PHNOM PENH WATER SUPPLY AUTHORITY
THE KINGDOM OF CAMBODIA

No. 1

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR IMPROVEMENT OF WATER SUPPLY FACILITIES IN PHNOM PENH, (PHASE II) IN THE KINGDOM OF CAMBODIA

OCTOBER 1996

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO ENGINEERING CONSULTANTS CO., LTD.

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PREFACE

In response to a request from the Royal Government of Cambodia the Government of Japan decided to conduct a basic design study on The Project for Improvement of Water Supply Facilities in Phnom Penh, (Phase II) and entrusted the study to the Japan International Cooperation Agency (JICA).

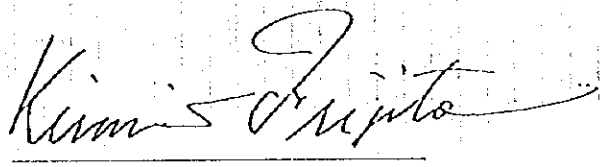
JICA sent to Cambodia a study team from Jun 4 to Jul 3, 1996.

The team held discussions with the officials concerned of the Royal Government of Cambodia, and conducted a field survey at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Cambodia in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Royal Government of Cambodia for their close cooperation extended to the team.

October 1996



Kimio Fujita
President
Japan International Cooperation Agency

October, 1996

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Improvement of Water Supply Facilities in Phnom Penh, (Phase II) in the Kingdom of Cambodia.

This study was conducted by Tokyo Engineering Consultants Co., Ltd.under a contract to JICA, during the period from May 27,1996 to November 22,1996. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Cambodia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

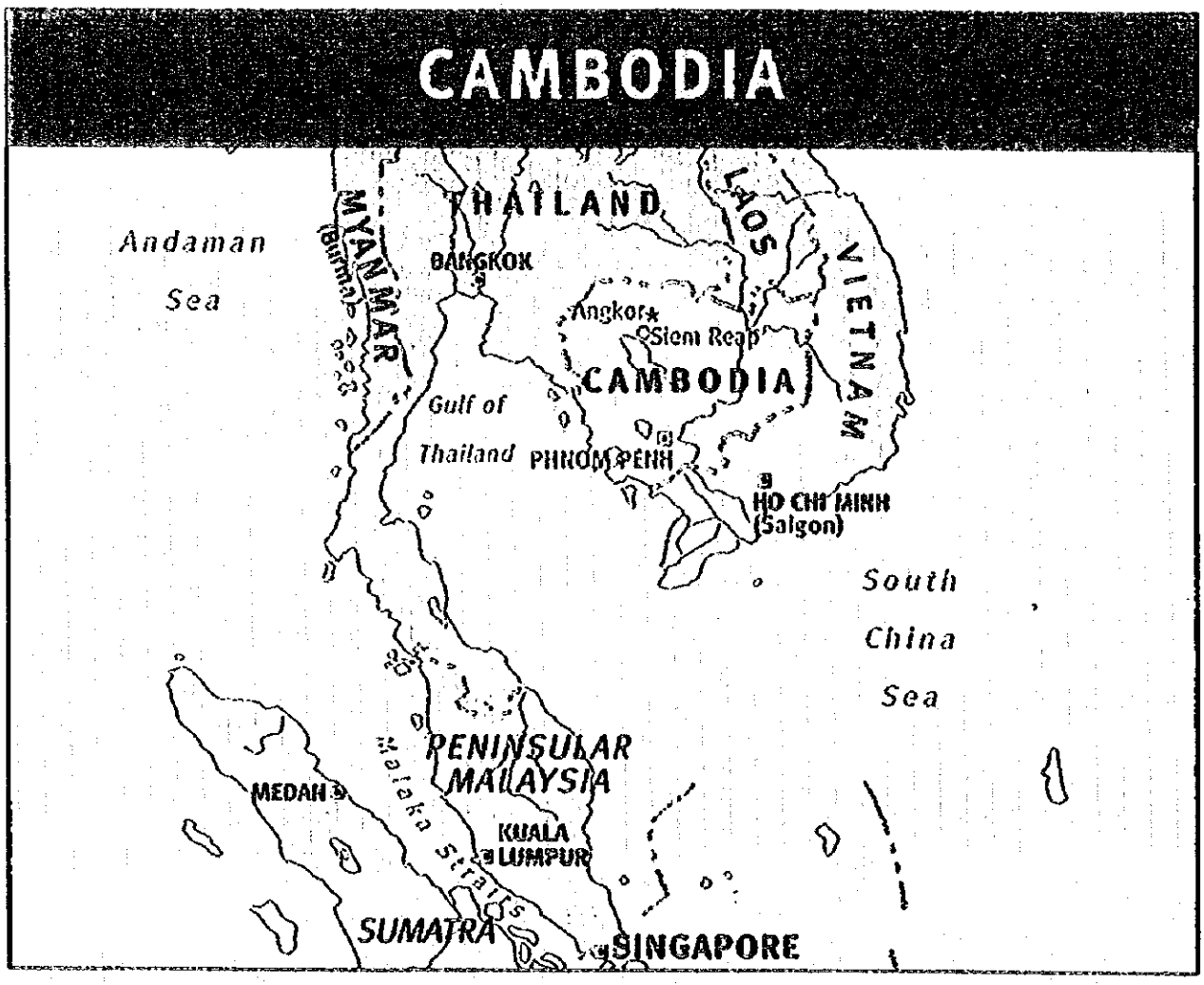
Very truly yours,

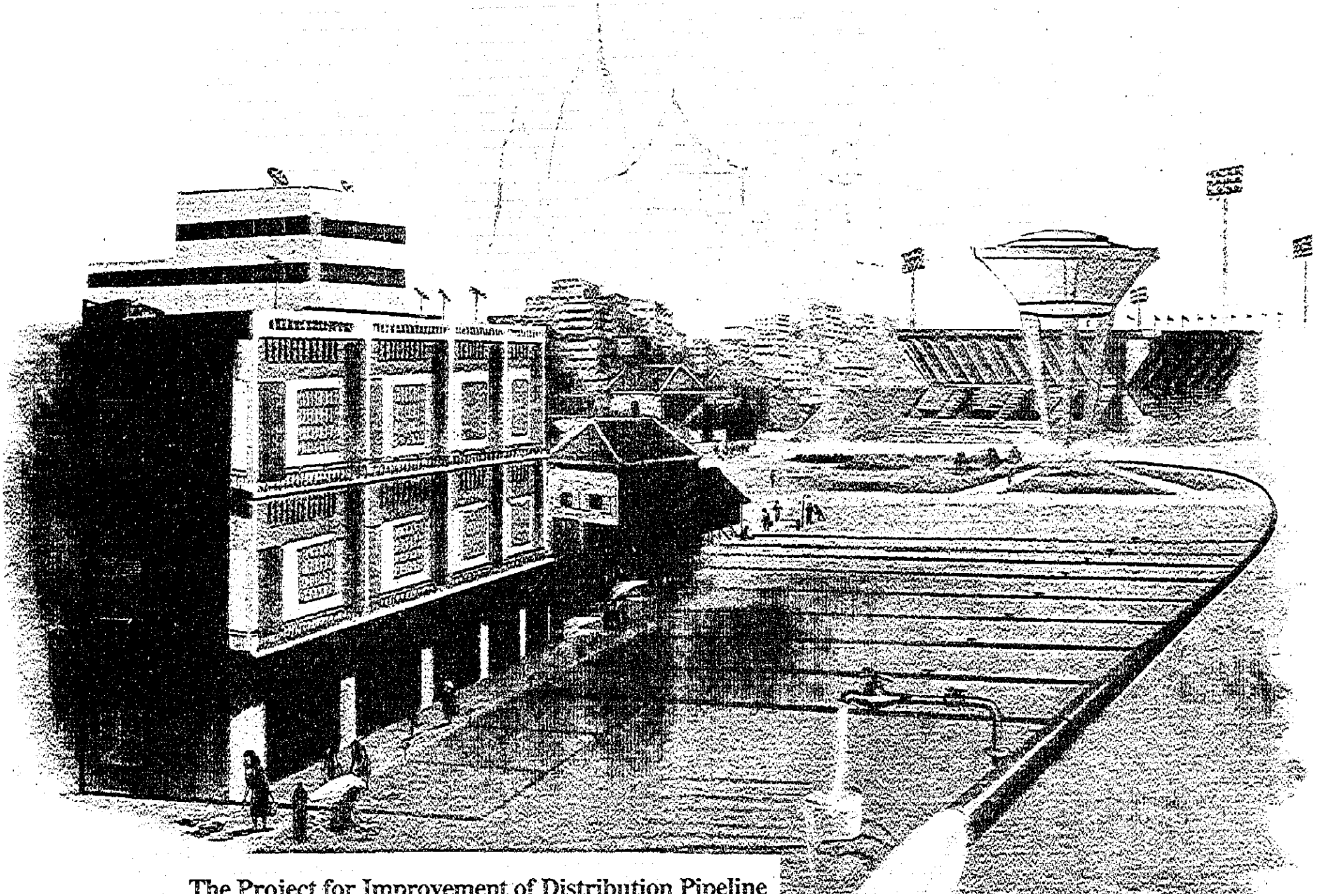
Kaoru SUZUKI
Project Manager,

Basic design study team on
The Project for Improvement of
Water Supply Facilities in
Phnom Penh, (Phase II)

Tokyo Engineering Consultants Co.,Ltd.

The Kingdom of Cambodia
Location of City of Phnom Penh





The Project for Improvement of Distribution Pipeline

Abbreviations

ADB	:Asian Development Bank
DCIP	:Ductile Cast Iron Pipe
F/T	:Freight Ton
HDPE	:High Density Polyethylene
IBRD	:International Bank for Reconstruction and Development
JICA	:Japan International Cooperation Agency
JIS	:Japanese Industrial Standard
JWWA	:Japan Waterworks Association
lpcd	:litter per capita demand
PPWSA	:Phnom Penh Water Supply Authority
UNDP	:United Nations Development Program

TABLE OF CONTENTS

Chapter 1
Background of the Project

Chapter 1: Background of the Project

The Kingdom of Cambodia, situated at the center but slightly to the south-west of the Indo-China peninsula, is surrounded by Vietnam, Laos and Thailand and has an area of about 181,000 km^2. The population is 10.3 million (as of 1994), and the GNP per capita is 820 US dollars (as of 1993). Cambodia has a tropical monsoon climate with high temperature, high humidity, and two seasons - the rainy season (from May to October) and the dry season (from November to April). Phnom Penh, the capital of Cambodia, has an average temperature of 27.4 °C and the maximum temperature occurs during March-April. The annual rainfall is about 1,400 mm.

Phnom Penh, the capital of Cambodia, has a population of about 700,000 (as of 1993), and is located at the confluence of the Mekong and Sap rivers. The water supply facilities of the city were constructed in the period 1895 to 1966, but these facilities have deteriorated considerably because of the turmoil over a prolonged period after the coup d'etat in 1970, when some of the facilities were destroyed and maintenance was neglected. As a result, the treatment capacity of 140,000 m^3/day in 1966 dropped to as low as 63,000 m^3/day in 1992, and the distribution pipelines showed a leakage of nearly 50%.

The International Bank for Reconstruction and Development(IBRD), United Nation Development Program(UNDP), and France started aid projects in earnest from 1992 for rehabilitating the water supply to Phnom Penh. Japan also prepared the Master Plan called the "The Study on Phnom Penh Water Supply System" during 1993 to 1995, and implemented repairs for two projects through grant aid - the "Phum Prek Water Treatment Plant" and "Elevated Water Tanks" based on the Master Plan that needed most urgent attention.

With the restoration of water treatment capacity, France carried out repairs to the water distribution pipelines, particularly to the old pipelines buried in the Don Penh district (population 106,000 as of 1992) at the center of the city. However, repairs in other districts were delayed and did not progress as anticipated, and water leakage still remained a major problem. In view of this situation, the government of the Kingdom of Cambodia requested the government of Japan for grant aid for improving the Seventh January district and a part of the Toul Kork district, located at the center of the city.

Chapter 2
Contents of the Project

Chapter 2: Contents of the Project

2-1 Objectives of the Project

The Seventh January district and a part of the Toul Kork district (area: 394 ha, population supplied with water: 190,000), located at the central part of Phnom Penh and having a high population density, for which the request for rehabilitation of distribution pipelines was received, has distribution pipelines that were mostly laid in the sixties. Due to the civil war, maintenance of these pipelines was neglected, the pipelines deteriorated and a large amount of water leakage occurred. The low-pressure situation that accompanied this leakage led to stealing of water from the pipelines and sedimentation of sludge due to blocked distribution pipelines. The state of water supply services for the inhabitants of the area has deteriorated considerably. Extensive maintenance of the entire distribution pipeline network is urgently required for improving this situation.

The objectives of this project are to renew the old distribution pipelines and improve the state of deteriorating water supply services by rebuilding the complete network of distribution systems.

2-2 Basic Concept of the Project

The IBRD/UNDP, and France started aid projects in earnest from 1992 for rehabilitating the water supply capacity of Phnom Penh. At the request of the Cambodian government, Japan International Cooperation Agency(JICA) prepared the report titled "The Study on Phnom Penh Water Supply System" during 1993 to 1995, prepared a Master Plan for Phnom Penh city and an urgent rehabilitation program for existing facilities. From 1995 to 1996, improvements were carried out on the Phum Prek water treatment plant (distributing reservoir) and elevated water tanks through grant aid, and great strides were made toward rehabilitation.

The Master Plan mentioned above envisaged maintenance of distribution pipelines starting from "areas with high distribution pressure, namely areas near water treatment plant", and "areas with very old pipelines", giving priority to reducing the water leakage. The priority sequence decided was 1: Don Penh district; 2: Seventh January district; 3: Chamkar Morn district; and 4: Toul Kork district. With the help of France, work began in the Don Penh district from 1992. Japan received a request for grant aid for the rehabilitation of the Seventh January district, which is scheduled to start from 1997. An additional request was also received for rehabilitation of the southern part of the Toul Kork district, neighboring the Don Penh district, and this work was also added to the project since it was not included in any of the other projects.

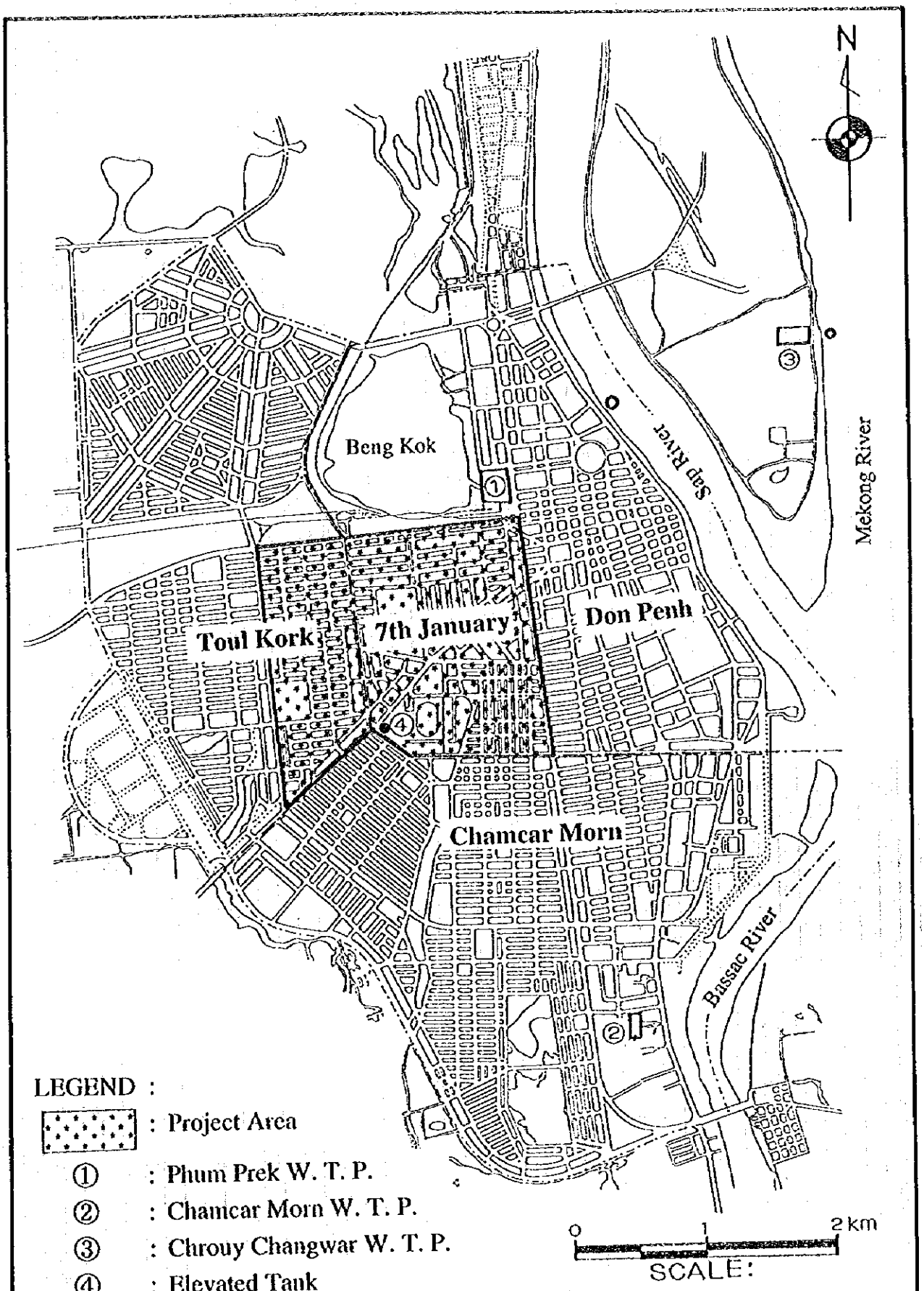
Means for rehabilitating distribution pipelines include "renewal" and "repair." Renewal refers to the laying of completely new distribution pipelines of required cross section area, while "repair" refers to the air scouring (blowing compressed air), scraping

(scraping out, raking out) the pipes and re-using them. For this project, the results of the studies on site showed that the pipe material had deteriorated excessively, and even after maintenance, the required flow and pressure would not be obtained, therefore, it was decided to renew the pipelines.

The pipelines have dead ends at various locations in the distribution systems of the area in question, the cross sections of pipes have reduced in size due to clogging of sediment, and these have become major bottlenecks obstructing the efficient and stable supply of water. In view of these facts, a network of the distribution systems should be formed under the renewal plan. Moreover, sluice valves did not function systematically, therefore in case of an abnormal outflow of water due to an accident, the water supply to a wide area had to be cut off. Valves need to be installed dividing the network into various blocks so that the effect of cut in the water supply can be controlled, and maintenance and repairs are facilitated.

The work to be carried out by the Japanese side is all work until the laying of the secondary distribution pipelines. Pipe materials and water meters for tertiary pipelines are to be procured by the Japanese side. The Cambodian side will quickly lay tertiary water service pipelines in parallel with the work performed by the Japanese side.

Based on the study results , the basic concept of the project is to provide a distribution network capable of supplying a steady quantity of about 80,000 m^3/day to about 247,000 inhabitants in a part of the Seventh January district and Toul Kork district.



LOCATION OF PROJECT AREA

2-3 Basic Design

2-3-1 Design Concept

The design concept for establishing the renewal plan for distribution pipelines, after considering the natural and social conditions, construction and procurement status, other problems in Cambodia, and features of the relevant project, is given below.

1) Natural Conditions

The rainy season in Cambodia is from May to October, and the average monthly rainfall is nearly 200 mm. with heavy rains concentrated within a short period of time. On an average, the project area has mostly viscous soil with poor grain distribution, and this is likely to cause unsatisfactory working conditions on site when it rains.

The number of non-working days in a year due to unsatisfactory working conditions on site when it rains is estimated to be about 72, according to data recorded in 1995. This factor needs to be considered when estimating the work schedule.

Monthly rainfall (1995) (Units: mm)

Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
-	-	18.0	94.3	234.6	146.8	156.4	208.9	277.1	243.6	22.4	11.2	1,413

(Source: Department of Meteorology)

Days in a month with rain (1995) (Units: mm)

Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Seep.	Oct.	Nov.	Dec.	Total
-	-	3	4	11	15	18	20	23	16	2	3	115

(Source: Department of Meteorology)

(2) Temperature

Monthly average temperatures (1995) (Units: °C)

Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Seep.	Oct.	Nov.	Dec.
25.8	26.6	28.8	30.4	29.3	28.7	27.7	27.5	27.1	27.2	26.3	24.7

(Source: Department of Meteorology)

Rainfall and number of non-working days after rainfall

	(I) Gravel, cobble stones, pit-run gravel	(II) Soil with good grain distribution and sand	(III) Soil with poor grain distribution, clay, cohesive soil	(IV) Clay with high water content, cohesive soil, Kanto loam
No rain	0	0	0	0
0 to 3 mm	0	0	0 to 0.5	0 to 0.5
3 to 10 mm	0	0	1 to 1.5	1.5 to 2.0
10 to 30 mm	0 to 0.5	0.5 to 1.0	1.5 to 2.0	2.0 to 3.0
30 mm and above	1	1.5 to 2.0	2.0 to 3.0	3.0 to 4.0

"Documents for Construction Machinery Management and Expense Calculations" (published by the Construction Research Institute)

Since the properties of soil at the project areas is considered to lie between (II) and (III) in the table above, the working conditions were set as given below.

Amount of Rainfall	**Working conditions**
No rain	Work full day
0 to 3 mm	Work half day
3 to 10 mm	Work half day
10 to 30 mm	No work for 1 day
30 mm and above	No work for 2 days

2) Construction matters

For the laying of distribution pipelines, the conditions for permission to excavate and restore roads and traffic-regulated areas, and the time for regulating traffic are as given below.

(1) Trunk roads (Monivong Street, Charles de Gaulle road)

In principle, all work is to be carried out at night, and excavation, pipe laying, backfilling, and temporary restoration of road are to be completed on the same day.

(2) Permission for excavation

Application is to be submitted for the construction method (test excavation to be carried out beforehand, and other objects buried underground to be investigated), traffic-regulated areas and time for regulating the traffic.

(3) Road paving work

Road paving work in the city is classified as given below. The City Road Bureau receives the request and carries out the paving work directly.

* Type 1: Bitumen-paved roads (main roads)
* Type 2: Asphalt-paved roads (general roads)
* Type 3: Laterite or gravel-paved roads

Local sub-contractors capable of implementing small-scale work are available, but there are few that can undertake work independently, therefore they cannot be considered for participation in this project. Transfer of technology through the piping work of the first stage of grant aid was substantial. General piping work (direct laying of pipelines) poses no problems, but since experience in special fields, such as safety management during work involving soft and weak foundations, fittings and pipe crossings is inadequate, skilled pipe fitters from Japan should be employed.

With regard to cement and concrete, there is adequate stock of these materials imported from Thailand and there is no problem in the quality of the materials. Small quantities of standard reinforcing bars can be imported from Singapore and Malaysia. Since there are no problems in compliance with standards and quality, these materials can be locally procured. However, since pipes and valves are not being manufactured in neighboring countries, these materials should be procured from Japan.

3) Management and maintenance capability of the implementing organization

The Phnom Penh Water Supply Authority(PPWSA), the organization responsible for implementing the project, has enforced various measures listed below with the aim of setting up an autonomous business accounting system, and has been successful so far. Management and maintenance of the project should pose no problem.

i) By introducing computers, an efficient water tariff collection system is being established.
ii) To enhance the awareness of the consumer for conserving water, a meter-rate system in which heavy consumers are charged high rates and light consumers are charged low rates will be introduced.
iii) Water meters should be extensively installed so that water tariff is properly collected from all consumers.
iv) Illegal connections and stealing of water should be eliminated by laying new distribution pipelines.

4) Deciding the scope, grade of facilities and equipment

(1) Distribution pipelines
i) Pipe diameter

The pipe diameters are decided based on a population of 247, 085 taking the target year for the project as 2015, the per capita consumption as 325 l/person.day and the flow rate as 80,301 m^3/day (calculated by district), after confirming by pipe network calculations that the minimum pressure (2.5 kg/cm^2) at maximum flow is satisfied.
ii) Type of pipe

Ductile cast iron pipe, the most economical option available, that complies with internal pressure (water pressure) and external pressure (soil pressure), should be used.

iii) Installation of pipes

The position for laying pipes is generally near the shoulder looking at the plan view, and buried to a depth of 1.0 to 2.0 m considering the softening of impact due to vehicles and the operation of valves, when seen from the cross-section view. The pipes should be designed so that they can be connected to the transmission lines when the transmission pipeline project (for the suburbs of Phnom Penh city) through ADB loan is completed in 2000.

(2) Valve arrangements

Forming a network and various blocks composed of the distribution pipeline systems is very effective in adopting a prompt response in the event of an accident or abnormal outflow during the work. Sluice valves should be installed in the branches from the main distribution line to suit the nature of the roads.

(3) Installation of fire hydrants

PPWSA has no installation standards for fire hydrants. The standards for this project were decided as given below, after referring to the standards of the Don Penh area project, which precedes the present project.

* Install fire hydrants of dia. 150 mm to 300 mm in areas where the population is dense.
* Install fire hydrants on roads that are wide enough to accommodate fire engines.

(4) Installation of air valves

Air valves should be installed based on the concepts below.

* Since all the branches from the secondary distribution pipelines to the water service pipelines are horizontal, air in the secondary distribution pipelines cannot be removed, therefore one air valve should be installed at one location in each small block.
* Air valve should be installed on the upwardly projecting part in the form of a siphon when the secondary distribution pipeline intercepts a buried object.

(5) Installation of water meters

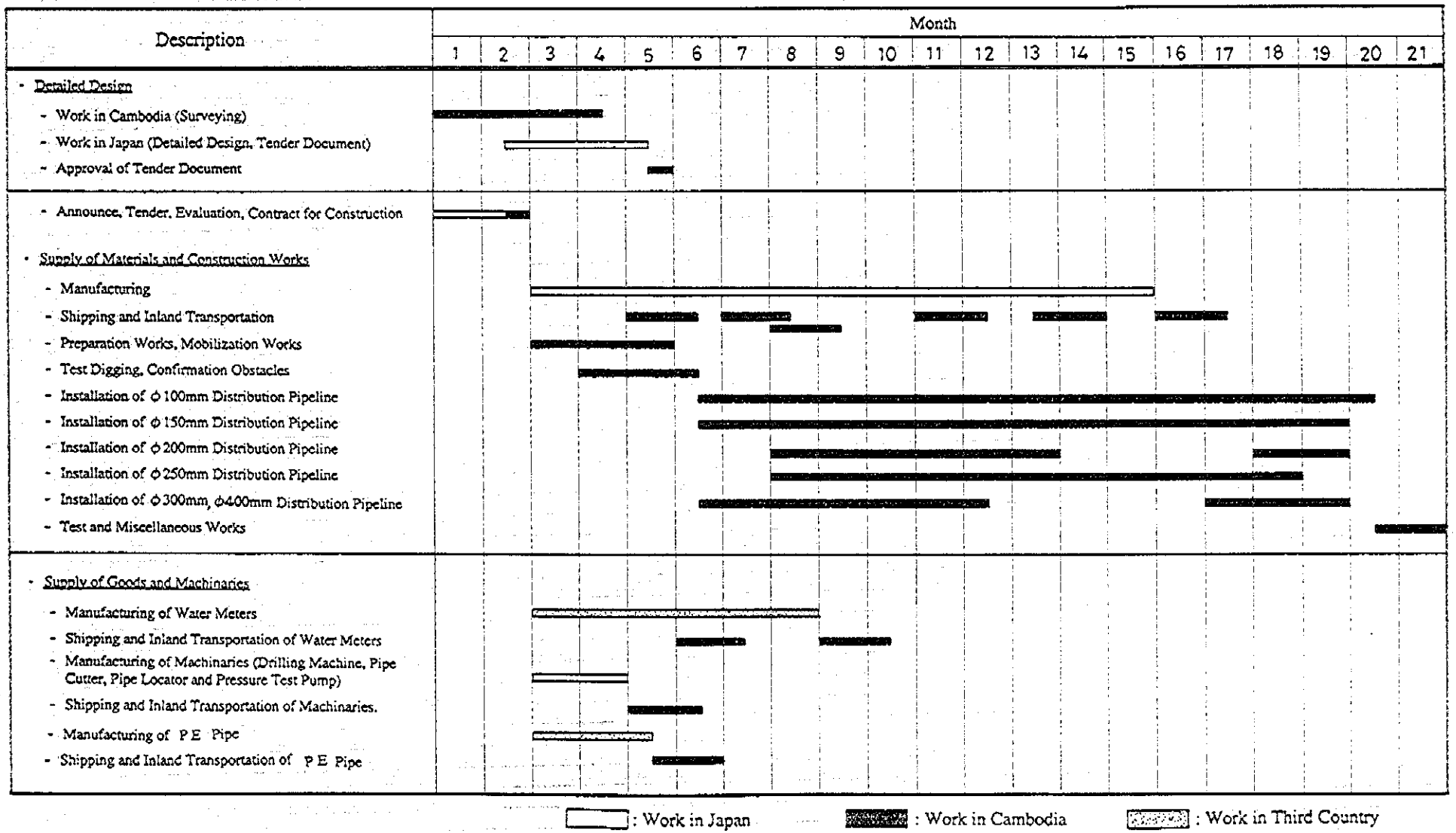
Water meters for industries and businesses should be installed on priority. They should be installed in distribution block units for domestic households. During the First Grant Aid Program, Chinese water meters were used and there were no problems. For this project also, water meters made in China may be used.

5) Policy on work schedule

The work in this project involves the installation of about 70 km of new distribution pipelines. The work site is located at the center of Phnom Penh city, and work has to be carried out during night time at many of the locations. In addition, restrictions on work, such as prohibition on the placing of excavated soil at temporary locations, restoration of excavated locations by the next day, are severe.

The work team on the Cambodian side consists of 8 groups. Priority is to be given to installation of water meters and installation of tertiary pipelines, and finally the Cambodian side has to carry out the work of connecting the tertiary branch lines and changing over the water supply in parallel with the work performed by the Japanese side, to complete the work of delivering water to domestic households. If the overall work stages are studied based on the above, 19 months are necessary for completion of the work. (Please refer to the table of work schedule.)

IMPLEMENTATION SCHEDULE



2-3-2 Basic Design

1) Overall Plan

The work in this project involves the maintenance (renewal of pipes) of distribution pipelines over a total area of 394 ha, which includes the Seventh January area (235 ha) and a part of the Toul Kork area (159 ha). The basic items related to the design of new distribution pipelines (renewal) are as described below.

* Water demand prediction
* Network analysis

(1) Water demand prediction

i) Target year

Presently, the maintenance of distribution pipelines is being implemented in the Don Penh district with the assistance of France. A transmission pipeline project is scheduled to start from 1997 with the help of ADB loans. The target year for this project is set as 2015, after considering the coordination with these associated water supply projects.

ii) Population served

PPWSA has determined the population in 2015, the target year, after setting the population increase by district, taking the base year as 1994. The Don Penh district project and the ADB project are also using the same population figure. This figure is to be adopted for the present project also for consistency with the other projects.

The Seventh January district is located at the center of the city, with a concentration of commercial establishments and middle-class apartment houses. The average annual increase in population is estimated as 1.00% based on the records of increase in recent years. The rate of increase in population varies in the Toul Kork district, but a simple average of 1.95% is taken to project the population. Based on the above figures, the population to be supplied with water in both the districts is 247,085. The population by area and the locations are shown in the figures below.

Current status and future population of Seventh January area

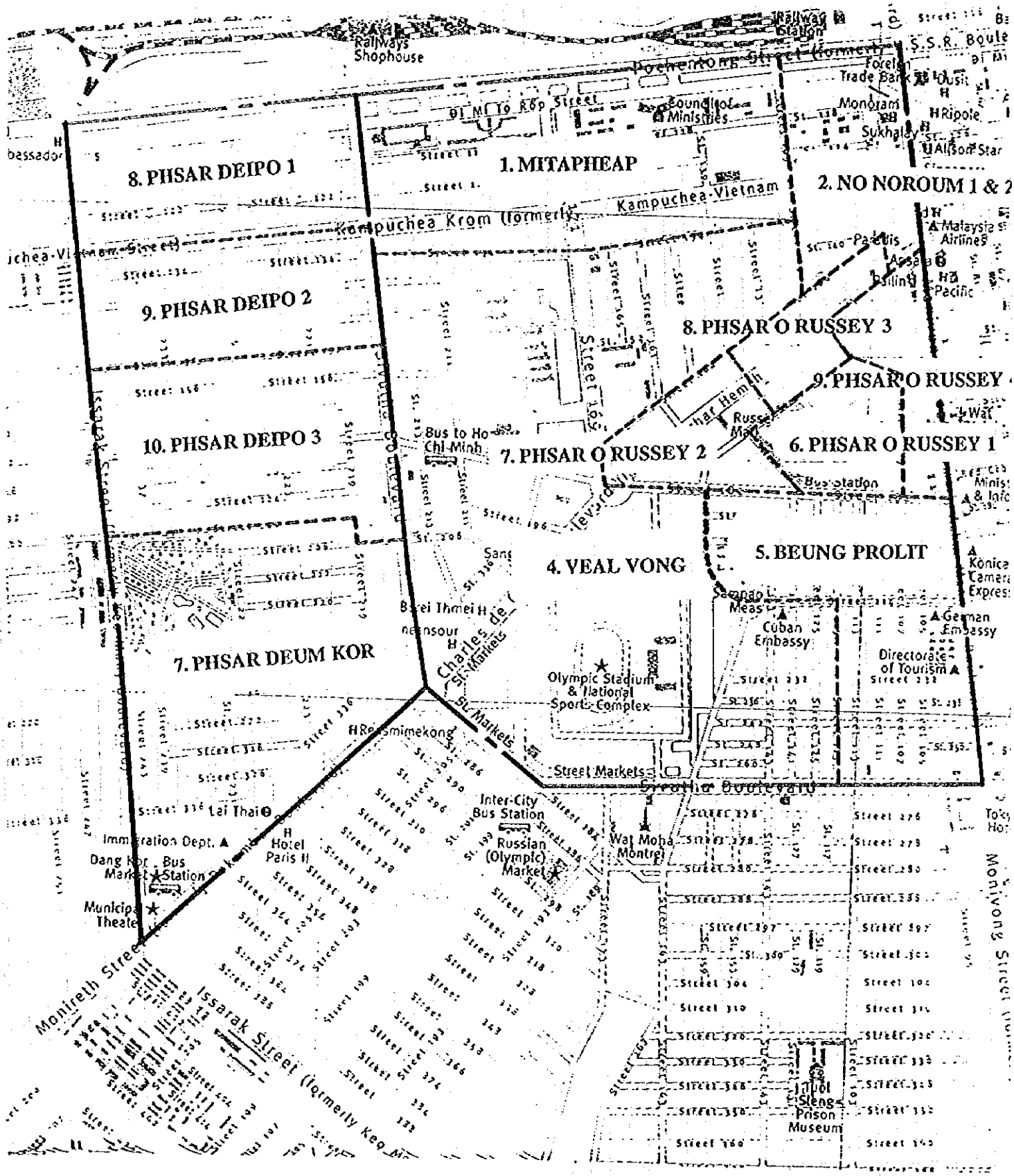
	District	1994	1998	2000	2010	2015	Growth Rate	Area (km^2)
1	Mitapheap	17,013	17,704	18,060	19,949	20,967	1.0%	0.45
2	Nonoroum 12	19,696	20,496	20,908	23,095	24,274	1.0%	0.24
3	Veal Vong	25,243	26,268	26,796	29,599	31,109	1.0%	0.74
4	Beung Prolit	18,009	18,740	19,117	21,117	22,194	1.0%	0.40
5	Phsar O Russey 1	14,834	15,437	15,747	17,394	18,282	1.0%	0.14
6	Phsar O Russey 2	16,608	17,283	17,630	19,475	20,468	1.0%	0.14
7	Phsar O Russey 3	12,961,	13,487	13,758	15,197	15,973	1.0%	0.11
8	Phsar O	14,523	15,112	15,416	17,029	17,898	1.0%	0.13

	Russey 4							
	Total	138,888	144,527	147,452	162,855	171,165		2.35

Current status and future population of Toul Kork area (part of area)

	District	1994	1998	2000	2010	2015	Growth Rate	Area (km^2)
7	Phsar Deumkor	15,435	15,449	15,621	15,937	16,097	0.2%	0.66
8	Phsar Deipo 1	12,132	13,185	13,743	16,918	18,771	2.1%	0.37
9	Phsar Deipo 2	11,291	12,270	12,790	15,745	17,469	2.1%	0.24
10	Phsar Deipo 3	11,686	13,358	14,282	19,953	23,583	3.4%	0.32
	Total	50,544	54,371	56,436	68,553	75,920		1.59

Location Map



iii) Per capita figures

According to actual studies by PPWSA, the average consumption per day in 1992 was 100 l/person.day. At this time, the leakage rate due to old distribution pipelines, is estimated to be close to 50%, and the load factor for maximum daily capacity at about 30%.

PPWSA estimates the per capita figures until 2000 to increase by approximately 5%. This rate increases because of the higher standard of living and this figure is considered to be appropriate. The leakage rate is estimated to become 20% in 2015, and with the progress in provision/maintenance of distribution pipelines, this figure will evidently decrease gradually. Based on the above, the figures according to the JICA Master Plan given below, are to be used for this project.

	2000	2010	2015
Per capita consumption (a)	150 lpcd	200 lpcd	200 lpcd
Max. to ave. daily demand ratio (b)	1.3	1.3	1.3
Per capital consumption (c) = (a) x (b)	195 lpcd	260 lpcd	260 lpcd
Leakage ratio (d)	40%	20%	20%
Per capita demand (e) = (c)/{1-(d)} (daily maximum)	325 lpcd	325 lpcd	325 lpcd

iv) Water demand

The water demand is obtained by multiplying the served population in (ii) and the per capita demand figures given in the table below.

Water demand in the study area

	Seventh January	2000	2010	2015
1	Mitapheap	5,870	6,483	6,814
2	Nonoroum 1, 2	6,795	7,506	7,889
3	Veal Vong	8,709	9,620	10,110
4	Beung Prolit	6,213	2,863	7,213
5	Phsar O Russey 1	5,118	5,653	5,942
6	Phsar O Russey 2	5,730	6,329	6,652
7	Phsar O Russey 3	4,471	4,939	5,191
8	Phsar O Russey 4	5,010	5,534	5,817
	Sub-total	47,916	52,927	55,628
	Toul Kork area			
7	Phsar Deum Kor	5,077	5,179	5,231
8	Phsar O Russey 1	4,466	5,498	6,100
9	Phsar O Russey 2	4,157	5,117	5,677
10	Phsar O Russey 3	4,642	6,484	7,665
	Sub-total	18,342	22,278	24,673
	Grand total	66,258	75,205	80,301

(2) Network analysis

It was decided to form a pipeline network so that new distribution pipelines can distribute water efficiently and steadily to the relevant areas in 2015. For this analysis, a software called "Picolo" developed by a French company, SAFEGE, which was also used for the JICA Master Plan in 1993, was used. The calculation program uses the basic equations of Hazen- Williams, assuming the energy level at each node to be an unknown quantity, and finding the energy level that satisfies the flow conditions at each node. The flow conditions here are based on the water demand by area in 2015.

i) Basic equation

$$H = 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85} * L$$

where,

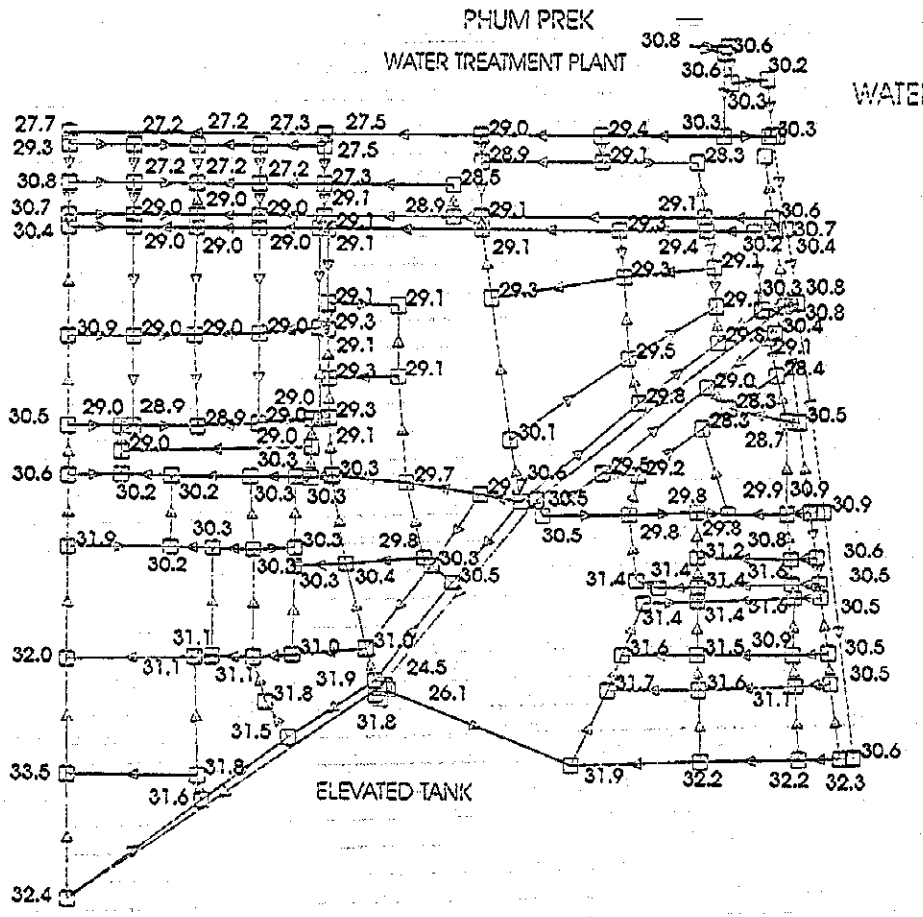
H (m): Head loss
C (130): Flow speed coefficient
D (m): Pipe diameter
Q (m^3/sec): Flow rate
L (m): Extension of pipeline

ii) Boundary conditions

* Minimum diameter of distribution pipeline: 100 mm
* Minimum pressure: Greater than 2.5 kg/cm^2 at the branches of distribution and service pipelines

iii) Calculation results

Based on the assumption that water is supplied to all households and commercial establishments in the relevant areas equally, distribution pipelines were assumed for all roads that can accommodate vehicles. The results gave a water pressure distribution in the range of 2.72 to 3.35 kg/cm^2 for the entire distribution network, and confirmed that water can be supplied equally at the appropriate pressure to the project areas.



WATER PRESSURE IN 7 TH JANUARY IN 2015

BRANCH DEFINITION

- BRANCH (D > 100.00 AND D <= 200.00)
- BRANCH (D > 200.00 AND D <= 300.00)
- BRANCH (D > 300.00 AND D <= 400.00)
- BRANCH (D > 400.00 AND D <= 500.00)
- BRANCH (D > 500.00)

The Results of Network Analysis

2) Facilities plan

(1) Distribution pipeline equipment

i) Design

The design is to be based on the prerequisite that the distribution pipelines can be connected to the transmission pipelines (diameter 900 to 1400 mm) that pass through the project area according to the plan making use of ADB loans.

ii) Type of pipe

The design accounts for a water pressure of 4.2 kg/cm^2 due to pump pressure at the Phum Prek water treatment plant. If the pressure of 2.1 kg/cm^2 due to water hammer (50% of pump lift) is added (when the pump is stopped suddenly), the maximum water pressure becomes 6.2 kg/cm^2. Four types of pipe can be used for this pressure - ductile cast iron pipes, steel pipes, hard PVC pipes, and polyethylene pipes. From these types, hard PVC and polyethylene pipes are vulnerable to external pressure (soil pressure). On the other hand, welded joints need to be used for steel pipes, and pipe-laying efficiency will drop drastically in the project areas where the level of underground water is high. Considering the above, ductile cast iron pipe was selected, and it was decided that the three most economical types of pipes should be used.

iii) Water pressure

The minimum dynamic pressure was set at 2.5 kg/cm^2 based on the standards for a three-story building. In the event of a fire, the minimum water pressure, same as in the normal situation should be available, but the load on the distribution pipeline would be excessive. Moreover, it is rare for a fire to occur during maximum flow. Therefore, it was decided that this would be adequate in the event of a fire, if existing fire hydrants develop the required pressure.

iv) Pipe diameter

The pipe diameter has already been decided in the pipeline network calculations, and is based on the fact that the distribution of dynamic water pressures in the distribution areas is uniform.

v) Pipe foundation

A sand bed of depth 10 cm using good quality soil was decided for the foundation.

vi) Protection of fittings

For protecting fittings, it was decided to use Mechanical Joint with Locking Bolts.

vii) Water pressure test

After installation of distribution pipelines in small block units, water pressure tests are to be carried out. The test should be carried out by injecting water gradually into the pipeline, pressurizing the pipeline to the required test pressure, maintaining the

pressure for a specific period of time, checking for defects in the pipe and studying the changes in pressure during this period of time.

(2) Fire hydrants

Similar to the Don Penh area, the hydrants will be installed at locations where houses are densely concentrated, near public facilities (markets, hospitals), and where fire engines can easily enter.

* One-hole fire hydrant: Installed in distribution pipelines of dia. 150 mm to dia. 300 mm (dia. 75 mm x dia. 65 mm: With compensating valve)
* Two-hole fire hydrant: Installed in distribution pipelines of dia. 300 mm and above (dia. 100 mm x dia. 65 mm: with compensating valve)

(3) Water meters

Considering the collection policy, installation of water meters in 100% of the households is necessary, but considering the existence of a large number of collective households (apartment houses), this figure was taken as 70% in concurrence with PPWSA.

i) Year of completion of distribution pipelines: End of 1998
ii) Population (in 1998 in the project area): Approximately 190,000
iii) Number of households: 190,000 / 6 persons per household x 70% ≈ 22,000
iv) Water meters already installed: 6,700 (as of 1995)
v) Water meters required: 22,000 - 6,700 ≈ 15,000
vi) Breakdown of water meters: Dia. 15 mm - 10,000 meters
Dia. 20 mm - 4,500 meters
Dia. 40 mm - 300 meters
Dia. 50 mm - 200 meters
vii) Country of manufacture: China (same as during the First Grant Aid Program)

(4) Paving plans

According to a public announcement by the Phnom Penh City Public Works and Transport Department, the paving of roads in the project area can be classified into the three types listed below.

* Type 1: Bitumen-paved roads (main roads)
* Type 2: Asphalt-paved roads (general roads)
* Type 3: Laterite or gravel-paved roads

For Types 1 and 2, permanent restoration is necessary after the temporary restoration as described below.

i) Immediately after laying the pipes, backfilling and tamping should be carried out, and temporary restoration carried out based on the specifications of the Public Works and Transport Department
ii) About 1 to 1.5 months after (i), the state of settlement due to consolidation should be observed.

iii) Since temporary restoration needs to be completed on the same day by the sub-contractor, permanent restoration work is to be performed by the City Public Works and Transport Department, which has the construction machinery for the paving work and paving materials, under the responsibility of the sub-contractor.

In Type 3, restoration to existing status is the general case. If settlement occurs later, laterite or sand can be used for paving.

(5) Dewatering / shuttering plans

The underground water level in the project area is high. For excavation and earth jobs, dewatering by pumps and shuttering using trench sheets are necessary.

3) Material plans

(1) Quantities of important materials

Equip.	Unit	ϕ100	ϕ150	ϕ200	ϕ250	ϕ300	ϕ400	Total
Ductile cast iron pipe	m	29,290	20,290	5,330	10,910	4,830	100	70,750
Sluice valve	loc.	295	156	18	48	19	0	536
Air valve	loc.	16	17	5	9	9	0	56
Sluice valve for tertiary branch	loc.	0	2	40	108	50	0	200
One-hole fire hydrant		0	23	6	17	0	0	46
Two-hole fire hydrant	loc.	0	0	0	0	7	0	7

Note: "loc." in the table above indicates number of locations.

(2) Specifications of important materials

* Ductile cast iron pipe (direct pipe): Mortar lining on inside surface, epoxy lining on outside surface, 3 types of pipe, K and T type joints
* Ductile cast iron pipe (fittings): Epoxy lining on inside and outside surfaces, K type joints
* Sluice valve: JIS 7.5 kg/cm^2, flange type, vertical sluice valve
* Air valve: JIS 7.5 kg/cm^2, flange type, air valve (dia. 75) with compensating valve
* One-hole fire hydrant: Ground/safe-strike-to-fall type dia. 75 x dia. 65
* Two-hole fire hydrant: Ground/safe-strike-to-fall type dia. 100 x dia. 65 x dia. 65
* Special joints for tertiary pipe connections: Loose flange dia. 75, PE valve socket (D90), PE reducer (D90 x D63), rubber packing, ball nut

(3) Material procurement quantities

No.	Name of material	Unit	Quantity
	Water meter		
1	Dia. 15 mm water meter	No.	10,000
2	Spare parts for above	Sets	2,000
3	Dia. 20 mm water meter	No.	4,500
4	Spare parts for above	Sets	900
5	Dia. 40mm water meter	No.	300
6	Spare parts for above	Sets	60
7	Dia. 50 mm water meter	No.	200
8	Spare parts for above	Sets	40
	Under-pressure drilling machine		
9	Manually-operated under-pressure drilling machine (drill diameter: 13 mm, 20 mm, 25 mm)	Sets	8
10	Power-operated under-pressure drilling machine (drill diameter: 40 mm, 50 mm)	Sets	2
11	Steel pipe/cable detector	Sets	4
12	Auto pipe cutter	Sets	1
13	Water pressure testing pump	Units	2
14	Polyethylene pipe (including fittings) for tertiary distribution pipeline - D90, D63	m	8500, 12500

(4) Specifications of materials to be procured

i) Water meter

- Type: Dry vane wheel type water meter
- Flow rate

Bore	Qmax (m^3/h)	Qn (m^3/h)	Qmin (m^3/h)
13(15)	3.0	1.5	0.03
20	5.0	2.5	0.05
40	20.0	10.0	0.2
50	30.0	15.0	0.5

Qmax: Maximum instantaneous flow rate; Qn: Nominal flow rate; Qmin: Minimum accurate flow rate

- Tolerance: Minimum flow rate ± 5%
- Operating temperature: 0°C to 50°C
- Operating water pressure: ≤1 MPa
- Water pressure loss: ≤ 0.1 MPa
- Accessories: Digital unit (Meter quantity x 20%)

ii) Under-pressure drilling machine

* Hole diameter: 13 (15) mm, 20 mm, 25 mm

- Type: Manually-operated type
- Stroke: 240 mm
- Type of pipe drilled: Cast iron pipe, polyethylene pipe
- Accessories:
  25 mm x 13 mm adapter - 3 no.
  25 mm x 20 mm adapter - 3 no.
  Drill for cast iron pipe: 13 mm - 50 no.; 20 mm - 30 no., 25 mm - 20 no.
  Drill for polyethylene pipe: 13 mm - 30 no., 20 mm - 20 no.; 25 mm - 15 no.
  Tools - 1 set

* Drilled hole diameter: 40 mm, 50 mm

- Type: Power-driven
- Stroke: 240 mm
- Type of pipe drilled: Cast iron pipe, polyethylene pipe
- Accessories:
  40 mm wrench - 3 no.
  50 mm wrench - 3 no.
  40 mm cutter - 6 pairs
  50 mm cutter - 6 pairs
  Gasoline engine - 2 no.
  Flexible shaft - 3 no.
  Tools - 1 set

iii) Steel pipe/cable detector

- Detecting functions: Positioning function - ±2 cm at a depth of 1.2 m; ±25 cm at depths less than 5 m
  Depth detection: ±5% at a depth of 2 m; ±10% at a depth of less than 5 m
  Detecting distance: Differential connection bar antenna - 340 m ±10%
  : Connection bar antenna - 420 m ±10%
- Electrical specifications: Transmitter:
  : Transmission output - 0.5 W
  : Transmission frequency - 100 kHz
  : Power supply voltage - 9 V (UM1 x6)
  : Power supply current - 1000 mA approximately
- Receiver: Receiving frequency - 100 kHz
  : Receiving sensitivity - Less than 2 microvolts
  : Antenna type - Bar antenna differential connection
  : Power supply voltage - 9 V (UM1 x6)
  : Power supply current - 1000 mA approximately
- Components: Transmitter -1
  Receiver - 1
  Antenna for steel pipe detector - 1
  DC connecting wire - 1

Earth wire - 1
Shoulder strap - 1
Safety work flag - 1
External magnetic coil - 1
Wire for external magnetic coil - 1
Case for storage - 1

(iv) Auto pipe cutter (for cast iron pipes)

- Flexible shaft: 10 m
- Diameter of pipe cut: 100 mm to 700 mm
- Power: Engine, 5 HP at 3600 rpm
- Spares: Flexible shaft - 10 m x 2 no.; engine - 1 no.; blades - 50 no.

v) Water pressure testing pump

- Pressure- 50 kg/cm^2
- Intake flow rate - 35 l/min.
- Prime mover - 182 cc, output - 3.5 to 5.0 PS, recoil start
- No. of blank jars - 3
- Bore diameter: Intake - PF 3/4; priming - PF 1/2; discharge - 1/2

vi) Polyethylene pipe

- Type: High density polyethylene pipe
- Density: 0.492 g/cm^3
- Water absorption rate: 0.03%
- Tensile yield strength: Greater than 19.6 N/mm^2 (greater than 200 kgf/cm^2)
- Flexural strength: Greater than 19.6 N/mm^2 (greater than 200 kgf/cm^2)
- Flexural modulus: Greater than 784 N/mm^2 (greater than 8000 kgf/cm^2)
- Coefficient of thermal conductivity: 0.46 to 0.50 W/m.K
- Softening temperature: Greater than 115°C

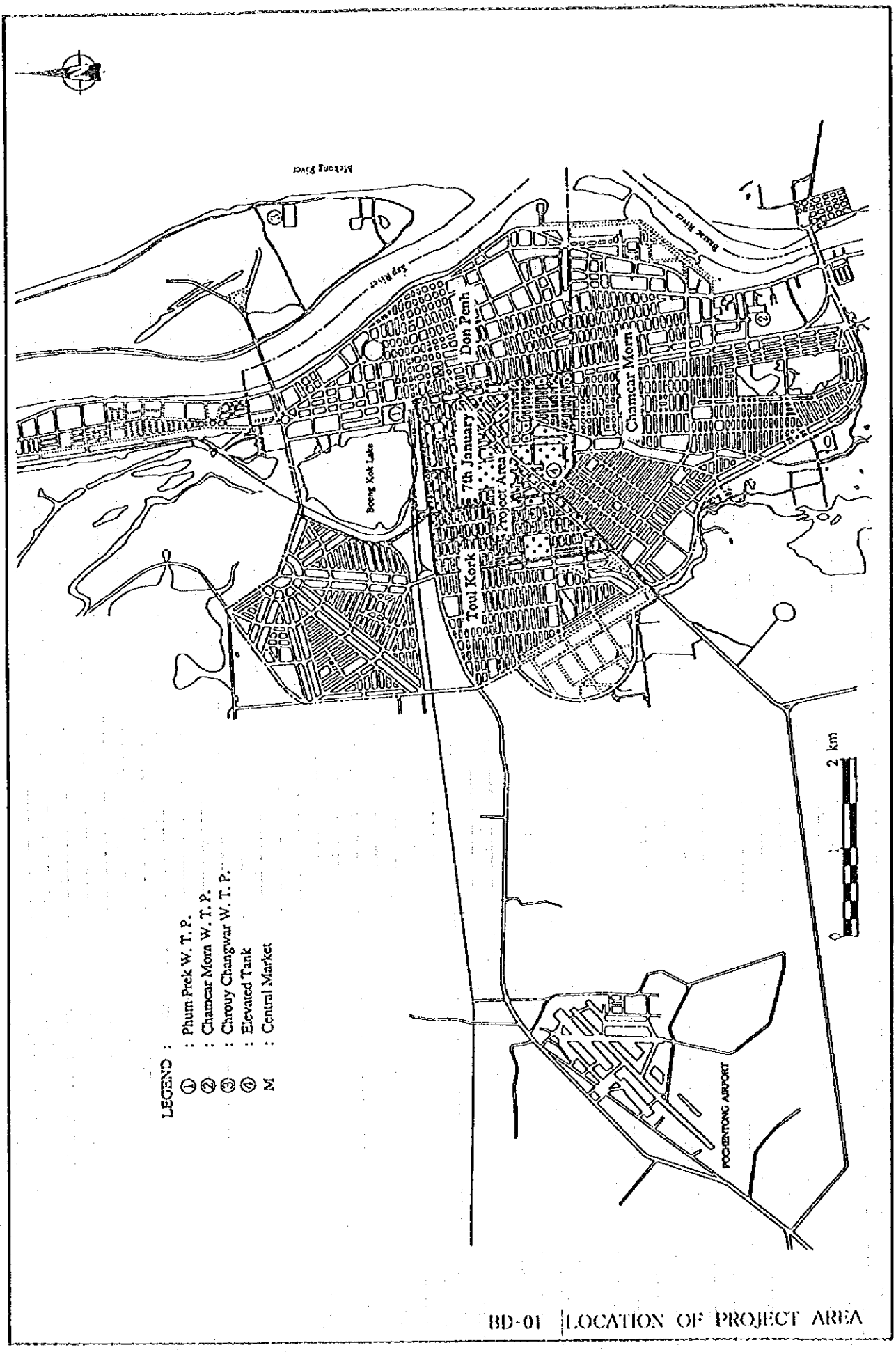
4) Basic design drawings

The total number of basic design drawings is 37 and include drawings showing location of project area, key maps, pipeline installation drawings, standard drawings of horizontal sluice valves, standard drawings of air valve chamber and vertical sluice valve, standard pipe crossing drawings, and installation drawings of one-hole and two-hole fire hydrants.

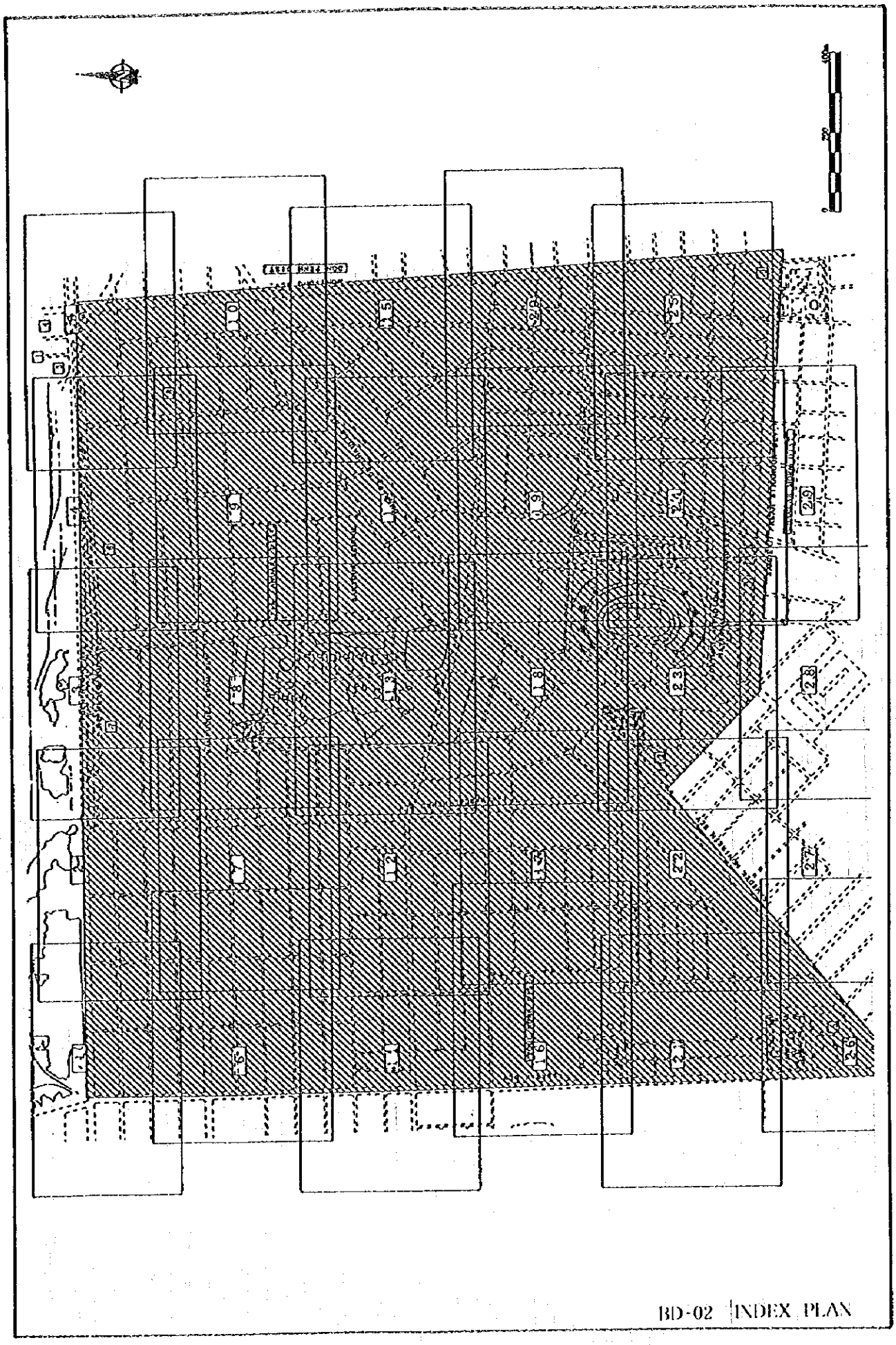
THE PROJECT FOR IMPROVEMENT OF WATER SUPPLY FACILITIES IN PHNOM PENH, PHASE-II
THE KINGDOM OF CAMBODIA
INDEX OF DRAWINGS

Drawing No.	TITLE
BD-01	LOCATION OF PROJECT AREA
BD-02	INDEX PLAN
BD-03	PLAN OF DISTRIBUTION PIPELINE (1 / 29)
BD-04	PLAN OF DISTRIBUTION PIPELINE (2 / 29)
BD-05	PLAN OF DISTRIBUTION PIPELINE (3 / 29)
BD-06	PLAN OF DISTRIBUTION PIPELINE (4 / 29)
BD-07	PLAN OF DISTRIBUTION PIPELINE (5 / 29)
BD-08	PLAN OF DISTRIBUTION PIPELINE (6 / 29)
BD-09	PLAN OF DISTRIBUTION PIPELINE (7 / 29)
BD-10	PLAN OF DISTRIBUTION PIPELINE (8 / 29)
BD-11	PLAN OF DISTRIBUTION PIPELINE (9 / 29)
BD-12	PLAN OF DISTRIBUTION PIPELINE (10 / 29)
BD-13	PLAN OF DISTRIBUTION PIPELINE (11 / 29)
BD-14	PLAN OF DISTRIBUTION PIPELINE (12 / 29)
BD-15	PLAN OF DISTRIBUTION PIPELINE (13 / 29)
BD-16	PLAN OF DISTRIBUTION PIPELINE (14 / 29)
BD-17	PLAN OF DISTRIBUTION PIPELINE (15 / 29)
BD-18	PLAN OF DISTRIBUTION PIPELINE (16 / 29)

Drawing No.	TITLE
BD-19	PLAN OF DISTRIBUTION PIPELINE (17 / 29)
BD-20	PLAN OF DISTRIBUTION PIPELINE (18 / 29)
BD-21	PLAN OF DISTRIBUTION PIPELINE (19 / 29)
BD-22	PLAN OF DISTRIBUTION PIPELINE (20 / 29)
BD-23	PLAN OF DISTRIBUTION PIPELINE (21 / 29)
BD-24	PLAN OF DISTRIBUTION PIPELINE (22 / 29)
BD-25	PLAN OF DISTRIBUTION PIPELINE (23 / 29)
BD-26	PLAN OF DISTRIBUTION PIPELINE (24 / 29)
BD-27	PLAN OF DISTRIBUTION PIPELINE (25 / 29)
BD-28	PLAN OF DISTRIBUTION PIPELINE (26 / 29)
BD-29	PLAN OF DISTRIBUTION PIPELINE (27 / 29)
BD-30	PLAN OF DISTRIBUTION PIPELINE (28 / 29)
BD-31	PLAN OF DISTRIBUTION PIPELINE (29 / 29)
BD-32	TYPICAL DRAWING OF HORIZONTAL SLUICE VALVE CHAMBER
BD-33	TYPICAL DRAWING OF AIR VALVE CHAMBER & VERTICAL SLUICE VALVE BOX
BD-34	TYPICAL DRAWING OF PIPE CROSSING UNDER WAY
BD-35	TYPICAL DRAWING OF SINGLE MOUTH & DOUBLE MOUTH GROUND TYPE FIRE HYDRANT
BD-36	TYPICAL DRAWING OF TRENCH EXCAVATION & PAVEMENT



BD-01 LOCATION OF PROJECT AREA



BD-02 INDEX PLAN

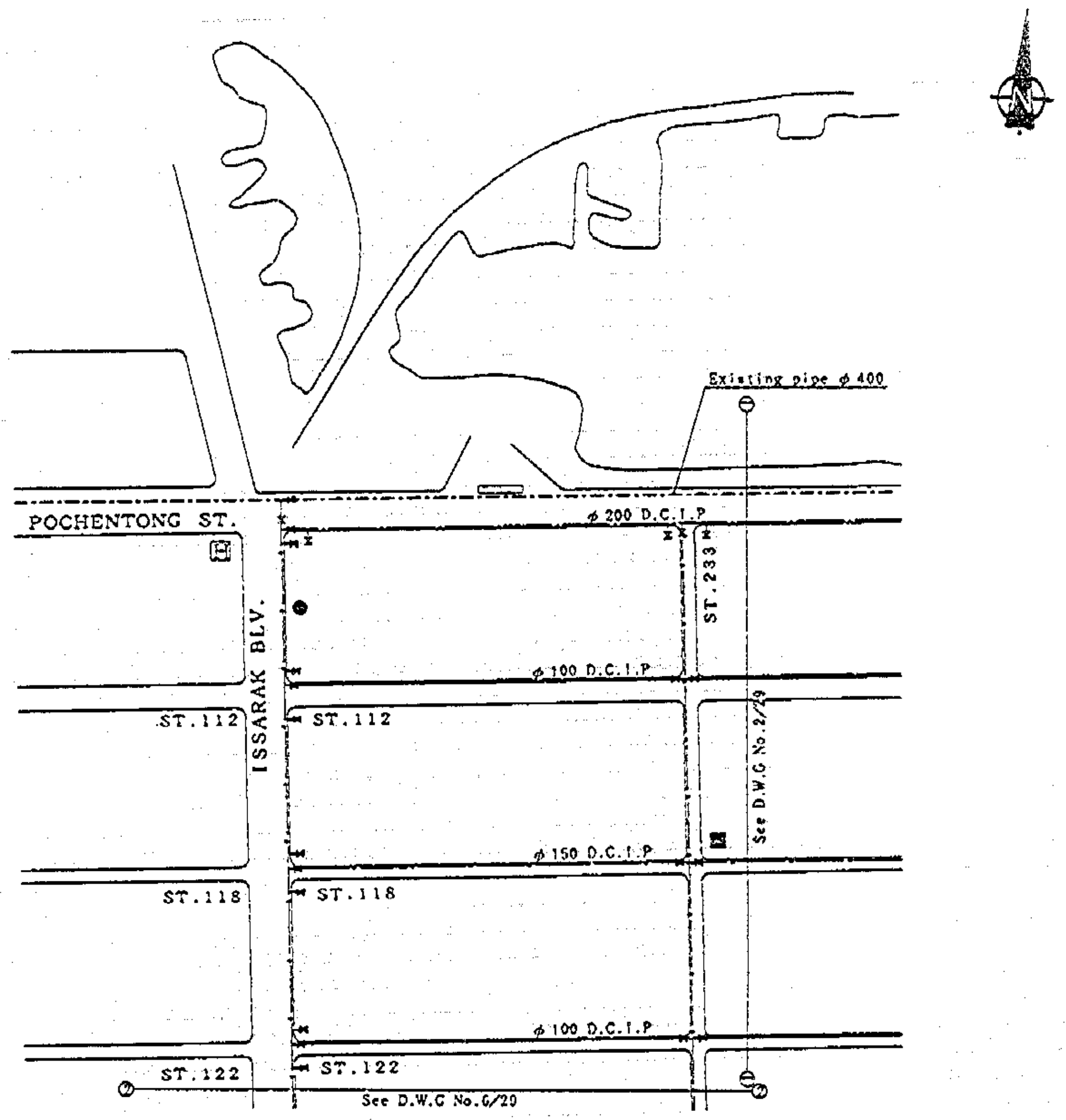
LEGEND:

- -------- Boundary
- [H] Hotel
- [M] Market

1. PHUM PREK W.T.P
2. ELEVATED WATER TANK
3. RAILWAY STATION
4. STUPA WITH BUDDHA RELIC
5. MUNICIPAL THEATER
6. COUNCIL OF MINISTRIES
7. MINISTRY OF NATIONAL DEFENCE
8. MINISTRY OF HEALTH
9. TRAINING CENTER MINISTRY OF POSTS & TELECOMMUNICATIONS

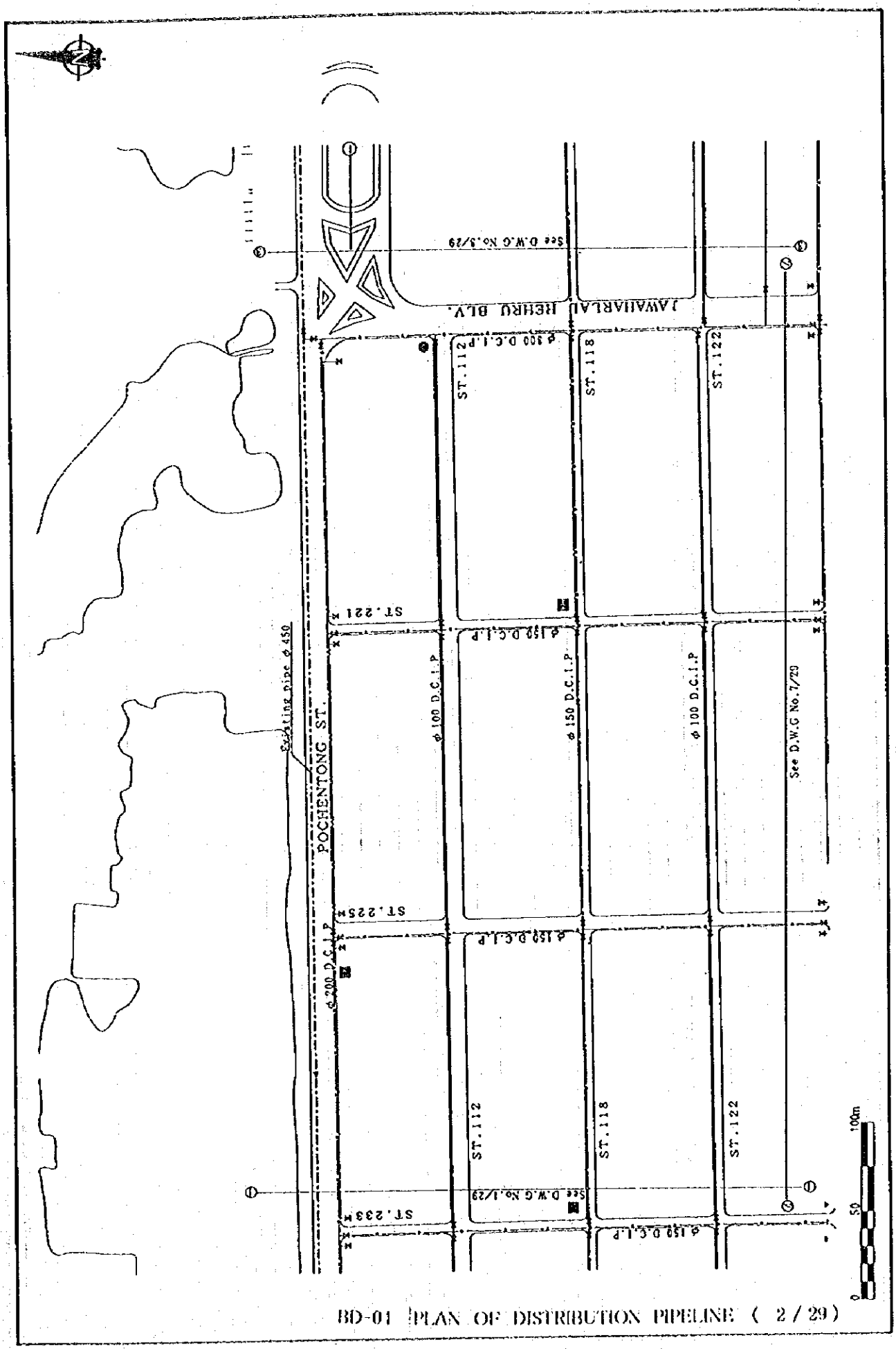
- ϕ 100 D.C.I.P
- ϕ 150 D.C.I.P
- ϕ 200 D.C.I.P
- ϕ 250 D.C.I.P
- ϕ 300 D.C.I.P

- ● FIRE HYDRANT (GROUND TYPE , DOUBLE)
- ■ 〃 (〃 , SINGLE)
- ISOLATING VALVE

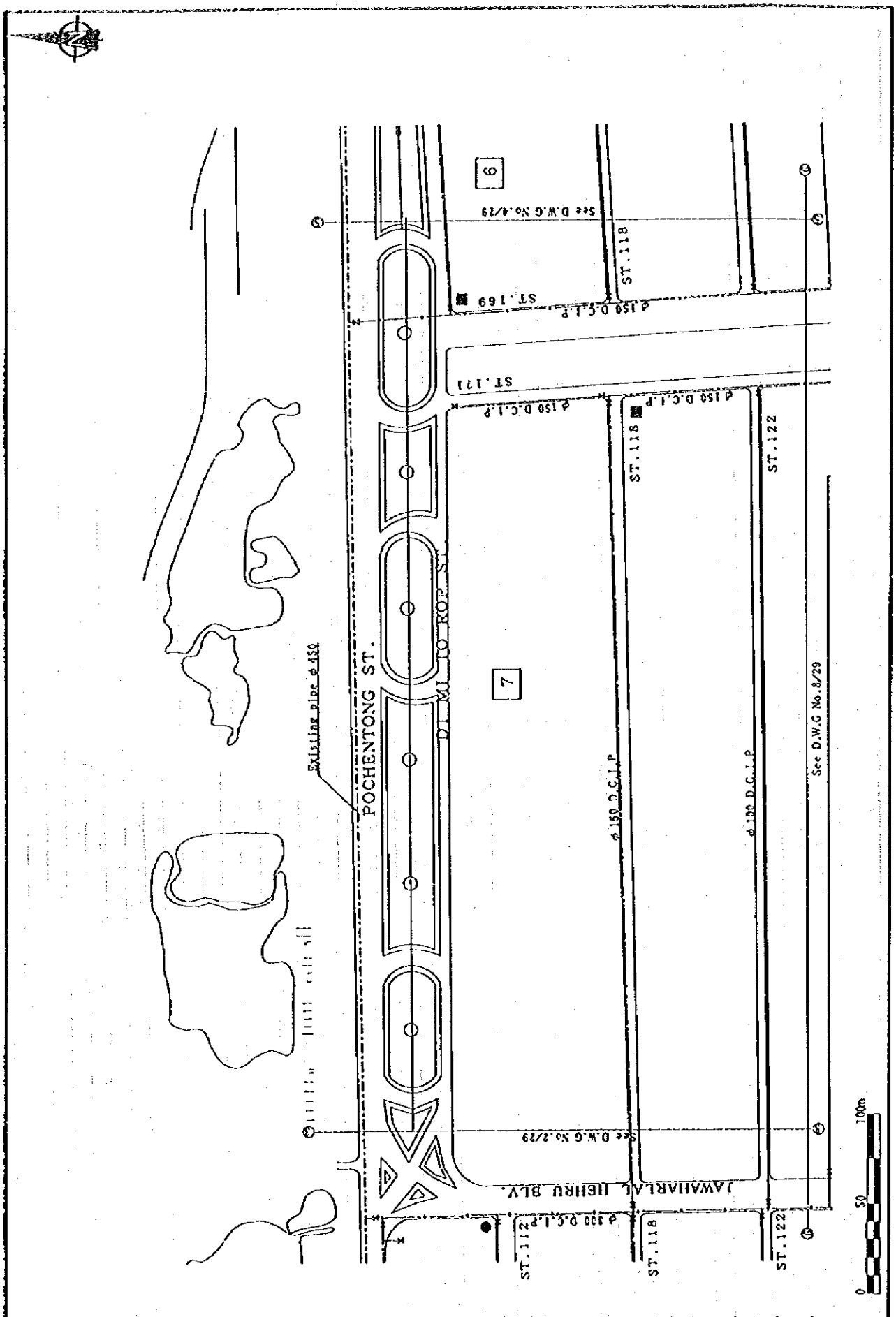


0 50 100m

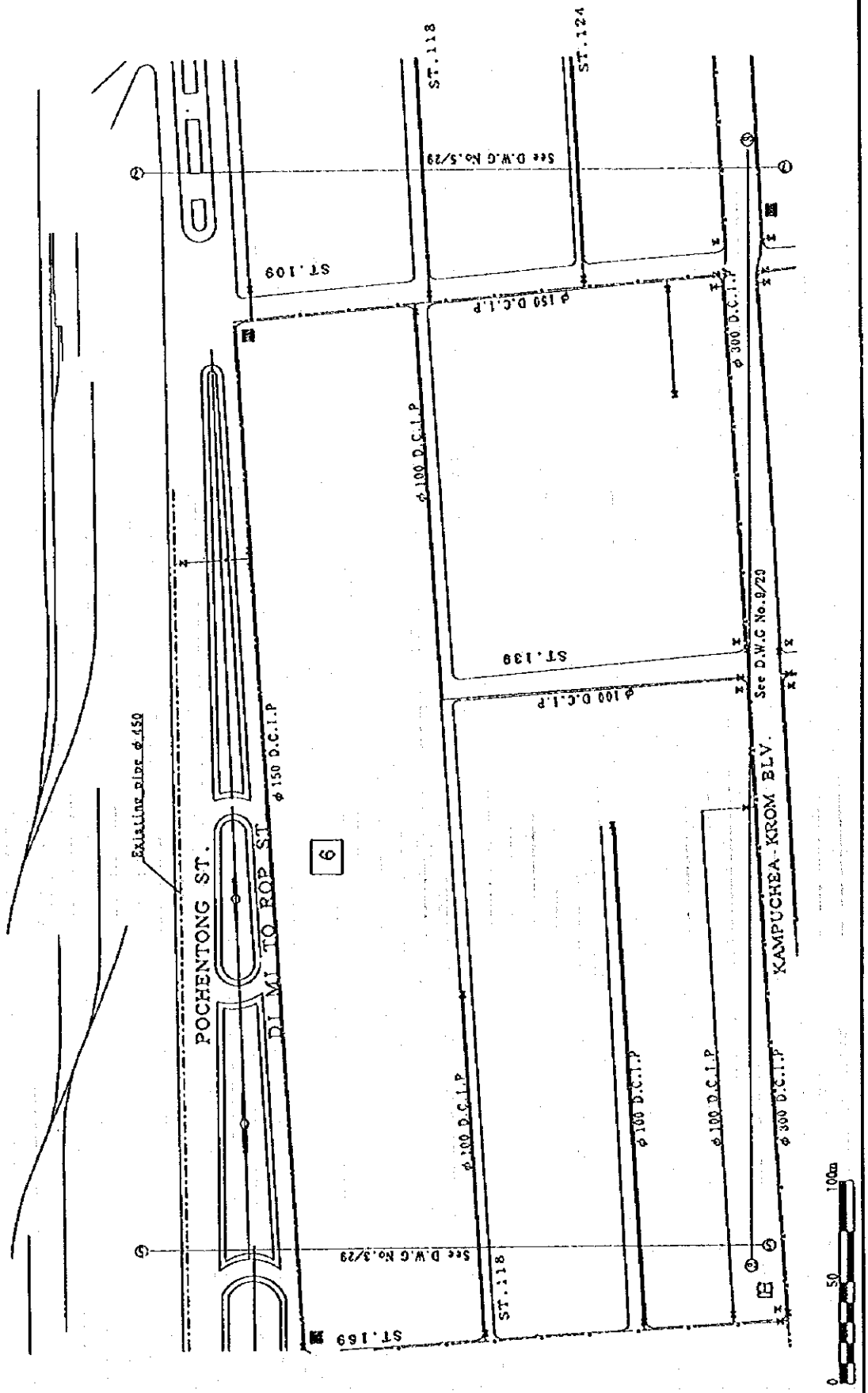
BD-03 PLAN OF DISTRIBUTION PIPELINE (1 / 29)



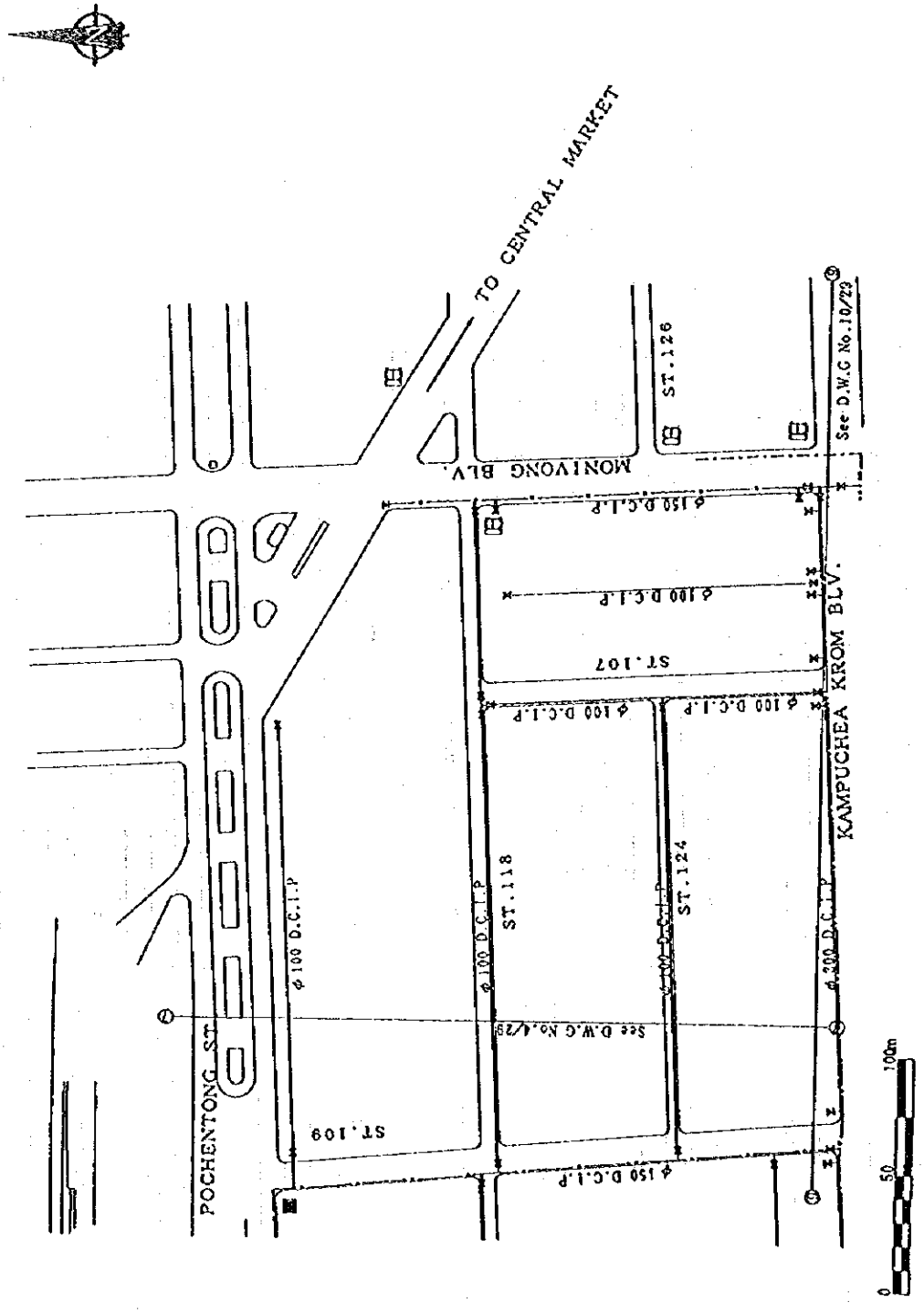
BD-01 PLAN OF DISTRIBUTION PIPELINE (2 / 29)



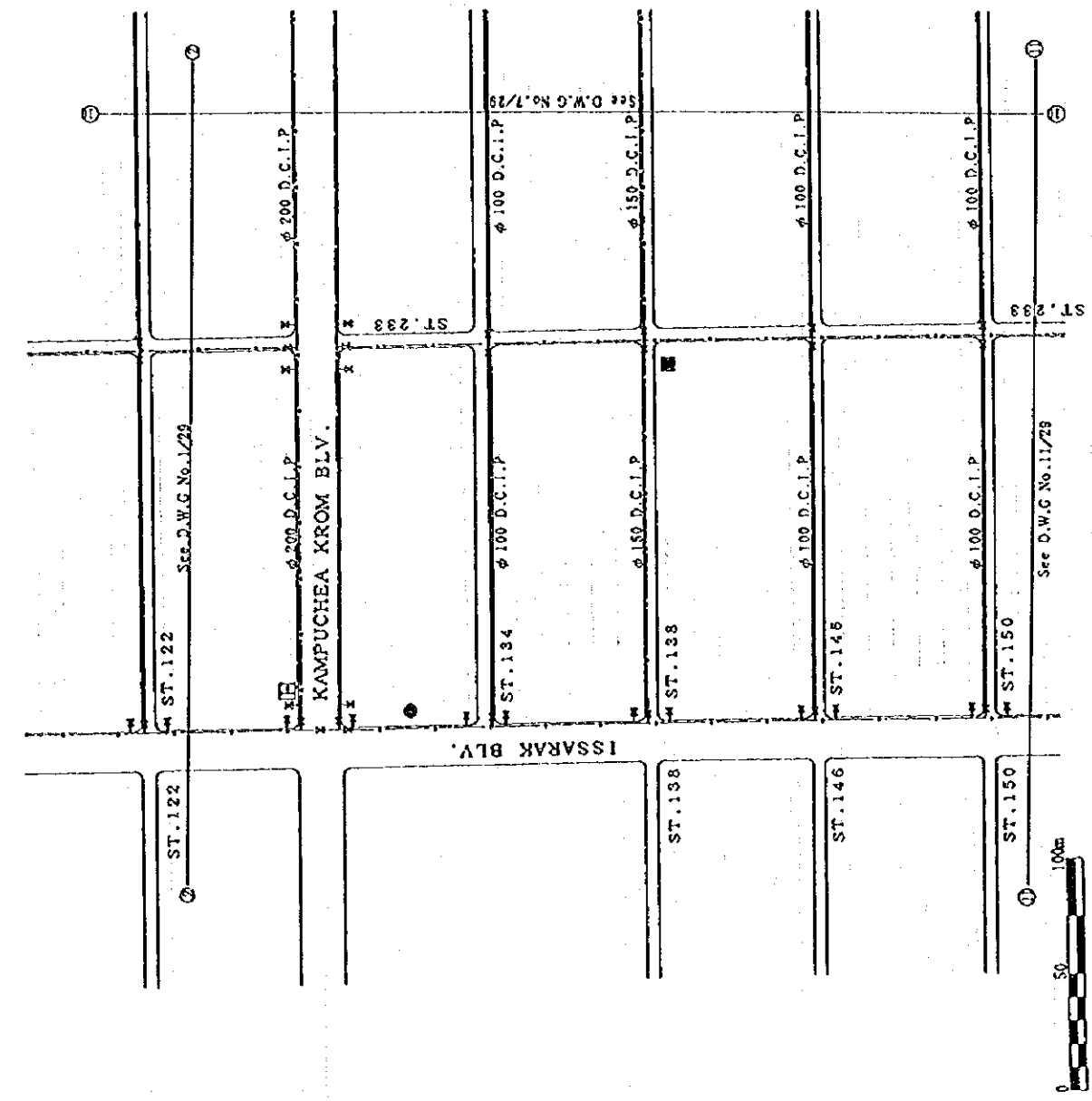
BD-05 PLAN OF DISTRIBUTION PIPELINE (3 / 29)



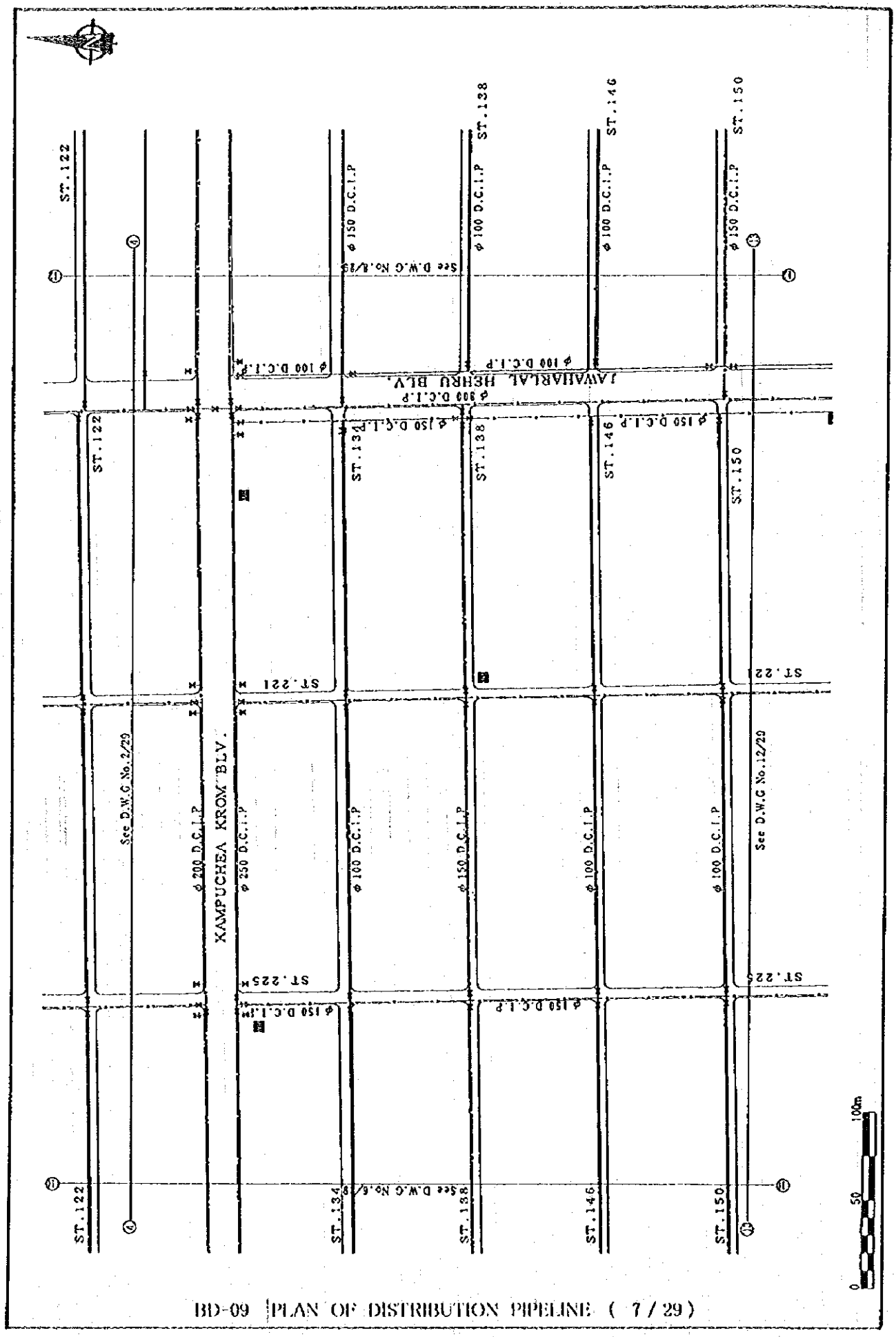
BD-06 PLAN OF DISTRIBUTION PIPELINE (1 / 29)



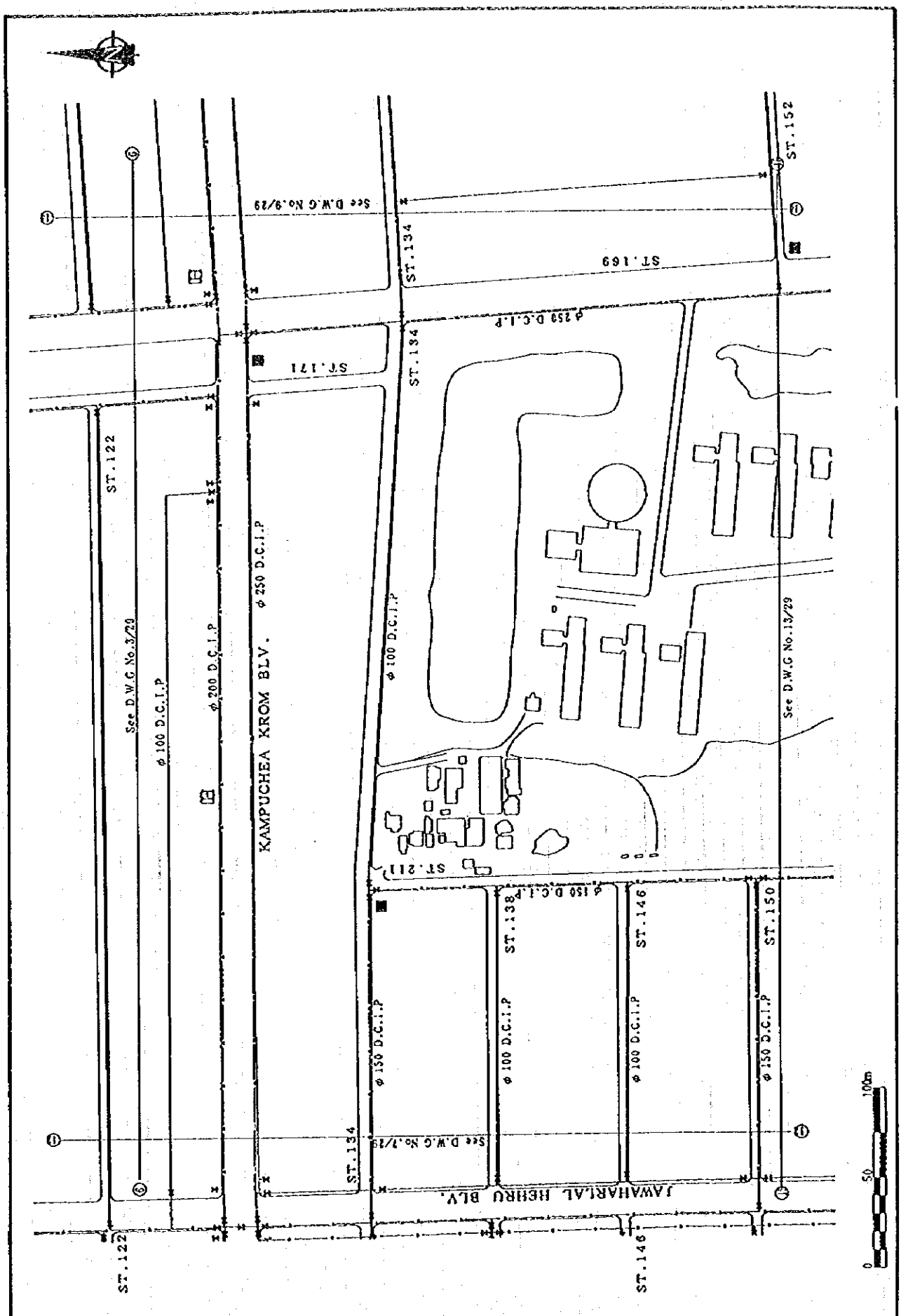
BD-07 PLAN OF DISTRIBUTION PIPELINE (5 / 29)



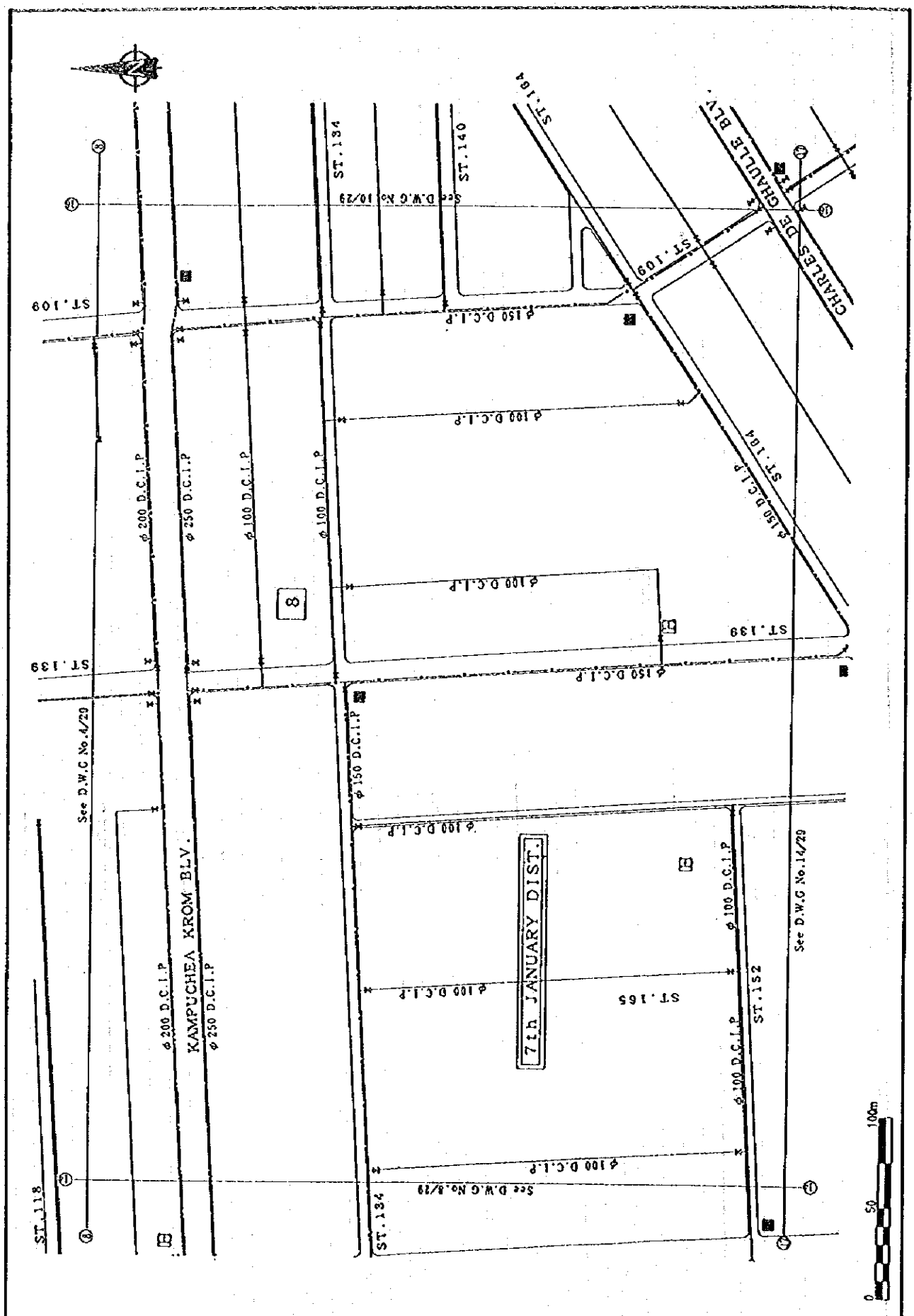
BD-08 PLAN OF DISTRIBUTION PIPELINE (6 / 29)



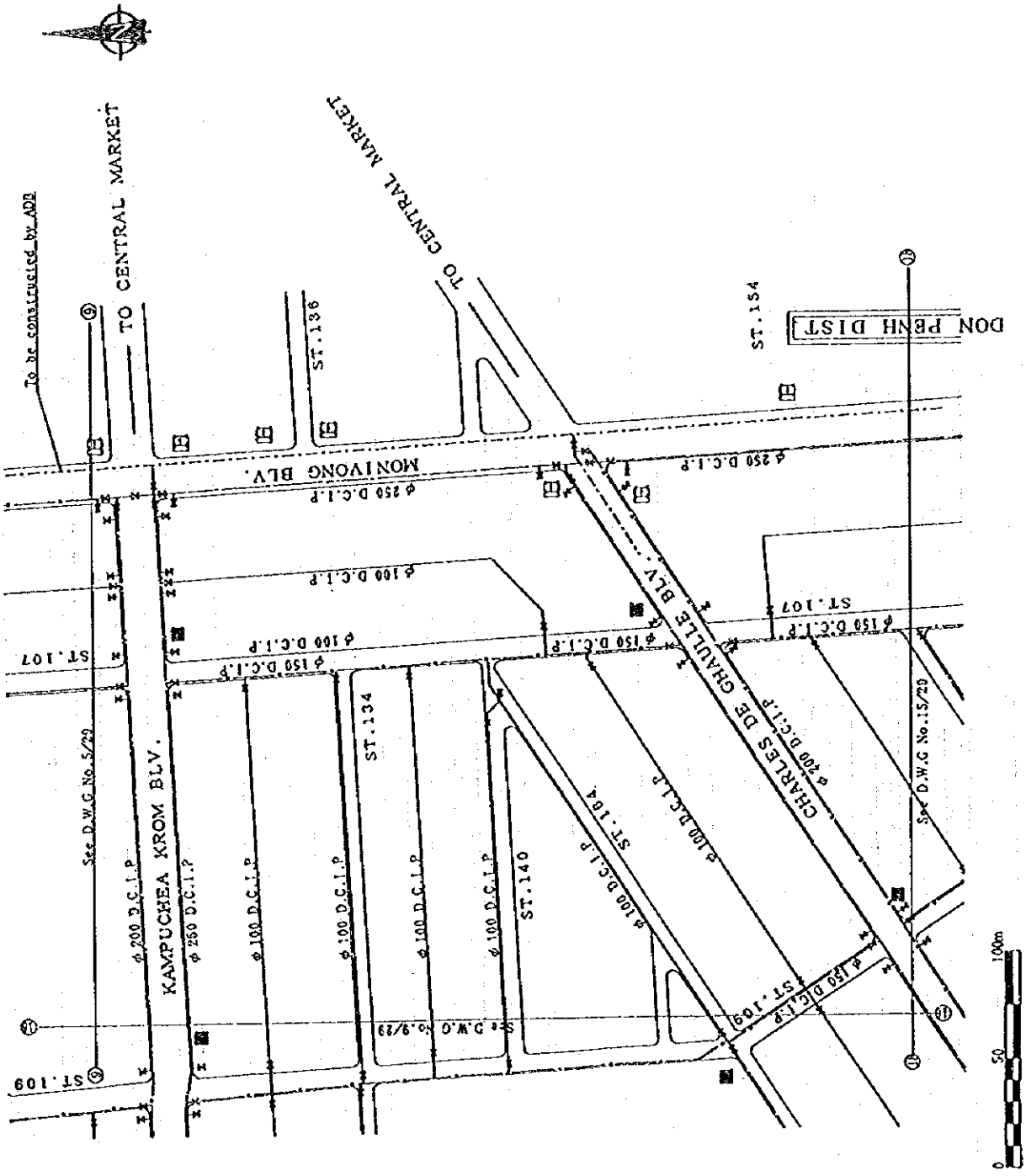
BD-09 PLAN OF DISTRIBUTION PIPELINE (7 / 29)



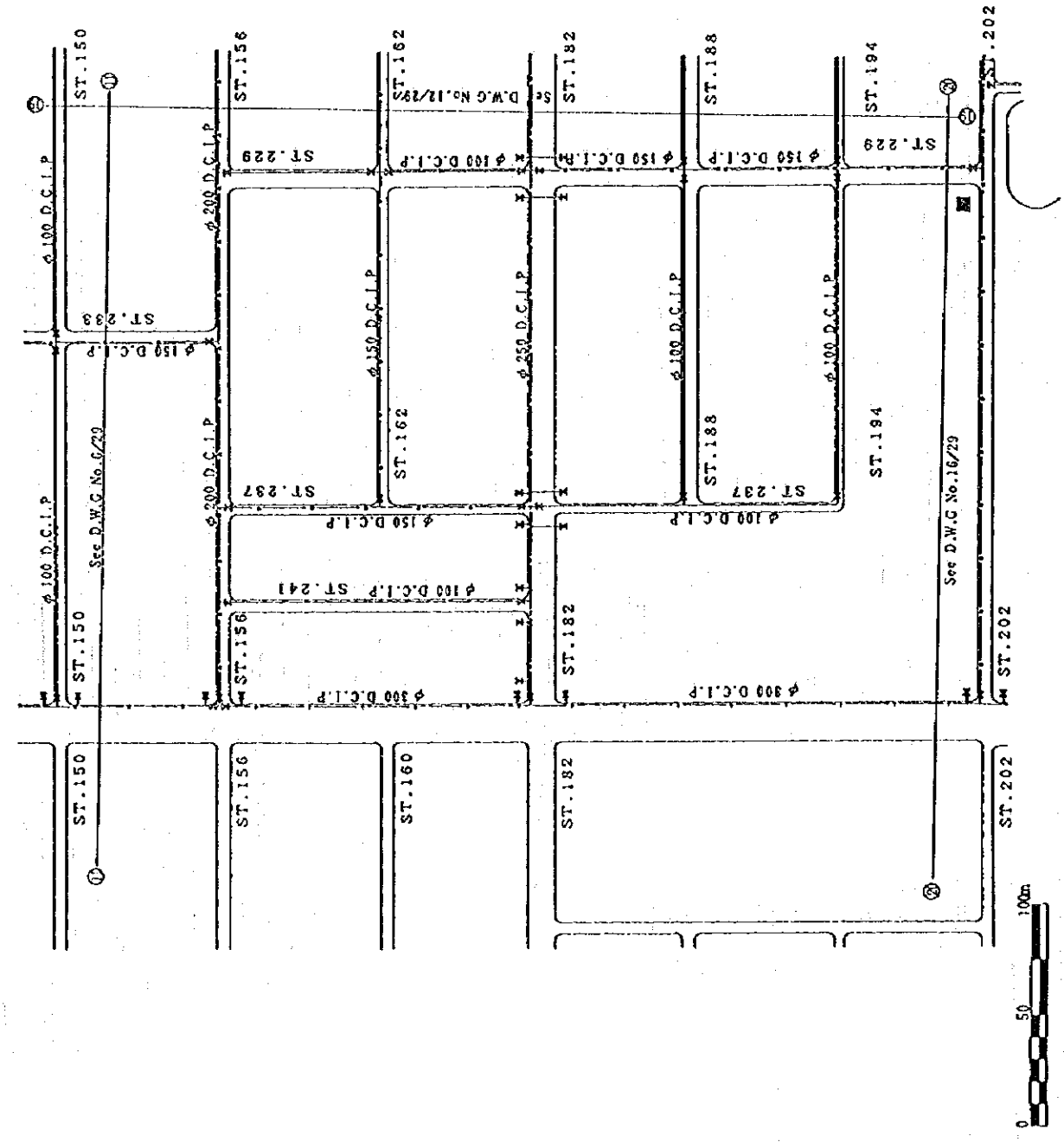
BD-10 PLAN OF DISTRIBUTION PIPELINE (8 / 29)



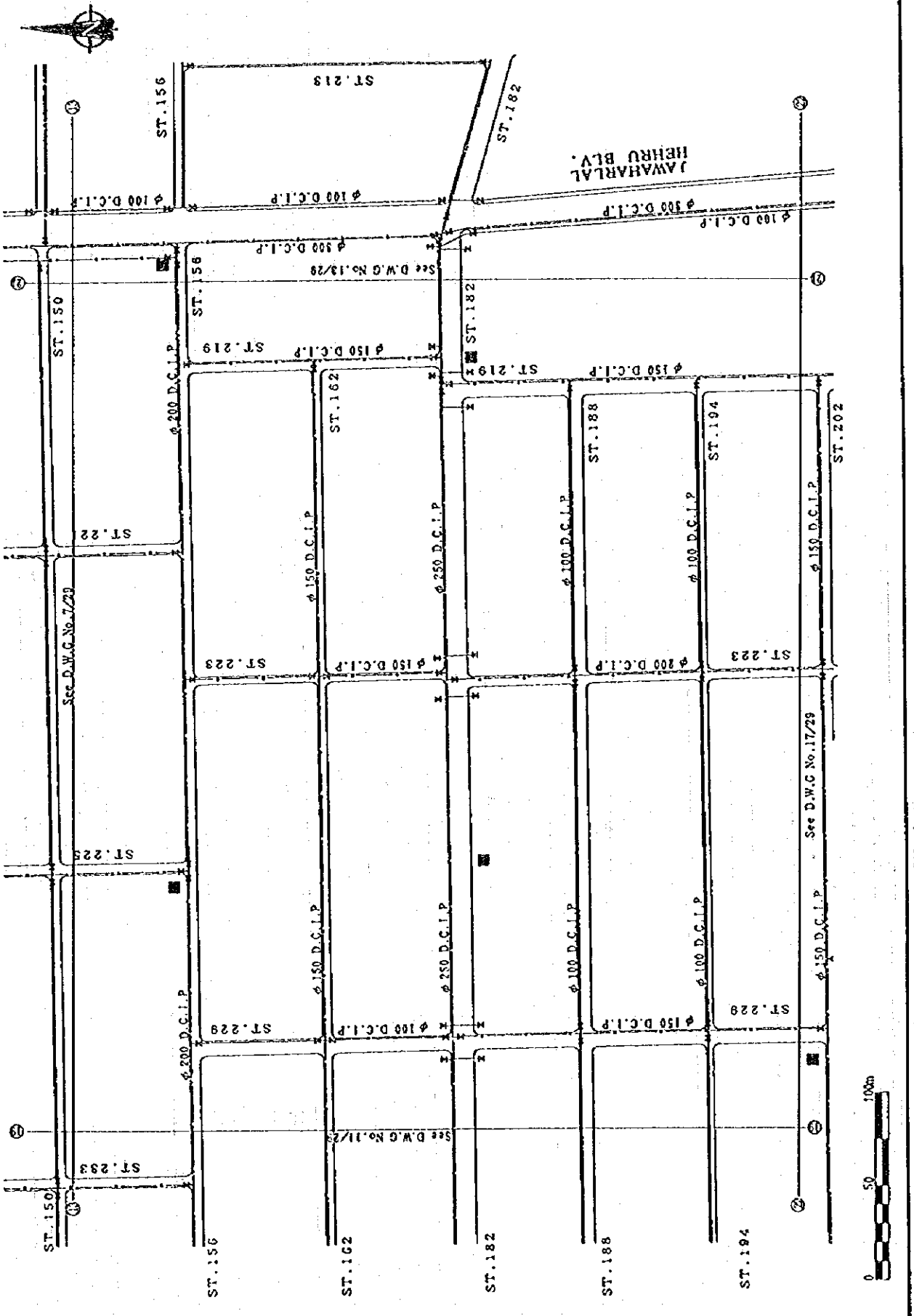
BD-11 PLAN OF DISTRIBUTION PIPELINE (9 / 29)



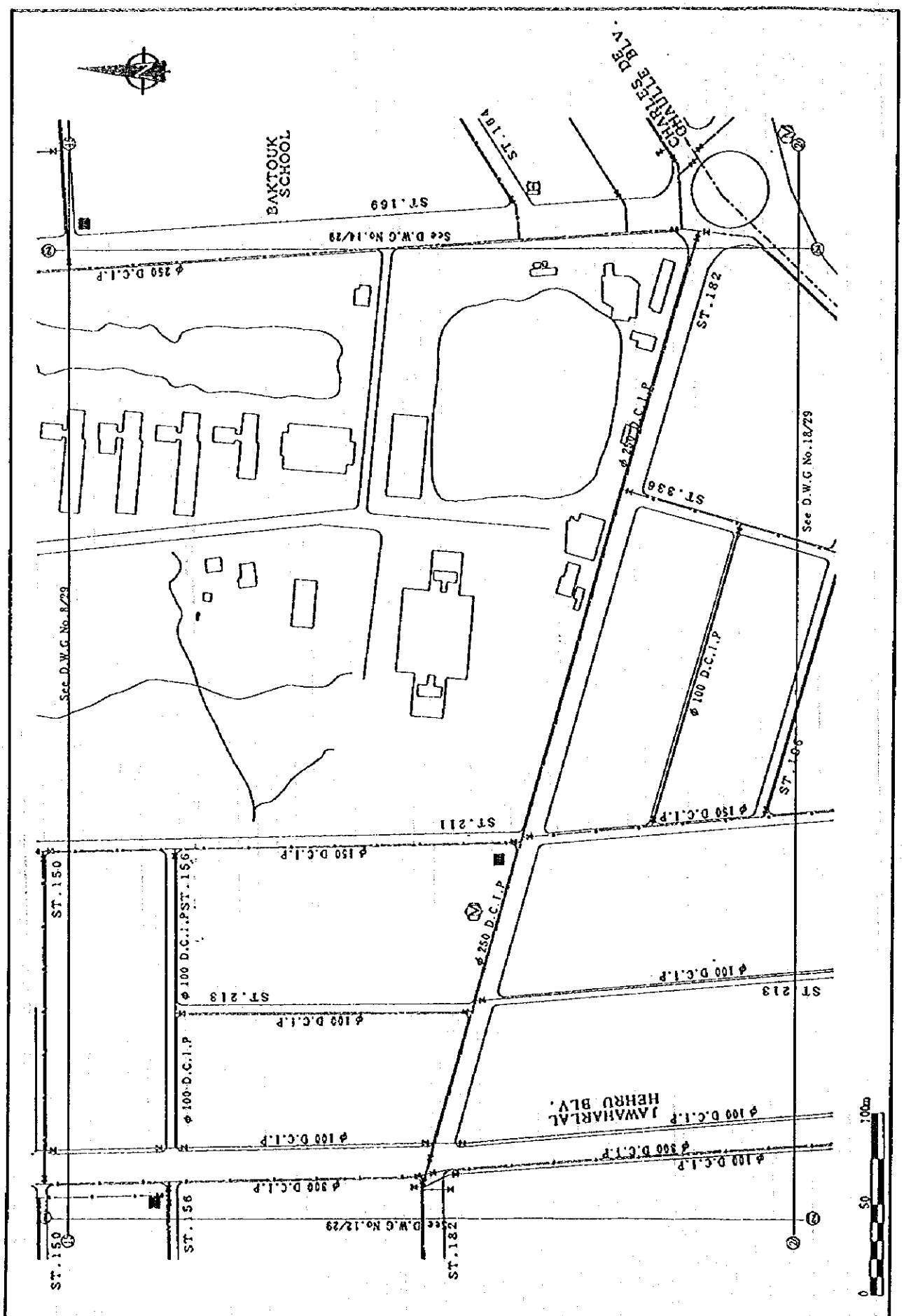
BD-12 PLAN OF DISTRIBUTION PIPELINE (10 / 29)



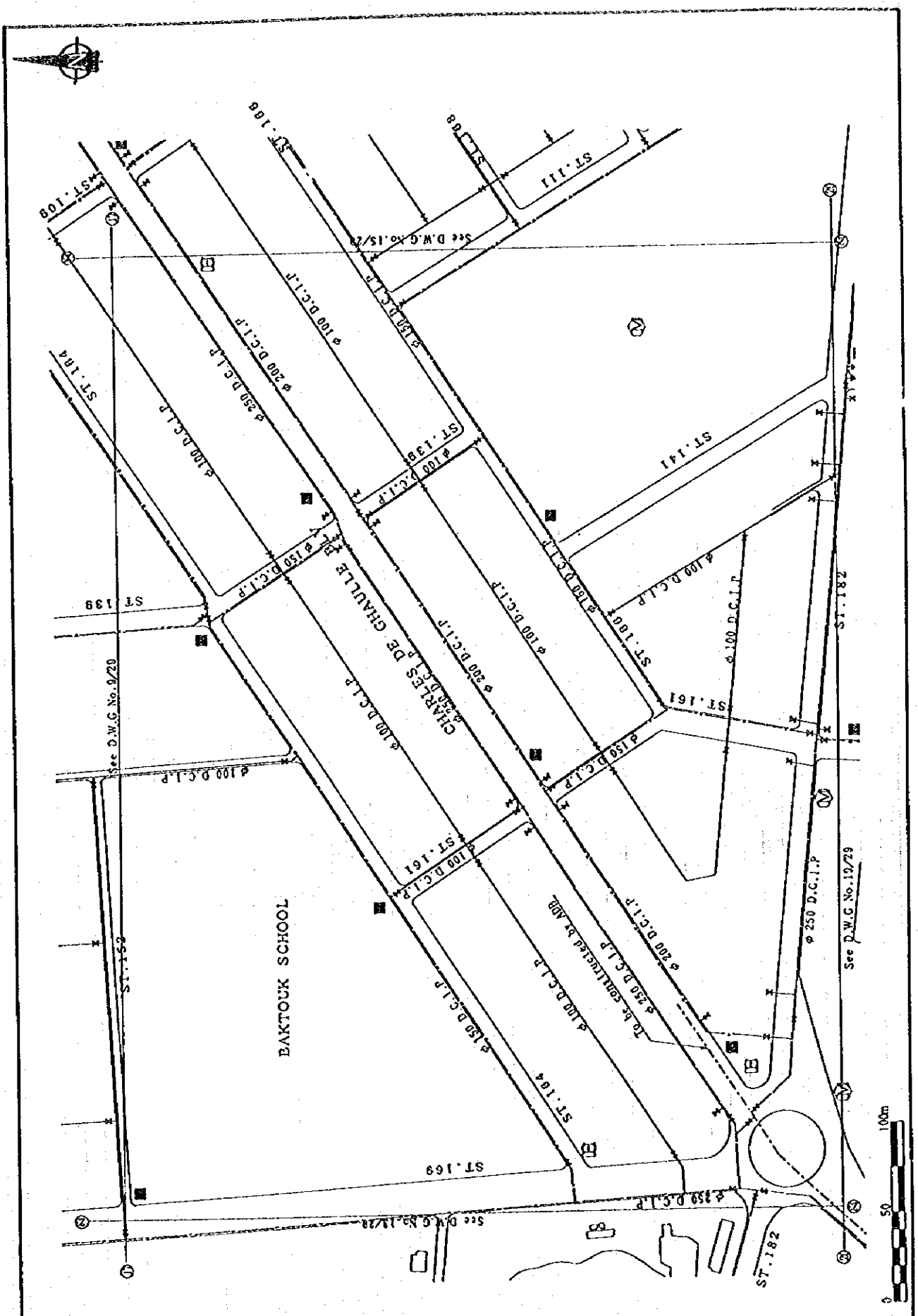
BD-13 PLAN OF DISTRIBUTION PIPELINE (11 / 29)



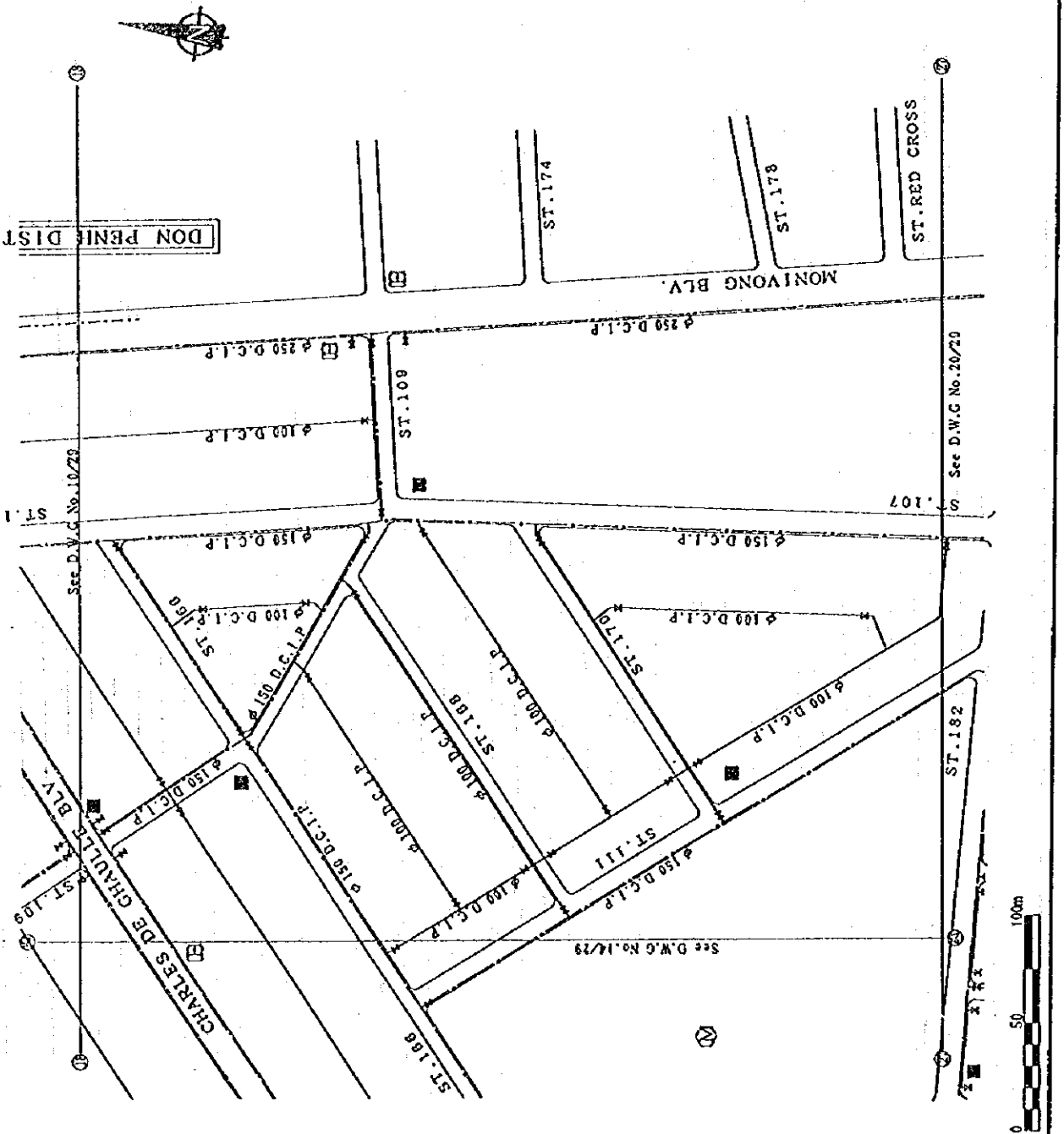
BD-14 PLAN OF DISTRIBUTION PIPELINE (12 / 29)



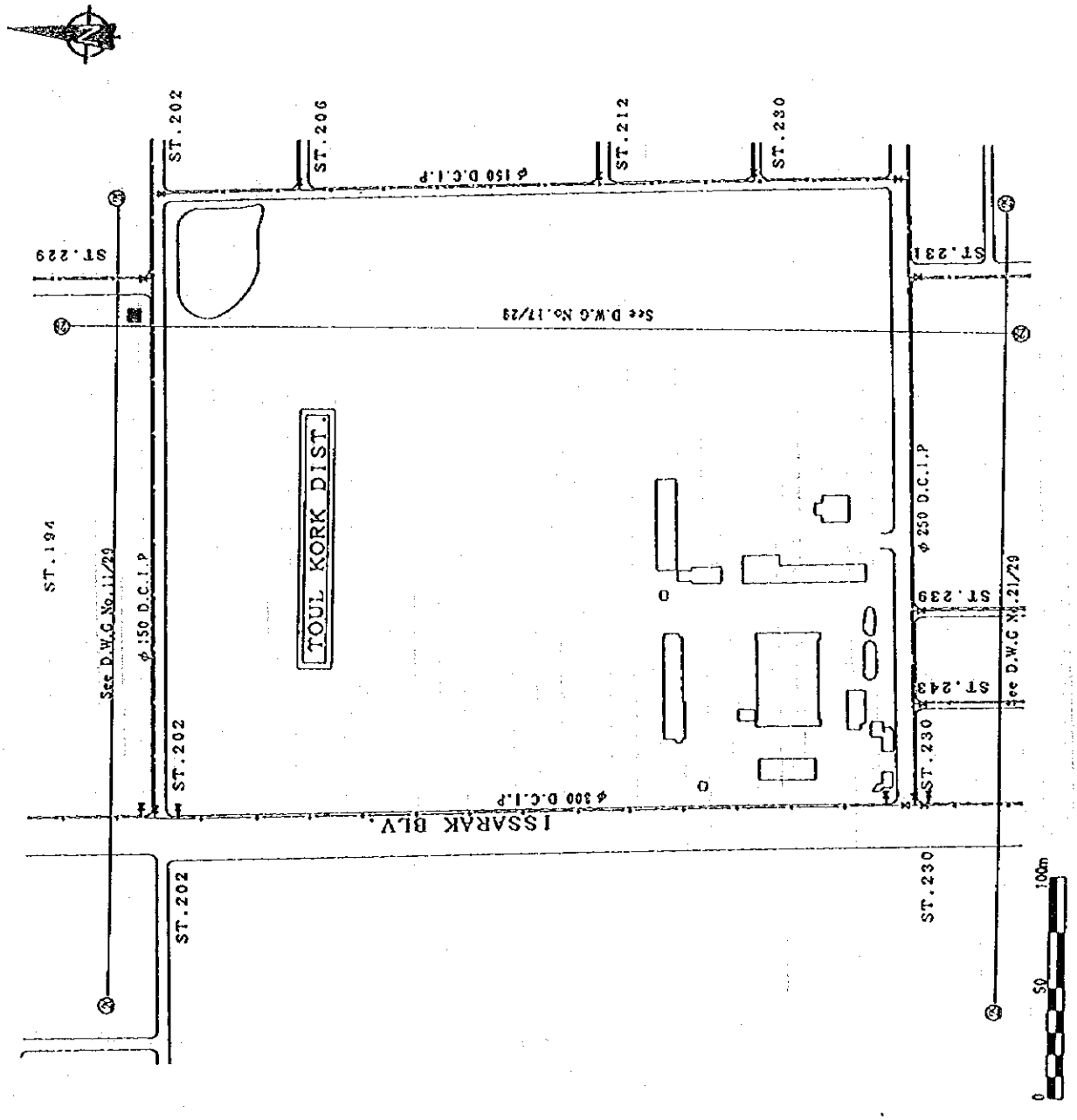
BD-15 PLAN OF DISTRIBUTION PIPELINE (13 / 29)



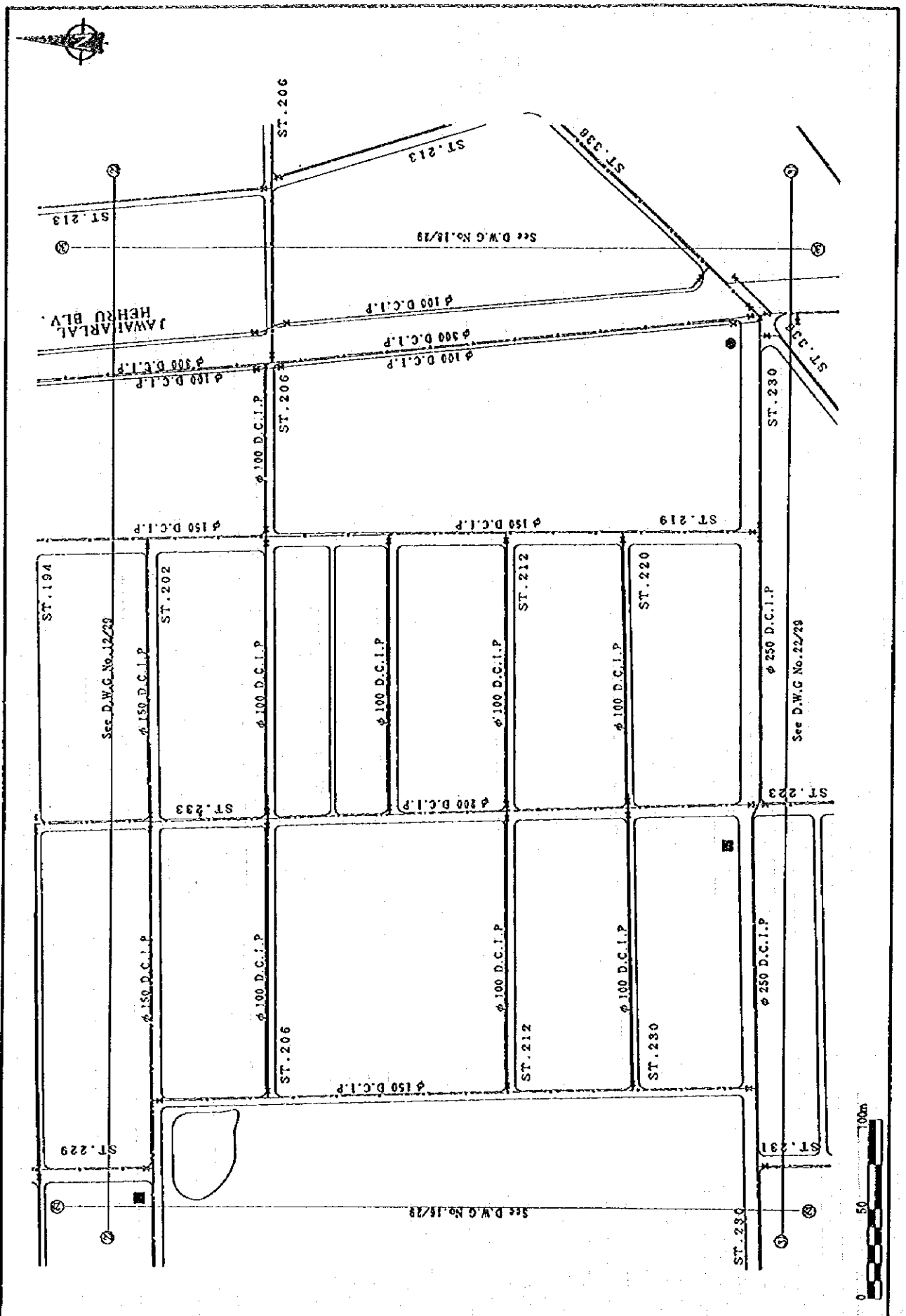
BD-16 PLAN OF DISTRIBUTION PIPELINE (11 / 29)



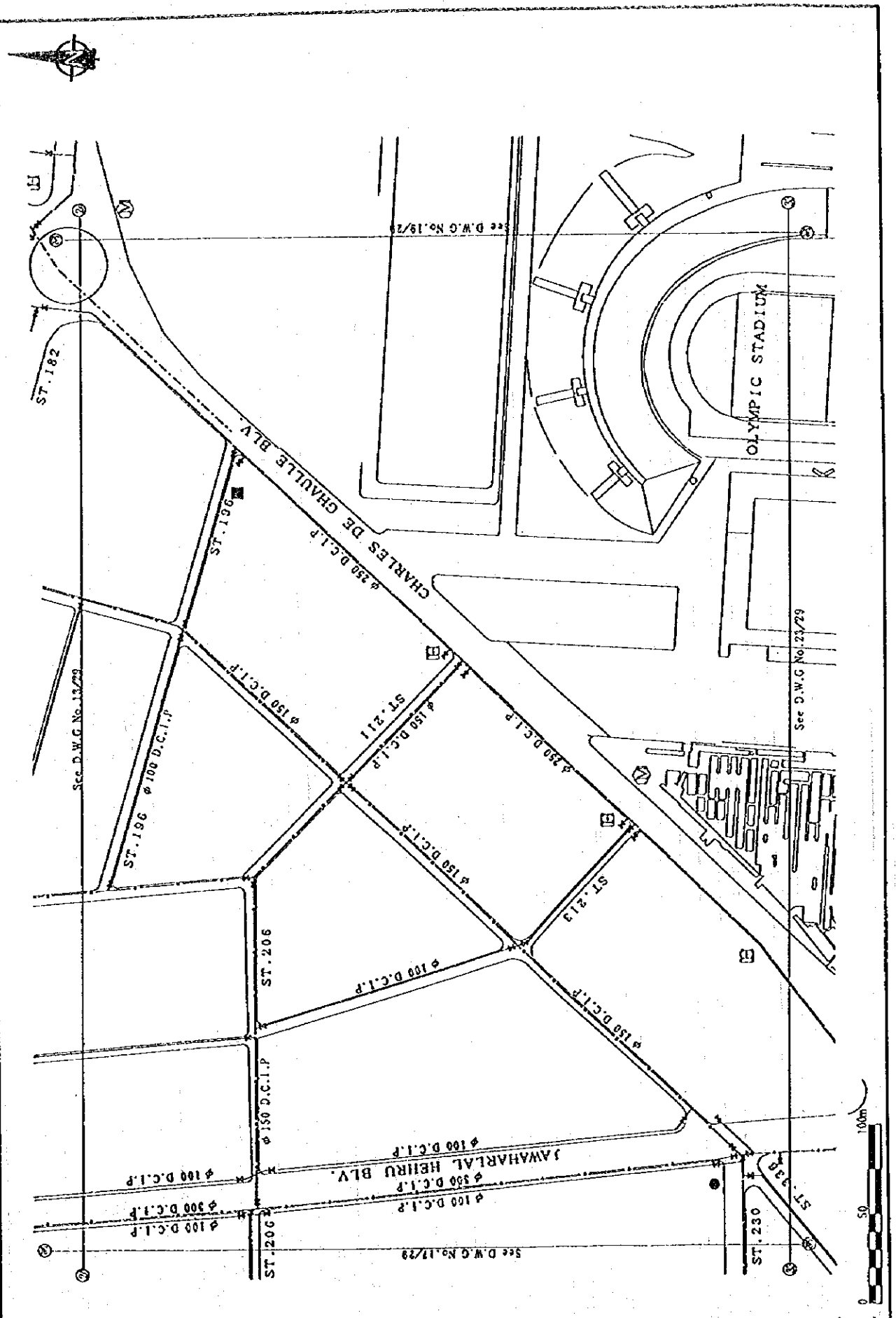
BD-17 PLAN OF DISTRIBUTION PIPELINE (15 / 29)



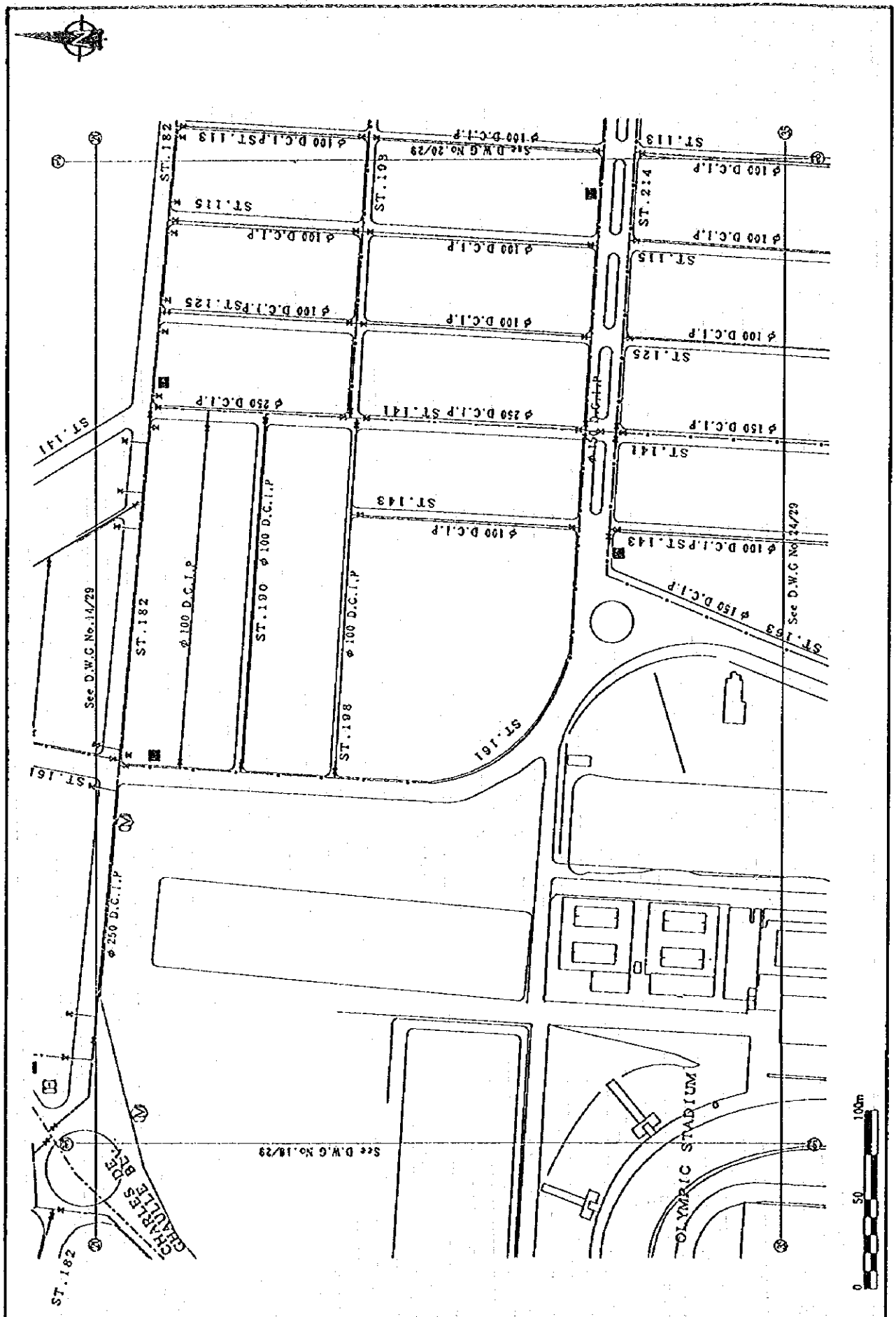
BD-18 PLAN OF DISTRIBUTION PIPELINE (16 / 29)



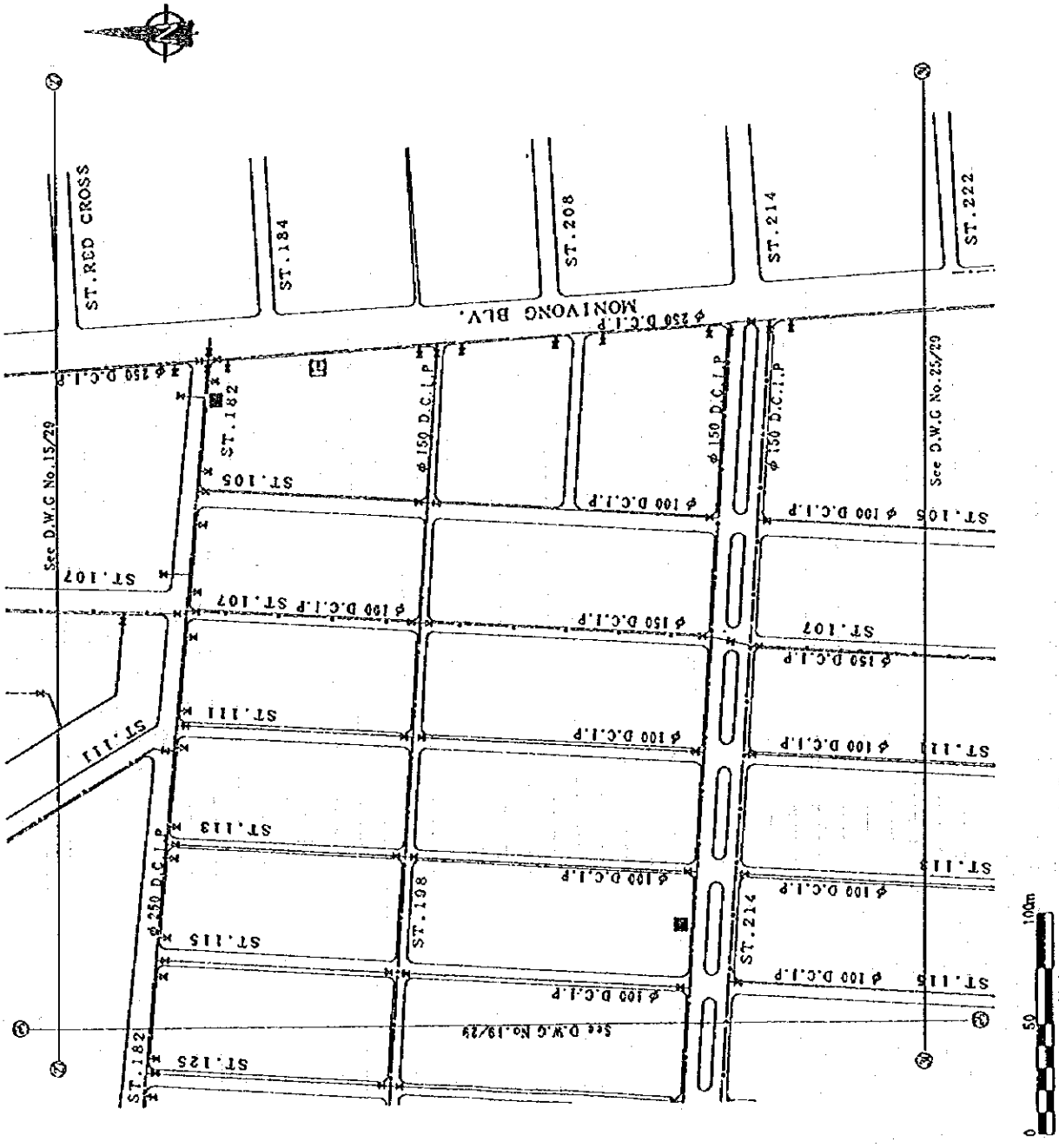
BD-19 PLAN OF DISTRIBUTION PIPELINE (17 / 29)



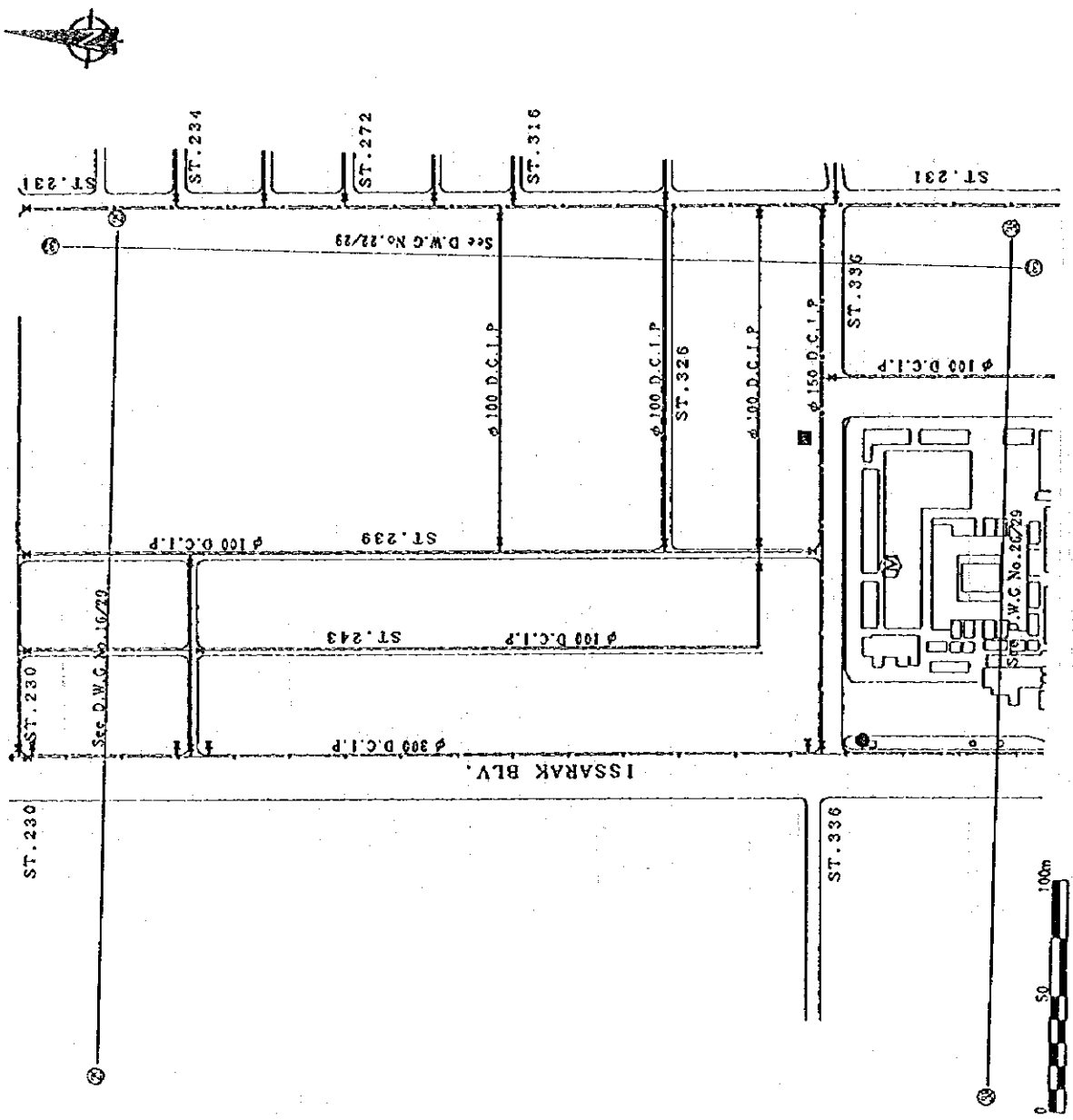
BD-20 PLAN OF DISTRIBUTION PIPELINE (18 / 29)



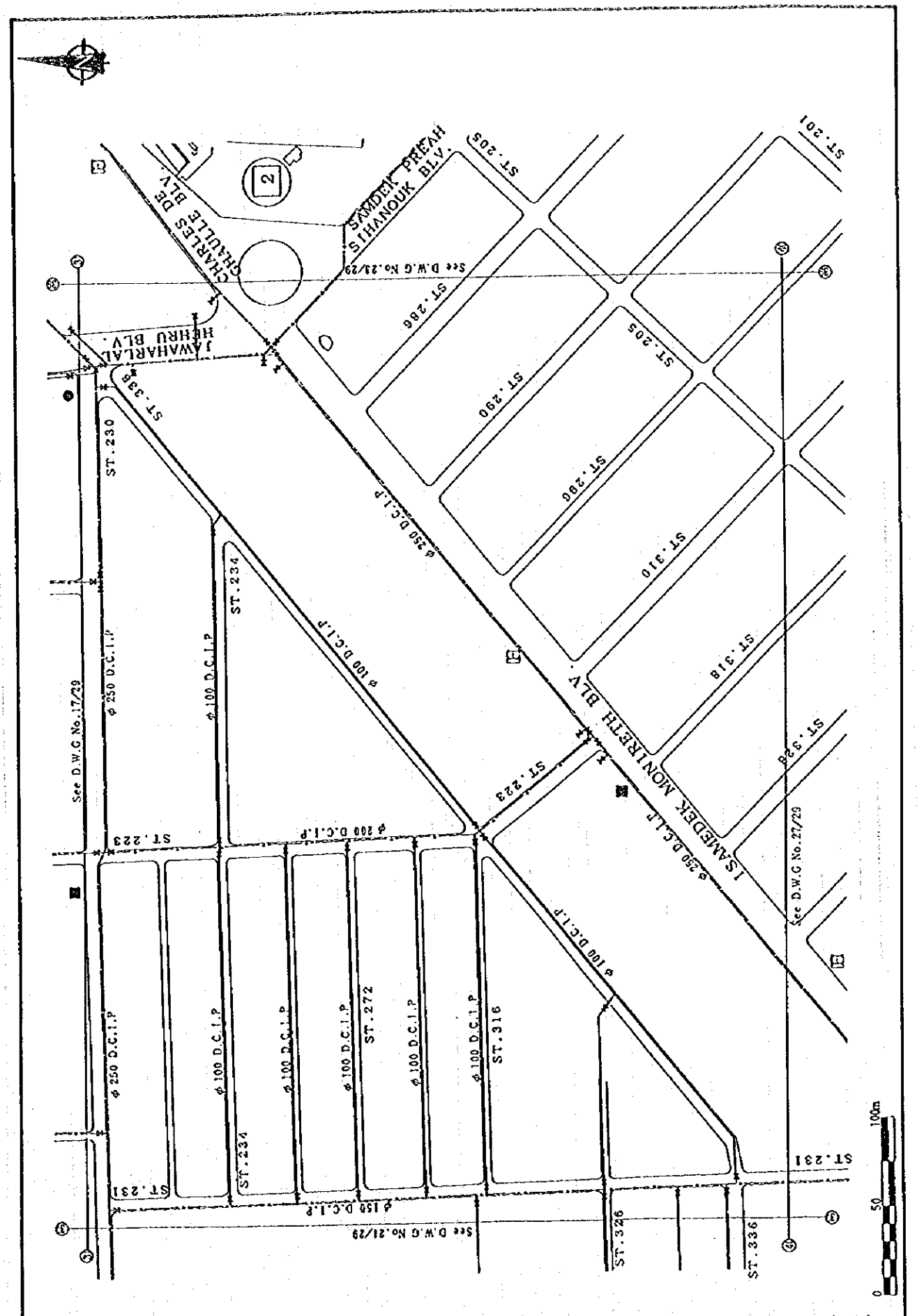
BD-21 PLAN OF DISTRIBUTION PIPELINE (19 / 29)



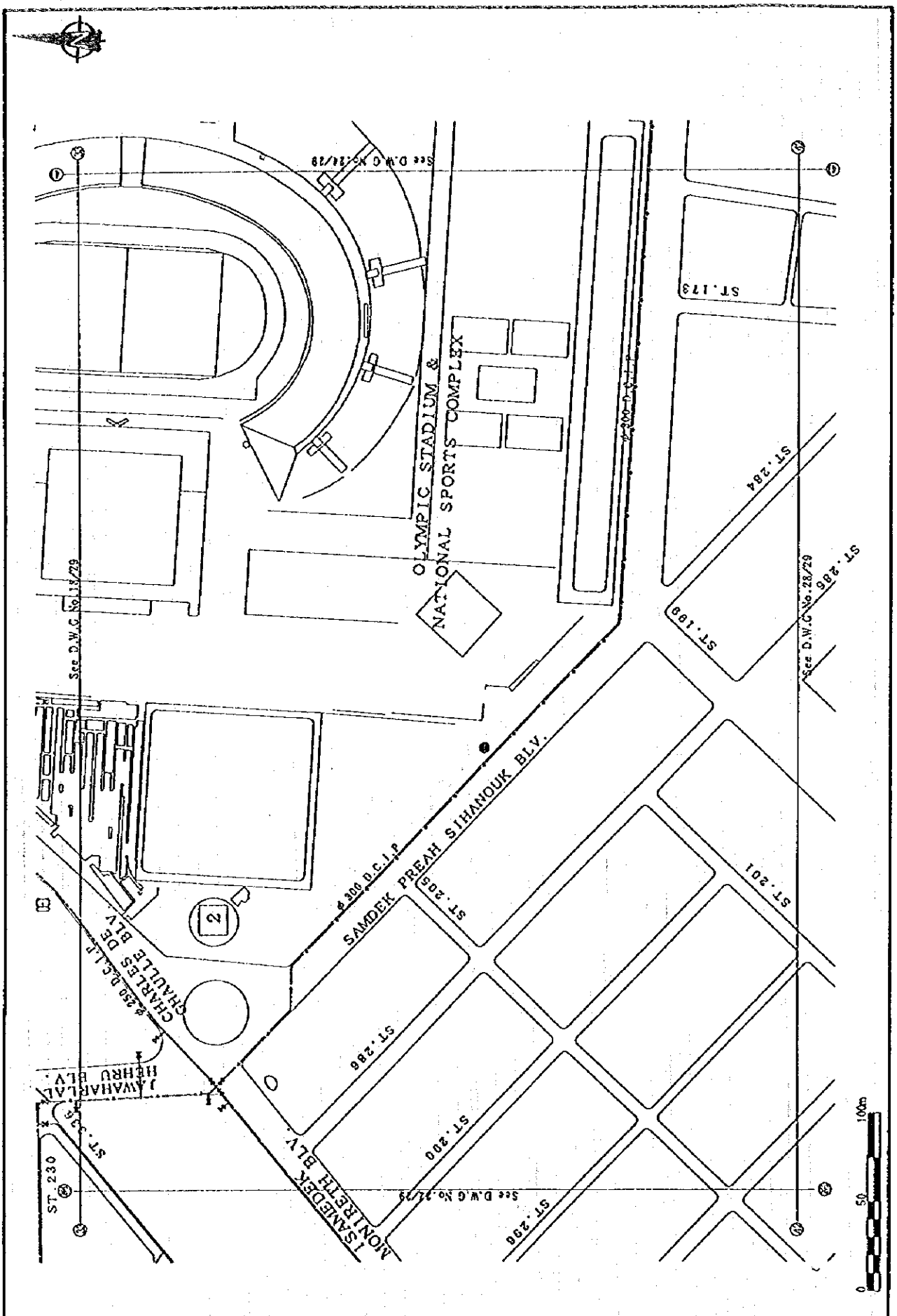
BD-22 PLAN OF DISTRIBUTION PIPELINE (20 / 29)



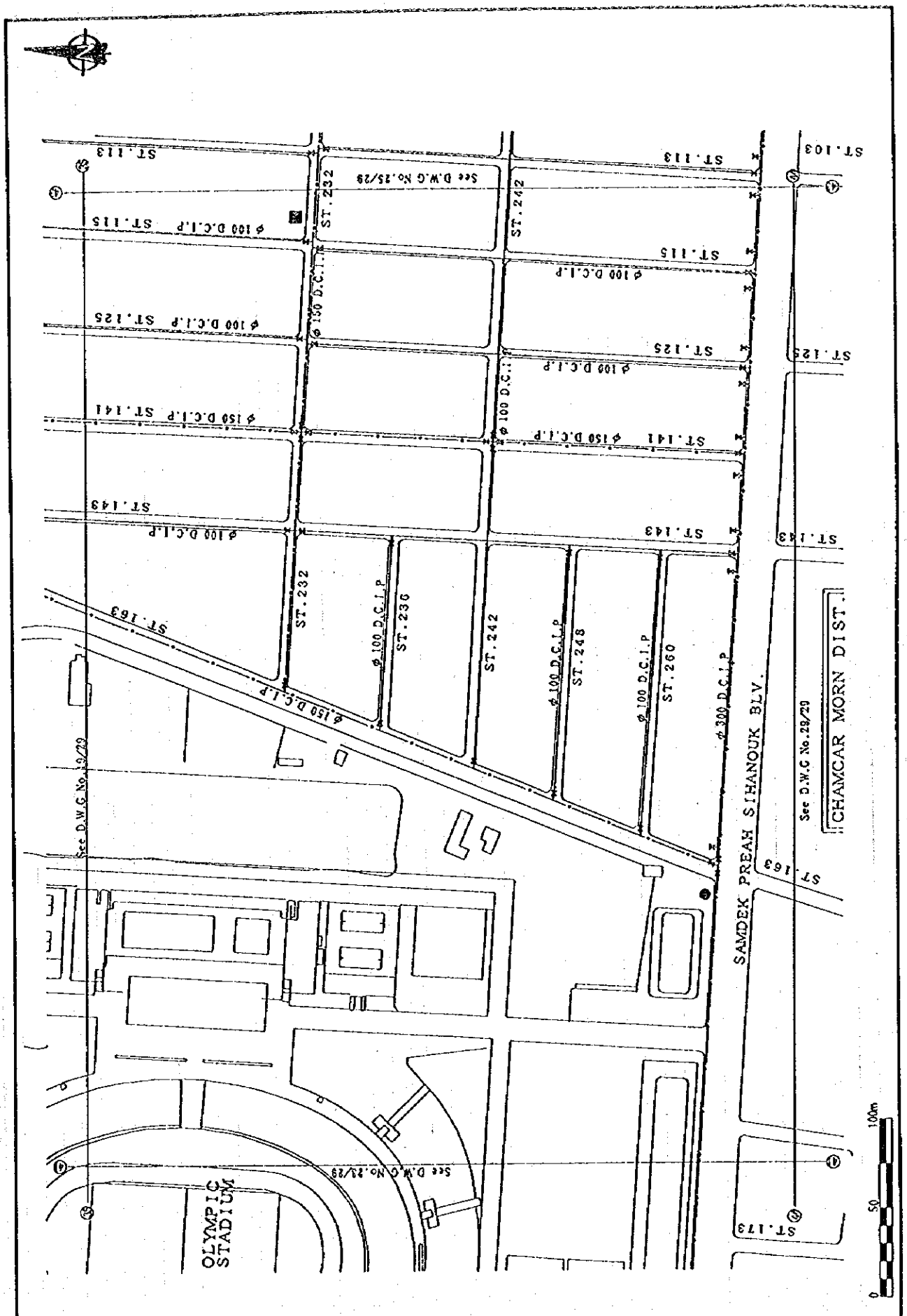
BD-23 PLAN OF DISTRIBUTION PIPELINE (21 / 29)



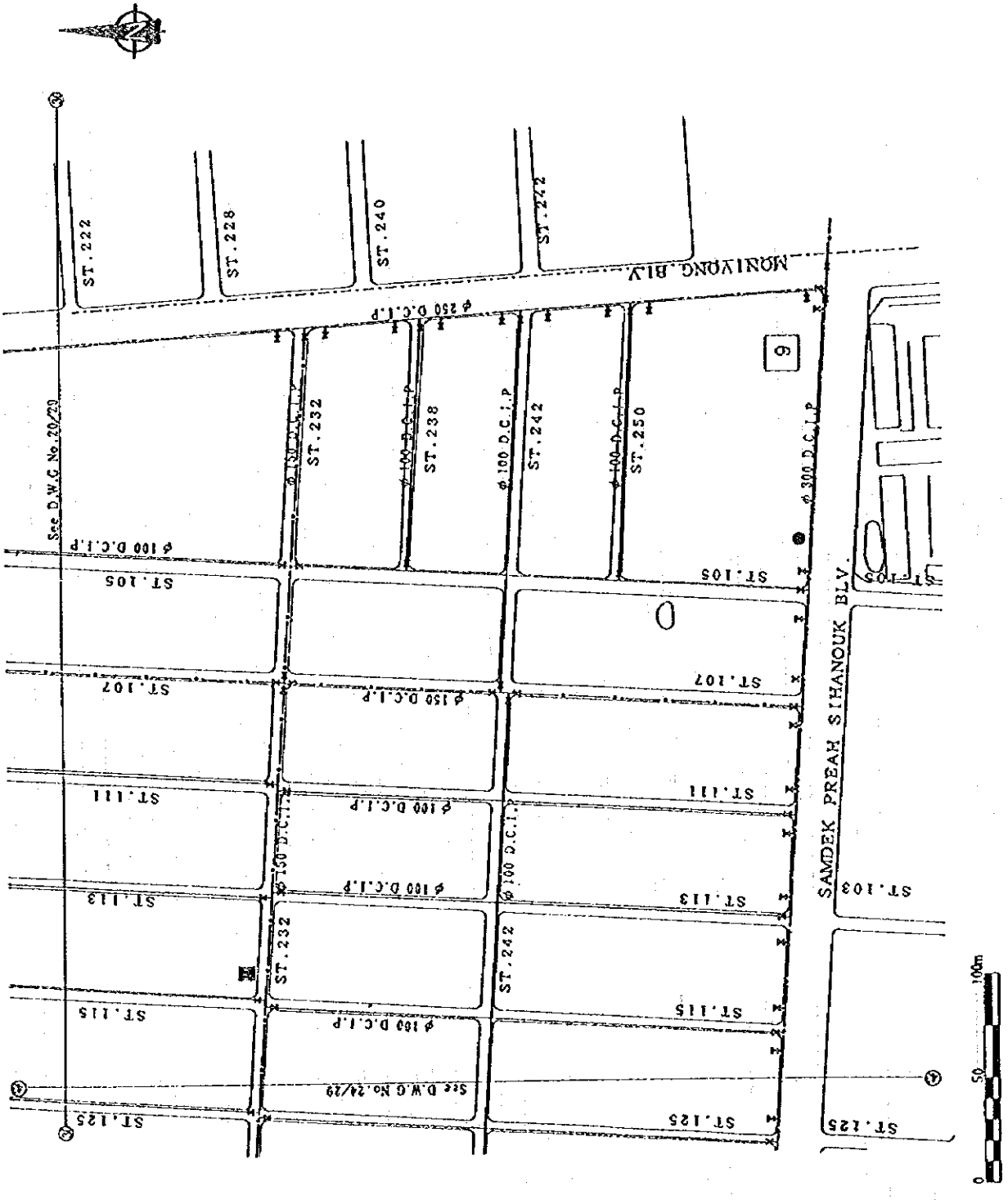
BD-24 PLAN OF DISTRIBUTION PIPELINE (22 / 29)



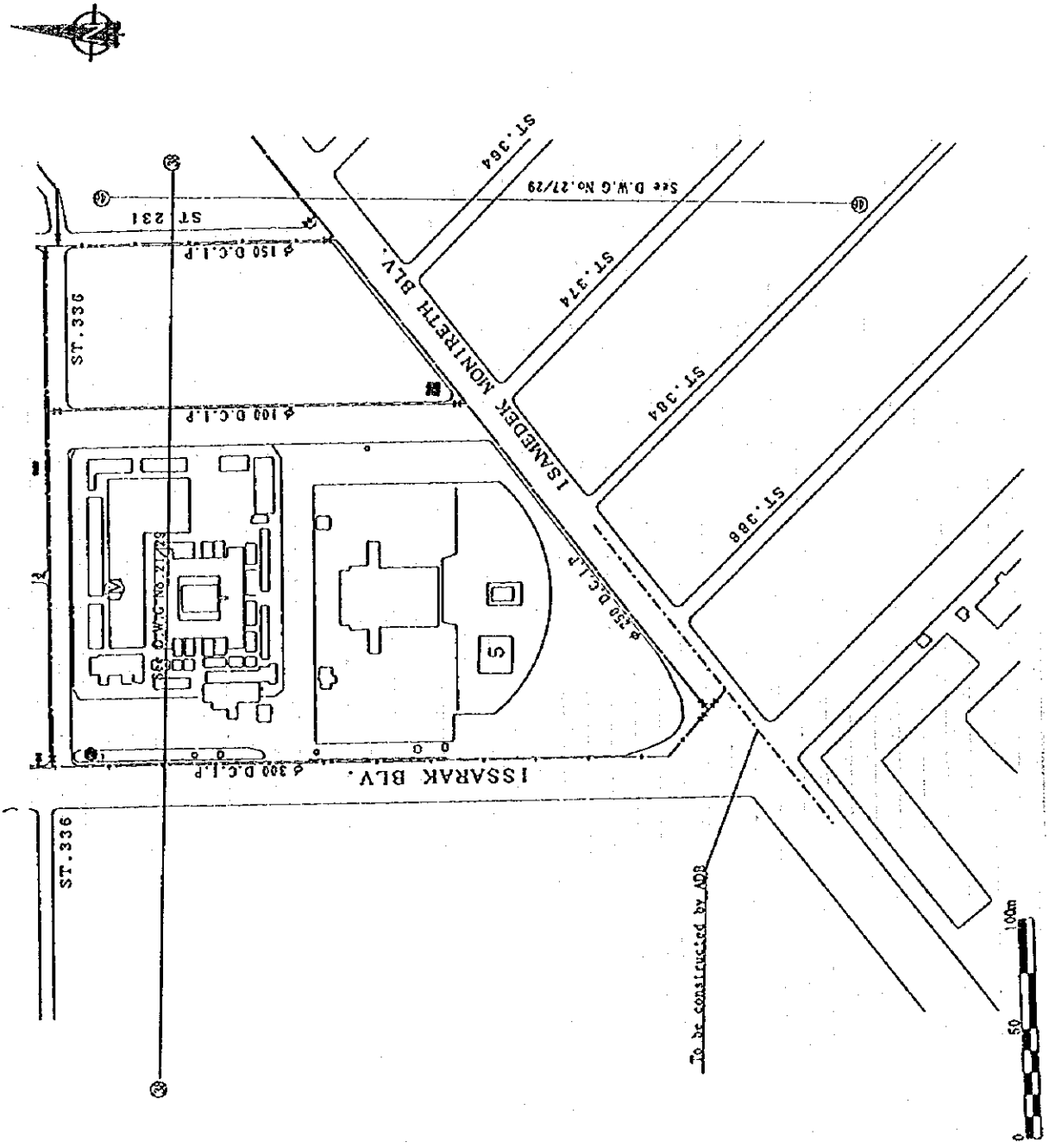
BD-25 PLAN OF DISTRIBUTION PIPELINE (23 / 29)



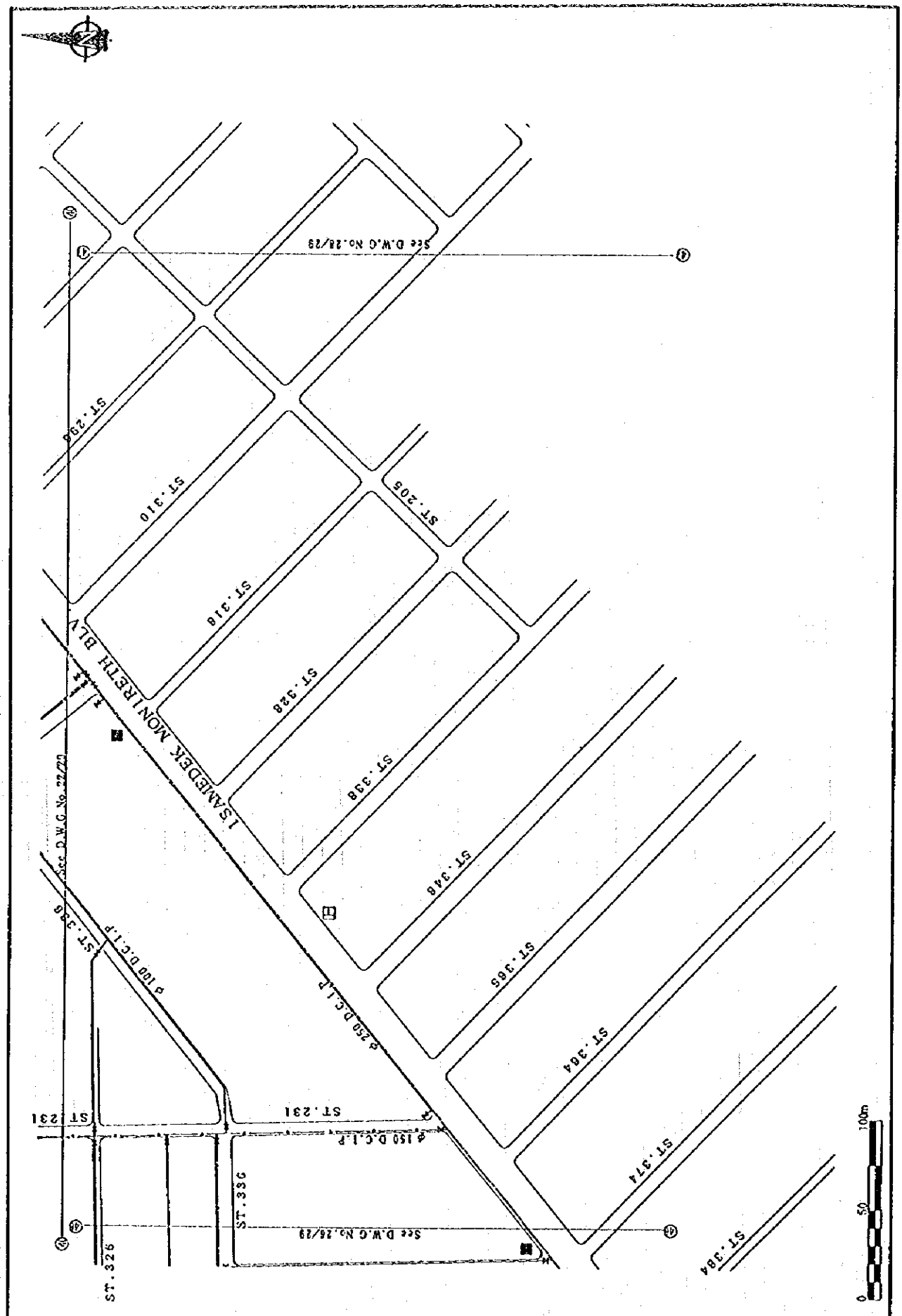
BD-26 PLAN OF DISTRIBUTION PIPELINE (24 / 29)



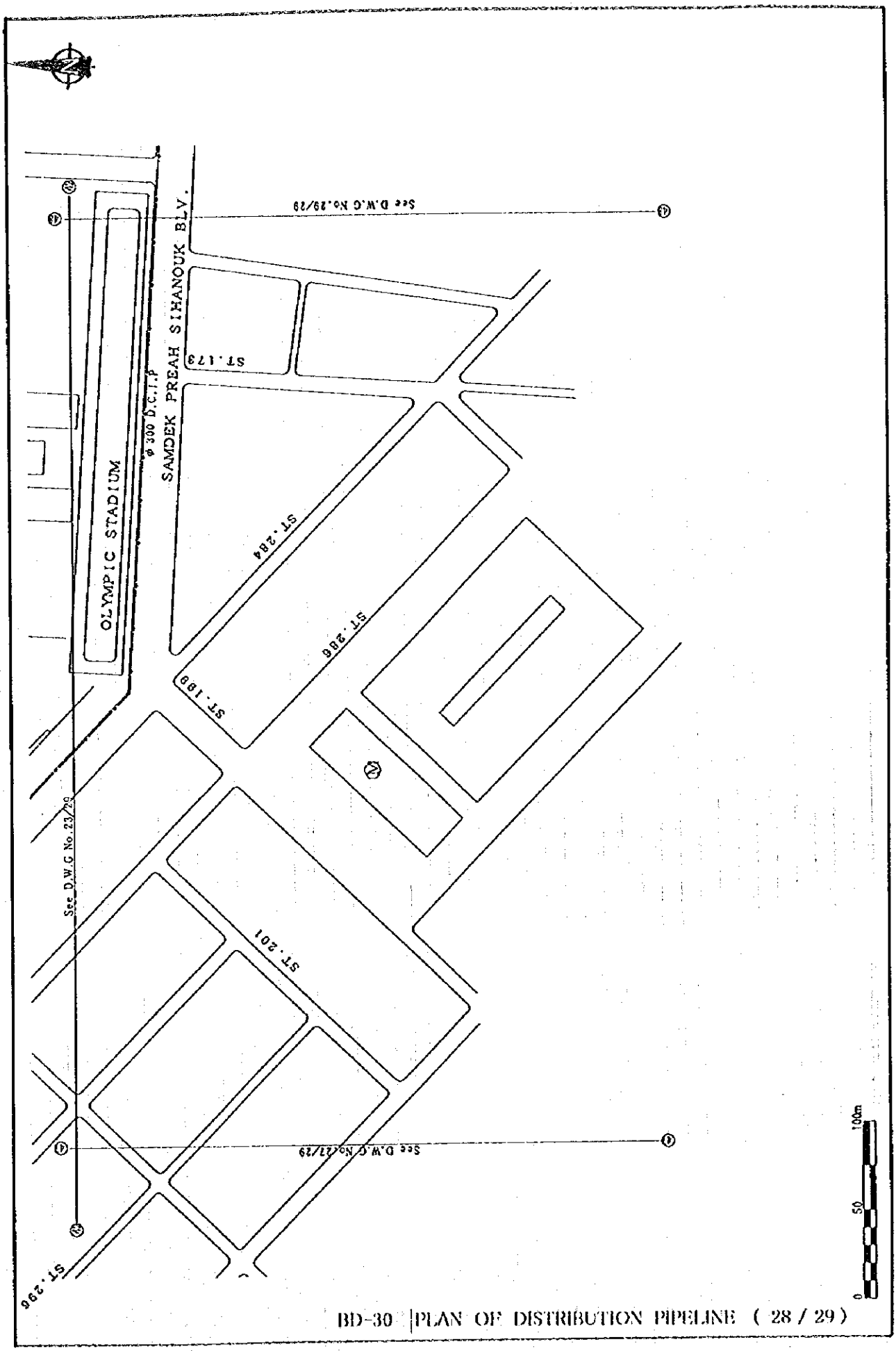
BD-27 PLAN OF DISTRIBUTION PIPELINE (25 / 29)



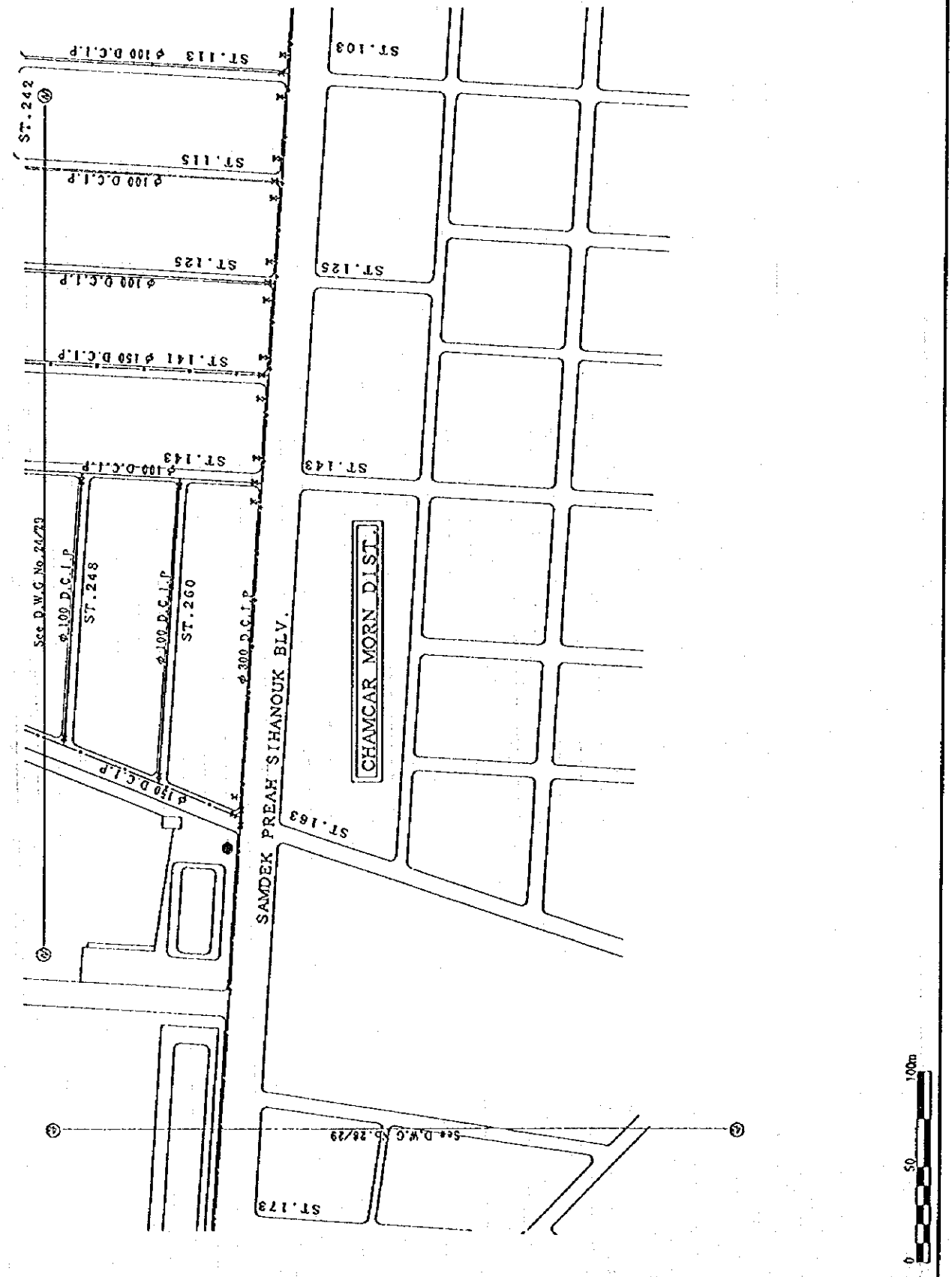
BD-28 PLAN OF DISTRIBUTION PIPELINE (26 / 29)



BD-29 PLAN OF DISTRIBUTION PIPELINE (27 / 29)

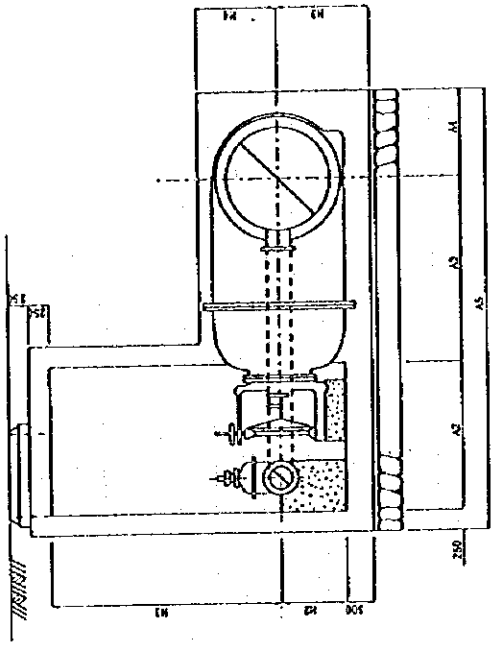


BD-30 PLAN OF DISTRIBUTION PIPELINE (28 / 29)

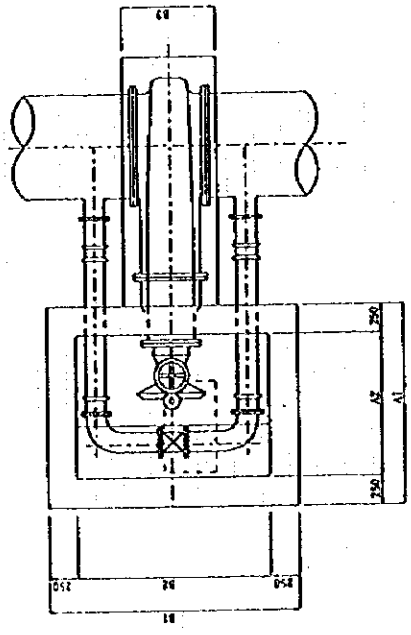


BD-31 PLAN OF DISTRIBUTION PIPELINE (29 / 29)

SECTION



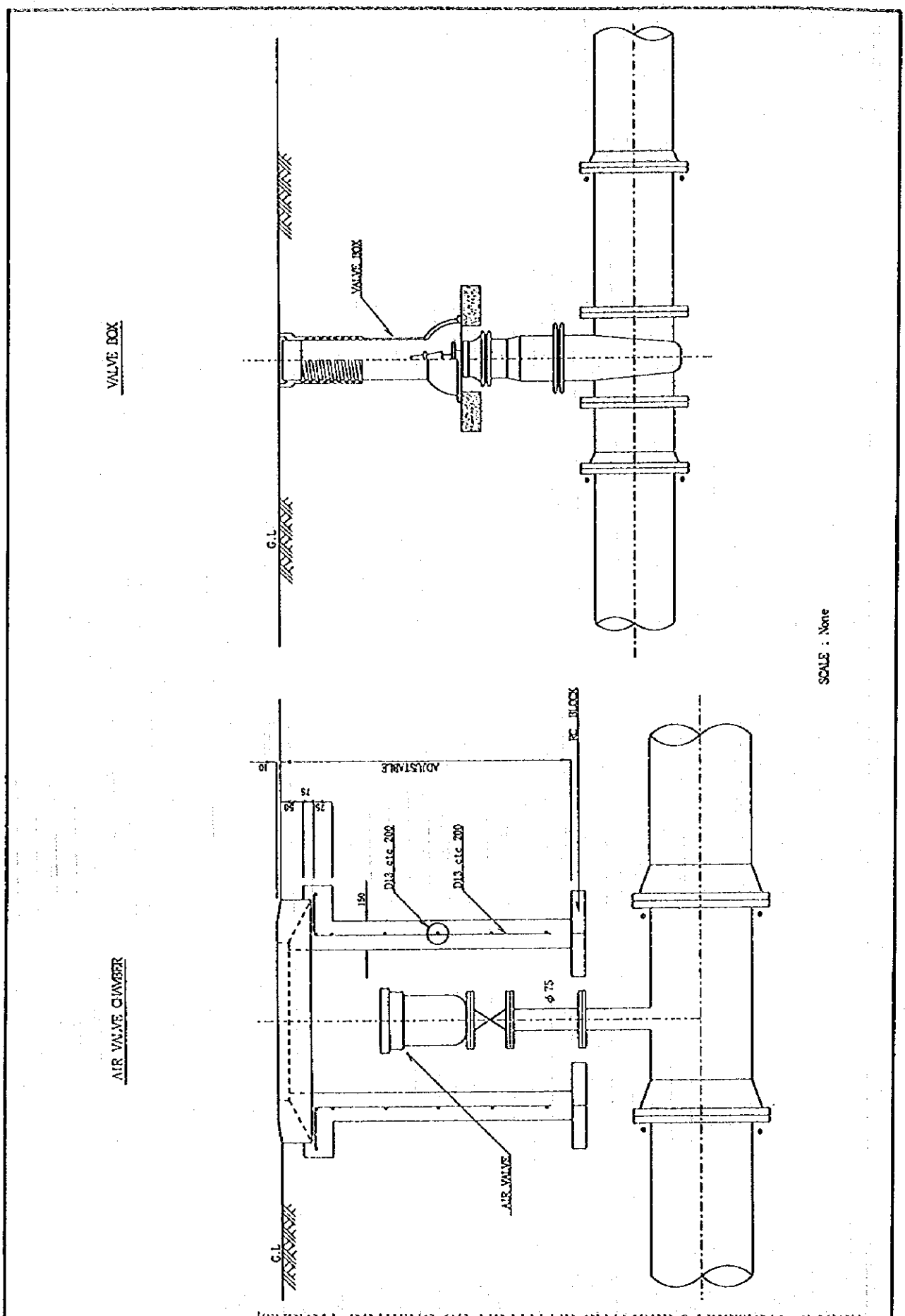
PLAN



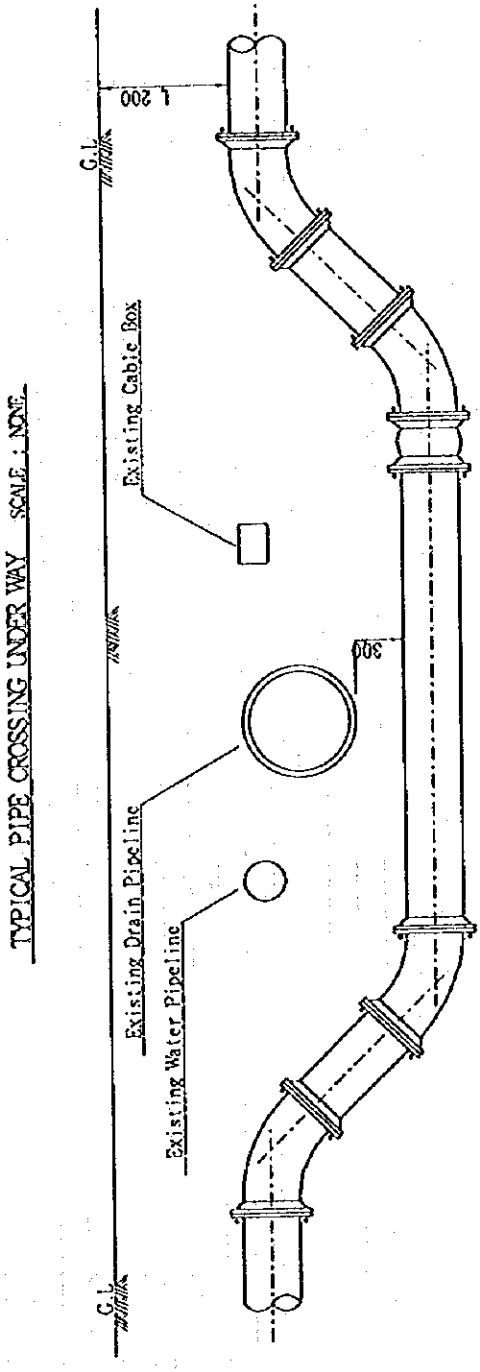
SCALE : None

D	A1	A2	A3	A4	A5	B1	B2	B3	H1	H2	H3	H4
400	1 550	1 050	700	500	2 500	1 800	1 300	600	950	300	600	450
450	1 550	1 050	830	500	2 630	1 900	1 400	650	950	300	600	450
500	1 600	1 100	910	550	2 810	1 950	1 450	700	975	350	650	500
600	1 700	1 200	1 050	600	3 130	2 000	1 500	750	1 000	400	700	550
700	1 750	1 250	1 240	650	3 390	2 200	1 700	800	1 025	450	750	600
800	1 750	1 250	1 420	700	3 620	2 300	1 800	850	1 050	500	800	650
900	1 900	1 400	1 580	800	4 030	2 600	2 100	900	1 100	600	900	750
1 000	2 000	1 500	1 740	850	4 340	2 700	2 200	950	1 125	650	950	800

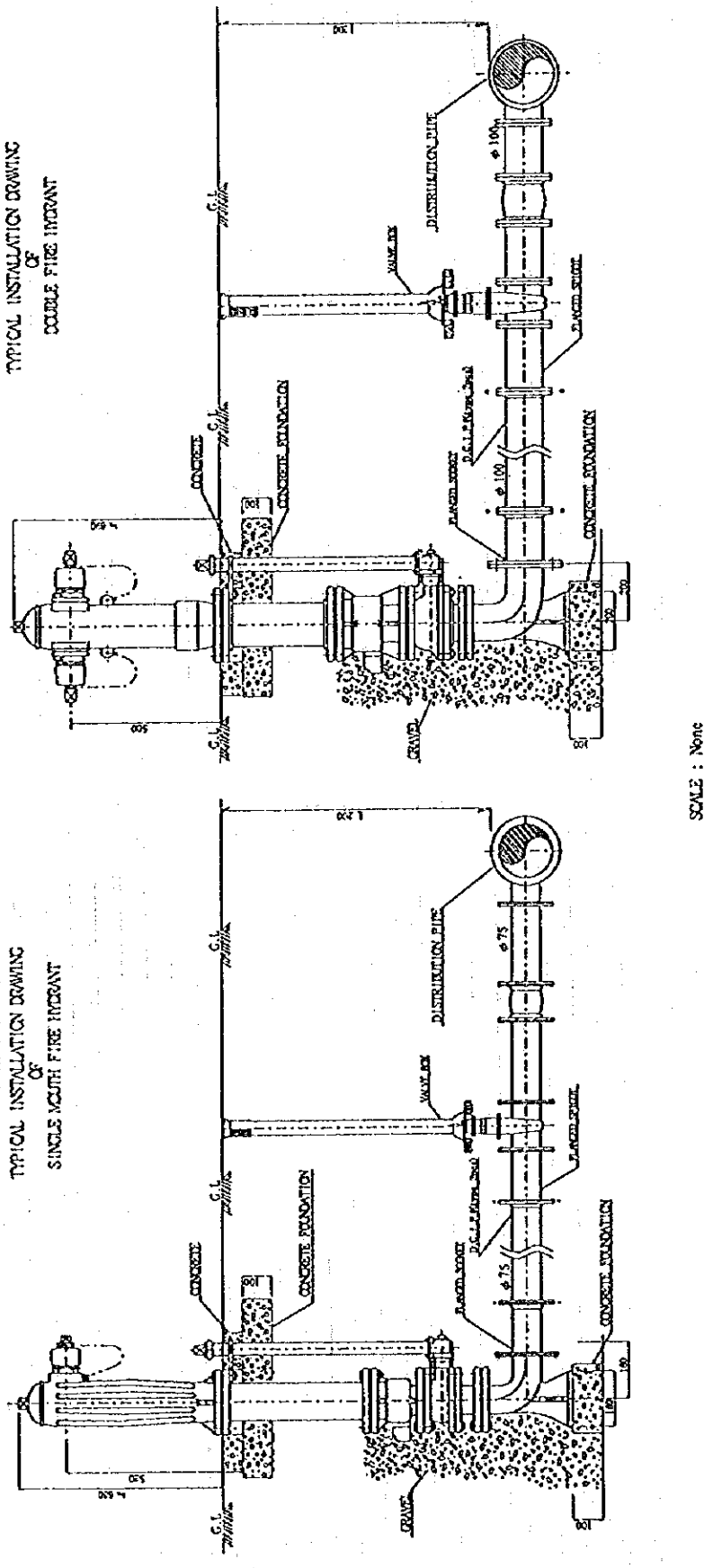
BD-32 TYPICAL DRAWING OF HORIZONTAL SLUICE VALVE CHAMBER



BD-33 TYPICAL DRAWING OF AIR VALVE CHAMBER & VERTICAL SLUICE VALVE BOX

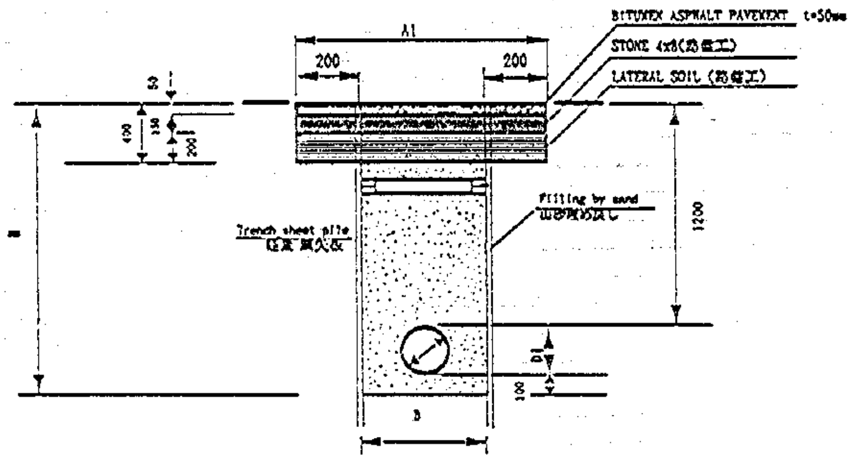


BD-31 TYPICAL DRAWING OF PIPE CROSSING UNDER WAY

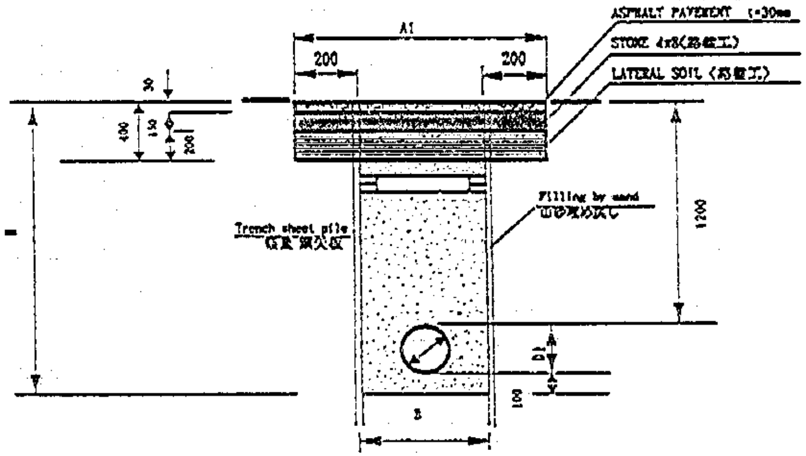


BD-35 TYPICAL DRAWING OF SINGLE MOUTH & DOUBLE MOUTH GROUND TYPE FIRE HYDRANT

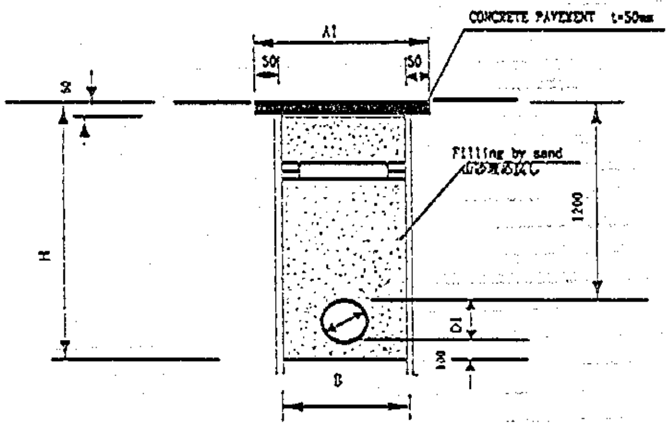
Trench Excavation for Bitumen Asphalt Pavement Road(1st Category)



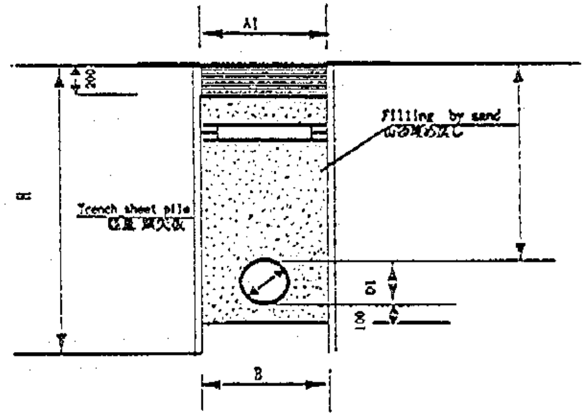
Trench Excavation for Asphalt Pavement Road(2nd Category)



Trench Excavation for Concrete Pavement Road



Trench Excavation for Lateral Pavement Road



Dimension of Trench Excavation

口径 (mm)	1st Category ; Bitumen Asphalt Pavement A1 (m)	B (m)	H (m)	D1 (m)	2nd Category ; Asphalt pavement A1 (m)	B (m)	H (m)	D1 (m)	Concrete Pavement A1 (m)	B (m)	H (m)	D1 (m)	Lateral Pavement A1 (m)	B (m)	H (m)	D1 (m)
φ100	1.300	0.900	1.418	0.118	1.300	0.900	1.418	0.118	1.000	0.900	1.418	0.118	0.900	0.900	1.418	0.118
φ150	1.300	0.900	1.469	0.169	1.300	0.900	1.469	0.169	1.000	0.900	1.469	0.169	0.900	0.900	1.469	0.169
φ200	1.300	0.900	1.520	0.220	1.300	0.900	1.520	0.220	1.000	0.900	1.520	0.220	0.900	0.900	1.520	0.220
φ250	1.500	1.100	1.572	0.272	1.500	1.100	1.572	0.272	1.200	1.100	1.572	0.272	1.100	1.100	1.572	0.272
φ300	1.500	1.100	1.623	0.323	1.500	1.100	1.623	0.323	1.200	1.100	1.623	0.323	1.100	1.100	1.623	0.323
φ350	1.600	1.200	1.674	0.374	1.600	1.200	1.674	0.374	1.200	1.100	1.674	0.374	1.100	1.100	1.674	0.374
φ400	1.600	1.200	1.726	0.426	1.600	1.200	1.726	0.426	1.300	1.200	1.726	0.426	1.200	1.200	1.726	0.426
φ450	1.600	1.200	1.777	0.477	1.600	1.200	1.777	0.477	1.300	1.200	1.777	0.477	1.200	1.200	1.777	0.477

BD-36 | TYPICAL DRAWING OF TRENCH EXCAVATION & PAVEMENT

Chapter 3
Implementation Plan

Chapter 3: Implementation Plan

3-1 Implementation Plan

3-1-1 Implementation Concept

The areas relevant to this project are located at the center of Phnom Penh and consist of a mix of densely populated commercial and residential areas. Although the distribution pipelines are old and deteriorated, and the water quantity and water pressure are inadequate, the residents are some how able to make use of the water supply system for their needs.

Considering the above, and considering that the water supply has to be switched over from existing pipelines to newly-installed pipelines without disrupting the supply, and accounting for the road system with dense traffic conditions, the items for basic policy for ensuring that there is no hindrance to the points mentioned above, are summarized below.

(1) The boundaries of responsibility of the Japanese side and the responsibility of the Cambodian side should end and start respectively the point where the direct branch pipeline connection and the point where the service branch pipeline connection are taken. Therefore, detailed adjustments are necessary prior to carrying out the work.

(2) To enable the Cambodian side to complete the branch pipeline work and immediately start the switching-over work, the Japanese side should use the valves at hand and carry out water flow tests in partial sections.

(3) Since procurement of construction machinery in Cambodia is difficult, the materials for the main distribution pipelines should be procured from Japan and the ASEAN countries. However, based on the experience during the First Grant Aid Program, water meters should be procured from China.

(4) In principle, the work of laying pipes in main roads should be carried out during night time because the traffic on these roads is very heavy. A two-shift system should be adopted, so that work for other roads can be carried out during the day time.

(5) Local sub-contractors should be used whenever possible considering the aspects of technology transfer and reduction in project costs.

3-1-2 Implementation Condition

1) Conditions for exclusive use of roads

The areas relevant to this project are located at the center of Phnom Penh city. Particularly, restaurants, hotels, and shops are concentrated along main roads such as

Monivong Street and Charles de Gaulle Street, and commercial activities are vigorous in these roads. In principle, permission is required for working at night time, and the complete sequence of work such as excavation, pipe laying, backfilling, temporary restoration of pavement should be completed on the same day.

For "construction methods (performing test excavations and study adjustments beforehand in case power transmission lines, telephone lines, sewer lines exist at the excavation site)," "traffic-regulated spaces" and "working hours" related to the work, the contractor must apply to the City Road Bureau and obtain permission for excavation.

2) Arrangements for distribution pipeline work

Distribution pipeline maintenance work has already started in the Don Penh area and Chamkar Morn area in Phnom Penh city. If the period of work for this project clashes with the period for the above-mentioned work, there is likely to be a shortage of skilled workers particularly for pipeline work. Therefore, the use of skilled workers from third countries including Japan is necessary. The number or workers required is estimated as 4 during the work stages.

3) Procurement of construction machinery

Construction machinery available in Cambodia are dump trucks and excavators only. For machinery other than the above, arrangements should be made for procurement from third countries including Japan.

4) Measures for underground water

Most shielding systems in the city make use of laterite. If water is included, then the handling of soil becomes very difficult. Particularly, the underground water level in the zone along Monivong Street, Road No. 171, Road No. 169 and Road No. 161, is extremely shallow - ranging between 0.4 m to 0.6 m, therefore, measures such as shuttering should be adopted.

5) Road surface restoration

The paving of roads in the city can be classified into the three types mentioned below. Since the work is to be carried out, in principle, by the Phnom Penh City Road Bureau directly, contractors will have the work entrusted to them by the Bureau.

* Type 1: Bitumen-paved roads (main roads)
* Type 2: Asphalt-paved roads (general roads)
* Type 3: Laterite or gravel-paved roads

6) Safety measures

Safety measures to be adopted by work personnel, such as surveillance by guards, illumination at night, and fencing the area, are necessary for ensuring safety of materials in the stockyard.

3-1-3 Scope of Works

To define clearly the scope of responsibility of work for the Japanese and Cambodian sides, the distribution and service pipelines are classified below by diameter, and the scope of work for each side determined according to this classification.

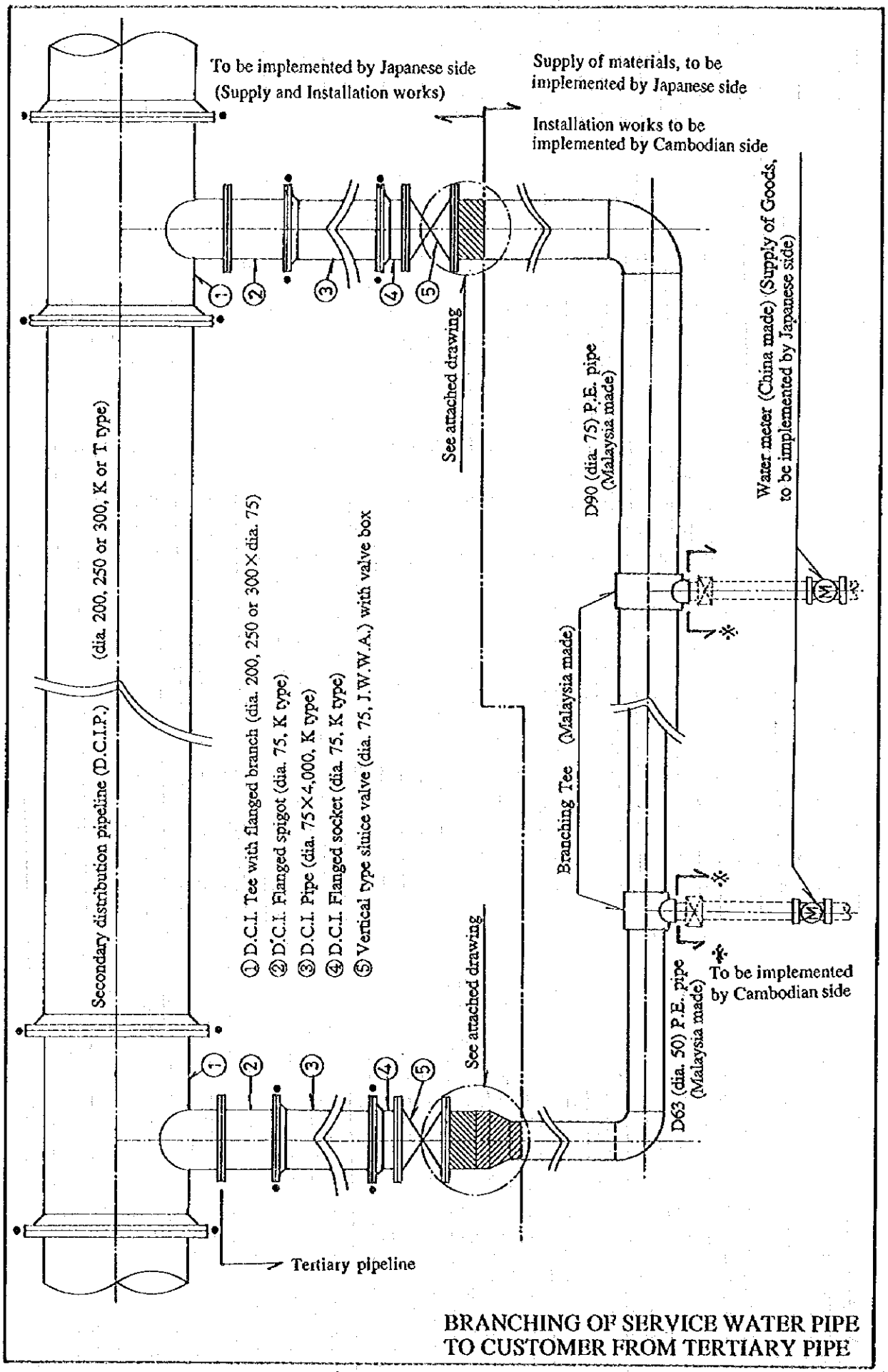
(Distribution pipelines: Responsibility of the Japanese side)
* Branch distribution pipelines - Distribution pipelines of diameter greater than 250 mm in the distribution areas
* Small distribution pipelines - Distribution pipelines of diameter from 100 to 200 mm in the distribution areas
* Distribution pipelines - General name for pipelines in the distribution areas

(Service pipelines: Responsibility of the Cambodian side)
* Service pipelines - Small distribution pipelines of diameter less than 100 mm
* Supply facilities - From the small distribution pipelines to the water meters
* Supply equipment - From the water meters to items owned by each household consumer

Since most of the routes for branch distribution pipelines (diameter greater than 250 mm) cover areas where traffic is very heavy during daytime, occupying one side of the road would make traffic conditions difficult, therefore the work for these pipelines should mainly be performed at night. The demarcation of the scope of work of the Japanese and Cambodian sides occurs in the small distribution pipelines (diameter 100 mm to 200 mm), therefore, the locations and pipe diameters that fall under the scope of work for each side are already decided.

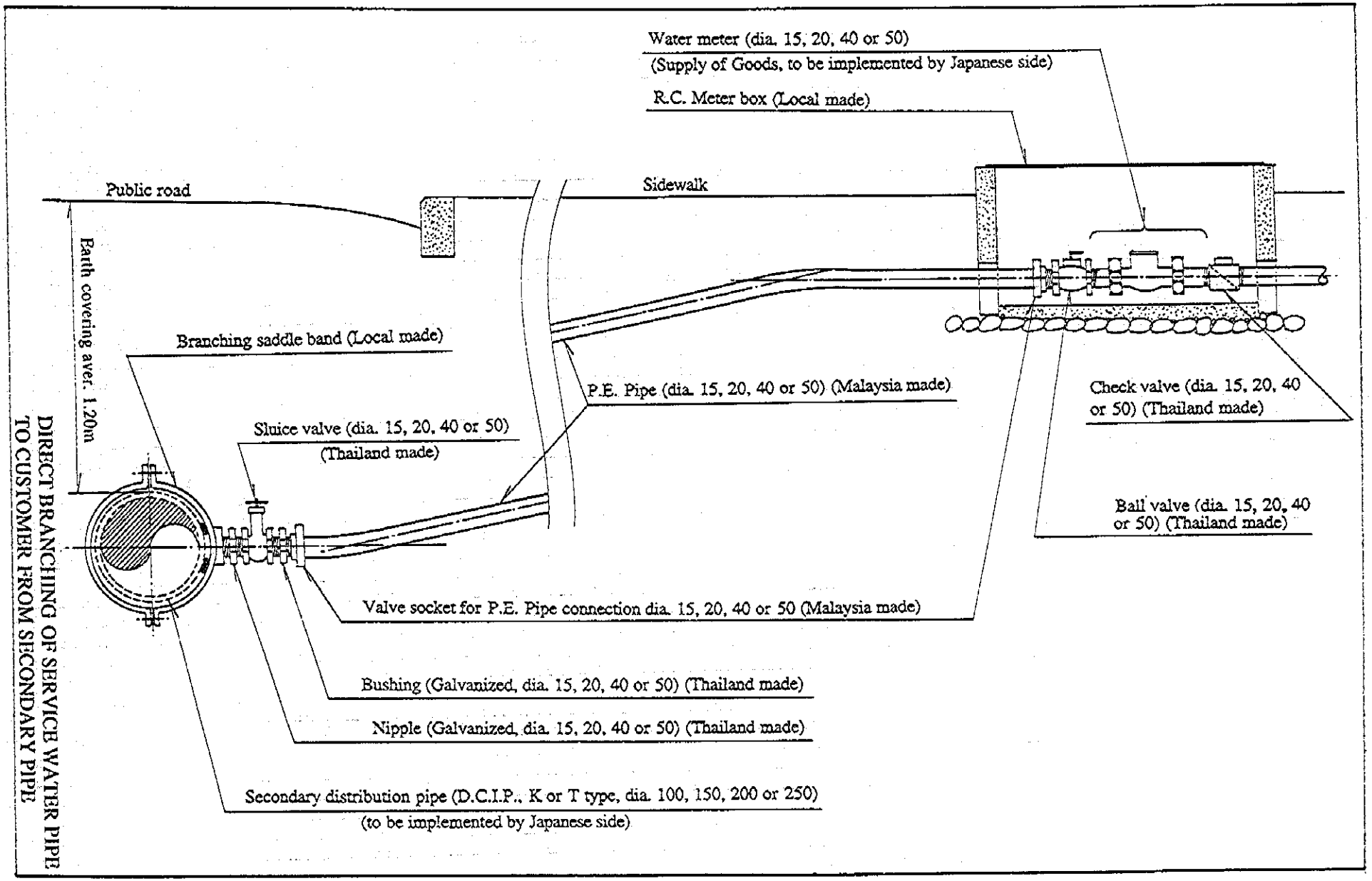
1) Scope of work of the Japanese side

The execution schedule will be prepared taking "excavation, pipe laying, backfilling, and temporary restoration" as the basic cycle. It has been confirmed by both sides that the scope of work for the Japanese side ends and the Cambodian side starts at the end of the valves. After the service pipeline connection, backfilling and temporary restoration fall in the scope of work of the Cambodian side. The Japanese side will ensure that valves are installed in the branch distribution pipelines, offer measures for maintenance, ensure that water pressure tests are carried out without difficulty, and make arrangements so that the benefits of newly installed pipelines reach every household.



BRANCHING OF SERVICE WATER PIPE TO CUSTOMER FROM TERTIARY PIPE

DIRECT BRANCHING OF SERVICE WATER PIPE TO CUSTOMER FROM SECONDARY PIPE



2) Scope of work of the Cambodian side

The Cambodian side will coordinate its work with the work performed by the Japanese side, or install service pipelines and water meters beforehand. When the valve connections and water tests of small distribution pipelines are completed, the Cambodian side will immediately start the work of switching over the water supply to the households and the restoration work.

3-1-4 Consultants Supervision

The supervisory system for implementing design and work supervision as a grant aid project shall be established after considering the items listed below.

(1) Understand the contents and history of the basic design study.
(2) Understand the grant aid plan.
(3) Study the final documents exchanged between Japan and Cambodia.
(4) Understand similar projects executed in Cambodia by the Japanese government.
(5) Study the basic policy of the Phnom Penh City Waterworks and the movements of other assisting organizations.
(6) Re-confirm the conditions for implementing work that falls under the responsibility of the Cambodian government and requested during the basic design.
(7) Re-check formalities for tax exemption when bringing machinery and materials into the country, and cooperate with the Phnom Penh City Waterworks so that there is no effect on the work stages.

1) Consultant's scope of work

After the exchange of official documents (E/N) between the two governments, the Cambodian Government shall conclude a works contract with the consultant. The contents of the work include detail design and work supervision.

(1) Detail design

Detail design mainly involves the preparation of documents necessary for the works tender based on the basic design, that is, overall design, after carrying out detailed site studies. Sufficient time and stationing of personnel on site are considered to be necessary for carrying out on-site studies. Subsequently, the main work of the consultant in the country includes preparation of tender documents, assistance for examining tender qualifications, presence during a tender opening, assessing tender bids, assistance in negotiating work contracts, and assistance related to work contracts.

(2) Work supervision

Work supervision can be broadly divided into the two tasks explained below.

i) Supervisory duties

These include discussions with related personnel before start of work, confirmation of design drawings, inspection of machinery and materials before shipping them, supervision of work on site, attendance during installation of machinery and equipment, preparation of work reports during the work stages, issue of work completion certificates and payment certificates, and carrying out final inspection.

ii) Duties at the completion of work

These include issue of certificates at the completion of work, compliance with formalities for handing over at the completion of work, preparation of final work report, and following the procedures for completing the work.

Detail design (total strength - 5 persons)
General - 1 person
Pipeline design - 1 person
Civil works design - 1 person
Estimates - 1 person
Tender documents/ Tendering duties - 1 person

Work supervision (total strength - 5 persons)
General - 1 person (spot)
Permanently stationed supervisors - 2 persons (2-shift system since work is carried out during daytime and night time)
Pipeline/civil works design - 1 person (spot)

3-1-5 Procurement plan

The countries for procuring materials and equipment are given in the table below.

Name of material/equip.	JPN	Site	TC	Name of material/equip.	JPN	Site	TC
Ready mixed concrete		O		Lubricating oil		O	
Sand, gravel		O		Pipe material (DCIP)	O		
Cement		O		Pipe material (PE; Malaysia)			O
Reinforcing bar		O		Air valve (emergency discharge type)	O		
Plywood for formwork		O		Fire hydrant (one-hole and two-hole types)	O		
Wood		O		Water meters (China)			O
Trench sheet	O			Under-pressure drilling machine	O		

Galvanized corrugated steel plate		O		Steel pipe/cable detector	O		
Paints		O		Auto pipe cutter	O		
Laterite (for backfilling and paving)		O		Water pressure testing pump	O		
Paving material		O					
Fuel		O					

Note: "JPN" in the table above indicates Japan, and "TC" indicates Third Country.

1) Cement and concrete

Cement is being periodically imported from Thailand and there is no problem in the quality. Since the quantity to be used for this project is small, cement as well as ready mixed concrete shall be procured locally.

2) Reinforcing bar

Small quantities of standard reinforcing bars are being imported from Singapore and Malaysia. For this project, reinforcing bar is required only for small structures such as air valve chamber, therefore, this item shall be procured locally.

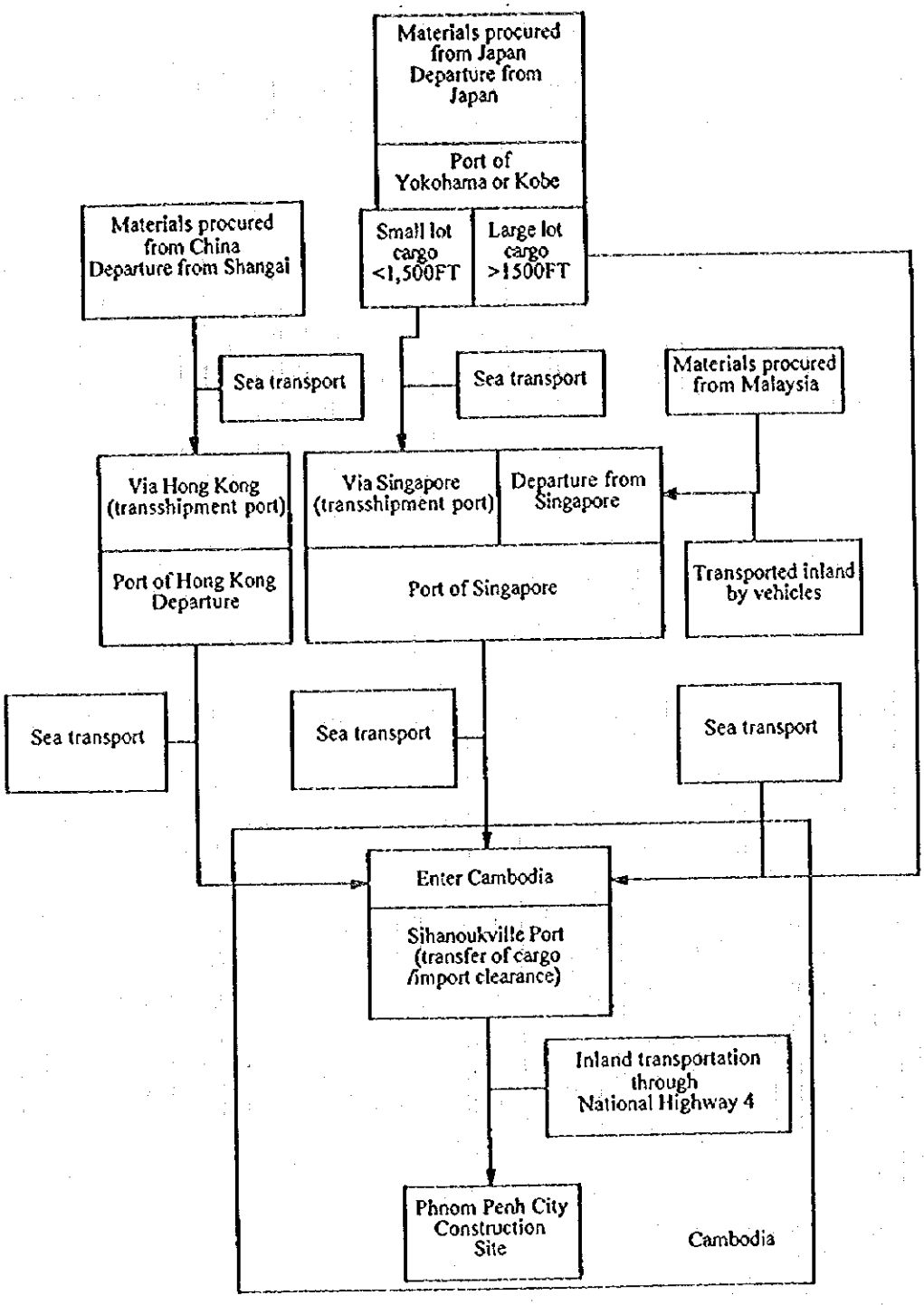
3) Piping materials and valves

Since primary and secondary distribution pipelines, which fall mainly under the scope of work of the Japanese side, are to be laid under roads these pipes are particularly required to have good durability. It was therefore decided that ductile cast iron pipes conforming to Cambodian standards would be used.

The possibility of countries neighboring Cambodia (Thailand, Malaysia and Singapore) as procurement sources were studied, but since this type of pipe is not being manufactured in any of these countries, it was decided to import the pipes from Japan. A similar decision was made for valves.

4) Import route for materials

The plan for the import route of materials from Japan or a third country (China, Malaysia) is as shown below.



Note: There is another transportation route - the ship does not enter Sihanoukville port but directly enters the port of Phnom Penh via the Mekong river, making the port of Phnom Penh the unloading port. However, a part of the Mekong river from the mouth of the river to the port of Phnom Penh passes through Vietnamese territory. In the past, the border has been closed. If this action is repeated, the ship may

not be able to pass through Vietnamese territory. To avoid this risk, the transportation route described in the flow chart is considered in this project.

3.1.6 Implementation Schedule

The installation of an additional 70 km of distribution pipeline in this project starts with detail design and preparation of tender documents, and goes through the stages of trial excavation, pipe-laying work, water pressure tests and miscellaneous work, requiring a total of 19 months for completion. Ductile cast iron pipe, the main material used in the project is to be procured from Japan, and is to be transported in six batches over the sea and over land to the work site.

3.1.7 Obligations of Recipient Country

1. To secure the sites for the Project

2. To clear, level and reclaim the sites prior to the commencement of the construction

3. To undertake incidental outdoor works such as gardening, fencing, gates and exterior lighting in around the sites

4. To exempt taxes and to take the necessary measures of customs clearance of the materials and equipment brought for the Project at the port of disembarkation

5. To exempt Japanese Nationals from customs duties, internal taxes and other fiscal levies which may be imposed in Cambodia with respect to the supply of the products and services under the verified contracts

6. To accord Japanese Nationals, whose services may be required in connection with the supply of products and the services under the verified contracts, such facilities as may be required for the duration of their work

7. To maintain properly and effectively all the facilities constructed and equipment purchased under the Grant

8. To bear all the expenses other than those to be borne by the Grant, necessary for construction of the facilities as well as for the transportation and installation of the equipment

3.2 Project Cost Estimation

1) Costs borne by Cambodia: US dollars 2,826,600 (approx. 302 million yen)
(1) Costs for laying tertiary pipelines (excluding materials)(borne by PPWSA): US dollars 394,200 (approx. 42 million yen)
(2) Costs for laying new service pipelines to each household (including material and labor costs) (borne by recipients of the services): US dollars 2,097,400 (approx. 224 million yen)
(3) Costs for switching over to the already installed service pipe connections to each household (including material and labor costs)(borne by PPWSA): US dollars 335,000 (approx. 36 million yen)

Total cost = 2,826,600 US dollars (approx. 302 million yen)

2) Estimation conditions
(1) Estimation date: September 1996
(2) Exchange rate: 1.00 US dollar = 107 yen
(3) Work period: Detail design and construction, work period shall be as shown in the work process.
(4) Others: This project shall be implemented in accordance with the Japanese Government's Grant Aid Program.

3-3 Operation and Maintenance Costs

The key point of sound waterworks management is to ensure that the costs borne by consumers for the supplied water are balanced and fair. PPWSA has embarked on efficient organizational management measures such as "Use of Tariff Collection System by Introducing Computers," "Training for Personnel and Financial Managerial Staff," and "Extensive Installation of Water Meters."

PPWSA has also framed the "Five-Year Development Plan (1996-2000)" and has given the following estimates for its financial plan and personnel acquisition plan.

1) Financial plan

	1996	1997	1998	1999	2000
Revenue (riels x 1000)					
* Water tariff	6,785,000	8,944,000	10,537,000	19,378,000	28,167,000
* Others	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000
* Total	8,285,000	10,444,000	12,037,000	20,878,000	29,667,000
Expenditure (riels x 1000)					
* Electricity charges	2,887,000	3,255,000	3,325,000	5,337,000	7,000,000
* Repair costs	1,082,000	1,220,000	1,247,000	2,168,000	4,666,000
* Personnel expenses	1,082,000	1,220,000	1,247,000	1,778,000	2,333,000
* Depreciation	1,443,000	1,627,000	2,663,000	4,260,000	4,666,000
* Misc. expenses	722,000	813,000	832,000	1,334,000	2,333,000
* Eq. investments	3,838,000	3,588,000	2,500,000	2,500,000	2,500,000
* Total	11,054,000	11,723,000	11,814,000	17,377,000	23,498,000
Difference in totals	-2,769000	-1,279,000	223,000	3,501,000	6,169,000

The table above shows the comparison of water manufacturing costs (expenditure) and the water tariff (revenue), and predicts a surplus from 1998 onward.

(1) Possibility of setting up an autonomous business accounting system
With the implementation of this project, 15,000 water meters are likely to be installed. New revenues may be anticipated as estimated below from the new water tariff to be enforced from January 1997 and the water consumed per household.

0.200 m^3/person.day (daily average) x 6 persons/household x 1,100 riel x 15,000 households = 594 million riels per month (approximately 240,000 US dollars)

The amount (729,200 US dollars) to be borne by the Cambodian side for the implementation of this project can be recovered within three months after the enforcement of new water tariffs. This calculation also endorses the validity of a surplus budget from 1998 onward.

(2) Possibility of ensuring the amount (729,200 US dollars) borne by the Cambodian side

The Ministry of Finance of the government of Cambodia uses a system whereby it collects and summarizes all requests from various implementing organizations, related to provision of funds to be borne by the respective organizations for work in Grant Aid projects of various countries, pools this budget and disburses sub-contractors directly without going through the implementing organizations.

The amounts for PPWSA-related work disbursed between 1993 to 1996 are given below. However, in the breakdown for 1996, 65% (873,096 US dollars) was disbursed by the Ministry of Finance, while the remaining 35% (470,129 US dollars) was disbursed by the Phnom Penh city.

1993	77,800 US dollars	1995	642,610 US dollars
1994	179,925 US dollars	1996	1,343,225 US dollars

Based on the records of the budget above, it can be said that the scope of work related to this project can be implemented without problems by the Cambodian side.

(3) Connection costs borne by the residents

The costs required for new connections per household is 200 US dollars. This is a heavy burden on the low-income group. However, the low-income group resort to illegal means, buying water from a part of the residents, which clearly indicates their wish to obtain connections. As a means of lightening this burden on such households, PPWSA has been installing hydrants that can be shared by three to four households, and this action by the PPWSA is being received well by the residents.

2) Plan for employing and stationing personnel

PPWSA has a plan for employing 420 persons in 1996, based on the principle of 15 employees per 1000 consumers. It is planning to employ 525 persons in the year 2000, which works out to 7 employees per 1000 consumers, aiming for a more efficient organization.

1996	420 employees (15/1000)
1997	450 employees (13/1000)
1998	450 employees (09/1000)
1999	490 employees (07/1000)
2000	525 employees (07/1000)

Chapter 4

Project Evaluation and Recommendation

Chapter 4: Project Evaluation and Recommendation

4.1 Project Effects

The project area, located at the center of the city, has many old distribution pipelines with considerable leakage of water. Especially since the population density is high, the priority for implementing this project is high. The following beneficial effects are anticipated by implementing this project:

i) The reported existing leakage rate of about 50% will be reduced to approximately 10%. The leakage (10%) after installation of new pipelines, considering target values based on Japan's experience, is estimated to be slightly higher, in the range of 10% to 15%.

ii) Mixing of polluted water will be eliminated since the service pressure will be restored, and a stable supply of drinking water will be available. With the renewal of pipes, a supply pressure of 2.7 to 3.3 kg/cm^2 will be available, eliminating the possibility of entry of polluted water into the distribution pipelines.

iii) By installing valves and fittings to divide the pipeline network into blocks, maintenance and repairs become very easy. Currently, sluice valves control the entire system, therefore, if an abnormal outflow of water occurs due to an accident, water supply has to be cut over a wide area. When this project is implemented, water supply will be cut only in the block affected, so that repair work can be carried out in this block.

iv) Illegal connections (stealing water) will be eliminated when the project is implemented. As a result, new consumers will be re-registered, reinforcing the PPWSA management system. In the project area, there is demand for water in about 22,000 households. Re-registration will be carried out after installing about 15,000 water meters, enabling correct water tariffs to be collected.

v) Hydrants will be installed in areas with densely-concentrated households, thereby improving the fire protection environment in the city.

4-2 Recommendation

As mentioned above, various beneficial effects may be anticipated by implementing this project. At the same time, the project will contribute to the BHN of the residents in a wide area, and the validity of implementing it by grant aid can be endorsed. Moreover, the organization on the Cambodian side is considered to be adequate in regard to personnel and capital for implementing and managing the plan. However, if the following points are taken into account and improvements made, the present project can be implemented more smoothly and effectively.

1) Impartial and balanced supply of water

Distribution pipeline projects in progress in the various districts in Phnom Penh city, are scheduled for completion in 1998, except for a part of the Toul Kork district. The demand in 1998 is estimated as given below.

	Population (persons)	Per capita consumption (l/person.day)	Demand (m^3/day)
Don Penh	186,583	204	38,062
Chamkar Morn	197,804	204	40,252
Seventh January	144,527	204	29,483
Toul Kork (1)	54,371	204	11,091
Toul Kork (2)	130,273	325	42,338
Total			161,326

204 l/person.day: If the daily average consumption (100 l/person.day) in 1992 is taken as the basis, this figure becomes 134 l/person.day in 1998 considering an annual increase of 5%. Furthermore, the daily maximum consumption considering a load factor of 30% becomes 174 l/person.day. If the leakage rate after provision of distribution pipelines is assumed to be 15%, the maximum per capita consumption is 174 / (1-0.15) = 204 l/person.day.

325 l/person.day: The maximum daily per capita consumption when the leakage rate is 50%.

Against the demand above, the total capacity of the Phum Prek and the Chamkar Morn water treatment plants is 120,000 m^3/day, and the shortage in capacity in 1998 is estimated at about 40,000 m^3/day. From hydrological aspects, provision of distribution pipelines will result in a larger flow; areas not provided with distribution pipelines are likely to suffer from worse shortages.

Based on the above, an increase in supply to meet the shortage of absolute capacity is a topic that needs urgent attention. Considering a balanced and impartial supply of water, the flow of water in areas provided with distribution pipelines should be controlled by valves so that the water supply to the areas not provided with distribution pipelines does not drop down below the existing level.

2) Publicizing activities

With the installation of new secondary pipelines, the Cambodian side should complete the connections of service pipelines immediately. With this completion, the consumers are likely to re-register with the PPWSA, therefore, the PPWSA should take measures for widely publicizing the completion of the connections.

3) Cultivation of water quality experts

The turbidity of water in the Sap river, which is the intake source, increases in the rainy season, therefore the treatment facilities should be appropriately managed. The cultivation of water quality experts to the site will contribute effectively to improving water quality controls.

{Appendices}

1. Member List of the Survey Team

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I. Study Team

1.Leader,Ms.Keiko YAMAMOTO
Development Specialist
Japan International Cooperation Agency

2.Coordinator,Mr.Shinichi MASUDA
First Project Study Division, Grant Aid Study & Design Department
Japan International Cooperation Agency

3.Chief Consultant,Mr.Kaoru SUZUKI
Operation and Maintenance Planner
Tokyo Engineering Consultants

4.Pipeline Planner,Mr.Takayuki TANGE
Tokyo Engineering Consultants

5.Pipeline Designer,Mr.Judo HAGIWARA
Tokyo Engineering Consultants

II. Draft Basic Design Report Explanation Team

1.Leader,Dr.Yasumoto MAGARA
Director,Department of Water Supply Engineering,
The Institute of Public Health,Ministry of Health and Welfare

2.Coordinator,Mr.Hideaki MARUYAMA
First Regional Division, Planning Department
Japan International Cooperation Agency

3.Chief Consultant,Mr.Kaoru SUZUKI
Operation and Maintenance Planner
Tokyo Engineering Consultants

4.Pipeline Planner,Mr.Takayuki TANGE
Tokyo Engineering Consultants

2. Survey Schedule

Survey Schedule

Date		Day	Remarks		Components
Jun	4	Tue	Study Team	NRT～BKK	NRT：TG 641 (11:00 - 15:40)
	5	Wed	〃	BKK～PNH	BKK：TG 696 (11:00 - 12:15) Courtesy Call to JICA Office
	6	Thu			Courtesy Call to MFAIC、PPM、PPWSA and EOJ
	7	Fri			Discussion with WB,FE and PPWSA
	8	Sat			Site Survey
	9	Sun			Inner Meeting
	10	Mon			Discussion
	11	Tue			Signing on Minutes of Discussion
	12	Wed	Leader & Coordinator	PNH～BKK BKK～	PNH：TG 697 (13:15 - 14:20) BKK：TG 642 (22:15) →|
	13	Thu	〃	NRT	→NRT：(06:25) Study Team -Data Collection
	14	Fri			Data Collection
	15	Sat			Discussion with PPWSA
	16	Sun			Inner meeting
	17	Mon			Site Survey
	18	Tue			ditto
	19	Wed			ditto
	20	Thu			ditto
	21	Fri			ditto
	22	Sat			ditto
	23	Sun			Inner Meeting
	24	Mon			Site Survey
	25	Tue			ditto
	26	Wed			ditto
	27	Thu			ditto
	28	Fri			ditto
	29	Sat			ditto
	30	Sun			Inner Meeting
Jul	1	Mon			Discussion with PPWSA
	2	Tue	Study Team	PNH～BKK BKK～	PNH：TG 699 (16:45 - 17:20) BKK：JL 718 (22:30) →|
	3	Wed	〃	NRT	→NRT：(06:30)

Notes; MFAI: Ministry of Foreign Affairs and International Cooperation,

PPM: Phnom Penh Municipality, PPWSA: Phnom Penh Water Supply Authority,

WB: World Bank, FE: Frech Expert, EOJ: Embassy of Japan

Schedule

Date		Day	Remarks		Components
Aug	29	Thu	Study Team	NRT～BKK	NRT：TG 641 (11:00 - 15:40)
	30	Fri	〃	BKK～PNH	BKK：TG 696 (11:00 - 12:15) Courtesy Call to EOJ& JICA Office
	31	Sat			Site Survey
Sep	1	Sun			Site Survey
	2	Mon			Courtesy Call to MFAI, PPM and PPWSA
	3	Tue			Discussion
	4	Wed	Leader	PNH～BKK BKK～	Signing on Minutes of Discussion
	5	Thu			Discussion
	6	Fri	Study Team	PNH～BKK BKK～	PNH：TG 697 (13:15 - 14:20) BKK：TG 642 (22:15) →|
	7	Sat	〃	NRT	→NRT：(06:25)

Notes; MFAI: Ministry of Foreign Affairs and International Cooperation,
PPM: Phnom PenhMunicipality, PPWSA: Phnom Penh Water Supply Authority,
WB: World Bank, FE: Frech Expert, EOJ: Embassy of Japan

3. List of Party Concerned in the Recipient Country

Name List

Organization	Name	Position
Embassy of Japan	Mr.Shohei Naito	Ambassador
〃	Mr.Masato Iso	First Secretary
〃	Mr.Shigemitsu Tsukamoto	First Secretary
〃	Mr.Kenji Shigemura	Second Seretary
〃	Mr.Takayuki Suda	Second Seretary
JICA Cambodia Office	Mr.Hiroyuki Arai	Chief Representative
〃	Mr.Koji Sakane	Assistant Resident Representative
〃	Mr.Tetsuro Hamada	JICA Expert
Ministry of Foreign Affairs of Cambodia	Mr.Kem Mongkol	Director of International Cooperation
〃	Ms.You Ay	Director of General Department of ASEAN
Municipality of Phnom Penh	H.E. Chea Sophara	1st Vice Governor
〃	H.E. Chap Nhalyvoud	2nd Vice Governor
〃	Mr. Kim Saysamalen	Deputy Chief of Cabinet
〃	Mr. Lim Nora	Officer of International Relations Office
〃	Mr. Men Serey	Deputy Director of Planning
〃	Mr. Nhem Saron	Officer of Cabinet
Phnom Penh Water Supply Authority	Mr. Ek Sonn Chan	Director
〃	Mr. Seng Tong	Deputy Director
〃	Mr. Long Naro	Chief of Technical Office
〃	Mr. Kosal	Assistant Chief of Technical Office
World Bank	Dr. Johann Muehlbauer	Chief Technical Advisor
French Expert	Mr. J.P.Suratteau	Team Leader (SAFEGE)