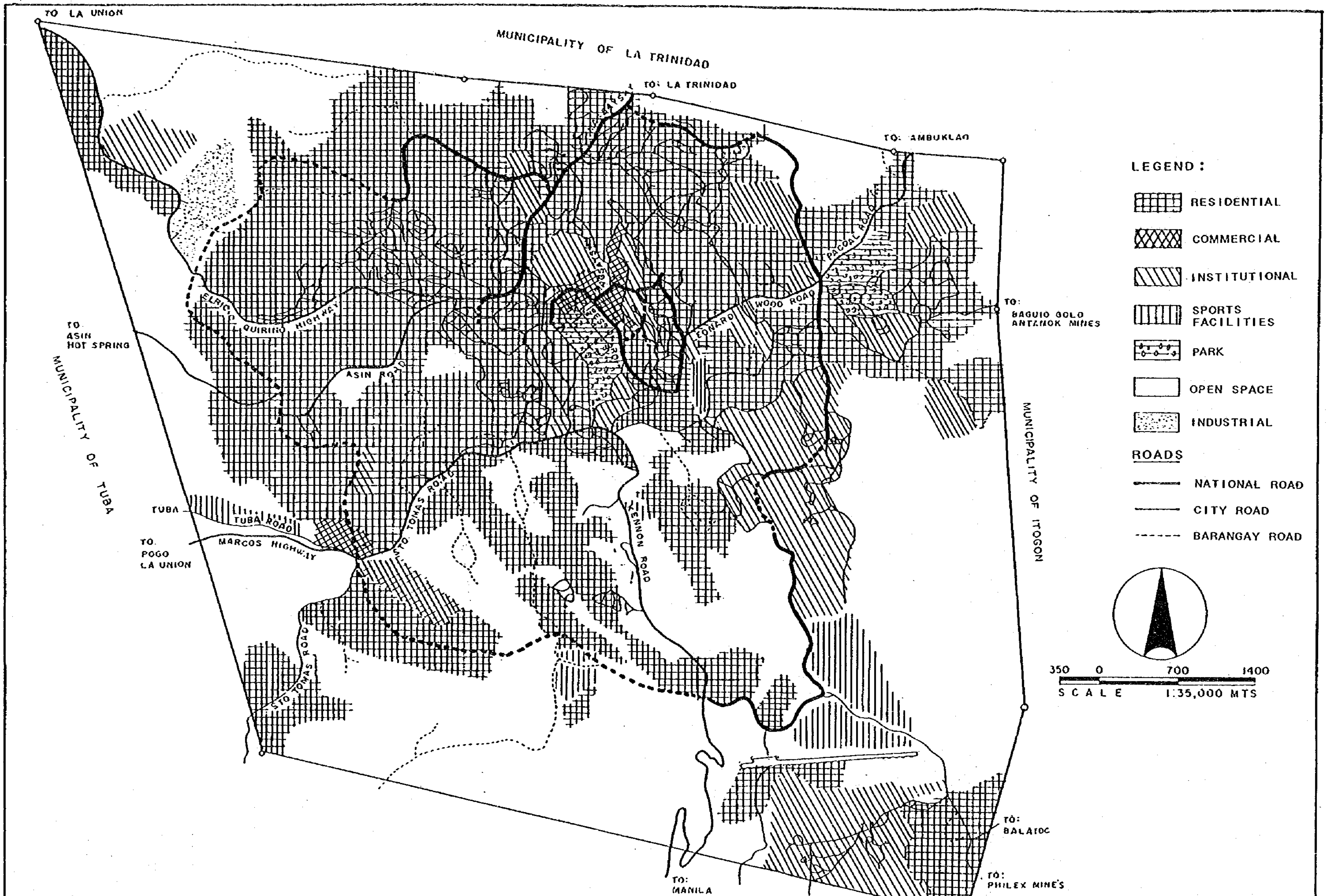


Fig. 3-1 Present Land Use Pattern of Baguio City

3-2 Present and Future Population of Baguio City

The population of Baguio City is categorized into permanent residents, transient students, and visitors. Population shifts are described below, especially for the years 1983 and 1986, the design year for this project.

3-2-1 Number of and increases in Parmanent Residents

Population censuses in Baguio City began in 1903 and were implemented up to 1980. Records of historical resident population, obtained from the NCSO, are presented in Table 3-2. The following is an outline of historical changes in the city.

The city has experienced rapid population growth since 1903, with a high of 17.43 % during the period 1903 to 1918. The growth rate from 1938 to 1948 was only about 2 % because of pre- and post-war turmoil. From the 1960s to the present, the annual population growth has been steadily increasing. Figures for 1970 and 1980 were, respectively, 67 % up and more than 100 % up on the 50,436 persons in 1960.

The average population density of the city in 1903 was 0.09 persons/ha. The density in 1980 was reported as 24 persons/ha., corresponding to the increase in population; and is much higher than the regional average figure of 1.64 persons/ha.

Table 3-2 Baguio City Population Growth Rate

Year	Baguio City Population	Average Annual Population Growth		Annual Growth Rate	Average Pop. Density (persons/ha.)
		Absolute	Relative		
1903	489				0.09
1918	5,464	331	67.82	17.43	1
1939	24,117	932	17.07	7.3	4
1948	29,262	514	2.13	2.17	6
1960	50,436	1,764	6.03	4.64	10
1970	84,538	3,410	6.76	5.30	17
1975	97,449	2,582	3.05	2.88	20
1980	118,560	4,312	4.42	4.00	24

All population data were obtained from the National Census and Statistics Office.

3-2-2 Prediction of Permanent of the City

The population of Baguio City in 1983 was estimated at 132,600. This figure is based on an annual growth rate estimate of 3.8 % for the period 1981-85, which, in turn, was derived from the growth rate of 4 percent per annum in the previous five years (1975-1980). Population estimates for the years from 1986 to 1990 are presented in Table 3-3, and are based on an annual growth rate of 3.6 percent. These population projections may be regarded as applicable for the next ten years, since the annual growth rates have been based on past trands.

In accordance with the above-mentioned projection by the city, the population in 1986, the assumed design year for this project, is estimated at 148,000.

Table 3-3 Future Permanent Residents of Baguio City

Year	Annual Growth Rate (%)	Population of the City
1975		97,449
1980	4.0	118,560
1983	3.8	132,600
1985	3.8	142,860
1986	3.6	148,000
1990	3.6	170,500

3-2-3 Transient Students

Baguio City offers various kinds of public facilities, including schools to students. Transient students include local and other Filipinos and alien students residing in the city. Approximately 40,000 transient students are presently enrolled at various schools. Baguio City forecasts the number of students in 1990 at about 50,000. However it was estimated that approximately 30 percent of the total number of students were Baguio residents, while some of them were relatives and acquaintances of residents.

3-2-4 Visitors

Vacationers and tourists represent the visitor population in the city. Statistics on the number of visitors to the city shows about 100,000 during the summer season (peak season: from March to May). Baguio City projects further increases in the future. The average period of stay was estimated to be one week.

3-3 Present and Future Water Supply of Baguio City

3-3-1 Current Water Supply

The water supply system of Baguio City has been under the administration of the Baguio Water District (BWD) since 1975. The water supply system is characterized by three hydraulically interconnected pressure zones to meet the complex terrain of the area. The subject area for this project covers most of areas in low and medium pressure zones.

The present supply system obtains water from three types of water sources, surface (creeks), spring, and deepwell. These sources are used in different combinations during the dry and rainy seasons as shown below.

Dry season	:	80 percent of total intake is from surface/spring and the remaining 20 percent from deepwell.
Rainy season	:	80 percent from deepwell and 20 percent from surface/spring.

Approximate monthly combined production of the existing water sources, water consumption and the water unaccounted for is as follows:

(1) Water production : 800,000 m^3/month (26,667 m^3/day)

(2) Water consumption : 500,000 m^3/month (16,667 m^3/day)

(3) Water unaccounted for : 300,000 m^3/month (10,000 m^3/day)

The amount of water unaccounted for, which includes water losses, water for fire fighting, inaccuracy in water metering and water not billed owing to other reasons, was recorded at an average of 37.5 percent recently.

3-3-2 Water Supply by Service Zone

The Baguio Water District has divided the present service area into 20 zones as shown in Figure 3-2. The record of water consumption by service zone as of December 1983 was reported as shown in Table 3-4. The amount by zone was estimated using water charges based on meter readings at water connections.

Table 3-4 Water Consumption by Service Zone, Dec. 1983

Service Zone	Monthly Consumption (m^3/month)	Daily Consumption (m^3/day)
1	24,588	793.2
2	16,333	526.9
3	35,578	1,147.7
4	33,727	1,088.0
5	28,204	909.8
6	23,882	770.4
7	30,282	976.8
8	30,053	969.5
9	13,533	436.5
10	13,046	420.8
11	21,404	690.5
12	9,169	295.8
13	18,878	609.0
14	19,142	617.5
15	19,901	642.0
16	16,232	523.6
17	15,230	491.3
18	23,441	756.2
19	16,262	524.6
20	24,429	788.0
Total	433,314	13,978.1

Remark: the total amount includes that for the Baguio Export Processing Zone (17,016 m^3/month or 548.9 m^3/day)

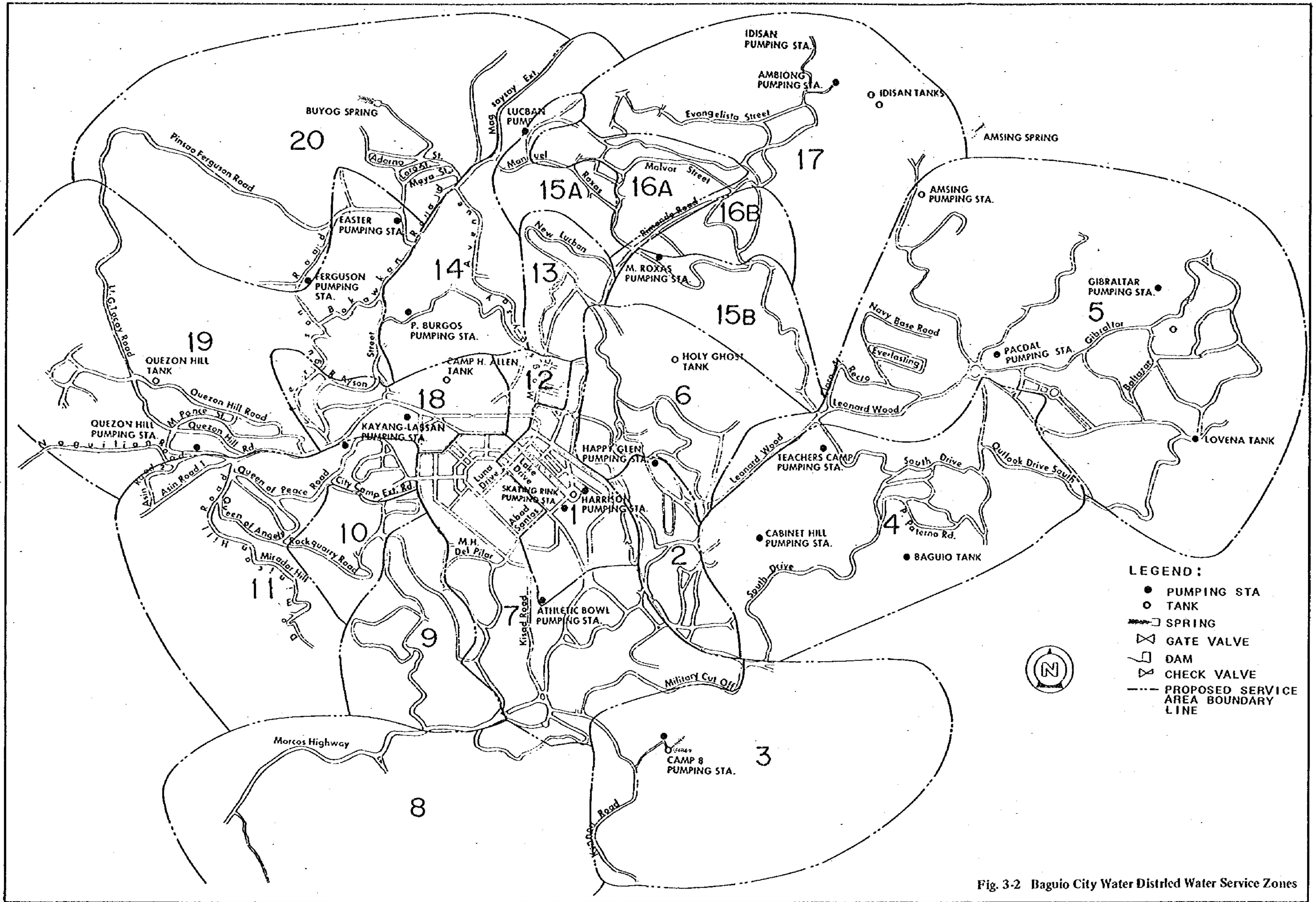


Fig. 3-2 Baguio City Water Distrlcd Water Service Zones

3-3-3 Average Water Consumption Per Capita Per Day

Served population by service zone was estimated assuming an average of nine persons per water connection. Average daily water consumption per capita by service zone was calculated using estimated population and consumed water amount, as shown in Table 3-5. The number of persons per water connection was used in accordance with the recommendation of the General Manager of the BWD. Per capita daily water consumption by service zone varies depending on the location of hotels and commercial areas and population density with a range from 70 lit./cap./day to 250 lit./cap./day. The average unit water consumption in the entire area was calculated to be 120 lit./cap./day. The average unit water consumption for design of the Level III water supply facilities in the Philippines is 100 lit./cap./day. In comparison with this figure, the calculated average amount of 115 lit./ cap./day may be of the same order as nationwide average water consumption: approximately 15 percent can be taken to be that of commercial and industrial water consumption per capita. The per capita water consumption in the design year, 1986 is taken to be the same as the present amount since it is difficult to determine factors which could significantly change water-use patterns in the city.

Self-control of water consumption by residents would also contribute to maintaining the present per capita water consumption in the future.

Table 3-5 Estimated Served Population and Per Capita Water Consumption by Service Zone

Service Zone	Number of Water Meters (pieces)	Estimated Served Pop. (persons)	Daily Water Consumption (m^3/day)	Per Capita Water Consumption (lit./cap./day)
1	435	3,915	793.2	205 *1
2	682	6,138	526.9	85
3	671	6,039	1,147.7	190
4	482	4,338	1,088.0	250 *2
5	723	6,507	909.8	140
6	695	6,255	770.4	125
7	513	4,617	976.8	210 *3
8	858	7,722	969.5	125
9	629	5,661	436.5	75
10	622	5,598	420.8	75
11	894	8,046	690.5	85
12	310	2,790	295.8	105
13	724	6,516	609.0	95
14	588	5,292	617.5	115
15	853	7,677	642.0	85
16	771	6,939	523.6	75
17	756	6,804	491.3	70
18	734	6,606	756.2	115
19	620	5,580	524.6	95
20	992	8,928	788.0	90
Total	13,552	121,968	13,978.1	115

*1 including commercial area
*2 Hyatt Hotel
*3 including commercial area

3-3-4 Monthly Fluctuation of Water Consumption in Baguio City

Table 3-6 shows monthly water consumption of the city in 1983. Consumption is highest in September and lowest in June, representing 112 percent and 93 percent of monthly average, respectively. The fluctuation of water consumption throughout the year is within 10 percent as seasonal changes in water use do not differ much, unlike Japan with its four seasons.

The Sto. Tomas Reservoir is expected to be completed by the middle of 1984, allowing for increased water supply to the city. In addition, seasonal increases in water consumption may occur in the future, being attributable to influxes of visitors. The fluctuation in water consumption caused by the aforementioned must be considered for design/operation of sewage treatment facilities.

Table 3-6 Monthly Fluctuation in Water Consumption

Month	Water Consumption (m^3/month)	Ratio to Yearly Average Monthly Consumption	Remarks
Jan.	434,841	99.8	
Feb.	439,680	100.9	
March	415,642	95.4	
April	467,936	107.4	Monthly
May	440,283	101.0	fluctuation
Jun.	406,010	93.2	to the
July	431,794	99.1	yearly
Aug.	407,454	93.5	average is
Sept.	488,779	112.2	within 10
Oct.	429,873	98.7	percent
Nov.	436,719	100.2	
Dec.	428,766	98.0	
Total	5,227,777	-	
Yearly Ave.	435,648	100	

3-4 Subject Area for Sewage Treatment and Present Water Consumption in the Area

Baguio City has 25 political districts, as shown in Figure 3-3, consisting of 128 barangays. However, the BWD has divided the present service area into 20 zones. The boundaries of these service zones are different from those of the districts. The political districts associated with the sewered area in the Balili River basin are 14, as listed in Table 3-7.

下水道のある地区（14地区）

No	地　区　名　称
2	Aurora Hill - Trancoville
4	Campo Sioco-Baguio General Hospital
5	Camp Allen - New Lucban
7	Campo Filipino
9	Central Business District
10	Central City
11	City Camp
13	Government Center - Teachers Camp
14	Guisad - Pinsao
16	Holy Ghost Hill
20	Mansion House - Mines View
21	Pacdal
22	Quirino Hill
23	Quezon Hill

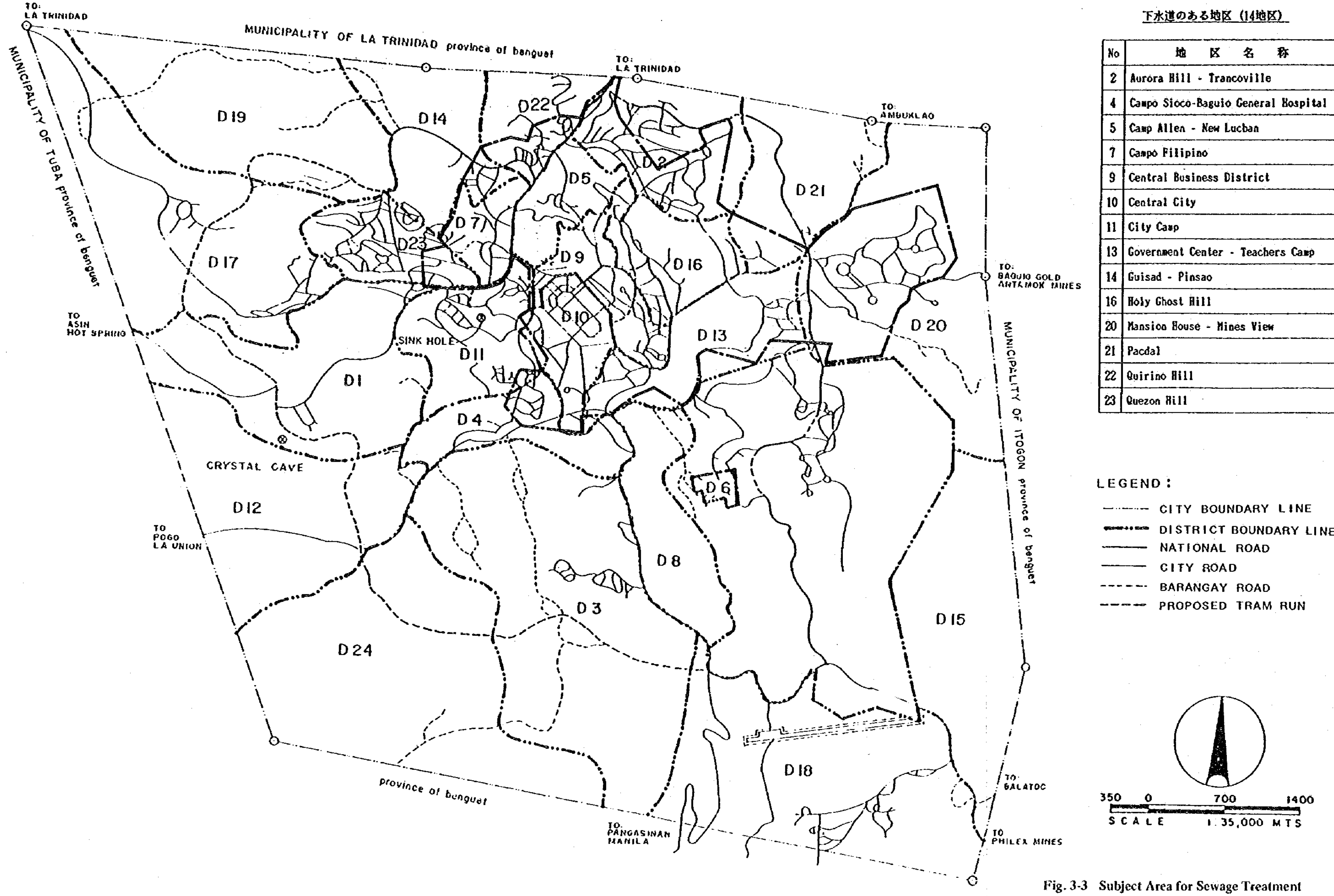


Fig. 3-3 Subject Area for Sewage Treatment

Table 3-7 Districts in the Served Area in the Balili River Basin

District No.	District Name
2	Aurora Hill - Trancoville
4	Campo Sioco - Baguio GenHosp.
5	Camp Allen - New Lucban
7	Campo Filipino
9	Central Business District
10	Central City
11	City Camp
13	Gov't Center - Teachers' Camp
14	Guisad - Pinsao
16	Holy Ghost Hill
20	Mansion House - Mines View
21	Pacolal
22	Quirino Hill
23	Quezon Hill

Among water service zones, 16 zones are included in/related to the subject area of the upcoming project (Figure 3-4). The present water consumption and estimated served population in the subject area are presented in Table 3-8 using water service zones prepared by the BWD. The present water consumption in the subject area was estimated at approximately 11,000 m^3/day. Service zones outside the subject area number four, namely Nos. 3, 8, 10 and 11. One half of water amount was counted in the subject area for No. 9 zone.

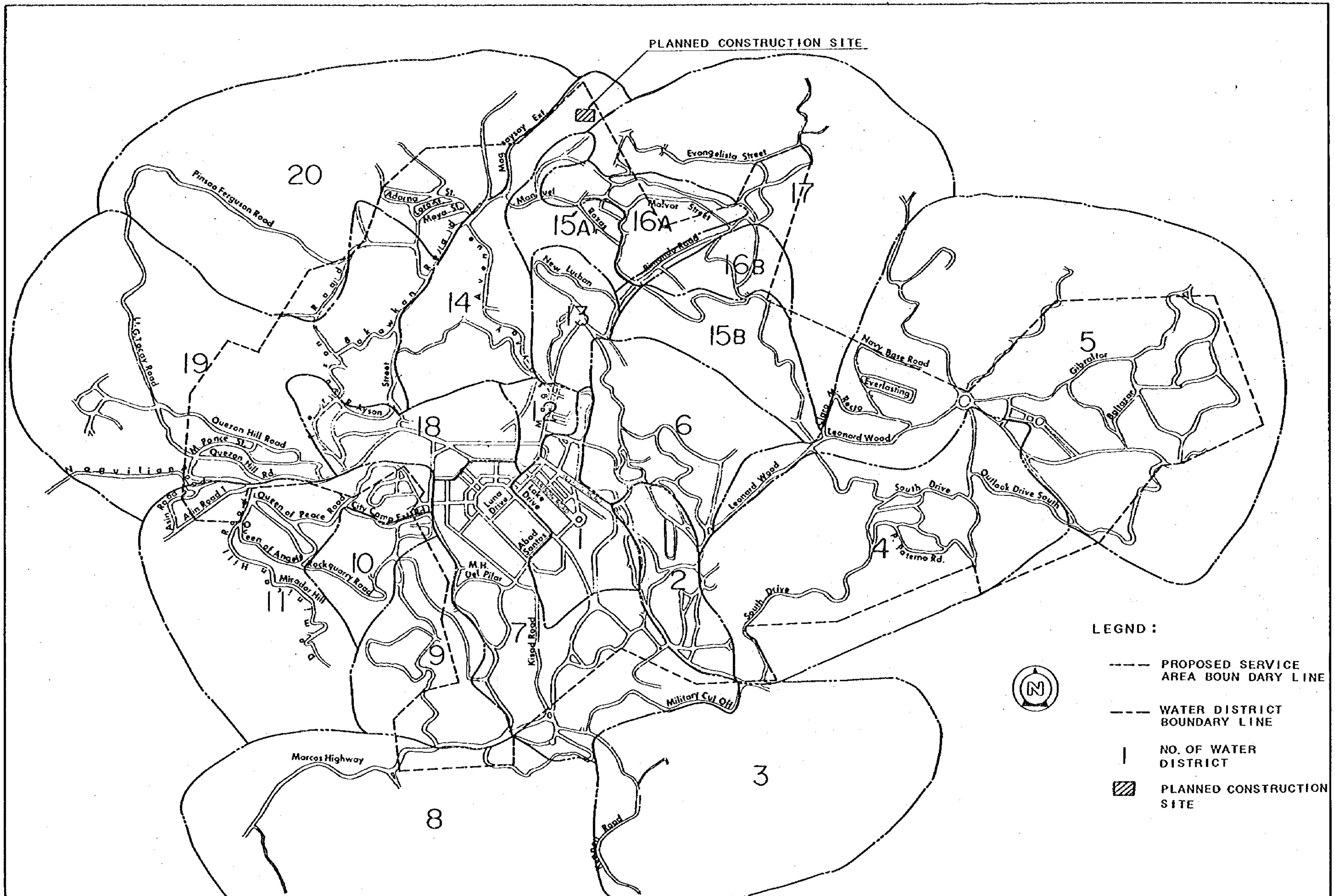


Fig. 3-4 Relationship between Subject Area and Water Service Zones

Table 3-8 Daily Average Water Consumption and Estimated Served Population in the Subject Area (Dec. 1983)

Service Zone (No.)	* Estimated Pop. (Persons)	Water Consumption (m^3/day)	Remarks
1	3,915	793.2	in the subject area
2	6,138	526.9	"
3	-	-	outside the subject area
4	4,338	1,088.0	in the subject area
5	6,507	909.8	"
6	6,255	770.4	"
7	4,617	976.8	"
8	-	-	outside the subject area
9	2,830	218.3	one half in the subject area
10	-	-	outside the subject area
11	-	-	outside the subject area
12	2,790	295.8	in the subject area
13	6,516	609.0	"
14	5,292	617.5	"
15	7,677	642.0	"
16	6,939	523.6	"
17	6,804	491.3	
18	6,606	756.2	"
19	5,580	524.6	"
20	8,928	788.0	"
Total	91,732	10,531.4	
	≑ 92,000 persons	≑ 11,000 m^3/day	

* Served population was estimated using number of water meters and average number of 9 persons per water connection.

3-5 Water Polution and Sanitary Conditions in Baguio City

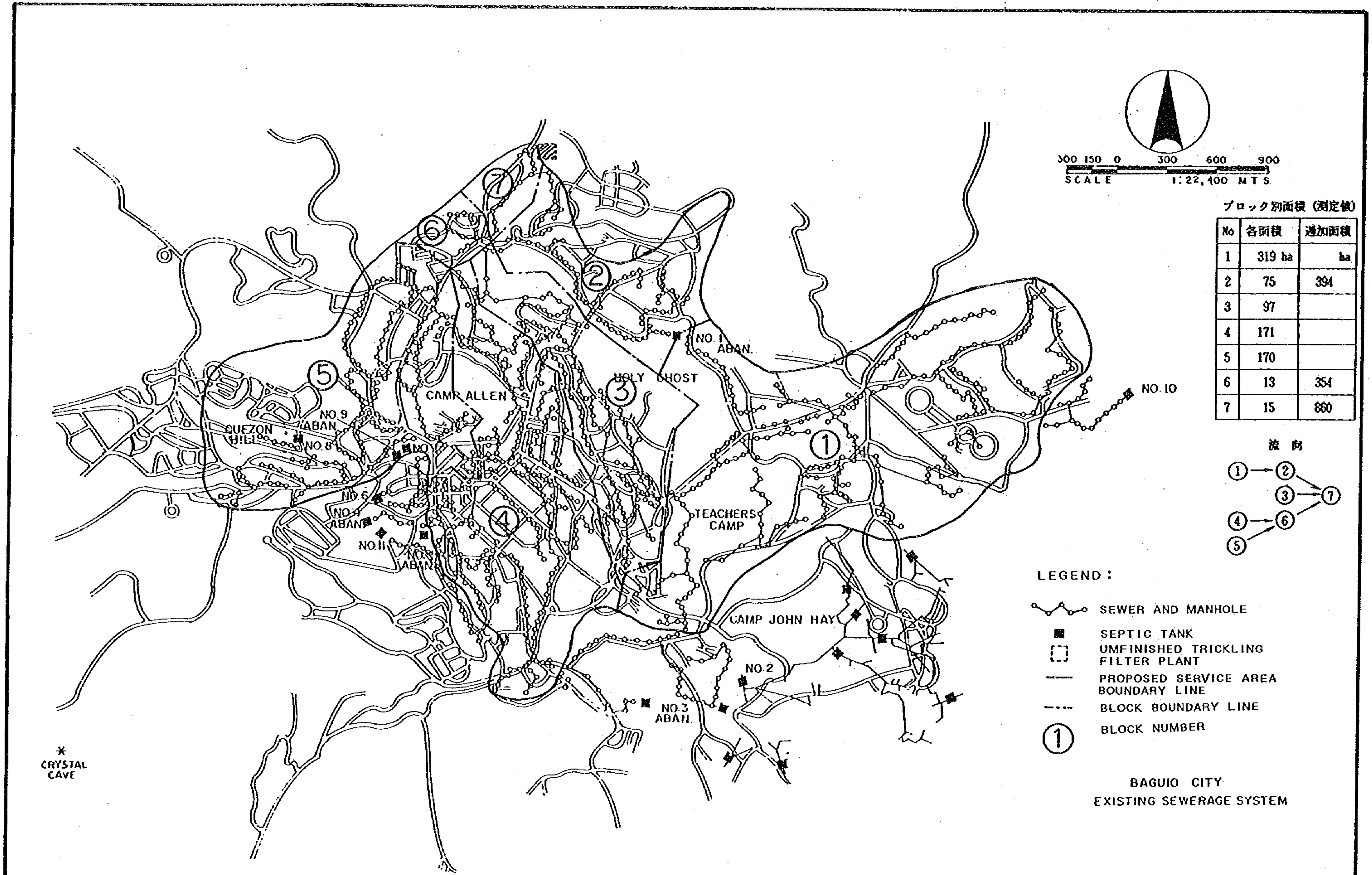
3-5-1 Situation of Existing Sewerage System

Baguio City has two separate sewage collection systems: one for sanitary waste: and the other for storm run-off. The sanitary sewage from households connected to the system is conveyed through conduits to septic tanks or stream outfalls without treatment. Most of the sewers are laid in the Balili River basin as shown in Figure 3-5. Although overloaded, there exist several septic tanks operable at the present time in the surrounding area of the Balili River basin.

The system, at its early period of operation, served approximately 50 percent of the highly developed areas, an equivalent of 620 hectares. However, due to maintenance problems, it was reported that less than 30 percent of the central areas are served by the deteriorating system. A recent survey carried out by the city showed the ratio of sewered population to total residents in the Balili River basin (estimated population, 92,000) to be 60 to 70 percent.

Regarding the sewers, there are 58 lineal kilometers, ranging in sizes from 150 to 300 mm and made of black steel, cast iron, vitrified clay, and concrete pipes. These sewers are laid either underground or aerially.

The main outfall of the sanitary sewerage system to convey sewage generated in the Balili River basin was destroyed in the 1972 typhoon and was never restored. The septic tanks which complement the sanitary sewer systems have poor operational capacities. With the condition of the existing sewerage facilities, pollution of creeks and land has been prevalent in the city. Although septic tanks are used in the subject area/Balili River basin, improvement/reconstruction of these septic tanks will be essential in view of sanitation improvement of the entire city. Figure 3-5 depicts the existing sewer system in the subject area with seven subcollection areas. The subject area is divided into two collection systems: the eastern portion and part of the central area (block Nos. 1, 2 and 3); and the western portion and the remaining part of the central area (block Nos. 4, 5 and 6). The main sewers of each sewer system are laid along major creeks which were confirmed during a field surveys. A considerable amount of raw sewage flows into these creeks at present. In this connection, improvement/construction of main sewers is indispensable in the section between the point 1 km upstream from the Magsaysay Bridge to the planned sewage treatment plant.



ブロック別面積（測定値）

No	各面積	逓加面積
1	319 ha	ha
2	75	394
3	97	
4	171	
5	170	
6	13	354
7	15	860

Fig. 3-5 Main Sewer Systems and Subdivision of Subject Area

3-5-2 Situation of Existing Sewers and Creeks Based on the Field Survey

Since the 1972 typhoon sewage collected by the existing sewer system has been discharged directly into the creeks/Balili River due to lack of appropriate main sewers downstream of the sewer system. Three major polluted creeks flowing into the Balili River are described in this section on the basis of a survey conducted for the assessment of the present sanitation conditions of the city.

(1) The creek along Magsaysay Avenue : Creek (A) collecting sewage from Pines Hotel and an area of Burnham Park;

(2) The creek along Manuel Roxas : Creek (B) joining the creek crossing Arman Avenue, which collects sewage from the Teachers' Camp and Hyatt Hotel;

(3) The creek collecting sewage from Holy Ghost Hill and Saint Louise University : Creek (C).

Figure 3-7 shows the points where sewage is overflowing from manholes and directly discharging into creeks and land from damaged sewers. The following outlines the situation observed during the field survey.

Creek (A)

A considerable amount of sewage was observed upstream from the junction point of creek (A) and creek (B), located in Magsaysay Private Road.

No. 1 : Sewage was leaking from the joint of a steel pipe installed beside the bank due to clog of pipes. The sewage flows into the nearby creek (A).

No. 2 : Sewage was overflowing from a manhole into the creek because of overloading of sewers

No. 3 : It was observed that sewage flows down the drainage along Magsaysay Avenue. Some of the sewage flows into the creek at several points and the remainder goes down to Magsaysay Bridge along Magsaysay Avenue.

No. 4 : Sewage discharged from the central area flows through a horse-shoe type channel just downstream from the junction point of Magsaysay Avenue and Bonifacio Avenue

Creek (B)

No. 5 : Sewage overflowing from manhole flows into the creek

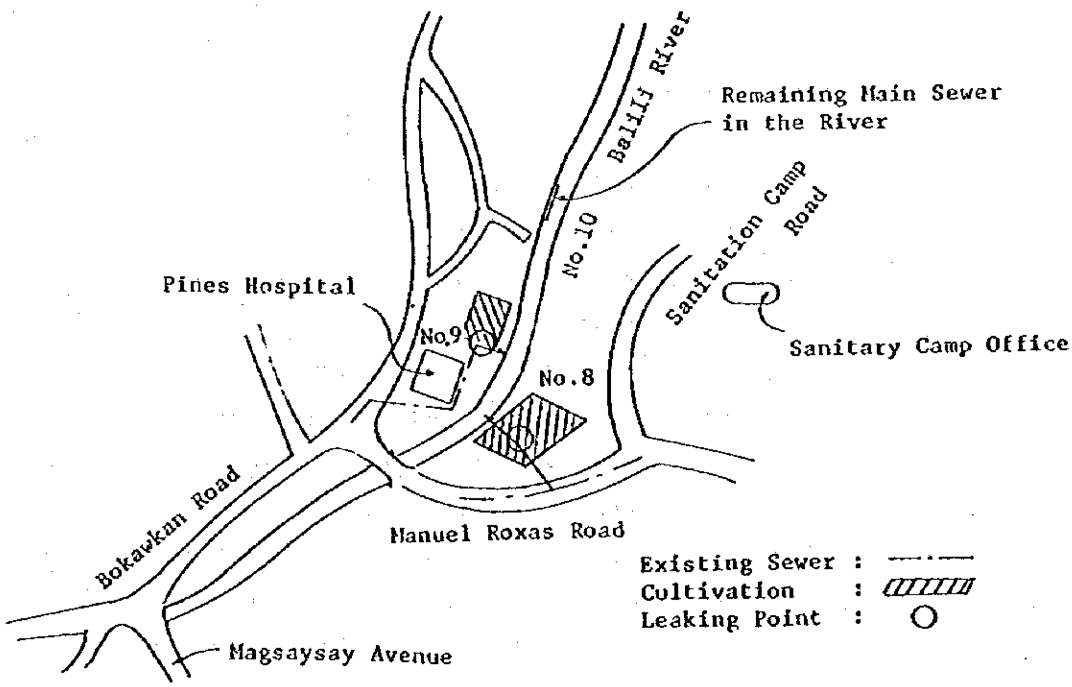
No. 6 : Sewage diluted with spring water was observed, but changed to raw sewage in appearance having increased in quantity after joining creek (C).

Creek (C)

No. 7 : Sewerage pipe conveying sewage discharged from Holy Ghost Hill, including Saint Louise University, ends at this point and sewage was falling into the creek.

No. 8 : This point is located near the Sanitary Camp Office. Under the existing plan, the main sewer was designed to cross the Balili River at this point and join the main sewer on the left bank having collected sewage in the eastern and part of central areas. However, vegetables are cultivated in this area using sewage overflowing at less than 5 l/sec from a manhole, and excess sewage was flowing into the Balili River.

Fig. 3-6 Location of Observed Points (No. 8 to No. 10)



No. 9 There exists a manhole beside Pines Education Center into which collected sewage from the western portion and part of the central area was planned to flow (see Figure 3-6). A small quantity of sewage entering the manhole was observed. Vegetables were cultivated in the vicinity of the Center using sewage overflowing from the manhole.

No. 10 Left bank of the Balili River near Pines Hospital; Existing sewerage concrete pipes with a diameter of 300 mm were exposed on the slope of the left bank of the Balili River downstream from Pines Hospital. These pipes are those remaining after damage by the 1972 typhoon. Main sewers should not be laid in the river. Therefore, it is recommended that a new main sewer line be constructed under the planned access road to connect the sewage treatment plant.

3-5-3 Water Pollution in the Subject Area

Water sampling in the subject area was carried out on Feb. 16th on the basis of preliminary investigation conducted on Feb. 15th. Sewage examination was undertaken at the Water Quality Research Center in Manila. The following is an outline of the procedure for obtaining quantitative data relating to the sewage.

(1) Objectives of water quality analysis:

1) To obtain information on the water pollution of creeks in Baguio City;
2) To ascertain the extent of water pollution attributable to overflow sewage from septic tanks;
3) To obtain data on water quality of sewage flowing in sewers.

In addition to the above purposes, water quality research was conducted in the Balili River, into which effluent from the sewage treatment plant will be discharged and whose water is to be used for irrigation in La Trinidad.

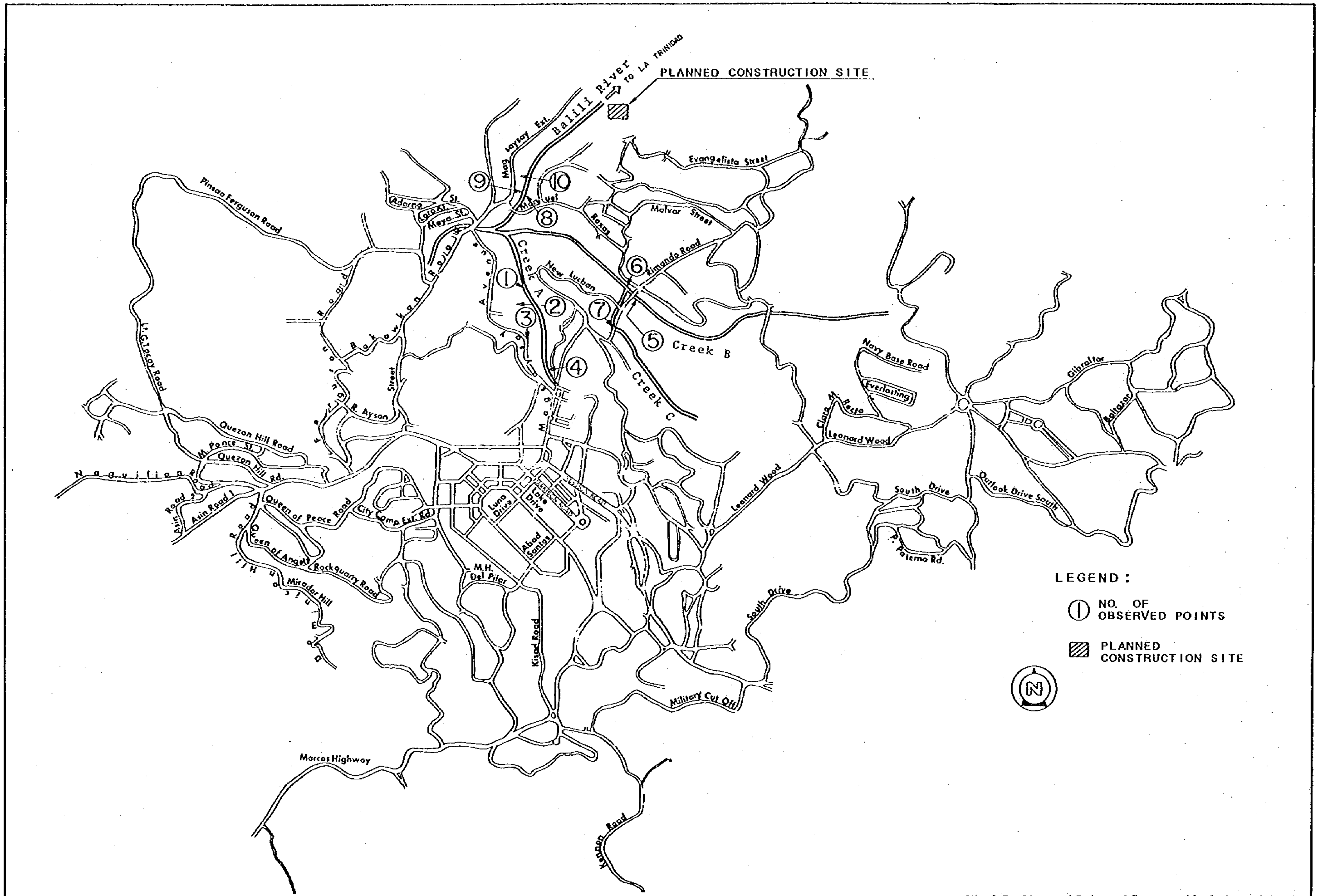


Fig. 3-7 Observed Points of Sewerage Manholes and Creeks

(2) Indeices covered and research methods

Water temp., pH, SS, BOD, COD, coliform-group bacteria, T-N, NH_3-N, DO, Cl^-, ORP.

The water quality analysis was made in accordance with the Philippine Standard Method for the Analysis of Air and Water (Human Settlement Commission, 1978).

(3) Measurement and sampling points

Points measured in terms of water temp., pH and ORP during preliminary investigation are shown in Figure 3-8. Sampling points for examination of water quality are given in the same figure.

(4) Results of measurement and water quality analysis

(5) Water pollution in the subject area

The results of water quality examination shown in Table 3-9 reflect the situation in appearance and offensive smell observed during preliminary survey and sampling.

1) Creeks in Baguio City

Most of the creeks in the city have been converted to main sewers revealing the features of raw sewage in appearance and offensive odor. However, it was observed that in terms of suspended solids the water quality varied between morning and afternoon. In particular, comparatively clean water was found in some creeks in the early morning, resulting from dilution of sewage by spring water. The phenomenon was verified by the results of water quality analysis.

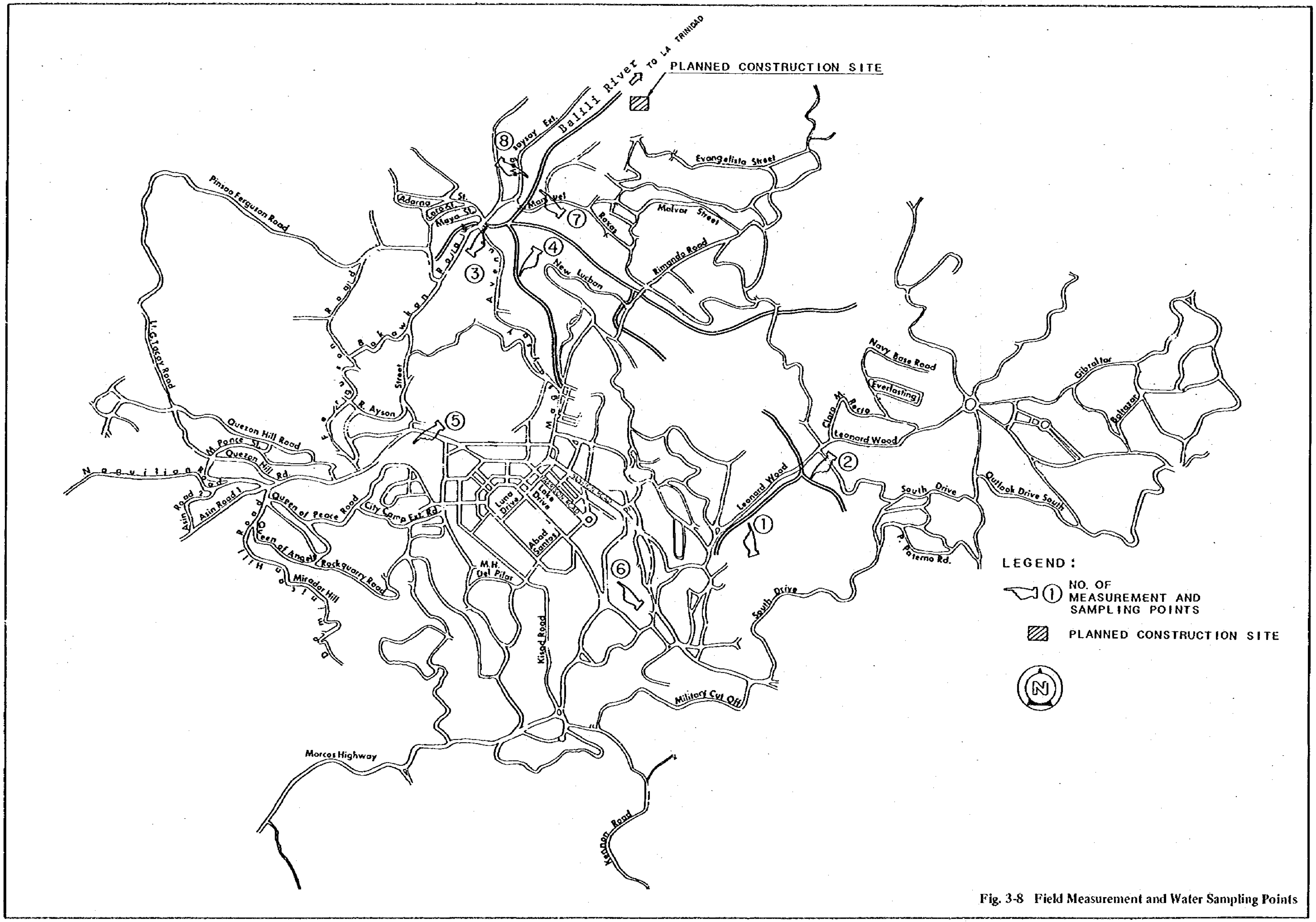


Fig. 3-8 Field Measurement and Water Sampling Points

Table 3-9 Result of Examination of Sewage Quality

Point Name	Field Survey			Chemical								Coliform group bacteria	Remarks
	Water Temp. °C	pH	ORP (mv)	pH	Total SS (mg/l)	NH_3-N (mg/l)	T-N (mg/l)	Cl (mg/l)	DO (mg/l)	COD (mg/l)	BOD (mg/l)	MPN/100 ml	
Creeks in the city												x 40	
1. Teachers' Camp	19	7.46	-50	7.0	10	6.00	21.6	150	0	40	18	22.4	Creek
2. Brookside	22.5	8.04	104	7.1	6	0.10	0.7	82	7.9	10	1.2	22.4	Diluted by spring water
3. Magsaysay Bridge	22	7.52	-18	6.5	3	1.70	4.6	150	0	40	60	1.1	Creek
4. Mag. Private Road	22	7.66	180	6.7	530	7.60	74.6	266	0	520	190	1.1	Creek
Overflow sewage from septic tanks													
5. Naguilian & Kayang	21	7.11	-220	7.1	340	9.30	108.0	308	0	490	400	324	Overloaded
6. Pines Hotel				6.9	16	0.31	2.1	83	0	150	40	22.4	Laundry waste-water
Sewage in sewers													
7. Sanitary Camp	22	7.37	-150	2.3	460	7.30	125.0	242	0	700	370	22.4	Overflow from manhole
8. Pina Hospital	21	7.01	-220	7.0	140	8.30	55.8	196	0	260	120	22.4	

Field Survey : Feb. 15, 1984 Weather : Fine
Sampling : Feb. 16, 1984 Weather : Fine

Brookside was selected as one of the sampling points representative of clean spring water. The result of examination showed that dissolved oxygen is saturated, BOD 1 ppm and ORP positive values while negative values were measured at other all points.

On the contrary, water quality at the sampling point of the creek near Magsaysay Private Road revealed characteristics of raw sewage rather than river water; this was confirmed in examination results which showed high contents of NH_3-N, TN, and BOD 190 ppm.

BOD at Teachers' Camp and Magsaysay Bridge recorded comparatively low concentrations ranging from 20 to 60 ppm, since water sampling was conducted early in the morning. During the time of sampling, water quality of the creek seemed to be affected by spring water. In any case, since considerable amounts of NH_3-N, T-N and Cl^- were detected from the samples at the above points, water in these creeks seemed to closely resemble sewage. Further, the appearance of the creek water in the afternoon showed considerable changes with increases in sewage amount; this was also confirmed by an ORP measurement of -50.

2) Overflow sewage from septic tanks

A septic tank had been used in the Balili River basin, but recently new pipes have been installed in the area to convey collected sewage downstream; and the septic tank has been abandoned. Several septic tanks are used in the valleys just outside the Balili River basin. Observation trips to the existing septic tanks were made by the team to investigate quality of effluent overflowing from manholes. Surrounding areas of these septic tanks, especially along the outflow channels are exposed to unsanitary conditions by the overflowing sewage due to inadequate maintenance and overloading of the tanks. The residents in the vicinity of the tanks complained, and desired to improve and augment these facilities. Water quality of overflow sewage at Naguilian & Kayang was examined. The septic tank was constructed to treat sewage for the Barangay with a population of about 500 to 600. The results of water quality examination confirmed the overloaded condition with high contents of NH_3-N and BOD 400 ppm. Almost every septic tank in the city seemed to be in the same condition as the one examined; thus, the city should urgently undertake countermeasures.

3) Sewage in sewers

Water sampling was conducted at the end of the existing two main sewers. Although BOD and SS concentrations at these points were different in the examination results, both samples contained considerable amounts of NH_3-N, T-N and Cl^-, which characterize raw sewage. The differences of BOD and SS at the two points, with ranges of 120 to 370 ppm and 140 to 460 ppm, respectively, are likely to be the result of a time lag of sewage flow in each collection area and the flow capability of the sewers. From these results it was established that sewage quality in the sewer fluctuates considerably throughout the day. The survey team visited these points several times in recognition of locational importance in the existing sewerage system and witnessed fluctuations in water quality throughout the day, with extreme deterioration at around 14:00 at both points.

3-5-4 Present Situation of Water Body into which Effluent will be Discharged

Effluent from the sewage treatment plant is scheduled to be discharged into the Balili River upon completion of sewage treatment facilities. The Balili River has been converted into a sewerage channel to receive untreated sewage from the basin. The problem of water pollution has been prevalent in spite of dilution by spring water from Burnham Park and other sources. Especially during the dry season, the nuisance derived from water deterioration in the river adversely affects not only living conditions in Baguio City but also water for use downstream in the municipality of La Trinidad. In these circumstances it is clear that early appropriate countermeasures have to be implemented. During the field survey, measurements of flow rate and water quality examination of the river, and a study of the assimilative capacity of the river were made as mentioned below.

(1) Flow rate of the Balili River

1) Objectives of measurement : To obtain information about daily discharge rate from the Balili River basin and reference to decide an appropriate design capacity of the sewage treatment plant;

2) Measuring point : Balili River downstream from junction of major creeks, beside the Sanitary Camp Office;

3) Measuring data and methods : Water level and flow velocity at two points using a current meter every hour from 8:30 to 18:00 on Feb. 22nd. Water level measurements were carried out during night time and early the following morning (19:00 to 22:00, 5:00 to 7:00);

4) Results of flow rate measurement : Flow rate through the day ranges from 0.19 m^3/sec to 0.22 m^3/sec (700 m^3/hour to 800 m^3/hour) with maximum measured at 14:00. Figure 3-9 shows flow rate for each measuring time. Flow rate during

23:00 to 5:00, which could not be read, was assumed to equal the minimum rate measured at 9:00.

Daily flow rate was estimated at about 18,000 m^3/day (average flow rate: 0.21 m^3/sec) by aggregating hourly flow rates in the above figure. The estimated flow rate is regarded as average for the dry season. The following is an assessment of daily flow rate in terms of spring water and sewage.

a) Minimum sewage amount

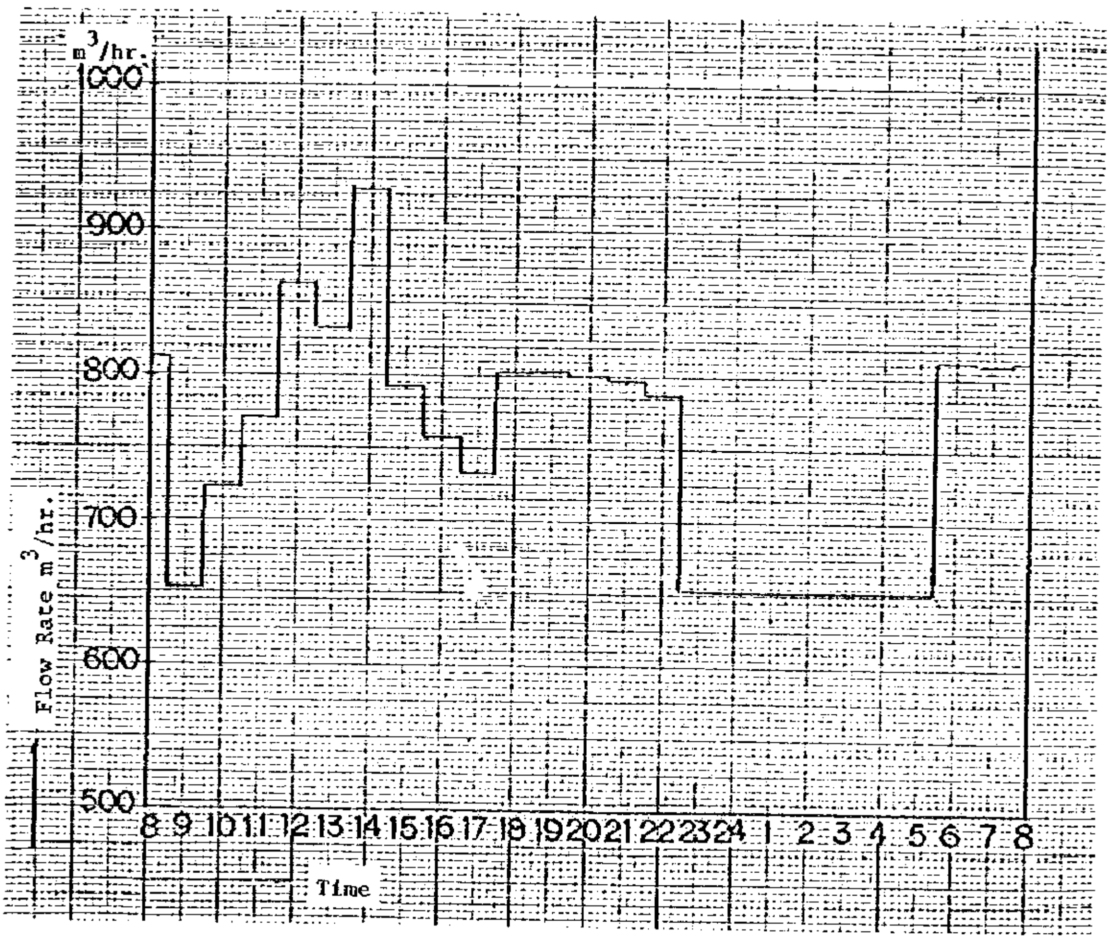
Assuming that the minimum flow rate at 9:00 corresponds to spring water alone, the quantity of sewage is calculated to be about 2,400 m^3/day (18,000 m^3/day - 650 m^3/hour x 24 hours). However, judging from observations the river water at 9:00 in appearance and smell, although undoubtedly diluted by spring water, obviously contained much sewage, with features such as raw sewage being evident, although not to the extent of the most deteriorated water quality of around 14:00. In this connection, the estimated sewage quantity of 2,400 m^3/day may be regarded as a minimum flow rate.

b) Supposition of spring water quantity

Spring water quantity is estimated at about 7,000 m^3/day using the present water consumption of 11,000 m^3/day in the Balili River basin and on the assumption that used water flows into the river without infiltration into the subsurface and leakage from existing sewers. However, the total amount of water used cannot reach the river without losses. With regard to this, approximately one half of the daily flow rate of the river is supposed to be due to spring water.

In addition to the study of the composition of the river water, having confirmed that 2,000 to 3,000 m^3/day of spring water was entering the creeks and effects of dilution by this water were observed even if in the creeks filled with sewage, the total sewage quantity discharged from the Balili River basin at the present time seems to be less than 8,000 to 9,000 m^3/day.

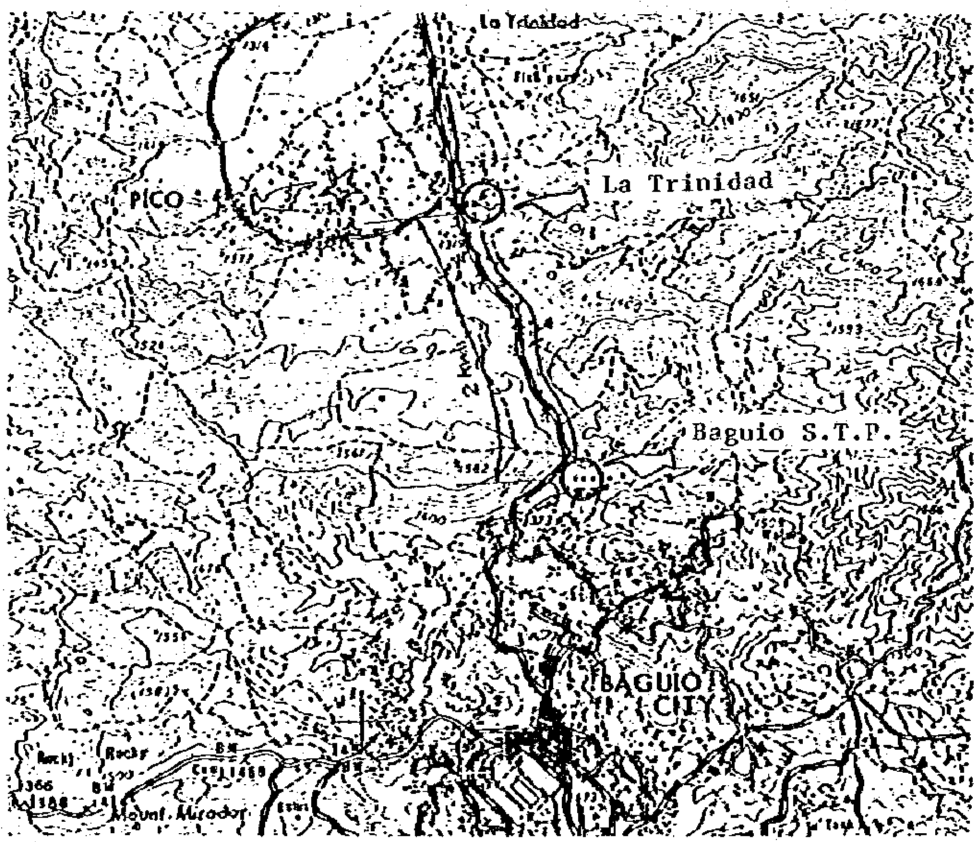
Fig. 3-9 Variation of Flow Rate in Balili River



(2) Water pollution status of the Balili River

A preliminary survey and water sampling were carried out on Feb. 15th and 16th, respectively to obtain information on the water quality of the Balili River. The same indices and research methods for sewage examination were employed for the investigation. Sampling points, shown in Figure 3-10 were selected; these are located beside the planned sewage treatment plant and at the entrance of La Trinidad. Additionally, water sampling at the irrigation channel whose water source is a mountainous area in La Trinidad, was conducted.

Fig. 3-10 Water Sampling Points along Balili River



1) Procedure for water sampling for study of assimilative capacity of the river.

   The time required between two points was estimated at 1 hour and 50 minutes using the distance of 2 km, and an average flow velocity of 0.3 m/sec (1080 m/hour) based on the preliminary survey results. Water sampling was carried out two times at each point.

2) Results of field measurement and sewage examination.

Table 3-10 Result of Field Measurement and Sewage Examination

Point Name	Field Measurement			Chemical						Bacteria
	ORP (mv)	pH	Total SS (mg/l)	NH_3-N (mg/l)	T-N (mg/l)	Cl^- (mg/l)	DO (mg/l)	COD (mg/l)	BOD (mg/l)	Coliform Group
Balili River										$\times 10^4$
9. Beside S.T.P. 8:00	(14:00) -140	7.1	45	6.90	20.3	150	0	80	60	1.1
10. Beside S.T.P. 9:00		7.1	170	10.00	27.9	174	0	180	74	1.1
11. La Trinidad 9:50	(14:20) -10	7.2	4	4.76	13.2	150	4.9	40	7.3	22.4
12. La Trinidad 10:50		7.2	10	3.52	11.9	150	3.1	60	15.0	22.4
14. Beside S.T.P. 11:00		7.0	280	9.70	53.6	220	0	320	60	22.4
Irrigation Channel (La Trinidad)										
13. Channel		6.9	4	2.32	4.9	104	2.0	20	14	22.4

Field Measurement : Feb. 24, 1984 (PM 2:00)
Sampling : Feb. 16, 1984 (Morning)
No.14 is an additional sampling

3) Present status of water pollution of the Balili River

The investigation was implemented under some constraints, such as the inadequacy of laboratory facilities in Baguio city for BOD tests; the time interval between sampling and water examination was taken into consideration when assessing results, since samples had to be transferred to Manila. Since the water sampling was limited to the morning of Feb. 16th, the variation of water quality of the Balili River through the day was assessed referring also to the results of ORP measurement as supplementary information.

According to the sewage tests results, BOD concentrations at both points beside the sewage treatment plant and at La Trinidad are 60 to 80 ppm and about 15 ppm, respectively; these were estimated from the appearance of the water during sampling. It was noticed that water quality of the river fluctuates considerably between morning and afternoon. To supplement the results of water quality analysis for water samples taken in the morning, ORP measurement was conducted on Feb. 24th at around 14:00 to 14:30 at the same points. ORP showed negative figures at both points and there was a marked deterioration of water quality in appearance and smell as compared with the characteristics of the water in the morning. Figure 3-11 depicts the relation between ORP and BOD prepared using results of measurement and sewage examination. Although the number of measurement data is limited, the result may be utilized as a guide since the object is sewage containing many organic substances. Two samples were excluded in the making the figure for the following reasons.

No. 1 : This point is located upstream from the creek and water quality varies between morning and afternoon. This being the case, ORP was measured in the afternoon and water sampling was made in the morning.

No. 2 : Time of measurement affected the water quality significantly. Each measurement of ORP and BOD was conducted at the times corresponding to maximum and minimum sewage qualities

To discuss the fluctuation of water quality in the river, BOD concentrations corresponding to measured ORP in the afternoon at the two points were forecasted using Figure 3-11.

Forecasted BOD figures are as follows:

Beside sewage treatment plant: more than 300 ppm;
Entrance of La Trinidad: 60 ppm

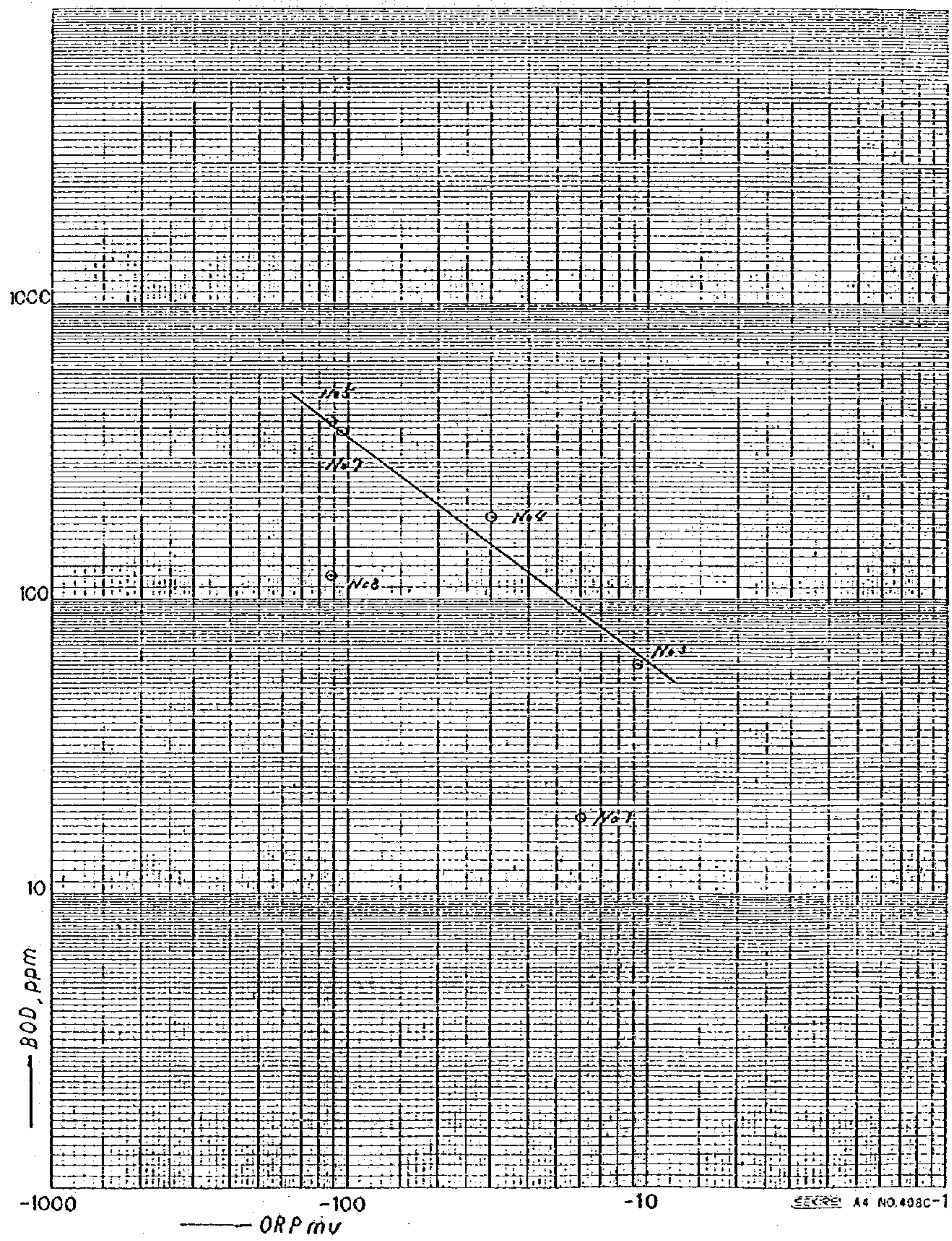
These BOD figures are supported by the observation that water at the entrance of La Trinidad at about 14:00 appeared to be as badly polluted as the river water beside the sewage treatment plant at 8:00 to 9:00 in the morning.

4) Purification Phenomenon of the Balili River

As a result of water sampling and water examination and considering the time lag between two points, it was found that the BOD concentration of 60 ppm fell to 15 ppm. This phenomenon represents a more than 70 percent purification due to the river in a broad sense including sedimentation of suspended solids. The measurement of flow rate at these points in the same date of sampling indicated that there were no great differences with the figures in the range of 0.3 m^3/sec to 0.4 m^3/sec.

Although purification in the river may be expected during the section of 2 km, considerable amount of organic

Fig. 3-11 Interrelation between BOD and ORP



substances travel downstream as deterioration of water quality upstream. Accordingly, the urgency of sewage treatment is emphasized to reduce water pollution in both appearance and chemical characteristics.

5) Water quality at irrigation channel in La Trinidad

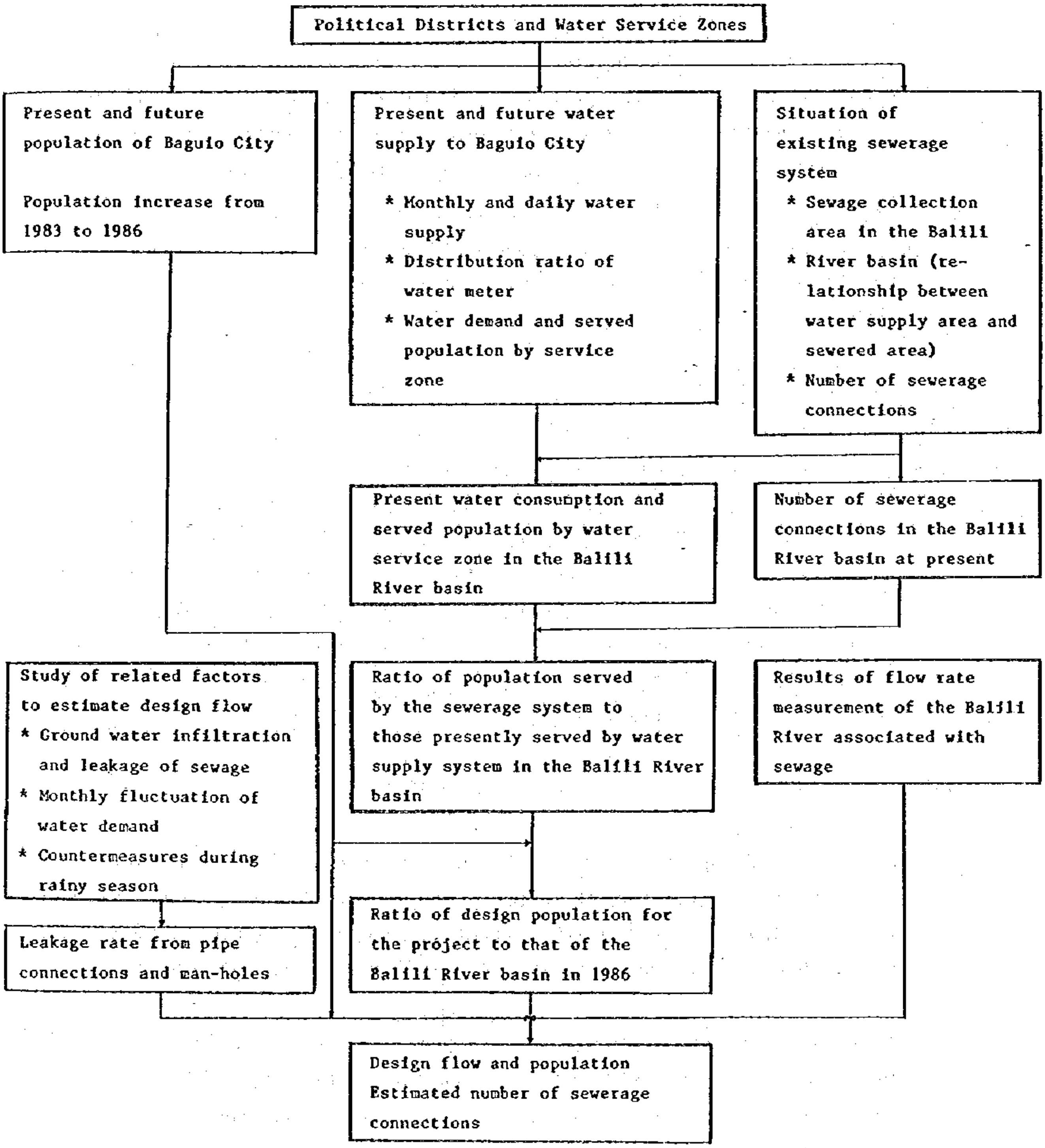
Water quality was also checked at the irrigation channel whose water source is located in a mountainous area. As a result, NH_3-N was detected and BOD concentration 14 ppm, indicating deterioration of water. The examined BOD concentration is as same as those in the morning at the entrance of La Trinidad. However, considering of the fluctuation of water quality in the river, sewage treatment in Baguio City would be the most effective and urgent measure.

3-6 Design Sewage Flow and Quality

Sewage flow for design of the sewage treatment plant was estimated on a practical basis referring to the results of the study by the preliminary survey team, supplementary data collected through this investigation, and discussions with people concerned. The present water consumption was used as a basis and population was treated as secondary data for the estimation of sewage flow. In addition, quality of influent was forecasted using the results of sewage examination.

Design flow, BOD, and SS concentrations for the year of 1986, the year when the plant is scheduled to come into service, were found to be 8,600 m^3/day (2.27 MGD), and 200 ppm, respectively. As shown in Figure 3-12, initially water consumption in 1986 was estimated from present water consumption in 1983 in the Balili River basin and expected population increases for up to 1986. Water consumption per capita per day was assumed to be constant from the present up to the design year. Influent volume to the sewage treatment plant was calculated employing the rate of sewered population to population served by

Fig. 3-12 Flow Chart to Estimate Design Flow



the water supply system in the Balili river basin and assumed ratio of leakage. The region has dry and rainy seasons and a considerable amount of storm water enters the sewers during the latter given the layout of the existing pipe system. Design flow should be established for that of the dry season, though increase of flow rate during the rainy season must be considered in designing sewage treatment facilities with reference to operation. Since there is no inflow of ground water to sewers during the dry season caused by topographic conditions and shallow pipe laying under the ground, ground water infiltration was taken to be negligible for this plan.

An outline of the major study items used to estimate design flow is shown in Figure 3-12.

3-6-1 Present Water Consumption and Served Population in the Balili River Basin

Among 20 water service zones, 16 are covered by the subject area of this project. The present water consumption of 11,000 m^3/day was estimated for the predicted 92,000 persons in the Balili River basin on the basis of the data provided by the BWD with reference to the present water consumption and estimated population served by service zone. The actual present water consumption was employed as a basis for estimation of design sewage flow.

3-6-2 Population Increase from 1983 to 1986

A recent population census of Baguio City was conducted in 1980. The estimate of population of Baguio City was based on annual increase rates of 3.8 percent and 3.6 percent for the periods from 1980 to 1985 and 1986 to 1990, respectively and a 1980 population of 118,560.

According to these assumptions, populations of 132,600 and 148,000 were estimated for 1983 and 1986, respectively. The 1986 population represents a 12 % increase over the present population. The rate of increase was assumed to be uniform both in the city and elsewhere in the Balili River basin, and total water consumption is assumed to increase in proportion to the increase of population.

3-6-3 Ratio of Planned Population Served by the Sewerage System to Total Predicted Population in the Balili River Basin.

Baguio City collects monthly sewerage charges in amount of about 35,000 peso. The correspondent number of sewerage connections is put at 7,000 at present. However there seems to exist approximately 2700 illegal ones. Of these connections, about 10 percent are connected to the existing septic tanks for treatment and effluent flows out of the Balili River basin. Accordingly, about 8,700 sewerage connections are located in the basin at present.

On the assumption that there is an average of nine persons per sewerage connection, 78,300 persons are served by the existing system or 85 percent of the estimated water-served population of 92,000 persons. Furthermore, since Baguio City is planning to expand the sewer system by completion of the sewage treatment plant, the increase of sewerage connections is expected in proportion to the increase of population.

3-6-4 Study of Related Factors to Estimate Design Flow

(1) Variation of monthly water consumption

The recorded monthly variation in the city was limited to 10 % controlled by several factors such as a constraint of water production amount and leakage from distribution pipes. Although this variation will be taken into account for design/operation of the sewage treatment facilities, it will not be considered for estimation of design flow.

(2) Groundwater

Groundwater infiltration will be disregarded for the design flow for the reasons given in (1) above.

(3) Leakage of sewage from pipe connections and manholes

In consideration of repair of the sewer system by the City, 20 percent of leakage rate to the generated sewage was proposed.

3-6-5 Design Flow

In accordance with the study described above, estimation of design flow was summarized as follows:

<u>Conditions</u>

(1)	Present water consumption in the Balili River basin	: 11,000 m^3/day
(2)	Increase in population from 1983 to 1986	: 12 percent
(3)	Ratio of population served by the sewerage system to total predicted population in the basin	: 85 percent
(4)	Leakage rate	: 20 percent

<u>Fundamentals for the design of sewage treatment facilities</u>

(1) Predicted population: 92,000 Ps x (1.0 x 0.85 + 0.12 x 1.0) ≒ 89,200 persons

(2) Design flow : 11,000 m3/D x (1.0 x 0.85 + 0.12 x 1.0) x 0.8 ≒ 8,600 m^3/day

(3) Estimated number of connections : 89,200 ÷ 9 ≒ 9,900 connections

The maximum sewage flow from the Balili River basin was examined to be 8,000 to 9,000 m^3/day through the field measurement. Therefore the estimated amount of sewage is adopted for design of related facilities.

3-6-6 Quality of Sewage Treatment Plant Influent

The average influent quality was estimated from the results of sewage examination carried out on Feb. 16th for water samples from sewers and creeks.

BOD concentration : Average figures of sewage examination at the following 4 points

Name of Point	BOD concentration	Remarks
Magsaysay Bridge	60 ppm	Sampling in the morning
Magsaysay Private Road	190	Sewage leaking from pipes
Sanitary Camp	370	
Pines Hospital	120	
Average concentration	185 ppm ≒ 200 ppm	

SS concentration : Figures ranging from 140 to 300 ppm were found after sampling water from sewers at the Sanitary Camp, Pines Hospital and overflow sewage from the septic tank at Naguilian & Kayang. The average concentration of SS was concluded to be 200 ppm in consideration of fluctuation of sewage quality.

CHAPTER 4

CHAPTER 4 BASIC DESIGN

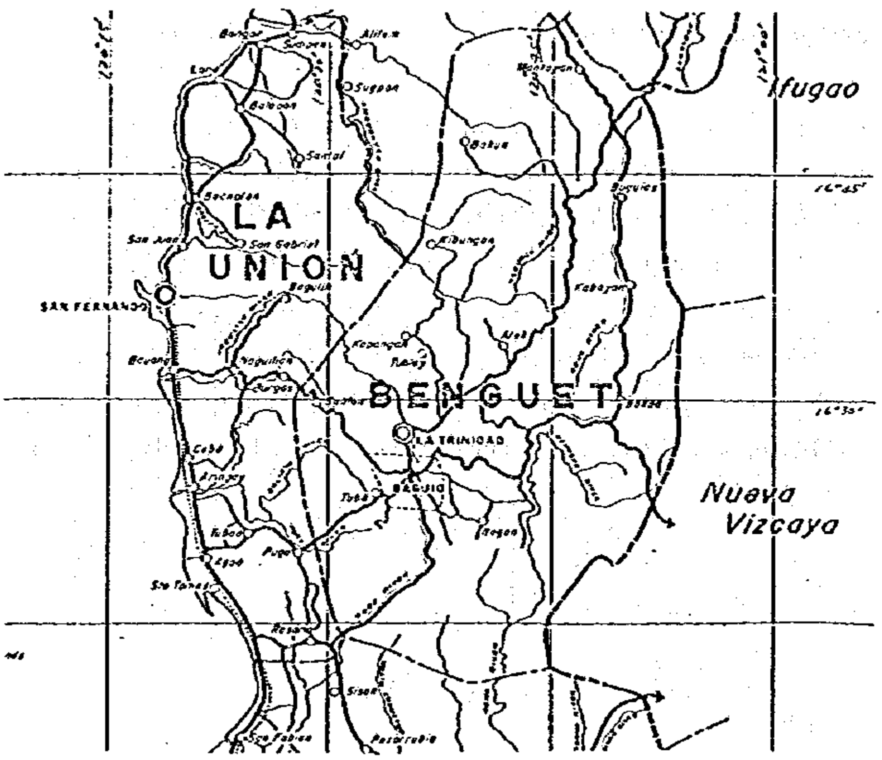
4-1 Location of Proposed Construction Site and its Surrounding Area

4-1-1 Location and Climatological Conditions

Baguio City is situated at an altitude of approximately 1,400 m at a latitude of 16°24' N and longitude 120°36' E and, though belonging to the tropical zone, has a comparatively bearable warm climate.

Its climatological characteristics are: two seasons in a year comprising rainy and dry seasons, heavy annual rainfall, and equable atmospheric temperatures.

Fig. 4-1 Location of Baguio City



The dry season lasts for 6 months from November to April, while the rainy season is from May to October. Annual precipitation registers about 3,710 mm, approximately 90 percent of which falls in the rainy season, and a maximum daily rainfall of 730.3 mm was recorded on May 15, 1980. Monthly average rain fall in Baguio City (1978-1982) is shown in Figure 4-2. Highest atmospheric temperatures are observed at the end of the dry season in April and May with monthly averages of 19.7 °C and 19.6 °C, respectively. The highest temperature recorded during the period 1978 to 1982 at 29.6 °C on April 4, 1981 . The yearly average is 18.5 °C. Figure 4-3 shows the monthly average temperature in Baguio City (1978-1982).

4-1-2 Surrounding Conditions at Planned Construction Site

The Balili River, which flows northward from the center of Baguio City is the largest of four rivers in the city. This river receives a comparatively stable yield from springs in its basin even during the dry season. It leaves Baguio to flow northward to La Trinidad.

The planned construction site shown in Figure 4-4 is located on level land along Balili River in the Barangay of North Sanitary Camp at the north end of Baguio City. The site was originally set aside for a previous sewage treatment plant after leveling the hilly ground. Presently there are several structures which have been abandoned during construction, such as a grit chamber, primary sedimentation tank, pump pit, disinfection tank, sludge drying bed, administration building and half-constructed primary sludge digestion tank.

Fig. 4-2 Monthly Average Rainfall in Baguio City (1978-1982)

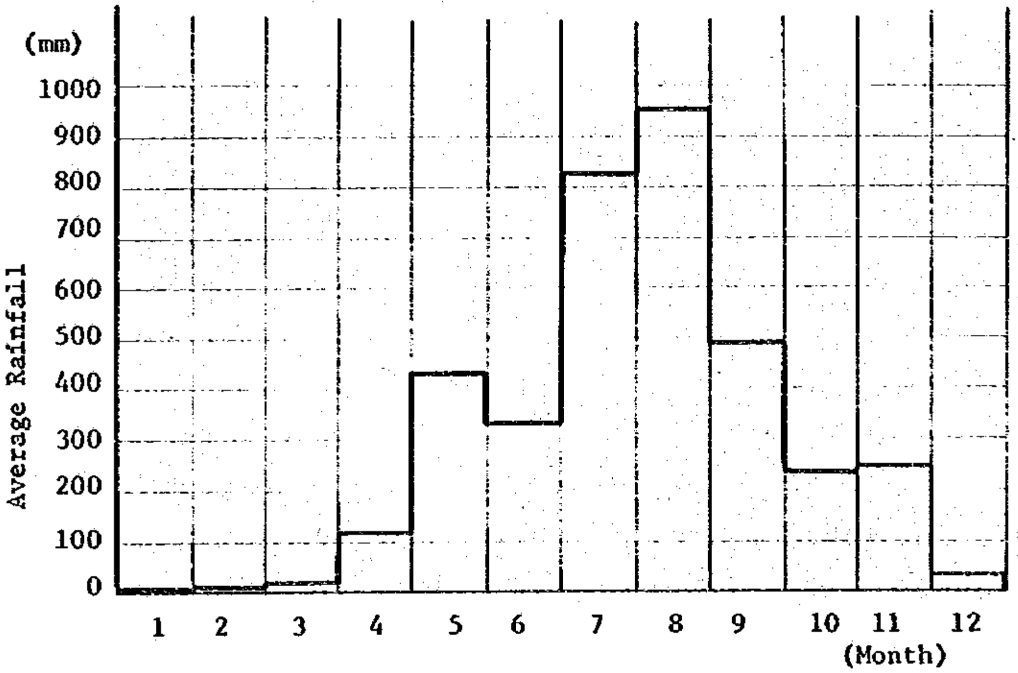
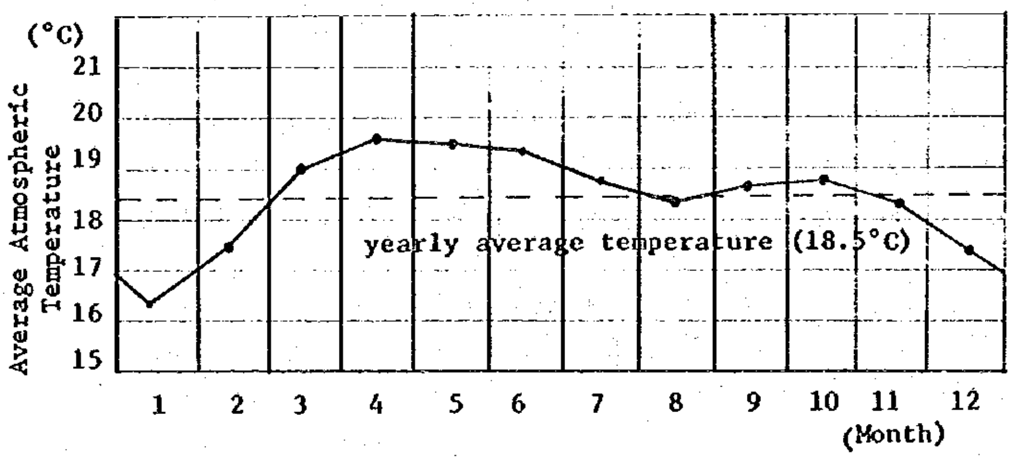
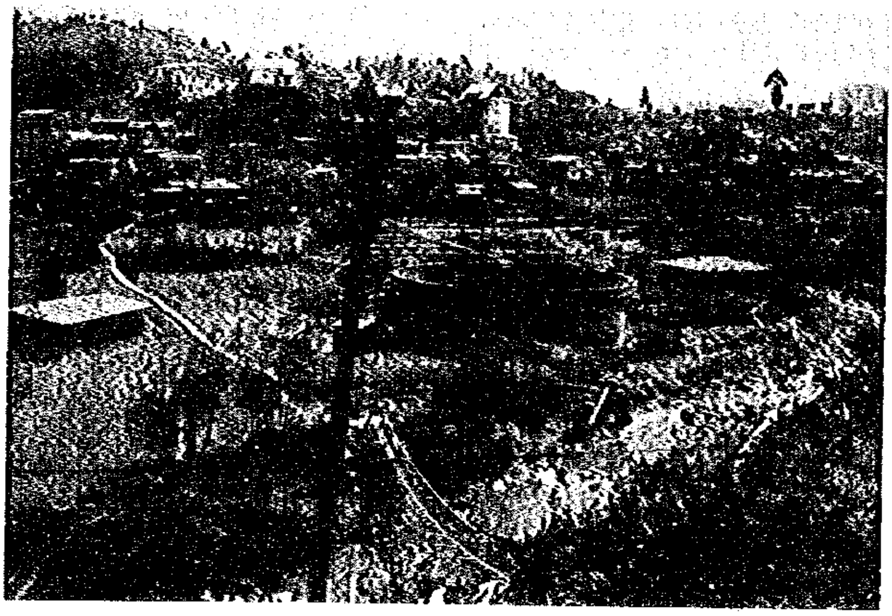


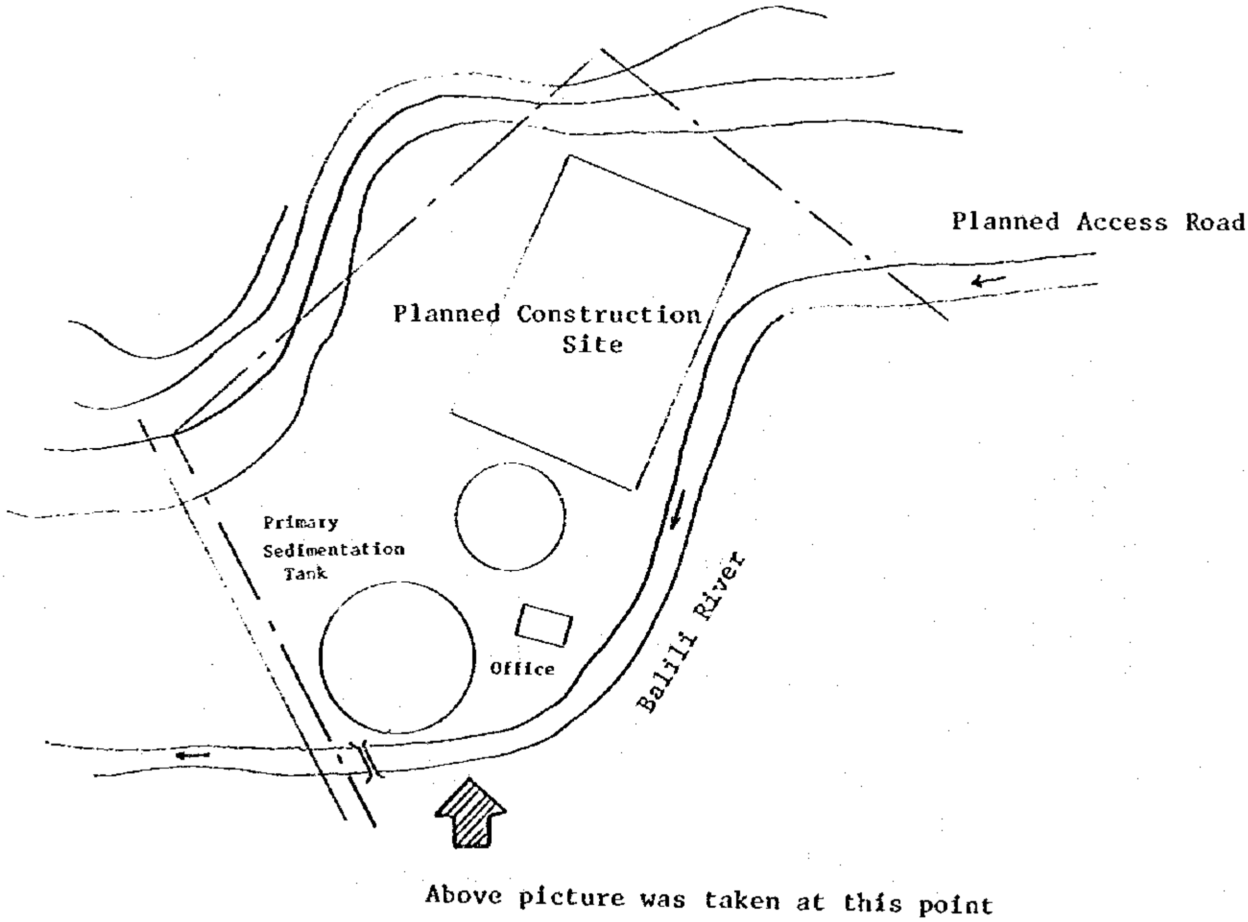
Fig. 4-3 Monthly Average Atmospheric Temperature in Baguio City (1978-1982)



Source: Ernesto A. Macabunga,
Chief Meteorological Offcer

Fig. 4-4 Planned Construction Site





4-1-3 Infrastructures

(1) Electric Power Supply

Electric power in the Philippines is generated by the National Power Corporation (NPC), while their distribution to consumers is handled by electric corporations established in each area. The total power generated by the NPC in 1978 was approximately 12,500 GWH. The electric power supply in the Baguio area is operated by the Benguet Electric Corporation (BENECO), and a power substation is located near the proposed construction site receiving at a voltage of 69 kV. A 20 MV transformer set is installed at this substation for primary and secondary voltages of 69 kV and 23 kV.

Power disconnections are rare in the Baguio area, with some 10 disconnections a year for repair and maintenance by BENECO, each averaging approximately 3 hours but not exceeding 6 hours.

Since the existing facilities are operating at full capacity, BENECO is to expand supply capacity by installing an additional 5 MVA transformer by the end of June 1984. Thus, there should occur no problems to the project in terms of power supply. In addition, the extension of a primary line to the project site from the said substation is to be conducted and shouldered by Baguio City.

Power rates charged by BENECO are as shown below. Demand charge, fuel costs, stream cost and others are also charged corresponding to the power consumption.

Baguio Water District benefits from a special rate below the above-mentioned charges for public buildings. Including annexed charges, the power rate for public utilities will be approximately 1.00 Peso/kWh.

BENECO Rates as of February 1984

Type of Consumer:

Residential		1st 15 kWh	16.05 Peso/kWh
		excess	1.06 "
Commercial	Small -	1st 25 kWh	28.00 "
		excess	1.12 "
	Large -	1st 200 kWh	224.00 "
		excess	1.12 "
Public Bldg.		1st 25 kWh	26.75 "
		excess	1.06 "
Industrial		case by case basis	
Street Lights			1.06 "

Source: BENECO Accountant

(2) Water Supply

Water supply services in Baguio City are handled by Baguio Water District. The water from deep wells and springs is disinfected by chlorine after water treatment. Comparatively stable water supply in both quantity and pressure is being ensured as is potability.

(3) Gas Supply

No urban gas supply system exists in Baguio City. In this regard, all of the energy sources for heating to be needed in control and water quality analysis rooms will depend on electric power.

(4) Telephone

The public telephone service in Baguio City is operated by the Philippine Telephone Corporation (PILTEL). In 1980 approximately 25 percent of households and enterprises were connected to this telephone network.

The daily operation and maintenance of sewage treatment facilities will be carried out during the daytime, while at nighttime security guards only will be present. Therefore, in case of emergency, it is desirable to connect a telephone line to the plant to enable smooth contact with authorities concerned. However, the installation of a telephone line will be studied further.

4-2 Sewage Treatment Facilities

4-2-1 Initial Plan and Situation of Existing Facilities

When designing a sewage treatment plant, various documents (such as a basic plan, a facility capacity calculation sheet, a hydraulic calculation sheet, a structural calculation sheet, an equipment calculation sheet, a bill of quantities, a cost estimation, specifications, drawings, etc.) are prepared and will be useful as a fundamental reference for the basic idea of the plant design. However, in the case of this project, findings will be described on the basis of the only information obtainable, namely the drawings together with the results of the field survey.

(1) Initial Plan

Existing facilities were designed with the following characteristics.

Planned sewage flow: 3 MGD (11,355 m^3/day)
Sewage treatment process: High-rate trickling filter process
Sludge handling and disposal process: Digestion and drying

The flow sheet for treatment, layout plan and the hydraulic profile are shown in Figures 4-5 to 4-8, respectively, and the outline of main facilities in Table 4-1.

Fig. 4-5 Flow Sheet for Treatment of Initial Plan

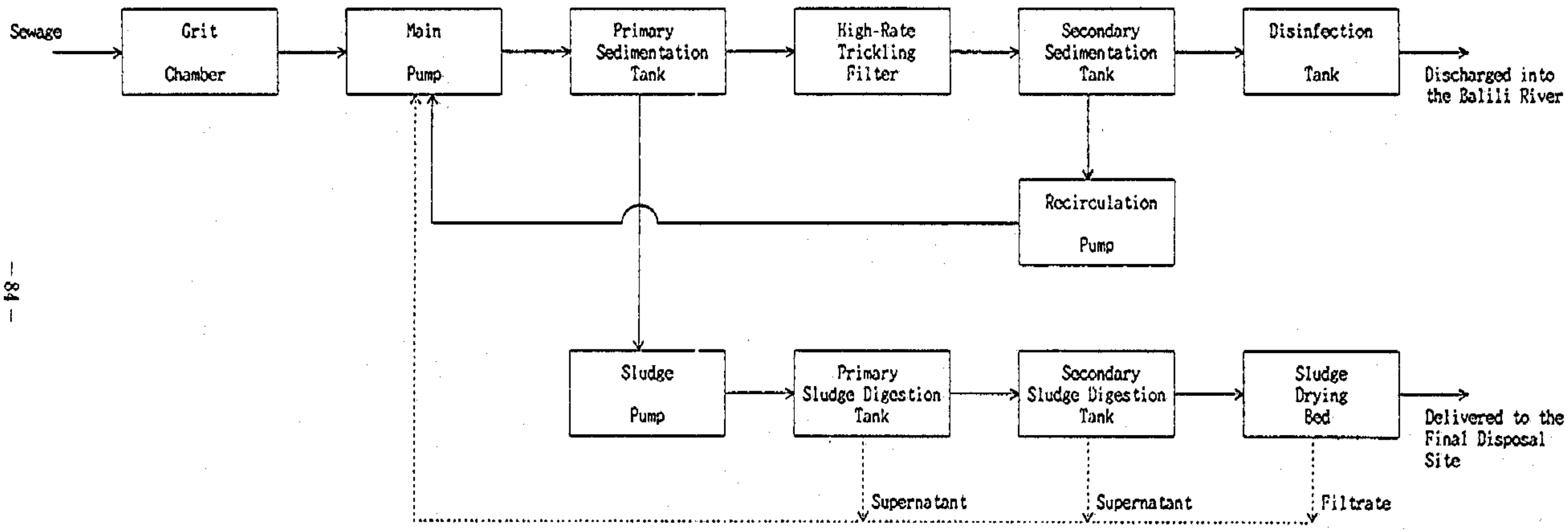


Fig. 4-6 Initial Layout Plan

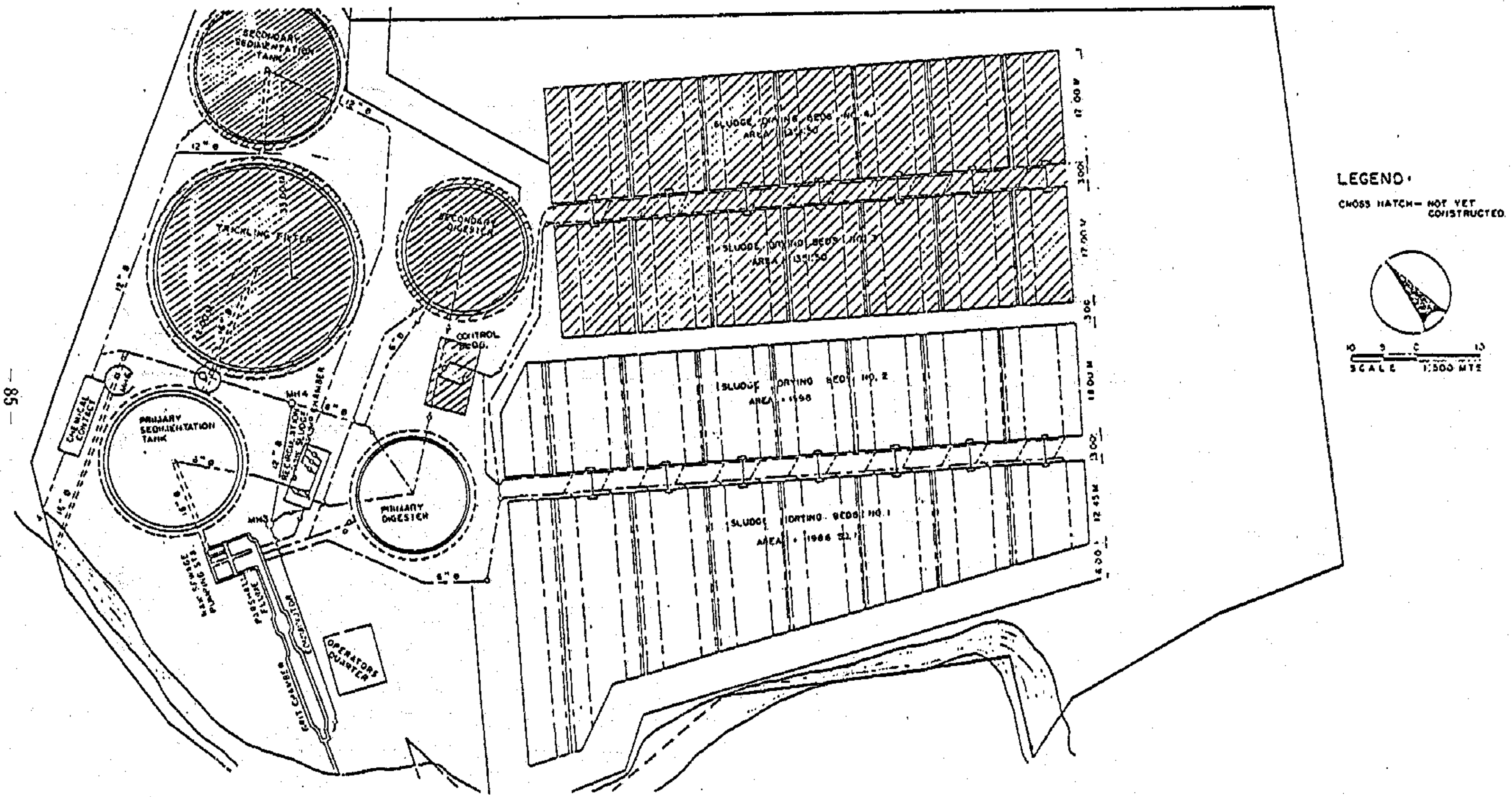


Fig. 4-7 Hydraulic Profile four Sewage Treatment Facilities of Initial Plan

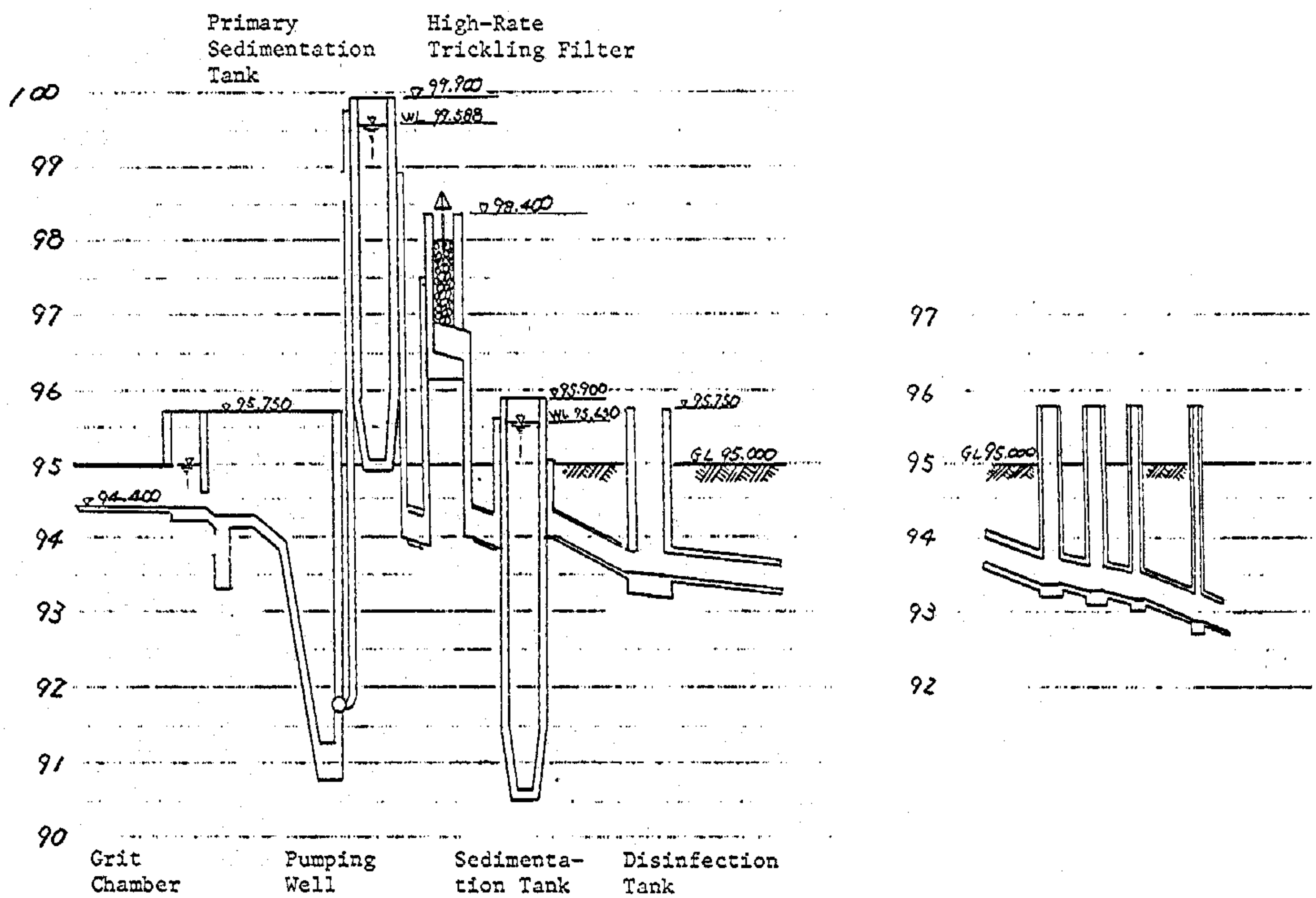


Fig. 4-8 Hydraulic Profile for Sludge Treatmet Facilities of Initial Plan

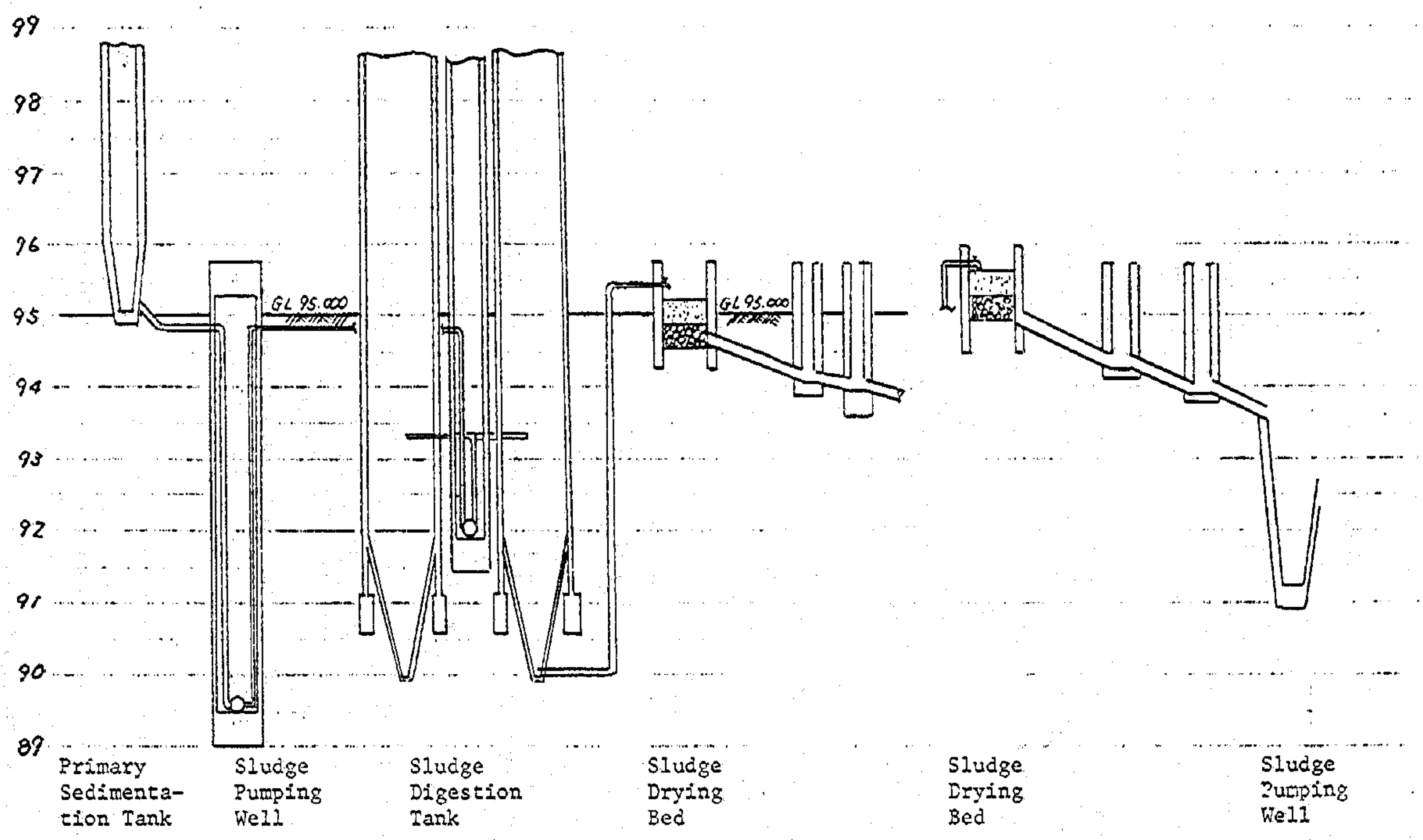


Table 4-1 Outline of Main Facilities

Facility Name	Dimension	Quantity	Capacity	
Grit Chamber	Parallel Flow Type W 0.61m x L 5.67 m	2-Existing	Overflow Rate Average Velocity	3,282 m^3/m^2 0.71 m/sec
Comminutor		1-Existing		
Parshall Flume	Throat Width 0.23 m (9")	1-Existing		
Pumping Well	W 3.00 m x L 4.60 m	1-Existing		
Main Pump		5		
Primary Sedimentation Tank	Radial Flow Circular Tank Dia. 21.34 m x D 3.60 m	1-Existing	Settling Time Overflow Rate Weir Rate	2.72 hrs 31.8 m^3/m^2/day 170 m^3/m^2/day
High-Rate Trickling Filter	Circular Tank Dia. 30.48 m x Media Depth 1.12 m	1	Hydraulic Loading Organic Loading	15.6 m^3/m^2/day 1.95 kg/m^3/day
Recirculation Pump		3		
Final Sedimentation Tank	Radial Flow Circular Tank Dia. 19.81 m x D 3.61 m	1	Settling Time Overflow Rate Weir Rate	2.35 hrs 37 m^3/m^2/day 187 m^3/m/day
Sludge Pump		2		
Disinfection Tank	Horizontally Baffled Flow Rectangular Tank W 3.70 m x L 11.70 m	1-Existing	Contact Time	2.7 min.
Sludge Digestion Tank	Non-Heating Gas Stirring Two Stage Circular Tank Dia. 18.29 m x D	1-Existing 1	Digestion Time	83 days
Sludge Drying Bed	Drying Area 5,687 m^2	2,984 m^2 -Existing 2,703 m^2	Drying Time Sludge Thickness	19 days 15 cm
Sludge Pumping Room	9.60 m x 3.90 m	1-Existing		
Operators Quarter	8.00 m x 9.45 m	1-Existing		

Note: The capacity is expressed for sewage flow of 3 MGD (11,355 m^3/day) except the case of a grit chamber for 6 MGD (22,710m^3/day).

(2) Study of Initial Design

Under the initial design, one each of primary sedimentation tank, high-rate trickling filter and final sedimentation tank was to be constructed. Therefore, should one of these tanks have been out of order, the whole plant operation would have to be shut down during repairs. There would have been no problem if the necessary replacement parts were readily obtainable in the Philippines, but in the case of importing, the delay would mean that sewage untreated would be discharged into the river for long periods.

Generally, effluent from a trickling filter or final sedimentation tank is pumped back for recirculation into the trickling filter, entering it into the together with raw sewage from a primary sedimentation tank. However, the initial design intended to use settled sludge from the final sedimentation tank, returning to the pumping well situated before the primary sedimentation tank. The return of excess sludge from the final sedimentation tank to the primary tank is often carried out to enable the sludge to mix and settle with raw sludge generated from raw sewage. Should sludge of several times as much as the volume of the influent have been returned to a primary sedimentation tank, sludge overflows into the trickling filter without sufficient separation and covers the surface of the biological membrane causing the micro-organisms to suffocate.

For the provision of sewage flow increase during rainy periods and trouble in the secondary treatment, a bypass from a primary sedimentation tank to a disinfection tank is usually installed to maintain the sedimentation treatment even under the most severs conditions, but such a consideration was not included in the initial design.

Fig. 4-9 Return Method of Recirculation

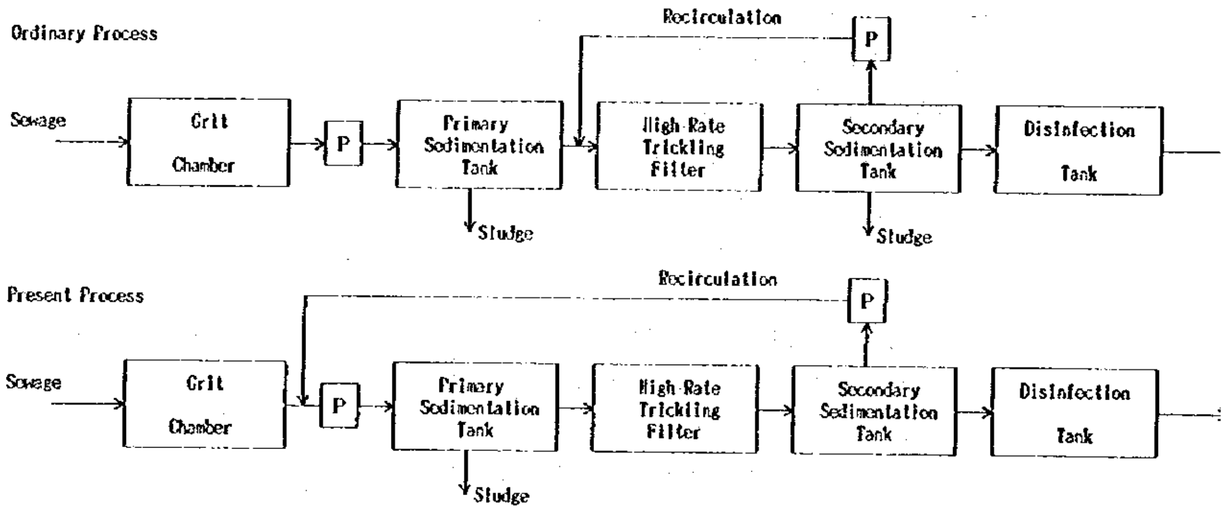
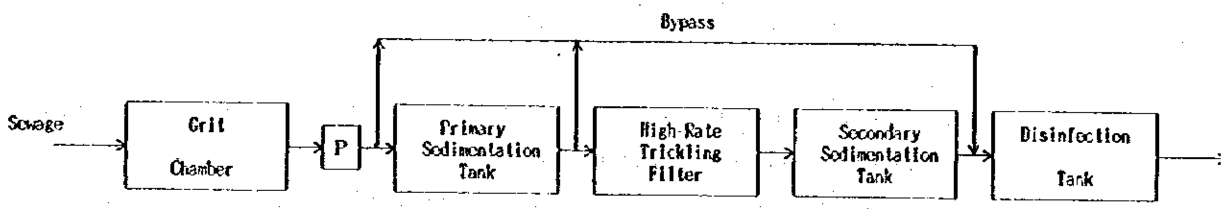


Fig. 4-10 Bypass



The above-mentioned matters are concerned with the function of a sewage treatment plant. Besides that the drawings prepared in the initial design have many problems in themselves. That is to say, the locational relationship between facilities and the dimensions and elevations of each facility are not given in sufficient detail in the drawings; and the fact that the preparation of the bill of quantities and the cost estimation were made in accordance with such drawings, as was the construction, is difficult to understand. If the drawings were correct, it would be possible to measure lengths from the drawings by scaling, but lengths on the drawings did not confirm with the scale given and, moreover, the note "Do not scale; dimensions given should be followed" was appended. Under these conditions it was impossible to determine the correct dimensions. Furthermore, the drawings gave detailed information on certain specified parts of equipment only.

(3) Existing Facilities

1) Grit Chamber

* The inlet part of the grit chamber lost its base ground during flooding of the Balili River, leaving it suspended and thus causing it to crack.
* The channels of the grit chamber are now being used for vegetable growing.
* Since the sections of the grit collecting and the grit-washing parts are almost identical, grit is apt to settle in the grit-washing part, and the grit-collecting part does not function effectively.
* The capacity is unsatisfactory.
* The pumping well and pump room were not constructed as indicated on the drawings.

2) Primary Sedimentation Tank

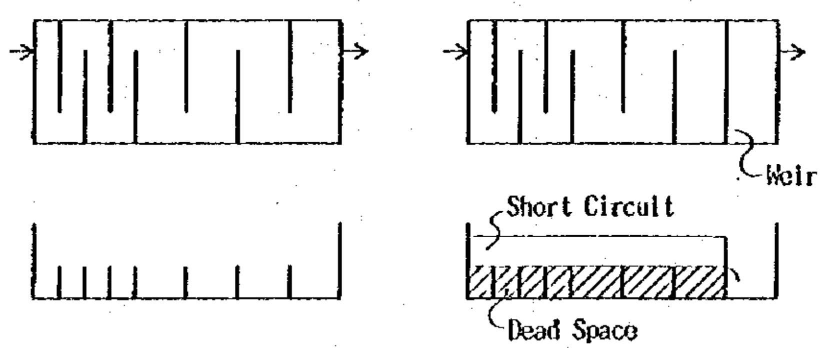
* Part of the foundation was exposed by flooding of the Balili River.

* Since most of the structure is on the ground without any ladder, the tank is maintained as it was constructed.
* The reinforcement bar arrangement is substandard and bars are exposed in a few places.
* The capacity is sufficient.
* The sludge withdrawal pipe is not located as indicated on the drawings.
* In the initial plan, the effluent pipe was designed to pass beneath the manhole, though this design in itself is questionable; but the manhole has already been constructed, while the pipe has yet to be laid.

3) Contact Chamber

* A residential house has been constructed adjacent to the tank.
* A constant water level cannot be maintained as there is no weir at the end of the channel.
* Even if a weir were installed in the tank, the intermittent baffles are so low as to generate a dead zone and short circuit.
* Sufficient chlorination is not expected due to a lack of capacity.

Fig. 4-11 Disinfection Tank



4) Sludge Digestion Tank

* The construction of a tank have been suspended on the way at the one-half completion and now the tank is used for a children's good pool.
* If constructed in accordance with the drawings, it would be structurally inadequate.
* The capacity is sufficient.

5) Sludge Drying Bed

* The river side portion of the bed was extensively damaged by flooding of the Balili River.
* The bed is now used for growing various kinds of vegetables and the layer of coarse gravel, fine gravel and fine sand for sludge drying has been completely destroyed by mixing with field soil.
* Several holes have been bored through each bed wall for irrigation.
* Though the availability of existing underground pipes is unknown, that these are partially damaged seems to be inevitable.
* For sewage flows of 3 MGD, four modules of the drying bed are not necessary; two modules would suffice.

6) Operators' Quarters

* Outside appearance has been maintained; however, the interior has been destroyed, that is to say, windows, inside walls and room floor have been damaged and the wall have been scrawled all over.
* The room was originally designed as an operator's dwelling house and is not functional as an administrative building.

4-2-2 Selection of Alternatives

So far many kinds of sewage treatment processes, each with their own characteristics, have been developed in response to social needs and through technological development. At present, the following processes are generally used.

Suspended Biological Process
- Conventional Activated Sludge Process
- Modified Activated Sludge Process
  - Step Aeration
  - Contact Stabilization
  - Extended Aeration
  - High-Rate Aeration-Sedimentation
  - Oxidation Ditch
  - Pure Oxygen Aeration

Fixed Biological Process
- Trickling Filter
  - Conventional Trickling Filter
  - High-Rate Trickling Filter
- Rotating Biological Reactor

Stabilization Pond

In the selection of the sewage treatment process for this project the prime considerations are as follows.

* The treatment capacity is comparatively small and the seasonal incremental population due to students and visitors is almost equivalent to the permanent population. These facts indicates that the flow and load variation of influent will be considerable and the treatment process to be selected should have the adaptability to cope with such fluctuations.
* Experience of municipal sewage treatment is very limited in the Philippines and therefore the treatment facilities should be easy

maintain and operate with limited professional skills and experience.

* Taking into account the city budget and level of residents' income, maintenance and operation costs should be minimized.
* The proposed site for the construction of the sewage treatment plant is located in difficult terrain; furthermore, in consideration of land use in the surrounding area, the possibilities for site expansion are very limited. Therefore, it is desirable to contain the plant on the site.

The U.S. Environmental Protection Agency (EPA) selects rotating biological reactor, trickling filter, complete mixing, contact stabilization, extended aeration, oxidation ditch and facultative lagoon as applicable processes to small-scale sewage treatment plants and evaluates their operational characteristics as shown in Table 4-2. In relation to the items concerned with the above-mentioned considerations in this project, the rotating biological reactor, trickling filter, extended aeration and oxidation processes are suitable as alternatives. The facultative lagoon process, a kind of stabilization pond, is the most natural process and has good characteristics, but has been discounted as an alternative because of its large site requirement.

The Japan Sewage Works Agency (JSWA), meanwhile, adopts the conventional activated sludge process as well as the rotating biological reactor, extended aeration and oxidation ditch processes for small-scale sewage treatment plants. Therefore, the following processes are feasible as alternatives in the study of the sewage treatment process.

Conventional Activated Sludge Process
Extended Aeration
Oxidation Ditch
Trickling filter
Rotating Biological Reactor

Table 4-2 Operational Characteristics of Various Treatment Process

Item	Rotating Disk	Trickling Filter	Complete Mix Contact Stabilization	Extended Aeration Oxidation Ditch	Facultative Lagoons
Process Characteristics					
Reliability with respect to:					
Basic Process	Good	Good	Fair	Very Good	Good
Influent Flow Variations	Fair	Fair	Fair	Good	Good
Influent Load Variations	Fair	Fair	Fair	Good	Good
Presence of Industrial Waste	Good	Good	Good	Good	Good
Industrial Shock Loadings	Fair	Fair	Fair	Good	Fair
Low Temperatures (20°C)	Sensitive	Sensitive	Good	Good	Very Sensitive
Expandability to Meet:					
Increased Plant Loadings	Good, must add disk modules	Good	Fair to good if designed conservatively	Good, ultimately more volume will be required	Fair, additional ponds required
More Stringent Discharge Requirements with Respect to:					
SS	Good, add filtration or polishing lagoons	Good, add filtration or polishing lagoons	Good, add filtration or polishing lagoons	Good, add filtration or polishing lagoons	Add additional lagoons and filtration
BOD	Improved by filtration	Improved by filtration	Improved by filtration	Improved by filtration	Improved by filtration
Nitrogen	Good, denitrification must be added	Good, denitrification must be added	Good, denitrification must be added	Good, denitrification must be added	Fair
Operational Complexity	Some, to simple	Some, to simple	Moderately Complex	Some	Simple
Ease of Operation and Maintenance	Very Good	Very Good	Fair	Very Good	Very Good
Power Requirements	Low	Relatively High	High	Relatively High	Low
Waste Products	Sludges	Sludges	Sludges	Sludges	Sludges
Potential Environmental Impacts	Odors	Odors	-	-	Odors
Site Considerations					
Land Area Requirement	Moderate plus buffer zone	Moderate plus buffer zone	Moderate plus buffer zone	Large plus buffer zone	Large plus buffer zone
Topography	Relatively Level	Relatively Level	Relatively Level	Relatively Level	Relatively Level

Source: Process "Design Manual-Wastewater Treatment Facilities for Served Small Communities" U.S. Environmental Protection Agency Environmental Research Information Technology Transfer, October 1977