JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DIRECTORATE GENERAL OF HUMAN SETTLEMENTS
MINISTRY OF PUBLIC WORKS
REPUBLIC OF INDONESIA

THE DETAILED DESIGN FOR URBAN DRAINAGE PROJECT IN THE CITY OF JAKARTA

FINAL REPORT

VOLUME I

MAIN REPORT

DECEMBER 1997

NIPPON KOEI CO., LTD.
TOKYO, JAPAN

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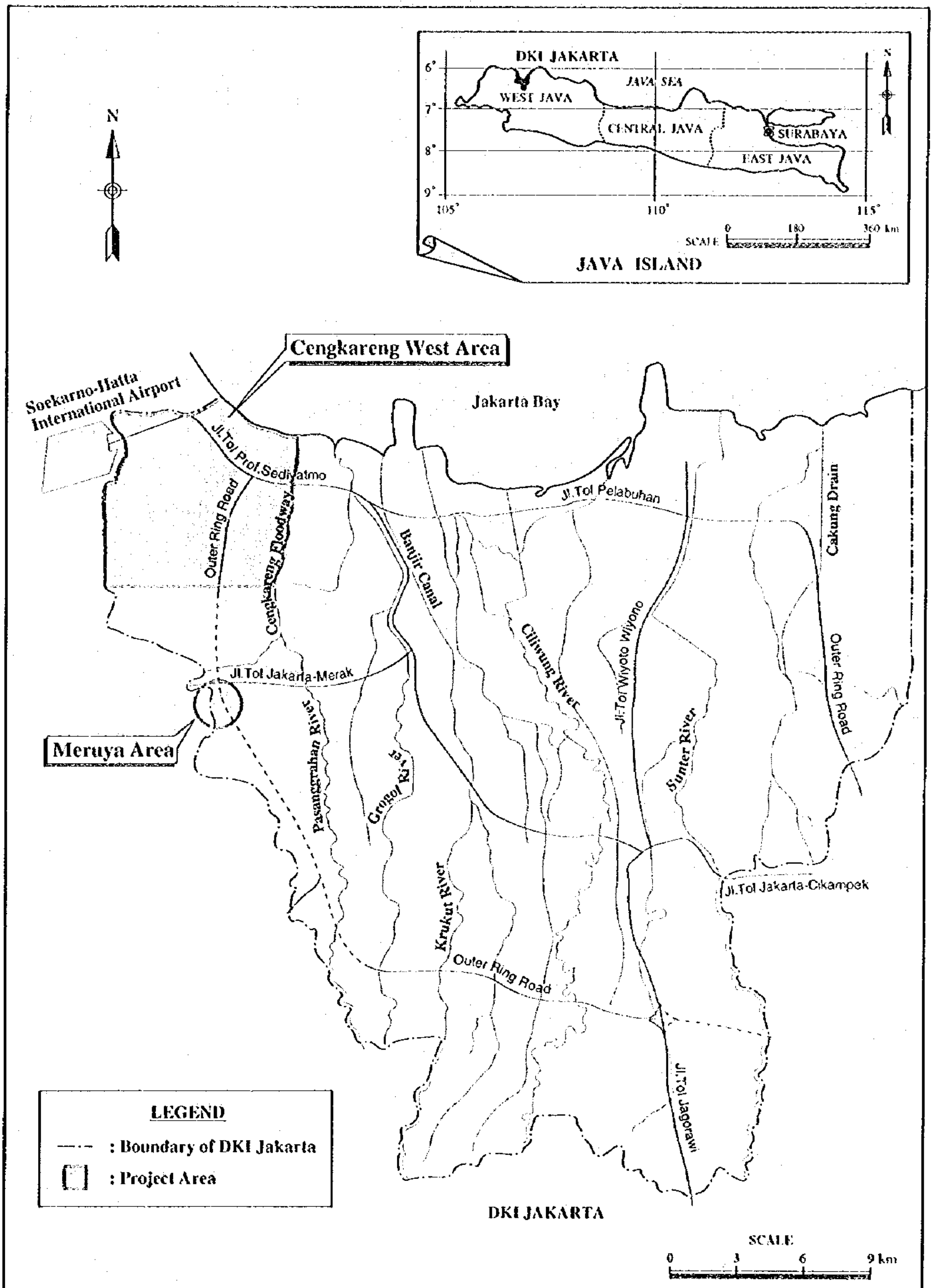
IMPLEMENTATION PROGRAM

The cost estimate is based on the price level of June 1997 and the monthly mean exchange rates in June 1997. The monthly mean exchange rates in June 1997 are:

US$ 1.00 = ¥ 115.00 = Rp. 2,350



Location Map

SUMMARY

This is a Design Report stating the results of field investigation including meteorological investigation, topographic survey and geo-technical investigation, design of the urban drainage plan including establishment of basic concept for urban drainage plan, review of flood discharge distribution, setting of design criteria, design of urban drainage project, construction plan and implementation schedule, cost estimate, economic evaluation of the plan and operation and maintenance plan, environmental impact assessment and social impact management program. The contents of the Design Report are briefly stated hereinafter.

1 FIELD INVESTIGATION

1.1 Meteorology and Hydrology

(1) Rainfall characteristics such as elevation-rainfall relationship, regional rainfall characteristics and hourly rainfall characteristics were studied based on the data obtained in this investigation, and rainfall intensity-duration relationship needed for estimation of probable flood discharge were analyzed based on the rainfall data for the selected rain gauge.

(2) Relationship between habitual inundation and rainfall intensity was studied to estimate flood damage and to incorporate these results for the project evaluation.

1.2 Topographic Survey

(1) The topographic survey performed comprises topographic profile survey along the proposed drainage channels in the Cengkareng west area and proposed drainage ditches in the Menya area and cross sectional survey for these drainage channels and ditches.

(2) Prior to the substantial survey works, check survey for the existing bench mark networks was performed based on the existing bench marks which have not been affected by land subsidence, in order to examine the accuracy of the existing bench mark networks established by TTG system. Result of this check survey revealed that the majority of the existing bench marks located in and around the project area include

errors due to land subsidence. The topographic profile and cross sectional surveys were carried out based on the modified elevation of the existing bench marks. In addition, it was clarified that elevation of the bench marks for PP system is 1m higher than that of TTG system.

1.3 Geo-Technical Investigation

(1) The geo-technical investigation has two main purposes: to establish the engineering properties of the soil foundation in the Cengkareng and Meruya areas and to evidence the subsidence affecting the entire alluvial plain around Jakarta.

(2) The investigation for the foundation consisted of drilling , laboratory testing and Dutch cone sounding. The results indicate that the soil cover in the study are is very deep and it consists of more than 70% of clay, carbonaceous and containing shells in the upper layers and residual (sandy) underneath. The soils are softer in the coastal area and more consistent from the highway to the south and in the Meruya area. The bigger structures to be constructed in the future need to have pile foundations. The minimal depth for the foundation is 16 m in the coastal area and only 10 m from the toll road to the south. The soft clayey soils are highly plastic, oversaturated and very compressible. Loading of such soil beds would lead to consolidation settlement.

(3) Important rates of subsidence have been reported in the past. This phenomenon is the result of self-weight consolidation, triggered by large scale pumping from the deep aquifer (40-250 m), underlying the alluvial plain. In order to evidence the subsidence, leveling survey of existing bench marks and fixed points, on existing structures has been planned. The phenomenon of the survey will be indicated if the chosen points have undergone any change in elevation. Another approach of the subsidence was by means of well monitoring. Any anomaly in the pore pressure (piezometric head) distribution would be an indicator of subsidence.

2. DESIGN OF URBAN DRAINAGE PLAN

2.1 Basic Concepts for Urban Drainage Plan

The basic concept for the urban drainage plan for two objective areas, Cengkareng west area and Meruya area was established considering rapid urbanization in the objective areas represented by housing development and drastic variation of the existing drainage networks due to (i) construction of interchange structures of Jakarta ring road and (ii) anticipating future land use condition. The basic concept for the proposed urban drainage plan is as follows:

(a) The future land use plan for the objective areas was established referring to the land use plan set out by DKI Jakarta and anticipating future land use condition from present land use progressing situation, and target year for this drainage plan is set at 2010. Comparison of the land use in the present and the target year 2010 is as follows:

(Unit: km^2)

Category of Area	Present Land Use	Land Use in 2010
- Residential area	22.44	27.98
- Industrial area	2.31	3.48
- Paddy field	5.55	2.27
- Fish pond	3.28	2.98
- Swampy/depression area	3.13	0
Total	36.71	36.71

(b) The drainage channels are designed under protection level of 10-year flood for the Cengkareng west area and 5-year flood for the Meruya area.

(c) Drainage water is drained by gravity flow in principle to minimize operation and maintenance cost for the drainage facilities after construction of the project.

(d) In the Cengkareng west area, only primary (main) drainage channels will be designed. For Meruya area, all of the major drainage channel is secondary level. In this design, major secondary drainage channel will be designed.

(e) Special consideration for land subsidence and clean water management was made for planning and designing of the proposed urban drainage project.

(f) There are many swamp and depression areas in the Cengkareng west area and these areas have been already acquired by private housing developer/industrial enterprise. The drainage channels in private owned areas should be constructed by themselves and the constructed drainage facilities will be handed over to DKI Jakarta for routine maintenance works. In the definitive plan, design criteria to be applied to the drainage channel for the private sectors such as design discharge, design channel bed slope and design channel bed elevation will be clarified

(g) Currently, the Jl. Tol. Prof. Sediyatmo is aligned in the swampy area in the northern part of the Cengkareng west area and it has repeatedly suffered from submergence in a rainy season. The cause of this road submergence is attributable mainly to lower elevation of the highway in an about 4 km long stretch in the Cengkareng west area. To cope with this submergence and also to cope with traffic volume increase in a future stage, it has been planned by JASA MARGA that the existing highway is widened to four lanes and heightened in the stretch between the Kamal drainage crossing site and Cengkareng flooway crossing site, and the bridges crossing the Kamal and Tanjungan drainage channels are to be designed and constructed by JASA MARGA themselves. Thus, in this design, the bridges for the Kamal and Tanjungan drainage channels, which cross the highway are excluded.

(h) The high tension electric lines and water supply pipe lines cross the existing drainage channel. Due to expansion of the drainage channels, treatment of these lines are needed. Besides, it is obliged to shift the existing telephone poles, concrete structure with gates for drainage facilities of highway, road signs, traffic signals, etc. due to expansion of the existing drainage channel. For these treatments, discussion is to be needed with authorities concerned. It is proposed that planning, designing and construction of expansion/shifting works of these structures are to be made by authorities themselves under the condition that the cost necessary for expansion/shifting works is born by the project.

2.2 Proposed Drainage Channel Alignment

In accordance with the above concepts, the drainage channel alignment and basic drainage plan were determined. The proposed drainage channels in the Cengkareng west area comprise five, namely, Kamal, Tanjungan, PIK Junction, Gede/Bor and Saluran Cengkareng. All of these channels except for the new channel were aligned by expanding the existing drainage channels. For the Kamal and Tanjungan drainage networks, channel alignment for the private owned areas was also studied. For the PIK Junction drainage channel, drainage channel was aligned by avoiding the foundation works of the interchange of the highway. Since it is impossible to drain water perfectly from the locally low land areas, it was contemplated to provide slide/flap gates in the proposed drainage channels along the low land areas. To prevent further expansion of inundation in the low land area along the Saluran Cengkareng drainage channel in case that a large magnitude flood takes place in the Cengkareng floodway and flood flows into the Saluran Cengkareng drainage channel, sluice gate facilities will be provided at the outlet of the Saluran Cengkareng drainage channel. In addition, at upstream end of the Saluran Cengkareng drainage channel, slide gate facilities were provided to release maintenance water in a dry season. In order to prevent dust and garbage from flowing into the drainage channel along the densely populated area in the Saluran Cengkareng drainage channel, open culvert with mesh cover and inlet screen will be provided. For Meruya area, the proposed drainage ditch was aligned so as to drain all of water to the western direction.

2.3 Flood Discharge Distribution

The flood discharge distribution established in the feasibility study was reviewed incorporating the rainfall data obtained in this study. The revised design flood discharges are almost same as those of the feasibility study stage.

2.4 Design Criteria

The design criteria necessary for the design of the drainage channel structures including channels, levees, revetments, bridges, culverts and gate facilities were established referring the standards applied in the Ministry of Public Works, DKI Jakarta and standards applied in Japan. In establishment of the design criteria, special consideration was given to the measures against land subsidence, especially for permanent structure such as bridge and culvert.

2.5 Design of the Drainage Facilities

The basic design for the civil works including a series of drainage channel structures and mechanical works such as slide gates and flap gates was carried out based on the topographic map with a scale of 1:1,000 and cross sections with an interval of 100m and applying the established design criteria.

(1) Longitudinal profile of the drainage channel

The longitudinal profile of the drainage channels was determined under the condition that the newly designed channel bed slope is not remarkably different from the present channel bed slope in principle. The determined channel bed slope is as follows:

- Kamal drainage channel : 1/3,200 and 1/1,800
- Tanjungan drainage channel : 1/5,000
- PIK Junction drainage channel : 1/600
- Saluran Cengkareng drainage channel : 1/3,000
- Gede/Bor drainage channel : 1/1,600
- Meruya drainage channel : 1/2,000, 1/260 and 1/700

(2) Design high water level and cross section of drainage channel

The drainage channels were designed by widening the existing channels and constructing new levees. Single cross section was applied for all of the proposed drainage channels under the condition that design water level should be lower than the ground elevation of the related drainage area in principle.

(3) Design of channel structures

Earth type levees and concrete parapet walls were adopted to meet design water level. The concrete parapet walls were applied in the channel stretches along the densely populated areas. Wet masonry type revetments were applied to stabilize side slopes of the drainage channels, except the channel stretches which will be provided with the earth type levees. Existing roads along the proposed drainage channels will be used as an inspection road for routine operation and maintenance works of the drainage facilities and also for periodical inspection. In case that no existing road is available for the inspection roads along the drainage channels, the inspection roads at least 5 m wide will be provided on the crest of the newly constructed earth type levees or along the drainage channels.

In order to drain water to the drainage channel and to prevent water from entering into the drainage area, slide type gates with 0.7-1.3 m square size were installed for majority of the junction of the secondary drainage channels and several flap type gates were provided for small drainage areas.

(4) Design of bridge

Due to the expansion of the existing drainage channels, 76 existing bridges were planned to be reconstructed. Based on the relationship among bridge span, girder height and kind of superstructures, two types of the superstructures, pre-tension girder and in-situ slab type bridges are applied. New 76 bridges comprise 54 pre-tension girder bridges and 22 in-situ slab type bridges. In this design, 37 type bridges were designed and designed structural sections were applied to the remaining 39 proposed bridges.

Major features of the drainage channels and related structures thus designed are as follows:

Name of Channel	Length (km)	Width* (m)	No. of bridge	No. of gate (Slide/Flap)
a) Cengkareng west area:				

-Kamal(main)	4.5	30 - 35	9	15
-Kamal(branch)	2.8	2 - 13	19	8
-Tanjungan	2.5	15 - 25	5	7
-PIK Junction	0.8	2.2	4	1
-Gede/Bor	1.2	10 - 11	10	5
-Saluran Cengkareng	4.2	6 - 10	13	15
b) Meruya area	2.3	1.2 - 8	16	0
Total	18.3		76	51

Note : * means bottom width

3 COST ESTIMATE

(1) The financial cost was estimated under the following conditions:

(i) The financial cost comprises main construction cost, compensation cost for households and land acquisition, engineering service and administrative costs, physical and price contingencies and interest during construction. The main construction cost was estimated on a unit price basis.

(ii) All the construction works of the project will be executed on a contract basis. The construction equipment, materials and labor to be required for the works will be supplied by the contractors to be selected through an international tendering for each package.

(iii) The cost estimate is made at the price level as of June 1997 because basic costs of labor, material and equipment had been collected at this period.

(iv) The cost estimate is made in terms of US Dollars for both the foreign currency portion and the local currency portion.

(v) The exchange rate in the cost estimate is US$1.0 = ¥115.00 = Rp. 2,350, on the bases of the TTS (=Telegram Transfer Selling) rates of the Bank of Tokyo-Mitsubishi in Japan as of monthly mean rates in June 1997.

(vi) Compensation cost for households and acquisition of lands was estimated based on experienced cost data in city of Jakarta.

(vii) The engineering service cost for assistance of tendering and construction supervision of the project works by consultant was estimated on an actual cost basis. The administration cost necessary for operation expenses of the project management office was estimated at 5 % of the main construction cost.

(viii) The contingency comprises physical and price contingencies. The physical contingency was estimated at 10 % of the sum of main construction cost, land and house compensation, and engineering service and administrative costs. The price contingency to cope with an annual price escalation was estimated at 2 % for both the foreign and local currency portions.

The financial cost estimated based on the above conditions is US$ 88.973 million comprising foreign currency portion of US$ 28.016 million and local currency portion of US$ 60.957 million including tax.

(2) An annual disbursement schedule of the project works was estimated based on the proposed construction schedule. The budget to be disbursed annually is summarized as follows:

(unit : 10^3 US$)

Year	Amount	Year	Amount	Year	Amount
1997	1,030	2001	14,245	2005	10,856
1998	854	2002	15,803	2006	7,447
1999	3,297	2003	12,487		
2000	8,152	2004	14,802		
	13,333		57,337		18,303

4 ECONOMIC EVALUATION

(1) The economic cost was estimated deducting the transfer payment, compensation cost and costs for price escalation and interest from the financial cost. The estimated economic cost is US$ 51.42 million for sum of the Cengkareng west area and the Meruya area.

(2) The project benefit was estimated assuming that the annual average flood damage corresponding to less than 10-year probable flood for the Cengkareng west area and 5-year probable flood for the Meruya area is regarded as the flood control benefit. For estimation of the flood damage, direct flood damages such as damage for general assets, agricultural damage and damage for infrastructures and indirect damage such as damage to economic activities due to its activity stagnation were estimated. The estimated flood control benefit is US$ 7.6 million for the Cengkareng west area and US$ 0.2 million for Meruya area.

(3) Economic viability of the project was evaluated by internal rate of return(EIRR) assuming that the project life time is 50 year, annual operation and maintenance cost is 0.5% of the direct construction cost. On the basis of the estimated economic cost and

project benefit, EIRR was estimated at 17.9 %.

5 OPERATION AND MAINTENANCE PLAN

(1) Present conditions of operation and maintenance works

Water flow of the existing drainage channels has been sometimes disturbed due to obstruction such as garbage, vegetation, etc. especially in the dry season. To know the present operation and maintenance conditions performed by DPU DKI, Jakarta, organization, staffing, their function and maintenance method were investigated. Present organization for operation and maintenance works of DPU DKI, Jakarta is illustrated in Fig 7.1. Under the chief of DPU DKI, maintenance division has been established. This maintenance division has four sections, namely, technical and planning for water related project, technical and planning for road and bridge, controlling and supervision for water related project and controlling and supervision for road and bridge. These four sections treat with a large scale drainage channels such as primary drainage channel or first class road and bridges. The maintenance works have bee carried out by both a force account and a contract systems depending on the amount of the maintenance works. The smaller scale maintenance works have been carried out by the force account system by hiring labor force and equipment from sub-district division. The technical and planning section has a function for monitoring and inspection of the project, survey and investigation and design works for maintenance works. The controlling and supervision section has a function for execution of the maintenance works and supervision of maintenance works done by maintenance division itself and sub-division. An average annual budget for operation and maintenance works disbursed for all the city of Jakarta in the past was Rp 24.5 billion.

(2) Proposed operation and maintenance plan

After implementation of the project, a number of bridge and gate facilities increases remarkably compared with present drainage condition. To carry out complete operation and maintenance works, effective organization and system should be established. Fig 7.2 shows the proposed organization established under the following concepts:

(i) To cope with operation for remarkably increased gate facilities, combination of systematic operation and maintenance works is duly needed. In addition, to avoid artificial inundation due to unsuitable operation of the gates, systematic operation of the gates is unavoidable.

(ii) In order to keep National Program of Clean Water (Prokasih), monitoring and observation of the completed drainage channel networks are duly needed.

(iii) In order to timely maintain the drainage facilities, minimum repairing equipment such as wheel loader, dump truck, etc. should be kept by the maintenance works group.

In the proposed organization, technical and planning unit will be divided into monitoring and observation group and design group. Under the controlling and supervision unit, operation group for metal works and maintenance group are established. In the monitoring and observation group, works for water quality and survey and investigation of damaged portions will be carried out. In the design group, design of the maintenance works for the drainage facilities including planning, design, cost estimate, and maintenance method will be made. In the operation group under the controlling and supervision unit, routine operation and maintenance works for about 50 units of the newly installed gates and their facilities will be carried out. In the maintenance works group, the maintenance works will be performed by hiring labor and apart of equipment from sub-district for a small scale maintenance works. In case that the maintenance works is a large scale, maintenance works will be made by local contract system under supervision of the maintenance group.

The operation and maintenance cost for this project was estimated for routine operation and maintenance works based on the work quantity of the project works and unit rate of work components. The estimated annual operation and maintenance cost for this project is Rp. 1 billion.

6 ENVIRONMENTAL IMPACT ASSESSMENT

(1) Noticeable present environmental conditions

There are 211 households with land certificate, generally termed as legal residents, directly affected by the project and that they are subject to relocation. Factories, schools, mosque, market place and government office and public space are also subject to relocation. The squatters directly affected by the project are 1,442 households. They are subject to evacuation from the present living areas. These make up 1,716 items of relocation within the framework of the project.

The Tanjungan drainage channel is constructed through mangrove plantation area where planting scheme is currently undertaken by the Department of Forestry of DKI Jakarta. The area is designated as "Protected Forest of Angke - Kapuk".

(2) Environmental impacts associated with the project

Relocation of the local residents, both legal residents and the squatters, is the most significant and negative impacts induced by the project. Thus relocation plan is conducted within the framework of the project. Details of the relocation plan is dealt with in the "Social Impact Management Plan".

Construction works taking place within the mangrove plantation area is considered to induce some negative and significant impacts to the mangrove protection area. Dust, noise and general degradation of air quality during the construction period is considered as negative but not significant impacts. Monitoring works will be conducted as a part of general requirement for construction works. Bridge construction works associated with the drainage construction works would induce negative and significant impacts as traffic congestion is inevitable and it would probably cause further negative impacts to the general economic activities in and around the project area.

(3) Environmental management plan

Relocation plan, generally termed as "Social Impact Management Plan", is a kind of environmental management plan. Details of the relocation plan is dealt with in the "Social Impact Management Plan". General precautionary measures of the construction works would be the environmental management plan during the construction implementation period.

The mangrove plantation area that most of the Tanjungan drainage channel is constructed through would have to be designated as the "Area of Biological Management Area" within the framework of the project and intensive effort of plating mangrove species should be conducted upon completion of Tanjungan drainage channel.

(4) Environmental monitoring

Throughout the project area, general air quality, dust, noise and vibration should be monitored during the construction period of all the drainage channels. Mangrove plantation area should be constantly monitored during the construction period of the Tanjungan drainage channel. Upon completion of the all the legal residents, follow-up survey for evaluation of the resettlement conditions should be monitored and evaluated.

7 SOCIAL IMPACT MANAGEMENT PROGRAM

(1) No. of households subject to compensation

Numbers of households and other buildings subject to relocation are as follows:

a.	Local Residents with land certificate	211 households
b.	Squatters	1,442 households
c.	Factories, schools, market place, etc.	63 places

(2) Cost of compensation

Summary of the cost of compensation is as follows:

a. Local Residents with land certificate;			
Rp. 42.01 million /household	x	211 households	Rp. 8,864.2 million
b. Squatters;			
Rp. 200,000 /household	x	534 households	Rp. 106.8 million
Rp. 50,000 /household	x	908 households	Rp. 45.4 million
c. Factories and others;			Rp. 8,427.5 million
Total			Rp. 17,443.9 million

(3) Cost of land acquisition

There are open spaces such as areas being unused in the low lying areas, agricultural lands, and fishponds within the project area that are subject to acquisition for drainage channel construction works as follows:

- Overall land area for the project 321,489.0 m^2
- Total cost of land acquisition Rp. 53,045.7 million.

(4) Resettlement areas

(a) Resettlement areas for those with land certificate

The prevailing cost of construction per unit of a low cost apartment is calculated as Rp.32.85 million. Thus, the total cost of construction of low cost apartment complexes for 162 households would be:

- Rp.32.85 million x 337 units = Rp. 11,070.5 million

Bulak Wadon in Tegal Alur, Cengkareng, adjacent to the mid stream area of the Kamal drainage channel (branch) is the place where these households could resettle.

(b) Resettlement areas for the squatters

There is no formally considered resettlement area for the squatters. They will be all encouraged to return to the villages of origin. However, because of the fact that some are originally from DKI Jakarta, or living in the present area for a considerably long period of time, creating bare lands to rent for the squatters is suggested. In order to avoid the squatters moving to other areas for claiming double payment, or not to cause further development of slum, bare lands to rent catered for resettlement of the squatters are suggested to be prepared over four locations within the project area. Initial investment will be necessary but the cost can be recovered after the 10 year renting period.

(5) Method of relocation operation

(a) Schedule of budget plan

A disbursement plan has been elaborated in order to distribute a large sum of budget for compensation and relocation relatively evenly over 9 years as follows:

	(Rp. million)	
Year 1997	2,000.0	(2.8 %)
Year 1998	1,474.4	(2.1 %)
Year 1999	5,446.2	(7.7 %)
Year 2000	7,909.5	(11.2 %)
Year 2001	17,668.9	(25.1 %)
Year 2002	19,135.5	(27.2 %)
Year 2003	9,127.9	(12.9 %)
Year 2004	4,822.8	(6.8 %)
Year 2005	2,904.5	(4.2 %)
Total	70,489.4	(100.0 %)

(b) Method of relocation operation

DPU DKI Jakarta is the organization responsible for conducting relocation operation and its method. In general, although there are a number of intricate government procedures to be followed when the resettlement operation is conducted, Department of Housing, DKI Jakarta takes over the entire resettlement operation for the development project conducted by DKI Jakarta within the boundaries of DKI Jakarta as considered necessary.

Department of Housing, DKI Jakarta would also construct low cost apartments in order to provide resettlement areas for the low income families subject to relocation. On the other hand, Department of Urban Planning determines appropriateness of the boundaries of drainage channels in relation to the urban planning of DKI Jakarta. Based on the final decision of the Department of Urban Planning, surveyed results of acquired lands are registered at the Regional Office of Land Administration. A simplified flow chart of relocation operation for the households with land certificate and the squatters is as follows:

Request made by DPU DKI Jakarta		Dept. of Housing
↓		↓
Formation of Land Procurement Committee at Kotamadya (Jakarta Barat and Utara)	→	Formation of Assisting Team for Land Procurement and Compensation
		↓
		↓
↓		
Evaluation of the rate of compensation	→	↓
		↓
		Negotiation
		↓
Kecamatan, Kekurahan, RW and RT	→	Witness
		↓
		Agreement and Payment
		↓
Kecamatan, Kekurahan, RW and RT	→	Witness
		↓
		Formal Hand-over of land
Dept.of Housing		↓
↓		Moving and Land Clearing
Construction of Low Cost Apartment		↓
↓		↓
		↓
Resettlement Operation with Assistance of Kecamatan, Kekurahan, RW and RT (vehicles etc. is sometimes provided)	←—←—←—←—←—	↓ Squatters are dispersed
↓		
↓		↓

↓ Survey of Acquired Land Area

↓ Issue of Land Certificate for the households with land certificate

↓ Approval by the Department of Urban Planning

↓ Registration of Acquired Land at Regional Office of Land Administration

↓ Implementation of the Construction Works

8 CONSTRUCTION PLAN AND IMPLEMENTATION SCHEDULE

(1) The proposed organization for implementation of the project is shown in Fig. 10.1. An executing agency of the project will be Directorate General of Human Settlements (CIPTA KARYA), Ministry of Public Works, the Republic of Indonesia, which is responsible for management of the project works including loan appraisal, loan agreement and overall management of the project works. The construction works will be entrusted and carried out by Project Management Office, DPU DKI Jakarta.

(2) The foreign currency portion of the construction cost is expected to be financed by an international organization with its soft loan. On the other hand, the local currency portion will be covered by the Indonesian national budget.

(3) Study on the contract packaging and project implementation plan was studied from two aspects, namely, sequence with emphasis on implementation of drainage channel system and sequence with emphasis on implementation of drainage works in local area with less compensation problems. In the study on contract packaging and project implementation plan with emphasis on implementation of drainage channel system, sequence of implementation of the drainage works was initially studied from three aspects, namely, (i) prospect of compensation of households and land, (ii)investment effect of the project cost, and (iii)technical priority. Based on this results, the contract package was determined in consideration of the following aspects:

(i) Sequence of implementation for drainage channel works studied so far
(ii) Harmonization of implementation works to avoid social inequality and administrative imbalance as pointed out by vice governor of DKI Jakarta.

(iii) Early implementation of drainage channel with less compensation area
(iv) Combination of drainage channels works in consideration of topographic conditions for construction works and of avoiding traffic jamming due to different contract packaged works
(v) Amount of contract package in consideration of international tendering

In consideration of the above situations, it has been proposed to proceed with the construction works of the drainage channels by dividing into the following three packages:

Package-1	:	Kamal drainage channel(main and branch)
		Stage I: Main (BP-KM15)
		Stage II: Main (KM16-KM48)
		Stage III: Main (KM48-KM57) and all branch stretches
Package-2	:	Tanjungan drainage channel and,
	:	PIK Junction drainage channel
Package-3	:	Gede/Bor drainage channel,
	:	Saluran Cengkareng drainage channel and,
	:	Meruya drainage channel

For formulation of the project implementation plan, the following matters were contemplated:

(i) Early implementation of drainage channels with less compensation areas
(ii) Loan validity by an international financing agency, and
(iii) Balanced compensation cost to be disbursed annually

At the explanation of the draft final report, it was requested by DKI Jakarta that the first priority should be given to Package -1 and next priority is Package-2, due to the reason that the drainage areas along the Jl Tol Prof. Sediyatmo (the highway) were quite densely populated and the highest economic development potential zones, and early implementation of the drainage channels for the Packages-1 and 2 was required.

In consideration of the above requested comment and items (ii) and (iii), it was proposed to proceed with the construction works of the drainage channels in accordance with the implementation schedule as shown in Fig 10.2.

Compensation problems are the key factor for implementation of this project. As an alternative for study on contract packaging with emphasis on implementation of drainage channel system, contract packaging with emphasis on implementation of drainage works in local area with less compensation problems was studied in consideration of the difficulty of land compensation. The drainage area in the northern part of the highway is considered as less compensation area. It is contemplated to combine the drainage works in the northern part of the highway as one package due to less compensation problems. However, this alternative has the following problem: even if flow capacity of only in the drainage channel in the northern part of the highway is increased, the drainage effect of one drainage system will not be expected unless drainage works in the southern part of the highway where drainage is in the worst condition are executed because drainage condition from secondary channel will not be improved unless the main drainage channel is improved, namely, increase in the safety factor of one drainage system would not be expected unless safety factor of the drainage channel from downstream to upstream is increased uniformly.

In consideration of the above disadvantages, it is proposed to proceed with the drainage works with emphasis on implementation of drainage channel system.

(4) Construction time schedule was formulated considering the following conditions:

- Drainage channel works shall be executed from downstream part in principle.
- Construction priority is given to the section having fewest number of households.
- Sluiceway under revetment shall be constructed during revetment construction period.
- Bridge construction in each section shall be made from downstream part in order to follow river structure construction.
- The construction periods of neighboring bridges shall not be overlapped.

The proposed construction time schedule is illustrated in Fig 10.2. The construction works are scheduled to be executed in 6.5 years from May 2000. The pre-construction activities in 1997 to 2000 consist of financial arrangement, pre-qualification of tender, tendering, tender evaluation and contract award. Besides those activities, land compensation and resettlement will be made timely in advance of commencement of the construction works at each site.

THE DETAILED DESIGN
FOR URBAN DRAINAGEPROJECT
IN THE CITY OF JAKARTA

VOLUME I
MAIN REPORT

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ABBREVIATIONS

(1) Local Terms

BAKOSURTANAL	Badan Koordinasi Survei dan Penetaan Nasional	:National Mapping Agencies
BAPPENAS	Badan Perencanaan Pembangunan National	:National Planning and Development Board
BPS	Biro Pusat Statistic	:Central Bureau of Statistics
BINA MARGA		:Directorate General of Road Development
CIPTA KARYA		:Directorate General of Human Settlements
DGWRD		:Directorate General of Water Resources Development
DINAS TATA KOTA		:Department of City Planning, DKI Jakarta
DKI Jakarta	Daerah Khusus Ibukota Jakarta	:Special Region of Capital City Jakarta
DPMA	Direktorat Penyelidikan Masalah Air	:Directorate of Hydraulic Engineering
DPU	Departmen Pekerjaan Umum	:Ministry of Public Works
DPU DKI Jakarta	Dinas Pekerjaan Umum DKI Jakarta	:Department of Public Works, DKI Jakarta
DPUP	Dinas Pekerjaan Umum Propinsi	:Provincial Department Office of Public Works
JABOTABEK		:Jakarta-Bogor-Tangerang-Bekasi
JASA MARGA		:Indonesia Highway Corporation
Kabupaten		:Regency
Kecamatan		:Sub-district
Kelurahan		:District
Kotamadya		:Municipal City
PELITA	Pembangunan Lima Tahun	:Five-Year Development
PERUM PERUMNAS		:National Urban Development Corporation

PMG	Pusat Meteorogi dan Geofisika	:Meteorological and Geophysical Center
P.P.	Priok Pile	
P.T.	Perusahaan Terbatas	: Private Estate Enterprise (Company Ltd.)
PWSCC	Proyek Pengembangan Wilayah Sungai Ciliwung-Cisadene	: Ciliwung-Cisadane River Basin Development Project Office
RKL		:Environmental Management Program
RPL		:Environmental Monitoring Program
REPELITA	Rencana Pembangunan Lima Tahun	:Five-Year Development Plan
TTG.	Tanda Tinggi Geodesi	

(2)International or Foreign Organization

GOI	:Government of the Republic of Indonesia
GOJ	:Government of Japan
IBRD	:International Bank for Reconstruction and Development
JICA	:Japan International Cooperation Agency
OECF	:Overseas Economic Cooperation Fund

(3) Foreign Terms

EIRR	:Economic Internal Rate of Return
FIRR	:Financial Internal Rate of Return
GDP	:Gross Domestic Product
GNP	:Gross National Product
GRP	:Gross Regional Product
PMF	:Probable Maximum Flood
NPV	:Net Present Value
O&M	:Operation and Maintenance
IEI	:Initial Environmental Evaluation
B/Q	:Bill of Quantities
TOR	:Terms of Reference

B/C	:Box Culvert
CAD	:Computer-aided Design
EIA	:Environmental Impact Assessment
ICB	:International Competitive Bidding
LCB	:Local Competitive Bidding
JIS	:Japan Industrial Standards
ASTM	:American Society for Testing and Mater

(4) Numerical Units

<u>Length</u>

mm	millimeter
cm	centimeter
m	meter
km	kilometer

<u>Weight</u>

gr	gram
kg	kilogram
ton	metric ton

<u>Area</u>

mm^2	square millimeter
cm^2	square centimeter
m^2	square meter
km^2	square kilometer
ha	hectare

<u>Time</u>

sec	second
min	minute
hr	hour
yr	year

<u>Volume</u>

cm^3	cubic meter
m^3	cubic meter
Ltr	liter

<u>Others</u>

%	percent
℃	degree centigrade
10^3	thousand
10^6	million
10^9	billion

<u>Money</u>

<u>Exchange Rate</u>

Rp.	Indonesian Rupiah	Official rate as of June 1997
¥	Japanese yen	US$ 1= Rp 2,350 = ¥ 115
US$	US dollar	

1 INTRODUCTION

This is a Main Report on urban drainage project (detailed design) in the city of Jakarta, which was carried out from August 1996 to December 1997.

The report on the urban drainage project in the city of Jakarta comprises design report including main report, supporting report and design drawings and a series of tender documents including tender drawings. The main report states a summary of the supporting report and presents the results of technical study including basic concepts for the urban drainage project, principle of design, procedures of design and economic viability of the project. The supporting report presents results of field investigations including meteorology and hydrology, topographic survey and geo-technical investigation, details of the design including design criteria, design and structural calculation for the drainage structures, work quantity calculation, construction plan and schedule, cost estimate and breakdown of unit costs, and details of the environmental impact assessment and social impact management program. The tender documents comprise a series of tender documents and tender drawings.

1.1 Background of Project

The feasibility study on the urban drainage project for four objective areas, namely, Cengkareng west area, Sepak area, Bojong area and Meruya area was carried out by JICA and completed in 1991, namely, 6 years ago. Since then, land utilization condition has largely changed due to mainly rapid urbanization represented by house development on the land created by land reclamation in the depression areas located in the project areas. The house development has rapidly progressing in many places, especially in the Cengkareng west area, Sepak area and Meruya area. The private developer themselves have constructed the drainage channels for drainage of housing areas in accordance with the Indonesian regulation that the private developer should construct the drainage facilities to drain the housing areas to the main drainage networks. In the Cengkareng west area ,many depression areas and swampy areas are located and all of these areas have already acquired by private house developers or private enterprise. It is anticipated that these depression and swampy areas will be utilized as house development areas by creating the lands by means of land reclamation. In the Sepak and Meruya areas, a large scale house complex has completed and further extension is progressing at present. In the Bojong area, rehabilitation works of the existing drainage facilities have completed. In addition to the rapid urbanization in the objective areas, interchange works for Jakarta ring road have been progressing at the northern part of the Cengkareng west area and eastern part of the Meruya area. Due to the construction of these interchanges, present drainage networks were largely changed compared with the situation investigated in the feasibility study stage.

Discussion meeting on determination of an alignment for the proposed drainage channels was carried out and it was determined that detailed design works for the Sepak and Bojong areas were canceled from the scope of works because objected drainage channels in the Sepak area had already constructed and being scheduled to be improved by private housing developers, and the drainage facilities in the Bojong area had recently rehabilitated and no further drainage works were needed. Due to change of the scope of works, basic study, definitive planning and detailed design for the urban drainage plan were carried out for the Cengkareng west and Meruya areas.

1.2 Objectives of Study

The objectives of the Study are:

(i) to formulate definitive plan of the urban drainage projects in the Cengkareng west area and Meruya area through review of the Study and execution of additional surveys and investigations.

(ii) to prepare detailed design documents and tender documents for the project, and

(iii) to transfer relevant planning and designing technologies to Indonesian counterpart in the course of the design works.

1.3 Scope of Study

The project area covers about 38 km^2 in total and composed of two sub-drainage areas, namely, Cengkasreng west area and Meruya area. The Study covers preparation of definite plan in phase-I stage and preparation of detailed design and tender documents in phase-II stage.

1.4 Outline of Project Works

The project works for the Cengkareng west and Meruya areas comprise mainly widening of the existing drainage channels and construction of levees including earth dike and concrete parapet, revetment and bridges and culverts and installation of spindle type gates and flap gates. Major features of the project works are as follows:

(1) Drainage works in the Cengkareng west area

(i) Kamal drainage channel (drainage area: 20.89 km^2)

Total length:	7.2 km
Design discharge:	$0.9m^3$/sec-$48.1m^3$/sec
Shape of drainage channel:	Trapezoidal section(side slope, 1:2.0 and 1:0.5) and rectangular section
Excavation:	$267,000m^3$
Embankment :	39,000 m^3
Concrete parapet :	484 lin.m
Concrete ditch:	452 lin.m
Revetment:	6,675 lin.m
Bridges:	28 bridges comprising 26 girder type bridges, and 2 slab type bridges
Gates:	23 slide/ flap gates

(ii) Tanjungan drainage channel (drainage area: 4.25 km^2)

Total length:	2.5 km
Design discharge:	9.6 m^3/sec-$19.0m^3$/sec
Shape of drainage channel:	Trapezoidal section(side slope, 1:3.0, 1:2.0 and 1:0.5) and rectangular section
Excavation:	51,000 m^3
Embankment :	52,000 m^3
Concrete wall :	1,134 lin.m
Revetment:	347 lin.m
Bridges:	5 girder type bridges
Gates:	7 slide/ flap gates

(iii) PIK Junction drainage channel (drainage area: 2.70 km^2)

Total length:	0.8 km
Design discharge:	$7.1m^3$/sec-$18.1m^3$/sec
Shape of drainage channel:	Rectangular section
Concrete ditch :	765 lin.m
Bridges:	4 slab type bridges
Gates:	1 slide gate

(iv) Gede/ Bor drainage channel (drainage area: 2.41 km^2)

Total length:	1.2 km
Design discharge:	15.5 m^3/sec-16.9 m^3/sec
Shape of drainage channel:	Trapezoidal section (side slope, 1:0.5)
Excavation:	29,000 m^3
Embankment:	2,300 m^3
Revetment:	2,300 lin.m
Bridges:	10 girder type bridges
Gates:	5 slide / flap gates

(v) Saluran Cengkareng drainage channel (drainage area: 3.08 km^2)

Total length:	4.2 km
Design discharge:	5.8 m^3/sec-18.8 m^3/sec
Shape of drainage channel:	Trapezoidal section(side slope, 1:2.0, 1:0.5) and rectangular section
Excavation:	83,000 m^3
Embankment :	41,000 m^3
Concrete parapet :	1,285 lin.m
Revetment:	4,188 lin.m
Concrete culvert:	391 lin.m
Bridges:	13 girder type bridges
Gates:	15 slide/flap gates

(2) Drainage works in the Meruya area (drainage area: 1.27 km^2)

Total length:	2.3 km
Design discharge:	1.6 m^3/sec-9.4m^3/sec
Shape of drainage channel:	Rectangular section
Concrete ditch and culvert :	2,798 lin.m
Bridges:	16 slab type bridges

2 FIELD INVESTIGATIONS

2.1 Topographic Survey

2.1.1 General

The survey works includes longitudinal profile survey, cross section survey with an interval of 100m and topographic mapping with a scale of 1:1,000 and contour interval of 1m for the Cengkareng west area and Meruya area. The topographic survey was carried out by local survey contractor, PT.Atlas Deltasatya, under the supervision of JICA study team.

2.1.2 Levelling works

1) Preliminary levelling

Preliminary levelling was conducted using digital levelling instruments (Leica NA-3000) after the field reconnaissance for existing bench marks and new bench marks. Preliminary levelling works were carried out to attain the following purposes:

(a) To select the bench marks that have not been influenced by ground subsidence or other damage and have a sufficient accuracy for substantial levelling works,

(b) To check the relative accuracy of the TTG (MSL) and PP (LLW) existing bench mark systems and,

(c) To link the elevation to the new bench marks, the cross section posts and the necessary existing structures.

2) Selection of bench marks with high accuracy

In order to select the bench marks which have not been affected by land subsidence and have a sufficient accuracy for the check levelling survey, check levelling survey was carried out on the route between TTG.281 and TTG.177 which are located in the southern part of the international airport for TTG.281 and at about 23km south-east of the project area for TTG.177. The existing bench marks have been provided on the line connecting the bench marks, TTG.281 and TTG.177. The check levelling for these bench marks was performed and difference of the elevation between the neighbouring bench marks were compared with that for the elevation of the existing bench marks as shown below:

Bench Marks	Length (m)	Relative Height(m) TTG DH	Checked DH	Error (mm)	Differential Accuracy (error/length)
TTG.281					
TTG.280	1.7	-2.162	-2.163	1	1/1,700,000
TTG.177	38	28.169	28.281	112	1/339,000
TTG.280	-	-	-	-	-
TTG.279	2.1	1.327	1.127	200	1/11,000
TTG.278	1.8	-5.764	-6.243	479	1/4,000
TTG.276	3.3	-1.399	-1.687	288	1/11,000
TTG.275	1.9	-1.734	-1.635	99	1/19,000
TTG.271	5.1	-1.525	-1.354	171	1/30,000
TTG.270A	1	0.914	1.28	366	1/3,000
TTG.260	3.4	-0.683	-0.896	213	1/16,000

Above table indicates that the relative height between TTG relative height and relative height by check survey in this time is 1mm between TTG.281 and TTG.280 and 112mm between TTG.280 and TTG.177, while a large errors occur in other seven existing bench marks. Considering these results, elevation of TTG bench marks, 281, 280 and 177 shows the correct values. Thus, it was determined to apply the elevation of these bench marks for check levelling for other bench marks. The elevation and survey date for these three bench marks are as follows:

Bench Marks	Elevation(m)	Survey Date
TTG.281	14.131	1981/1982
TTG.280(NWP.514)	11.969	1981/1982
TTG.177(HWP.60)	40.138	1981/1982

Note: NWP(Nauwkeurigheinds Waterpasing Punt) is old code name used by the Dutch.

Among these bench marks, TTG.177 was used for ground level subsidence analysis carried out in 1990.

3) Comparison of elevation of the TTG and PP systems

There are two different elevation systems used in Jakarta: the TTG (MSL) system used by the BAKOSURTANAL, and the PP system (LLW) used by the DKI Jakarta and other governmental authorities. To verify the correlation of these systems, the check levelling was carried out between existing bench marks TTG.177 and PP.407 which is located at about 6km south-west of TTG.177 and it has been reported that the this bench mark is located at the geologically most stable place in south Jakarta. Result of the check levelling is as follows:

Bench marks	TTG Elevation		PP	Relative
	G. EL*(1)	C. EL*(2)	elevation	height
TTG.177	40.138	-	41.141	1.003
PP.407	-	58.453	59.428	0.975

Note : *(1) Elevation by BAKOSURTANAL in 1981/1982
*(2) Elevation surveyed in this study inOct.1996
*(3) Elevation by DINAS PENGAIRAN TANAH since 1978/1982

The above table shows that the relative height between TTG.177 and PP.407 surveyed in this time is almost the same as that for the past survey result and elevation of the bench mark for PP system is 1m higher than that of TTG system.

4) Established bench marks with accurate elevation

Based on the elevation of the selected three TTG bench marks, elevation of the following existing and newly established bench marks were measured. For revision of the elevation of the bench marks, the existing mark of TTG, PP, DKI, DTK, BM, PB, CF and others were used.

- Newly established bench marks:	25	points
- Existing bench marks:	64	points
Total	89	points

5) Accuracy and adjustment of levelling results

The applied limit for the measurement of levelling accuracy is 10mm $\sqrt{L}$ (L =km). The error of the loop levelling routes and/or error of the round trip routes were estimated within this limit.

2.1.3 Longitudinal profile survey

Longitudinal profile survey was carried out by direct levelling from bench marks to measure the elevation of existing structures, such as bridges, cross section posts on both banks along the proposed drainage channels. The survey lines at the river mouth at Kamal and Tanjungan in Cengkareng west drainage channels were extended from approximately 1.75km -2.0km, from the river mouth to the offshore area. Single positioning was carried out for the proposed survey lines using the portable GPS device, Garmin GPS 100, which records geographical coordinates (lat.-long.) at an interval of 250m.

The longitudinal profiles were prepared according to the following scale:

- Horizontal scale: 1:1,000
- Vertical scale: 1: 200

The length of the longitudinal profiles is as follows:

Drainage Channel	Drainage Code	Length(km)
Cengkareng west area		
-Kamal	KM, KE, KH-C*, KM-C*, KC-C*, KS	13.8
-Tanjungan	TM, TB, TS	6
-New drainage	NM, NA	3.6
-Gede/Bor	GM, GA, GM-C*	4.4
-Saluran Cengkareng	CM	4.3
-Pedengkelan	PM-C*, PA-C*, PB-C*, PC-C*	6.4
Meruya area		
-Meruya	MM, MA	2.6
		41.1

Note: * check survey routes.

2.1.4 Cross section survey

Based on the cross section posts, cross section surveys were conducted at an interval of approximately 100m along the proposed drainage channels and at an interval of approximately 200m for the drainage channels in private owned area for check survey.

The width and number of cross sections were determined as follows, based on the plan of the drainage channels and topographic conditions along the drainage channels.

Drainage Channel	Drainage Code	Number	Width(m)
a) Cengkareng west area			
-Kamal	KM	62	100, 70, 50
	KE	34	50
	KH-C	12	10
	KM-C	5	25
	KC-C	9	25
-Tanjungan	TM	37	100, 50
	TB	18	80
-New channel	GM	17	50
	NA	12	50
-Gede/Bor	GM	17	50
	GA	13	50
	GM-C	10	20
-Saluran Cengkareng	CM	51	100, 50
-Pedengkelan	PM-C	16	25
	PA-C	12	25
	PB-C	9	25
	PC-C	5	25
b) Meruya area			
-Meruya	MM	30	30, 20
	MA	8	20
Total		395	

The cross section drawings were prepared according to the following scale:

- Horizontal scale : 1:100
- Vertical scale : 1:100

2.1.5 Topographic mapping

The topographic maps for the proposed drainage routes were prepared by conducting ground surveys using total station systems, the offset method based on the cross section posts, and in combination with the supplemental survey using existing topographic maps. The proposed drainage routes were mapped and the number of sheets used is 37 sheets in total. The drawing specifications for the topographic maps were as follows:

- Mapping scale : 1:1,000
- Interval of contour line
  - Main contour : 1.0m
  - Supplemental contour : 0.5m
- Map symbols and others : The map symbols and legends used were based on

the cartographic standards of the Ministry of Public Works

2.2 Geo-technical Investigation

2.2.1 General

Geotechnical investigation was carried out to clarify the characteristics of the foundation bed for the reparian structures and to evidence the subsidence known to affect the entire alluvial plain around Jakarta. The necessary field and laboratory works have been subletted to a local contractor.

2.2.2 Scope of geo-technical investigation

The field works consisted of the following items:

- Drilling with SPT- testing and undisturbed sampling
- Installing piezometers in the drill holes
- Laboratory testing
- Dutch Cone sounding
- Elevation survey of bench marks.

The scheduled work quantities are summarised in the table below:

Work Item	Code/ location	Depth/depth interval	SPT/Sounding (times)	Undisturbed samples
1. Drilling	A-1	35 m	32	6
	B-1	35 m	32	6
	B-2	30 m	27	5
	C-1	20 m	18	3
	D-1	20 m	27	3
	O-1	25 m	23	4
2. Piezometers	A-1			
	B-1	29 - 35 m		
	B-2			
	C-1			
	D-1			
	O-1			
3. Dutch Cone	KSC	11		
	TSC	8		
	NSC	7		

Work Item	Code/ location	Depth/depth interval	SPT/Sounding (times)	Undisturbed samples
	KGSC	5		
	CSC	9		
	MSC	7		
4. Elevation at 5 fixed and 5 target points survey				

Work Item	Samples	Physical tests	TriaxialUU,CU or CD	Unconfined compression	Consolidation
5. Laboratory testing	A-1	6	6	6	5
	B-1	6	6	6	5
	B-2	5	5	5	4
	C-1	3	3	3	2
	D-1	3	3	3	2
	O-1	4	4	4	3

Location map of the core drilling and Dutch cone sounding sites is illustrated in Figs 2.1 to 2.3.

2.2.3 Results of the drilling

Results of core drilling are illustrated in Figs 2.1. The sub-surface of the Jakarta plain consists of 250 m thick, Quaternary soils. Clays represent more than 70% of the soil cover. Thin sand layers are intercalated but laterally they are not continuous. The sands are fine grained and silty. The ground water is distributed over several thin and discontinuous layers and a clear distinction of aquifers is difficult. In general, the ground water level lies 2 m below the ground surface. The geological characteristics based on the geotechnical investigation consisting of Dutch cone sounding and drilling in the Cengkareng west area and Meruya area are as follows:

2.2.4 Results of Dutch cone sounding

Profiles of Dutch cone sounding are given in Figs 2.2 to 2.3. The consistence of the soils in the Cengkareng area increases with the distance from the coast. Very soft and soft, clayey and silty soils, SPT-value 0 to 3 blows, occur in the lower Kamal and Tanjungan areas, till the level of the highway. Their thickness is 9 to 11 m. Underneath, the soils are more consistent, SPT-values gradually increase to 20 and 30 blows, for an investigation depth of 35 m.

South of the highway, towards the Daan Mogot road, mixed or clayey soft soils, where the SPT-value is less than 10 blows, extend from the ground surface to 5 or 7 m of depth. Underneath, 1.5 to 7 m thick, cemented sands, SPT-value more than 50 blows, have been found. This bed is not continuous over the entire area. The sands are underlain by stiff to hard clays, SPT-values 15 to 30 blows.

The Meruya area is covered by red soils. These are mixed type of soils, containing equal amounts of clay, silt and sand, locally with gravel. Such soils are generally stiff to hard. From the sounding data a hard layer, possibly cemented sands, underlies the soil cover, at an average depth of 5 m.

2.2.5 Results of laboratory tests

Most of the soils analysed in the laboratory are high plastic CH clays. The liquid limits are higher than 100 %, the natural water contents 50-60% in average and the degree of saturation is close to 100%. The wet unit weights are close to the saturated unit weights, 1.654 t/m^3. The soils referred to as "sandy" are composed 67% of fines in average, belong to the MH class of soils and have natural unit weights of 1.775 t/m^3.

The shearing strength characteristics of the saturated, clayey soils have been estimated from triaxial unconsolidated undrained tests. The mean values obtained were 0.6 kg/cm^2 for the cohesion and 6° for the angle of friction. For the sandy soils (54-65% of fines) triaxial consolidated drained tests have been done. The obtained shearing strength parameters were 0.45 kg/cm^2 for the cohesion and 25° for the internal angle of friction.

The consolidation characteristics of the clayey soils show that most soils can be considered over consolidated, with consolidation yield stresses ranging from 0.6 to 3 kg/cm^2. The consolidation index values are generally higher than 0.4, indicating highly compressible soils.

2.2.6 Structure foundations

A soft layer covers the west Cengkareng area, its thickness decreasing from the coast, towards the south (Daan Mogot area). The low SPT- test values (less than 10), indicate that the soils have low bearing strength, in case a spread footing is considered. The measured compression indexes correspond to highly compressible soils. After loading, settlement by consolidation will occur. Considering the nature of the soil, pile foundations are recommended, especially for bridges.

From the coast to the area of Kapuk-Kamal, the upper soft soil is underlain by stiff clayey soils and friction piles, 12-15 m deep shall be considered. In the south part of the study area, Mookervaat Canal, a more competent cemented sand bed, in average 5 m thick, underlies the 5 to 7 m thick soft soil. This bed can be used as a rigid substratum for end bearing piles. Nevertheless it has to be considered that this bed is not always continuous and at some locations very thin and not sufficient to be taken as a substratum.

2.2.7 Land subsidence

The project area and the entire Jakarta plain have been affected by subsidence, due to self-weight consolidation in the deeper soil beds (40-250 m). This process is triggered by groundwater pumping from the deeper, confined aquifer and its impact on the sub-surface is far more important and the counter-measures imply long term decisions, on regional scale. At present, ground water has been extracted by more than 3,000 wells with about 300 m deep in the Cengkareng area for industrial purposes.

Several studies on the subsidence have been done in the past. Most of them are based on repeated bench mark elevation surveys. The same method has been adopted in the present study. Changes in elevations of existing bench marks have been evidenced in the Daan Mogot area, for the period 1981-1996. Based on former studies and the present observations, the subsidence rate of 8 cm/year (suggested by the DKI Jakarta) has been presumed for the Daan Mogot area, which is the most developed part of the study area. Other, more recent wells are concentrated along the Kamal-Kapuk road and a few along Kamal Raya, which will be developed in the near future. In these areas as well as along the Salurang-Cengkareng drainage channel the subsidence rate is lower, in average 6 cm/year.

3 PRESENT CONDITIONS OF URBAN DRAINAGE SYSTEM

3.1 General

The drainage areas to be studied comprise two areas, namely, Cengkareng west area, and Meruya area. Since the feasibility study was carried out, land utilisation condition has largely changed due to mainly rapid urbanisation represented by house development and an interchange work of Jakarta ring road which is connecting with the Cengkareng highway at the eastern part of the Cengkareng west area and providing the interchange roads at the Cengkareng west area and Meruya area. Present drainage condition and existing drainage facilities in the Cengkareng west and Meruya areas are stated in the followings.

3.2 Existing Urban Drainage Facilities and Related Structures

3.2.1 Cengkareng west area

The existing drainage networks of the Cengkareng west area is given in Fig 3.1. Present condition of the respective drainage areas and drainage facilities are as follows:

(1) Kamal drainage area

1) Drainage area and drainage facilities

The Kamal drainage area is located in the north-western part of the Cengkareng west area and it is bounded by Cengkareng highway in the west, main irrigation channel in the south and Jakarta ring road in the east. Drainage area of the Kamal drainage system is about 20.9 km^2 and its categories of the present land use are as follows:

- Residential area:	11.8	km^2
- Industrial area:	0.79	km^2
- Paddy field:	5.4	km^2
- Depression/swampy area:	1.16	km^2
- Others (fish pond):	1.74	km^2
Total	20.89	km^2

This drainage area occupies about 57 % of the Cengkareng west area. In the western part of this area, paddy fields are located and cultivated by irrigation water fed by the main irrigation canal in the southern fringe of this drainage area. The downstream of the Cengkareng highway forms fish pond. In the upstream part of the highway , small and middle scale industrial areas are developing along the highway on the land created by land reclamation. In centre and southern parts of this area, one swampy area and four depression areas are located as shown in Fig 3.1. The swampy area has 400 m wide and 1400 m long acreage. The depression areas which is lower elevation than neighbouring area and topographically difficult to drain by gravity flow is about 125 ha, 30 ha,18 ha, and 20 ha respectively. It has been reported that those swampy and depression areas had been already acquired by private developers for housing development. A part of the depression area has been developed as housing complex on the land created by land reclamation. Along the southern fringe of the swampy area, the drainage channel with width of about 8 m has been constructed by private sector. New housing complex is located near the swampy area and new housing complex is being constructed in the eastern and western parts of the swampy area.

The Kamal main drainage channels have about 11,700 m in total length comprising about 9,700 m long channel constructed and maintained by DKI and 2,200 m long channel constructed by private sectors. Lined channel with wet masonry is 9,700 m and unlined channel is 2,200 m as shown in Table 3.1. The channel is about 15 m wide and 2.5~3 m deep at the highway crossing and 10 m wide and 1.5 m deep at the junction portion of the channel extending from eastern direction. The channel bed slope is about 1:3,200 in about 2.3 km from channel mouth and 1:1,800 in its upstream channel stretch. Two secondary irrigation channels separated from the main irrigation canal are provided in the western boundary and one of these canals in the left side changes its function to drainage channel from depression area portion to junction of the Kamal drainage channel. The drainage channel parts are being rehabilitated by DKI at present. The drainage water flowing down from residential area, paddy field and depression areas in the southern drainage area is collected at the upstream end of the Kamal drainage channel. In addition, the drainage water from the most densely populated area in the left bank of the Jakarta ring road is collected to the Kamal drainage channel extending to south-eastern direction. The drainage water collected from the southern and eastern parts of the area is discharged to Jakarta bay through the existing Kamal drainage channel and a cross drain crossing the Cengkareng highway. Main irrigation canal provided in the southern boundary changes its direction to north at Jakarta ring road and this irrigation canal changes its function to drainage channel from about 1.2 km upstream of the confluence with Cengkareng floodway. A part of the irrigation water from this irrigation canal is released to the Kamal drainage channel extending from eastern direction as channel maintenance flow. At the outlet of this drainage channel to the Cengkareng floodway, a spindle type gate with about 1 2m wide and 2m high is provided, but it has not been operated due to its deterioration.

The present flow capacity of the Kamal drainage channels including the culvert crossing the highway is too small to discharge the drainage water, owing to mainly gentle gradient of water level and small scale drainage facilities. Due to this small flow capacity and topographically low land, an inundation takes place at low land areas along the Kamal drainage channel in the southern part of the highway. In every rainy season, water has been stagnated in depression and swampy areas in the center and southern parts of the drainage area.

2) Related structures

No channel related structures such as gates and weirs have been provided along the drainage channels. Thirty one bridges and one culvert cross the drainage channels. Features of these bridges and culvert are listed in Table 3.2. Majority of the bridges are single span and about 3~8 m in length. Among the related structures, the cross drain crossing the Cengkareng highway is the largest structure with two lanes of 10.8m in total width. In addition to these structures, high tension electric lines and telephone line are crossing the existing drainage channels. Along the existing drainage channel, electric poles, telephone poles, road sign, traffic signal, etc. are located. Location and features of these structures are listed in Table 3.3 and illustrated in Fig 3.2.

(2) Tanjungan drainage area

1) Drainage area and drainage facilities

The Tanjungan drainage area is located in the northern part of the Cengkareng west area and bounded by the Kamal drainage in the west and south and outer ring road and interchange of the outer ring road in the east. This drainage area comprises low land with elevation of about EL 0.5 m in the southern part of the highway and large scale depression/swampy areas in the centre part and eastern part of the drainage area as shown in Fig 3.1. It has been reported that these depression areas have been already acquired by private sector for house development. House development by private sectors has been progressing on the land created by land reclamation in the middle scale depression area along the ring road. The downstream part of the Cengkareng highway forms fish pond. Industrial areas are located along the highway. Drainage area of the Tanjungan drainage system is about 4.25 km^2 and categories of its land use are as follows:

- Residential area:	0.67	km^2
- Industrial area:	1.04	km^2
- Swampy/depression area	1.00	km^2
- Fish pond	1.54	km^2
Total	4.25	km^2

The Tanjungan drainage channel has about 1,700 m long lined channel with wet masonry and concrete as shown in Table 3.1. The drainage channel is about 5 m wide and 0.8 m deep at the highway crossing. The channel bed slope is so gentle as being about 1:5,000 in all channel stretch. Due to this gentle channel bed slope, drainage water is stagnating even in the dry season. Drainage water flowing from the densely populated area along the ring road is drained through the depression area and flows down to southern part of the highway. A cross drain with about 3.4 m wide and 1~2 m high has been provided under the highway. However, since road surface elevation of the Jl. Tol Prof. Sediyatmo is almost the same as tidal level due to subsidence of the highway, the cross drain crossing the highway functions as siphon. Due to this situation, remarkably small drainage water is discharged to downstream through the cross drain. The drainage water released through this cross drain flows into fish pond in its downstream and poured to Jakarta bay through about 900 m long canal provided in the upstream of channel mouth. According to the information concerning subsidence of highway, the subsidence of the highway has been progressing in the road stretch between the Kamal culvert portion and Cengkareng floodway bridge in the Cengkareng west drainage area and its extent is the most serious near the Tanjungan culvert crossing portion. Along the both sides of the highway, Large scale ditches are provided. In order to avoid submergence of the road surface of the highway in the rainy season, water collected in these ditches is discharged to downstream fish pond using several units of pumps installed along the side ditch portions.

2) Related structures

No channel related structures have been provided along the drainage channel. Five bridges and one cross drain cross the Tanjungan drainage channels as listed in Table 3.2. Features of these structures are listed in Table 3.3. The high tension electric line is crossing the existing drainage channel. Electric poles and telephone poles are located along the existing drainage channel. Two pumps have been provided near the junction of the Tanjungan drainage channel and highway to drain the rain water to fish pond in northern part of the highway. Location and features of these structures are given in Table 3.3 and illustrated in Fig 3.2.

(3) PIK Junction drainage area

1) Drainage area and drainage facilities

This drainage area is located in the north-east part of the Cengkareng west area and surrounded by an interchange of the outer ring road in the west, existing street with slightly higher elevation in the south and Cengkareng floodway in the east. The downstream of the Cengkareng highway forms mainly fish pond and golf yard. Along the highway, industrial areas are located. A depression area with acreage of 25 ha is located along the Outer ring road. Drainage area of the new drainage system is about 2.70 km^2 comprising1.25km^2 of residential area, 0.48 km^2 of industrial area and 0.97 km^2 of swampy/depression areas.

The drainage system in this area was drastically changed by construction of the interchange of the Jakarta outer ring road and drainage of this area has been interrupted by the interchange road. In this drainage area, 5 culverts with 0.8m in diameter are provided crossing the Cengkareng highway. It is reported that these culverts are constructed mainly to stabilise the highway by balancing the water level at the both sides of the highway. The drainage water collected from the densely populated area in the left bank of the Cengkareng floodway is drained along the low elevated fringe of the Cengkareng highway, but, due to obstruction of the interchange roads to the Cengkareng direction and airport direction, the drainage water is drained through seven culverts with 0.8 m in diameter provided crossing the highway and one culvert with about 0.7m in diameter provided at the interchange road.

2) Related structures

No related structures are located in this drainage area. Two bridges and two culverts are crossing the proposed drainage channel. As listed in Table 3.2. Electric poles, telephone poles, road sign and traffic signal are located along the proposed drainage channel. Location, number and features of these structures are shown in Table 3.3 and illustrated in Fig 3.2.

(4) Gede/Bor and Saluran Cengkareng drainage areas

1) Drainage area and drainage facilities

This drainage area is located in the southern part of the Cengkareng west area and bounded by higher elevated area in the west, boundary area in the south, main irrigation cannel in the north and Cengkareng floodway in the east. Drainage area of the Gede/Bor and Saluran Cengkareng drainage systems are about 2.41 km^2 and 3.08 km^2 respectively and all of these areas except for 6 % of the paddy field in the Gede/Bor drainage area have been utilized as residential area.

The drainage water discharged through Gede channel which is located inside the newly constructed housing complex is drained to the Bor canal. The drainage water from the Gede channel is divided into the southern direction to the Mookervaat canal and eastern direction to the Saluran Cengkareng channel. The Bor drainage channel has about 1.5 km in length to the Mookervaat canal and channel bed slope is about 1:1,100. While, Saluran Cengkareng drainage channel is about 4.2 km in total length to the Cengkareng floodway and channel bed slope is about 1; 3,000. It is presumed that majority of the drainage water is discharged to the Mookervaat canal through the Bor drainage channel due to steeper river bed slope of the Bor drainage channel.

The Gede/Bor drainage channel which drain to the Mookervaat canal comprises 1,500 m long channel constructed and maintained by DKI and 1,900 m long channel constructed by the private sector. The Gede drainage channel which is provided inside the new housing complex is about 8 m wide and 2 m deep. All of these channels are lined channel. About 4 m wide and 2 m deep Citra Garden II channel which drains from the south-western part of the area has been rehabilitated by private sector. In order to drain water from the Citra Garden II channel to the Mookervaat canal, the private sector already constructed a drainage channel to the Mookervaat canal in the right side of the existing Bor drainage channel.

The Saluran Cengkareng drainage channel which drains to the Cengkareng floodway has 4,200 m in total length comprising 3,400 m long lined channel and 800m long unlined channel. All of these channels were constructed by DKI. Several channel stretch portions of the Saluran Cengkareng channel were rehabilitated by DKI. Its dimension is 5~8 m wide and 1.5 m deep at upstream end and about 10m wide and 1.8 m deep at the confluence of the Cengkareng floodway. The drainage water collected through the Saluran Cengkareng channel flows down through remarkably densely populated area and drained to the Cengkareng floodway. A sluice facility with 2 units of 2.4m wide and 2.6 m high spindle type sluice gate is provided at the outlet of the Saluran Cengkareng channel to minimise inundation in locally low land area along the Saluran Cengkareng drainage channel at about 1,200m upstream from the channel mouth, due to back water of the Cengkareng floodway. Existing sluice gate has been operated under the condition that the gate is closed when the river water level of the Cengkareng floodway exceeds 10 cm over the drainage water level in the Saluran Cengkareng drainage channel at its outlet portion. The Saluran Cengkareng drainage channel in its downstream portion has been filled with dust and garbage at present. To prevent dust and garbage from throwing into the drainage channel, some structural measures will have to be considered for the design works. It has been reported that no inundation due to back water of the Mookervaat canal takes place in the area along the Bor drainage channel.

2) Related structures

Forty four bridges and two culvert cross these drainage channels. Features of these structures are listed in Table 3.2. At the confluence of the Cengkareng floodway, two units of spindle type sluice gates are provided. Features of these gate facilities are as follows::

a) Gate type: Steel made slide gate
   - Clear span: 2.4 m
   - Gate height: 2.6 m

b) Hoist type: Manually driven single stem screwed spindle hoist

High tension electric lines, water supply pipe lines and telephone lines are crossing the existing drainage channel. Electric poles and telephone poles are located along the existing drainage channel. Location and features of these structures are listed in Table 3.3 and illustrated in Fig 3.2.

(5) Pedongkelan drainage area

1) Drainage area and drainage facilities

This drainage area is located in the eastern part of the Cengkareng west area and bounded by Jakarta outer ring road and main irrigation canal in the west, boundary of the PIK Junction drainage area in the north and Cengkareng floodway in the east. Drainage area of the Pedongkelan drainage system is about 3.38 km^2 and all of this area has been utilized as residential area.

The majority of the centeral part of this drainage area is already occupied by the National Urban Development Corporation (PERUM PERUMNAS) and a new drainage system with poundage and pump facility of its outlet is being constructed to drain the drainage water to the Cengkareng floodway. The new drainage is located surrounding the housing complex. The drainage channel comprises about 6,600 m long lined channel with wet masonry as shown in Table 3.1. The drainage channel is about 4~5 m wide and 2~3 m deep on an average.

2) Related structures

No channel related structures have been located, but it has been planned to provide the regulation pond at the confluence portion of the Cengkareng floodway. Features of the planned regulation pond and related pump facilities are as follows:

a) Regulating pond : 6 ha in acreage
b) Pumping facilities : 3 units of pump with capacity of $0.8 m^3/sec$

3.2.2 Meruya area

1) Drainage area and drainage facilities

The Meruya drainage area is located at the southern part of the highway connecting Jakarta and Merak harbour and bounded by existing drainage in the west, higher elevated area in the south, and higher elevated street in the east. Drainage area of the Meruya drainage system is about $1.27 km^2$ and all of this area has been utilised as residential area.

Present drainage networks and flow direction are illustrated in Fig 3.3. The Meruya drainage channel to be studied is secondary level and comprises about 600 m long concrete ditch and 600 m long unlined ditch as shown in Table 3.1. The drainage ditch is about1~2 m wide and 1 m deep in an average. Drainage water collected from southern watershed flows towards northern direction and divided into eastern and western directions due to high undulation at the center part of the drainage area. The drainage water flowed down to the eastern direction once stagnates in low land or depression area in the eastern part of the drainage area and a part of drainage water discharges to existing eastern drainage ditch provided in the recently constructed private housing complex. The drainage water flowed down to the western direction stagnates in depression area in the western part of the drainage area and a part of drainage water discharges to the existing drainage ditch located in the northern part of the objective drainage area through the existing cross drains provided under the highway. In the rainy season, habitual inundation with long duration takes place in the above mentioned depression areas due to undulation of the ground surface and inadequate drainage canal alignment. Since the capacity of the drainage ditch constructed in the private owned housing area in eastwards is limited, drainage water flows down in the eastern part of the drainage area will have to be shifted to the western direction. In the north-eastern part of the drainage area, construction works of interchange works are being executed. Due to construction of the interchange facilities, drainage to the existing cross drains will be disturbed and only one outlet of the drainage water in the western part of the drainage area is a tributary of the Angke river at about 450m westwards of the drainage area.

2) Related structures

Nine bridges cross the existing drainage networks. Features of these bridges are listed in Table 3.2. High tension electric lines and telephone lines are crossing the existing drainage channel. Electric poles and telephone poles are located along the existing drainage channel. Location and features of these structures are shown in Table 3.3 and illustrated in Fig 3.2.

3.3 Flow Capacity of the Existing Drainage Channels

Based on the result of the topographic survey carried out in this time, the flow capacity of the existing drainage channels which were constructed by both the government and private sectors in the Cengkareng west area was estimated by means of non uniform flow. The estimated bankful flow capacity of the existing drainage channels in the Cengkareng west area is illustrated in Fig 3.4. This figure shows that the flow capacity of majority of the existing drainage channels corresponds to less than one-year recurrence. The flow capacity of these drainage channels is insufficient and widening of the channel is needed to discharge the design flood.

In the Menuya area, systematic drainage system is not yet established and the existing drainage ditch is provided partly and not continued to the downstream existing drainage channel. Due to this reason, flow capacity of the partly provided drainage ditch is unable to estimate.

4 DETAILED DESIGN OF URBAN DRAINAGE PROJECT

4.1 Basic Concept for Proposed Urban Drainage Project

The basic concept for the urban drainage project for two objective areas, Cengkareng west area and Meruya area, was established, considering rapid urbanization in the objective areas and anticipating future land use condition. The rapid urbanization is represented by house development and drastic variation of the existing drainage networks due to construction of interchanges of Jakarta ring road. The established basic concept for the proposed urban drainage project is as follows:

(1) A future land use plan in the objective areas was established, referring to the land use plan set out by DKI Jakarta and anticipating future land use condition from present land use progressing situation. The target year for this drainage plan is set at 2010. Comparison of the land use in the present and target year, 2010 is as follows:

(Unit: km^2)

Category of Area	Present Land Use	Land Use in 2010
- Residential area	22.44	27.98
- Industrial area	2.31	3.48
- Paddy field	5.55	2.27
- Fish pond	3.28	2.98
- Swamp/depression area	3.13	0
Total	36.71	36.71

(2) The drainage channels are designed with a flood protection level of a 10-year probable flood for the Cengkareng west area and a 5-year probable flood for the Meruya area.

(3) Drainage water is drained by gravity flow in principle to minimize operation and maintenance cost for the drainage facilities.

(4) In the Cengkareng west area, only primary (main) drainage channels are designed. For the Meruya area, all of the major drainage channels are secondary level. In this design, the major secondary drainage channels are designed.

(5) Special consideration for land subsidence and clean water management was made for planning and designing of the proposed urban drainage project.

(6) There are many swamp and depression areas in the Cengkareng west area and these areas have been already acquired by the private housing developers/industrial enterprises. The drainage channels in the private owned areas should be constructed

by themselves and the constructed drainage facilities will be handed over to DKI Jakarta for routine maintenance works. In the definitive plan, design criteria to be applied to the drainage channels for the private sectors' areas such as the design discharge, the design channel bed slope and the design channel bed elevation are clarified

(7) Jl. Tol. Prof. Sediyatmo (the Highway) is aligned in the swamp area in the northern part of the Cengkareng west area and it has suffered in many times from submergence in the rainy season. Cause of this road submergence is attributable mainly to the low elevation of the Highway in about 4 km long stretch in the Cengkareng west area. To cope with this submergence and also to cope with future increase in the traffic volume, it has been planned by JASA MARGA that the Highway will be widened to four lanes and raised up in the stretch between the Kamal drainage crossing site and the Cengkareng floodway crossing site, and bridges crossing the Kamal and Tanjungan drainage channels are designed by JASA MARGA themselves. Thus, in this design, design of the bridges for the Kamal and Tanjungan drainage channels, which cross the Highway, is excluded.

(8) The high tension electric lines and water supply pipe lines are crossing the existing drainage channels. Due to expansion of the drainage channels, treatment of these lines are needed. Besides, it is obliged to shift the existing telephone poles, concrete structures with gates for drainage facilities of the Highway, road signs, traffic signals, etc. due to expansion of the existing drainage channels. Planning, designing and construction of expansion/shifting works of these structures will be made by authorities concerned under the condition that the cost necessary for expansion/shifting works is born by project.

4.2 Design of Drainage Channels

4.2.1 Design criteria

(1) Design stretch

The detailed design was carried out for the proposed Kamal, Tanjungan, PIK Junction, Gede/Bor and Saluran Cengkareng drainage channels in the Cengkareng west area and key drainage channels in the Meruya area. The length of a design stretch in each drainage channel is as shown below:

Drainage Channel	Length (km)
1) Cengkareng west area	16.0(2.8)
- Kamal (main)	7.3(2.8)
- Kamal (branch)	2.8(0)
- Tanjungan	2.5(0)
- PIK Junction	0.8(0)
- Gede/Bor	1.2(0)
- Saluran Cengkareng	4.2(0)
2) Meruya area	2.3(0)
Total	18.3

Note: Figures in brackets show stretches in the areas acquired by private sectors

Out of the above design stretches, those in the areas acquired by the private sectors were examined only from a hydraulic viewpoint to clarify main features of the drainage channels such as the cross sections and channel gradients which will be required as a part of the drainage network to be newly constructed in the Cengkareng west area.

(2) Alignment of drainage channel

The alignments of the drainage channels are designed, based basically on the present channel alignments, in consideration of the following:

(i) The existing drainage channels shall be used as much as possible to minimize compensation cost, so far as the widening of the existing channels is economically feasible from the viewpoint of the compensation of lands, houses and other existing facilities, namely electriç poles, water pipes and telephone cable ducts.

(ii) The channel structures such as revetments and bridges which are expected to satisfactorily function in future shall be used as much as possible, if necessary with some modification works.

(3) Longitudinal profile of drainage channel

The longitudinal profiles of the drainage channels are determined based on the following criteria :

(i) The drainage channel bed is designed so as to gradually change from a steep slope in the upstream stretch to a gentle slope in the downstream one. In order to realize a stable channel bed having no detrimental scouring and sedimentation, the ratio of the channel bed gradients between the upstream and downstream stretches to be connected each other shall be smaller than 2.

(ii) The longitudinal profile of the drainage channel shall be determined under the condition that the newly designed channel bed gradient is not remarkably different from the present one.

(4) Design high water level

In principle, the design high water level of the drainage channel should be equal to or lower than the original ground elevation or the ground elevation for the land reclamation area. The design high water level is determined, through non-uniform flow calculation under the following conditions :

(i) The initial water levels for the Kamal and the Tanjungan drainage channels which discharge to Jakarta Bay are set at the spring tidal level (high water) of TTG System.

(ii) The initial water level for the Saluran Cengkareng drainage channel which discharges to the Cengkareng floodway is set at the 25 year flood water level in the floodway at the drainage channel outlet.

(iii) The initial water levels for other drainage channels are set at the water levels estimated by uniform flow calculation.

(iv) The roughness coefficient is 0.03 in a drainage channel of which the channel slopes will be protected on both sides by masonry revetment and 0.016 for concrete structures.

(5) Cross section of drainage channel

The proposed drainage channels are designed by widening their present channels and constructing new levees. The cross sections of the drainage channels are determined in consideration of effective use of existing structures in and around the drainage channels, such as revetments, bridges, roads, electric poles and telephone cable ducts, in order to minimize compensation of the structures. The cross sections are determined as follows:

(i) The new levees along the Tanjungan drainage channel will be constructed in the north part of Jalan Tol. Prof. Sediyatmo by dump-fill of earth materials to be obtained from excavation of the channel and in near borrow areas, since the water levels outside the channel are the same as the inside one and the levee is always saturated by water to the upper part. The side slope of the levee shall be 1:3.0.

(ii) The new levees except (i) above shall be of a earth embankment type and their side slopes are to be 1:2.0 .

(iii) A trapezoid shape channel protected by a wet masonry revetment is applied to the channels except for the stretches designated in (i) and (ii) above, in consideration of land and house compensation, maintenance of side slopes of the channel and convenience in water use for inhabitants. The side slopes of the revetment shall be 1:0.5

(iv) Freeboard shall be provided above the design high water level, as follows:

Drainage channel	Freeboard(cm)
1) Cengkareng west area	
- Kamal	50 (20 - 30)
- Tanjungan	40
- PIK Junction	30
- Gede/Bor	40
- Saluran Cengkareng	30-40
2) Meruya area	20-40

Note: Figure in brackets shows freeboard for branch channel

The above values were set forth with reference to actually employed freeboards in similar scale construction works of drainage channels to this project, in consideration of the following:

(a) The design discharges of the drainage channels are as small as 2 to 50 m^3/s, compard with those of river channels.

(b) In the channel stretches having design discharges of more the 10 m^3/s, the flood water levels will be controlled by backwater from Jakarta bay

(c) The velocities of the design discharges are in a low range of 0.5 to 1.0 m/s.

4.2.2 Special consideration for land subsidence and clean water management

(1) Land subsidence

Land subsidence is a serious problem in the Cengkareng west area. The extent of the land subsidence for 20 years since 1974 has been estimated by DKI Jakarta by means of levelling survey of existing bench marks in PP System. Based on the results of the levelling survey, the extent of subsidence per year was estimated as follows :

- Kamal drainage at Jalan Tol. Prof. Sediyatmo highway crossing : 6cm/year
- Tanjungan drainage at Jalan Tol. Prof. Sediyatmo highway crossing : 6cm/year
- Bor drainage at confluence with Mookervaat canal : 8cm/year
- Saluran Cengkareng drainage at confluence with Cengkareng floodway: 6cm/year

In due consideration of the above extent of the land subsidence rate per year, basic concept and criteria for design of this urban drainage project against land subsidence was set forth as follows:

(i) The drainage channels and related structures are designed so as to cope with land subsidence up to target year, 2010.

(ii) The drainage channels and related structures shall be designed under the condition that all of the riparian areas along the drainage channels are settled down at the rate of the above extent of subsidence per year and the tidal water level in Jakarta bay is unchanged. The drainage channels and related structures are designed by gravity flow up to the target year. If the design flood water levels of the Kamal, the Tanjungan and the Saluran Cengkareng drainage channels become higher than the elevation in riparian areas along the drainage channels due to land subsidence after the target year, pumping up facilities will have to be considered. To cope with such situations, a pump drainage plan with a regulation pond is examined at a preliminary level.

(iii) It has been presumed that subsidence takes place due to two parameters, namely settlement due to heavy burden in a shallow zone and self consolidation due to pumping up of ground water in a deep zone. In case of the design of permanent structures such as bridges and culvert structures, it is proposed to apply supporting or friction piles and to provide the height to meet a subsidence depth during the selected period above the freeboard of the design flood water level to cope with settlement in the shallow zone. However, it is impossible to cope with self consolidation in the deep zone, the type of a bridge and a culvert which can be technically heightened when land subsidence in the deep zone takes place will be adopted.

(iv) No allowance for the land subsidence is provided for the levees on condition that the levees shall be heightened after occurrence of detrimental subsidence in future, for the following reasons:

(a) Extra embankment 20 cm thick is provided for the levees against (i) future settlement in levee bodies and (ii) subsidence in the shallow zone under the levee bodies due to their heavy burden.
(b) It is difficult to quantitatively specify the extent of self-consolidation due to pumping up of ground water in the deep zone.
(c) Rather high safety against the protection level of a 10 year flood inheres in the designed high water levels of the drainage channels, because the high water levels correspond to respective 10 year floods calculated by the Rational Method.
(d) Future heightening works of the levees are able to be easily executed, as required.

(2) Clean water management

Drainage water containing contaminated water in the existing drainage channels in the Cengkareng west area stagnates in most of the channel stretches in the dry season due mainly to very gentle channel slope caused by the remarkably low land area and also reduction of flow capacity caused by throwing dust and garbage into the drainage channels. In particular, this phenomenon is conspicuous in the outlet of the Saluran Cengkareng drainage channel. Consciousness of inhabitants for improvement to clean water in the drainage channels is remarkably low at present. In order to keep and maintain drainage channels in clean condition, following structural and non-structural measures will have to be adopted.

(i) Along the downstream part of the Saluran Cengkareng drainage channel, many houses are densely located and the drainage channel has been filled with dust and garbage. To prevent dust and garbage from flowing into the drainage channel and to keep clean water, a structural measure of provision of a 400m long culvert with mesh cover and inlet screen is introduced in this densely populated drainage stretch. In addition, to prevent stagnation of drainage water, the drainage channel is designed so as to have so high velocity as the topographic condition allows
(ii) In order to flush out the contaminated water in the drainage channels in a dry season, a part of the irrigation water from the main irrigation canal provided at the southern part of the Cengkareng west area will be utilized as maintenance flow of the proposed drainage channels. To meet this requirement, connection of the drainage channels and the secondary irrigation canal is contemplated in this design.

(iii) In order to facilitate clean water management as non structural measures, the proposed operation and management plan including (a) technical aspects such as routine operation and maintenance methods and works and equipment to be needed, and (b) institutional aspects such as the proposed organization and system, annual budget to be disbursed and participation of inhabitants to operation and maintenance works is studied.

4.2.3 Proposed design flood discharge distribution

The design flood discharge prepared in the feasibility stage (1991) was reviewed by incorporating the data obtained in this design stage. Procedures of preparation of the design flood discharge distribution diagram are as follows:

(1) Calculation method

It has been determined to apply a 10-year probable flood for the design of the Cengkareng west area and a 5-year probable flood for the Meruya area. The flood peak discharges of the objective urban drainage channels were calculated by applying the following rational formula:

$$Qp = \frac{1}{3.6} \cdot f \cdot ra \cdot A$$

Where,

Qp : Flood peak run-off (m^3/s)

f : Run-off coefficient

ra : Basin average rainfall intensity during flood concentration time (mm/hr)

A : Catchment area (km^2)

(i) Run-off coefficient (f)

The flood run-off coefficient varies according to the land use patterns of the basin. It is assumed in this design as follows:

Category of Area	Run-off
-Residential Area	0.5
-Commertial Area	0.7
-Industrial Area	0.7
-Paddy Field	0.2
-Fish Pond	0.2

(ii) Basin rainfall intensity

Point rainfall intensity-duration relationship was studied in ANNEX-I, No 1, Meteorology and Hydrology and point rainfall intensity- duration curves are prepared, as shown in Fig 4.2.1. In this figure, the basin rainfall intensity (ra) was obtained by multiplying the point rainfall intensity by the rainfall reduction factor as estimated in No. 1, Meteorology and Hydrology, ANNEX-I.

(iii) Concentration time (tc)

The concentration time (tc) of a flood discharge consists of an overland time(t_1) and a drain time (t_2) as follows:

$$tc = t_1 + t_2 \quad \text{(min.)}$$

The overland time(t_1) is a flood concentration time along the longest time route from the base point to the uppermost point of the objective urban drainage channel. The overland time was estimated by dividing the route length by a flow velocity, assuming that :

$$\text{Route length} = \frac{\text{Catchment Area}}{\text{Length of Objective Drainage Channel}}$$

Flow velocity = 0.4 m/s.

The drain time(t_2) is a flood concentration time to the objective urban drainage channel. In the drain time calculation, a flow velocity is assumed as follows.

Velocity(m/sec)	Channel gradient
0.5	1:5,000<I < 1:1,000
0.4	I < 1:1,000

(2) Estimation of flood peak discharge and preparation of flood discharge distribution

The flood peak discharges at several points of the proposed drainage channels were estimated by using the rational formula. Based on the flood peak discharge, specific discharge- catchment area relationship was studied as shown in Fig 4.2.2. The figure shows that the specific discharge- catchment area relationship is divided into two groups, depending on the shape of the drainage area. Thus, the flood peak discharges at the selected points for respective drainage channels were estimated based on the width and length of the drainage area. The flood discharge distribution based on this estimation for the Cengkareng west area and Meruya area is given in Figs 4.2.3 and 4.2.4 respectively.

4.2.4 Alignment of drainage channels

In accordance with the above basic concept, the drainage channel alignments and basic drainage plan were determined as follows and these are illustrated in Fig 4.2.5 for the Cengkareng west area and Fig 4.2.6 for the Meruya area.

(1) Cengkareng west area

1) Kamal drainage channel

The drainage channels in the depression areas and swampy areas which had been acquired by the private sectors have already been constructed, and it is presumed that the drainage channels in the remaining depression and swampy areas, which have been acquired by private sectors, will be constructed by private sectors themselves by reclaiming the lands up to EL 4~6 m, under the condition that the drainage water is discharged by gravity flow. To drain the water from the upstream drainage areas to Jakarta bay, the drainage channel is aligned by expanding the existing drainage channel and reconstructing a bridge at Jl. Tol. Prof. Sediyatmo (the Highway). The gate facilities will be provided along the Kamal drainage channel in locally low land areas in southern part of the Highway.

2) Tanjungan drainage channel

The drainage channel in the depression area in the center part of the drainage area, which has been acquired by the private sector, will be constructed by a private sector under the condition that the depression area is reclaimed up to 2 m and the drainage water is drained by gravity flow. A low land is located at the southern part of the Highway. In order to drain water in this low land by gravity flow and to cope with land subsidence, it is necessary to heighten this low land up to EL 2 m. The drainage water in this low land will be discharged through sluiceways until completion of land reclamation in this low land. In order to drain water from the upstream depression areas and other drainage area to Jakarta bay, the Tanjungan drainage channel is aligned straightway to Jakarta bay by providing a bridge at the Highway and constructing the drainage channel in the fish pond.

3) PIK Junction drainage channel

The drainage condition in this area was drastically changed from that stated in the feasibility study (1991): drainage in this area is interrupted by a newly constructed interchange road which divides the drainage area into two zones. The drainage channel in the depression area, which is located along the ring road and already acquired by a private sector, will be constructed in the land to be reclaimed up to EL 2 m. Since the interchange road network crosses the proposed drainage channel, the proposed drainage channel will be aligned by avoiding this interchange road. The northern part of this drainage area is acquired by a private housing developer. The drainage water collected along the Highway is planned to be discharged to Jakarta bay through the existing 6 culverts with diameters of 0.80m~1m under the condition that the land already acquired by the private sector is heightened up to EL 1~2 m.

4) Gede and Bor drainage channels

Since majority of the Gede drainage channel was already constructed by a private house developer and also majority of the Citra Garden II drainage channel was constructed by a private sector, the remaining stretches of the Gede primary channel and the Citra Garden II drainage channel and all of the Bor drainage channel will be expanded to discharge the design flood to the Mookervaat canal. The Bor drainage channel will be designed by gravity flow without any gate facilities.

5) Saluran Cengkareng drainage channel

The Saluran Cengkareng drainage channel is connected with the Bor drainage channel at its upstream end and drainage water flowing in the Bor drainage channel is discharged to two directions at the connection point; namely the southern direction to the Mookervaat canal and the eastern direction to the Saluran Cengkareng channel. In order to minimize the width of the Saluran Cengkareng drainage channel in the downstream stretch in the densely populated area, the Saluran Cengkareng drainage channel is separated from the Bor channel. However, at the upstream end portion of the Saluran Cengkareng drainage channel, sluice gate facilities are provided to release the Bor water to the Saluran Cengkareng drainage channel as maintenance flow in a dry season. The Saluran Cengkareng drainage channel is designed by gravity flow without any pumping facility. To prevent further expansion of inundation in the locally low land area along the Saluran Cengkareng drainage channel in case that a large magnitude flood takes place in the Cengkareng floodway and the flood flows into the Saluran Cengkareng drainage channel, sluice gate facilities will be provided at the outlet of the Saluran Cengkareng drainage channel by modification of the existing gate facilities. Both banks of the present Saluran Cengkareng drainage channel along the low land area 1.5 km upstream of the outlet will be heightened to prevent drainage water from flowing into the low land area and sluiceways will be provided.

6) Pedongkelan drainage channel

In the center part of this drainage area, a large scale house complex is located and drainage channels surrounding this house complex and extending to the eastern direction to drain water to the Cengkareng floodway are being constructed by the National Urban Development Corporation (PERUM PERUMNAS) at present. It is planned in this drainage channel to provide a regulation pond and pump facilities to discharge drainage water to the Cengkareng floodway. Since construction of this drainage channel belongs to this house supply cooperation, design of this drainage channel was deleted.

(2) Meruya area

Since the ground elevation of Meruya area is lower than the surrounding area topographically, the habitual inundation areas are formed in the center part of the drainage area. A part of the drainage water from Meruya area flows into the existing drainage ditch located in the private housing complex in the eastwards of Meruya area. Since the capacity of the existing drainage ditch in the private owned housing area is limited, the drainage water caused by future development of Meruya area could not be drained to eastern direction. In addition, due to the construction of the new junction of Jl. Tol Jakarta-Merak (Kebon Jeruk Junction) in the north east part of the project area, the drainage to the existing culverts under the embankment of Jl. Tol Jakarta-Merak will be interrupted. Because of these reasons mentioned above, it is considered that the only outlet of the drainage from Meruya area is a tributary of Angke river located at about 480m west from the drainage area. The new drainage channel is aligned across the inundation areas in upstream and middle stream stretch, along Jl Tol Jakarta-Merak in downstream stretch, and connected to the tributary of the Angke river. The proposed channel alignment in Meruya area is shown in Fig 4.2.6.

4.2.5 Longitudinal profile of drainage channels

(1) Cengkareng west area

1) Drainage channel to be drained to Jakarta bay

Drainage water in the Kamal, the Tanjungan and the PIK Junction drainage channels is discharged to Jakarta bay. In order to drain as much discharge as possible within the limited channel width, a steeper channel bed slope should be applied. If this method is applied, channel excavation to off shore is needed and jetty will have to be provided to protect the excavated channel from scouring and depositing of sand. However, design of the jetty such as its direction and scale will not be made with no result of the coastal investigation. In addition, it is anticipated that the deepened channel bed alters to the original channel bed due to sea sand and sedimentation from upstream side. In view of the above, the design channel beds in the existing drainage channel portions are set at the original bed elevation for the Kamal and the Tanjungan drainage channels. The design channel beds for the depression and swampy area portions, which have been acquired by private sectors, are set in consideration of channels bed slope in the existing channels and the assumed ground elevations of the land reclamation areas. The design channel bed slope for the PIK Junction drainage channel is set in consideration of the existing channel bed slope along Jakarta Outer Ring Road and the ground elevation of the upstream drainage area. The determined channel bed slope is as follows:

-Kamal drainage channel : 1:3,200 and 1:1,800
-Tanjungan drainage channel : 1:5,000
-PIK Junction drainage channel : 1:600

2) Drainage channel to be drained to Cengkareng floodway

The Saluran Cengkareng drainage channel discharges to the Cengkareng flooway. The Saluran Cengkareng channel is affected in its downstream portion by the water level of the Cengkareng floodway. Even if the channel bed at outlet portion of the Saluran Cengkareng drainage channel is lowered, the flood capacity hardly changes. Thus, the design channel bed is set at the original channel bed elevation. The determined channel bed slope is 1:3,000.

3) Drainage channel to be drained to Mookervaat canal

The Gede/Bor drainage channel discharges to the Mookervaat canal. Since the Gede/Bor drainage channel is not affected by the water level of the Mookervaat canal, the channel bed at the outlet portion is slightly lowered and the steeper channel bed slope than that of the existing channel is adopted to minimize the channel width. The determined channel bed slope is 1:1,600.

4) Verification of safety in design water level

In connection with the design water level, check study was made from two aspects, namely, fluctuation of the tidal level in Jakarta bay and occurrence of larger floods exceeding the design flood.

In this design, the spring tide(high high tide) of P.P 1.2m in Jakarta bay is applied for determination of the design water levels of the Kamal and the Tanjungan drainage channels, while the maximum tide level of P.P 1.54m has been applied for the design of East Jakarta Flood Control Project. To verify the safety of the drainage channel in case of tide level occurrence of P.P 1.54m, check study was made. The result of the study verified that both drainage channels are able to discharge their design floods within the freeboard, receptively, even when the tide level of P.P 1.54m occurs in the Jakarta bay.

The check study was also made to verify the safety of the drainage channels in case that a 25-year flood takes place in the drainage channels in the Cengkareng west area. The study resulted in the verification that even if a 25-year flood occurs in the Cengkareng west area, it can be safely drained within the designed drainage channels due to the freeboard. Fig 4.2.7 exemplifies comparison of flood water levels for 10 and 25-year floods and the freeboards.

(2) Meruya area

In order to drain water from the drainage area by gravity flow to the tributary of the Angke river, following conditions were contemplated:

(i) In the partly high elevated areas in the drainage area, box culverts are designed under the existing roads to drain water to the westward of the drainage area.
(ii) All of the objective drainage area was already acquired by residents and provision of a new drainage channel in this acquired area is rather difficult because of compensation problem with residents. To avoid this compensation problem, the proposed drainage channel is to be aligned along the existing roads.
(iii) The proposed drainage channel is to have alignment crossing the city road along the west fringe of the drainage area, so as not to cross a pier portion of the road bridge across the Jakarta-Merak highway.

(iv) Foundation of the existing houses located along the proposed drainage channel in the center part area has been heightened by 0.5~0.7 m to avoid inundation. Since the ground elevation of the center part area is about 2m lower than those of neighboring areas, the design water level corresponding to a 5-year flood becomes about 0.5m higher than the foundation of the existing houses. Under such drainage conditions, it was contemplated to proceed with the drainage works by two stages. In the initial stage, a drainage channel with the same design water level as the foundation of the existing houses is designed considering convenience of inhabitants, on condition that inundation is allowed at a part of the center part area against a 5-year probable flood. In the final stage when substantial land reclamation will be carried out, the drainage channel will be heightened to discharge a 5-year probable flood.

Comparative study on the relationship among channel width, ground elevation along the drainage channel and channel bed slope was made. Among several alternatives, drainage plan with the lowest design water level was selected. The determined channel bed slope is 1:2,000, 1:260 and 1:700.

The determined longitudinal profiles showing existing channel bed, channel banks, design channel bed and design flood water level for the respective drainage channels are illustrated in Fig 4.2.8.

4.2.6 Cross section of drainage channels

A single cross section is applied for all of the drainage channels. The cross section was designed considering the following conditions:

a) The design water level should be lower than the ground elevation of the drainage area in principle,
b) In the drainage area of the Tanjungan drainage channel, it is necessary to heighten the low land in the southern part of Jl. Tol. Prof. Sediyatmo up to EL 2 m to discharge water by gravity flow and to cope with land subsidence.
c) Compensation for lands and houses due to widening the drainage channel should be minimized.
d) The freeboard as specified in the design criteria is applied.

Comparative study on alternatives of the channel cross sections was made for respective drainage channels as shown in Table 4.2.1 by means of non-uniform flow calculation. Among several alternatives, the cross section with the maximum channel depth to satisfy the above condition and the minimum width was selected for each channel stretch, except for locally low land areas. The designed cross sections thus selected are given in Fig. 4.2.9.

4.2.7 Measures against land subsidence for Kamal, Tanjungan and Saluran Cengkareng drainage channels

The Kamal, Tanjungan and Saluran Cengkareng drainage channels are designed by gravity flow. However, it is anticipated that the design water levels of these drainage channels will become higher than the elevations of the riparian areas along the drainage channels after the target year, 2010, if all the riparian areas along the drainage channels are settled down at a rate of 6cm/year and the tidal level in Jakarta bay is unchanged. To cope with this land subsidence problem in the future stage, a pump drainage plan including a regulation pond was studied at a preliminary level. The study results in the following table:

Drainage channel	Installation year	Pump capacity (m^3/s)	Regulation pond	
			Scale (length x width)	Storage capacity (10^3 m^3)
Kamal (main)	2018	20	400m x 400m	480
Tanjungan	2016	5	220m x 220m	150
Saluran Cengkareng	2018	3	270m x 270m	150

This table shows that pump drainage is required in and after 2016 for the Kamal (main), Tanjungan and Saluran Cengkareng drainage channels. It is conceived that pump facilities and a regulation pond shall be located near the downstream end of each channel, in consideration of land availability, drainage efficiency and possibility in future basin development.

4.2.8 Check of pumping up system for Pedongkelan drainage channel

The Pedongkelan drainage system has been designed: the drainage system plans to drain water by a pumping system because of the low elevation of the riparian area along the drainage channel. After examination of this pumping system, the pump capacity and the scale of the regulation pond were checked as follows:

(i) Drainage by a gravity flow method is impractical in the Pedongkelan area, because the drainage method requires a drainage channel having a 35 m wide bottom in the densely populated area.

(ii) The Pedongkelan pumping system can drain a 10 year flood safely by using the currently designed system, namely 3 sets of pump facilities (0.8 m3/s x 3) and a regulation pond of 0.2 mil. m^3.

4.2.9 Impact of land reclamation plan in shore area

It has been reported that the land reclamation plan in the shore area along Jakarta bay is being promoted and realized in the near future. A practical plan of the land reclamation such as the scale of the plan and details of the plan profile is unavailable. In order to evaluate impact of back water on the proposed drainage channels due to the land reclamation plan, back water calculation was made assuming the following conditions:

(i) As the distance between the present coastal line of Jakarta bay and future coastal line after the land reclamation, the back water calculation assumed five cases, namely, 500m, 1,000m, 1,500m, 2,000 and 2,500m.

(ii) The widths of the drainage channels of the Kamal and Tanjungan areas which drain through the land reclamation area are the same as those of the proposed drainage channels at the present coastal line.

(iii) The channel bed slopes in the land reclamation area are the same as those of the proposed drainage channels at their downstream stretches, namely, 1:3,000 for the Kamal drainage channel and 1:5,000 for the Tanjungan drainage channel.

(iv) The design discharge in the land reclamation area is the same as the present design discharge at the downstream end of the drainage channel, assuming that an independent drainage channel is newly constructed in the land reclamation area, in each case of the drainage channels.

The results of the calculation indicate that, in both channel cases, significant backwater raising, say 10 cm ~ 30 cm, will occur in the downstream stretches of Jl. Tol. Prof. Sediyatmo after the land reclamation of the five cases, though the raising heights are still in the range of the freeboard.

Accordingly, heightening works of the levees will be necessary before the land reclamation works to provide due freeboards in the stretches. However, the heightening works are considered to have little difficulty, judging from the extent of the estimated backwater raising height.

4.2.10 Connection of secondary irrigation canal and drainage channel

In order to flush out the contaminated water in the drainage channels in a dry season, it is contemplated to release a part of irrigation water as maintenance flow. In the Cengkareng west area, the secondary irrigation canals to feed irrigation water to the existing paddy fields is extended from the main irrigation canal in the southern part of the area. This secondary irrigation canal is changed to the drainage channel in the downstream stretch and connected to the Kamal primary drainage channel. At a junction of the main and secondary irrigation canals, a spindle type sluice gate is provided to feed irrigation water to the paddy fields. Since the function of the secondary irrigation canal and the drainage channel in its downstream is remained in this design, it is possible to release water to the drainage channel to flush the contaminated water in the Kamal drainage channel by operating the sluice gate, though discussion with the irrigation department is needed for releasing the irrigation water.

While, a small scale conduit is provided at the main irrigation canal at the middle portion of the Cengkareng west area. This conduit is opened to feed maintenance water to the Kamal branch drainage channel. This function is also remained in this design.

Except for the Kamal drainage channel, there is no possibility to connect the irrigation canal and other drainage channels from a topographic view point.

4.2.11 Capacity check of other drainage channels

In the private sector areas, 5 major drainage channels have been constructed by the private sectors themselves. On the other hand, one major secondary irrigation canal, which changes its function to the drainage channel in the downstream stretch after feeding irrigation water, joins the Kamal main drainage channel. Six major channels/canal, of which the locations are shown in Fig. 4.2.10 were examined in terms of flood capacity, because the channels/canal are expected to function as a part of the drainage channel network in the Cengkareng west area.

The examination revealed that the capacities are insufficient for the 10-year flood, except for the channel GA. Accordingly, it is recommended that the channels will be improved with the following channel features:

Channel name	Design discharge (m3/s)	channel slope	Channel width (m)	Side slope	Remarks
KM-C	30.3	1/1,800	12	1:0.5	
KC-C	27.7	1/1,800	20	1:0.5	
KH-C	16.9	1/250~ 1/1,800	15	1:0.5	
TM-C	9.6	1/5,000	10	1:0.5	
GM-C	13.8	1/1,600	7	1:0.5	

4.3 Design of Channel Structures

4.3.1 Design criteria

(1) Levee

It is required to construct new levees along the drainage channels in some low land areas. An earth type levee is adopted, if there is no special restriction in land for levee construction. However, a parapet wall is adopted if there is constraint in land acquisition in a densely populated area. The design criteria of these levees are as stated below.

(a) Earth type levee

(i) Clayey and silty earth materials which will be obtained from excavation for drainage channel widening and in near borrow areas shall be used as embankment material. Accordingly, a homogeneous type levee is constructed.

(ii) The earth type levee shall be of a trapezoid shape with 3 m in crest width and its side slopes shall be 1: 2.0 in principle. However, the crest shall be 5 m wide, in case that the crest is used as an inspection road.

(iii) A two(2) m wide berm shall be provided 3 m below the levee crest on the land side slope.

(iv) The foundation area of the levee shall be stripped up to 20 cm in principle.

(v) Extra embankment is necessary for levee construction to cope with future settlement of levee body and foundation, and the following values shall be applied:

Height of levee(m)	Extra embankment(cm)
Less than 3	20
3 to 5	30

(vi) The side slope surfaces of the earth type levee are protected by gabion mattress and sod facing on the channel and land sides, respectively, against local erosion due to rainfall and stream flow.

(vii) The levee constructed in fishponds is provided by dump fill of earth materials. The side slope of the levee is 1:3.0 and is protected with riprap only on the channel side.

(b) Parapet wall

The parapet wall is designed in the following stretches having difficulty in construction of an earth type levee due to constraint in land acquisition:

1) Stretches facing difficulty in land acquisition in densely populated areas, and
2) Stretches having no space for earth type levee construction because of narrow space between channel bank and existing road.

The parapet wall is an inverted T-type of reinforced concrete. The height of the wall is designed based on the design water level and necessary freeboard above the design water level. Other dimensions such as the width and thickness of the wall take into consideration the loading conditions after heightening the wall due to future land subsidence.

(i) Foundation type

Two (2) types of spread and pile foundations are conceivable for the parapet wall and the following criteria are applied for selection:

Type	Criteria
Spread foundation	$Qmax \leq Qa$
Pile foundation	$Qmax > Qa$

where, Q_{max}: Maximum bearing pressure(t/m^2) under full design load condition(t/m^2)
Qa: Allowable bearing capacity of foundation (t/m^2)

(ii) Cutoff wall of steel sheet pile

A cutoff wall is required at the foundation of the parapet wall to prevent piping phenomena due to seepage water in the foundation during flood. The required depth of the cutoff wall is calculated by applying the Lane's formula, which is presented below:

$$Cw \leq (\sum Lh/3 + \sum Lv)/\Delta H$$

where,

Cw	:	Lane's creep ratio (clay, Cw=3 to 5)
Lh	:	Length of horizontal creep line (m)
Lv	:	Length of vertical creep line (m)
ΔH	:	Difference in water level between channel side and land side (m)

(2) Revetment

For slope protection of the drainage channels, revetment works with wet masonry are employed in this design, except the channel stretches for the earth type levee.

The revetment of wet masonry consists of slope protection, toe protection and foot protection. Their structural design conforms to the following criteria.

(i) Slope protection

The slope protection shall be provided at least up to the design high water level. However, the protection shall be raised up to the top of the drainage channel or levee, depending on the local flow condition.

A transition of 3 m in length is provided at the upstream and downstream ends of the revetment, to avoid abrupt change in roughness and hardness between the wet masonry and levee slope, which may cause unfavorable flow turbulence. For this transition, gabion mattress is to be placed.

(ii) Toe protection and foot protection

In order to protect the toe potion of the slope protection from the damage due to local scouring or degradation at the channel bed, the toe protection by foot concrete will be provided. The depth of the foot concrete is 0.5 m. The foot concrete shall be provided 1.0 m below the design channel bed in the drainage channel and 0.5 m below the original ground surface for the levee revetment.

In order to avoid destruction of the wet masonry after uneven settlement of foundation due to durability of foundation material and future local subsidence, wooden piles are provided at the foot concrete.

The toe portion of the slope protection will be also protected against the scouring and degradation of the channel bed, and gabion mattress will be provided for foot protection in front of the toe protection.

(3) Sluiceway

As some inland rain water will be confined in low land areas along the drainage channels after construction of levees, revetments and other structures, the inland rain water will be drained to the drainage channels through sluiceways.

(a) Location of sluiceway

The location of sluiceway is determined based on the following consideration:

(i) The location is to be the same as the site of the major present drainage canal in principle. However, the location shall be determined so as no to impair the function of the existing and/or new drainage facilities

(ii) The number of sluiceway shall be minimized through integration of drainage areas to realize effective and efficient drainage.

(iii) The longitudinal direction of sluiceway shall be aligned perpendicular to the axis of the levee to minimize sluiceway length and to simplify sluiceway structure.

(b) Hydraulic design

(i) The sluiceway is designed under the hydraulic condition of the drainage channel which has a 10-year flood capacity.

(ii) A ten (10) year runoff discharge in the drainage area of the sluiceway is used as a conduit capacity. The probable runoff discharge is estimated under future land use condition by use of the Rational formula.

(c) Structural design

(i) Conduit

1) A box culvert type is applied because of its high drainage capacity.

2) A maximum size of a box culvert type conduit is limited to 2.3 m x 2.3 m at the outlet in consideration of manual gate operation.

3) The number of conduits is determined so as not to remarkably reduce the original

flow area of the secondary drainage channel to be connected.

(ii) A contraction joint shall be provided in the conduit, if its length exceeds 20m in terms of uneven settlement of foundation

(iii) The foundation of sluiceway is designed so as to safely transmit upper loads to subsoil. To avoid leakage through the foundation, base concrete of 10 cm is provided instead of gravel bedding.

(iv) The outlet sill elevation of the conduit is determined based on the design elevation of the drainage channel bed and topographic conditions of the inland area.

(v) The sluiceway is provided with a slide gate or a flap gate to prevent drainage channel water from inundating in the inland area during floods, in case that the inland surface is lower than the design high water level of the drainage channel at the sluiceway site.

1) The slide gate is designed so as to allow manual operation.

2) The flap gate is applied in case that the required conduit capacity is less than 0.2 m3/sec/ and no serious inundation damage is presumed in the inland area even in the case of malfunction of the gate.

(d) Cut-off wall of steel sheet pile

Safety of sluiceway foundation is carefully examined against piping caused by seepage water around the conduit, which results from water level difference between the upstream and downstream sides of the conduit. The property of foundation soil subject to examination is assessed based on the results of the geotechnical investigation conducted in this project.

The piping is examined by using the Lane's formula. If the piping is assessed to occur, steel sheet piles will be provided at the inlet and outlet of the conduit.

(e) Foundation

Spread and pile foundations are conceivable and the following criteria are applied for selection:

Type	Criteria
Spread foundation	$Q_{max} \leq Q_a$
Pile foundation	$Q_{max} > Q_a$

where, Q_{max} : Maximum bearing pressure(t/m^2) under full design load condition(t/m^2)

Q_a : Allowable bearing capacity of foundation (t/m^2)

(4) Inspection road

An inspection road is required on one side of each drainage channel not only for routine operation and maintenance works of such channel facilities as a drainage channel, levees, revetments and sluiceways, but also for periodical inspection of the facilities. The existing roads along the proposed drainage channels will be used as inspection roads. However, in the channel stretches where no existing road is available, inspection roads of at least 5 m wide will be newly provided along the stretches.

4.3.2 Channel structures

Table 4.3.1 summarizes improvement works of the drainage channels, which contain construction of levees, revetments, concrete walls and ditch structures. The locations of the works are shown in Fig. 4.3.1.

(1) Levee

(a) Earth type levee

The earth type levee is adopted for the channel stretches in rarely populated areas along the Kamal, the Tanjungan and the Saluran Cengkareng drainage channels, as shown below:

Drainage channel	Levee length (m)			Remarks
	Left bank	Right bank	Total	
Kamal (main)	1,893	2,770	4,663	
Tanjungan	1,737	1,743	3,480	
	(1,454)	(1,663)	(3,117)	( )dump fill
Saluran Cengkareng	1,912	1,537	3,449	

This earth type levee is of a trapezoid shape with a side slope of 1:2. An inspection road of 5 m wide will be provided on the top of the levee, in case that no existing road is available for an inspection road of the drainage channel.

The levee along the Tanjungan drainage channel is provided by dump fill of earth materials in the north part of Jl. Tol. Prof. Sediyatmo, because the channel is aligned in fishponds. The side slope of the levee is 1:3.0 and is protected with rip rap only on the channel side.

The typical cross section of the earth type levee is shown in Fig. 4.3.2.

(b) Concrete parapet wall

In 3 drainage channels as shown below, the concrete parapet walls were aligned along the channel stretches in densely populated areas.

Drainage channel	Parapet wall length (m)			Remarks
	Left bank	Right bank	Total	
Kamal (main)	493	0	493	
Tanjungan	567	567	1,134	L-type wall
Saluran Cengkareng	569	851	1,420	

The footing concrete is provided with friction piles of 250 mm x 250 mm because of insufficiency in bearing capacity of foundation soil. The typical cross section of the concrete parapet wall is given in Fig. 4.3.3.

In the upstream stretch of the Tanjungan drainage channel, a concrete L-type wall is employed, in consideration of (i) needlessness in construction of masonry revetment (ii) shortening of foundation pile length and (iii) future land reclamation in the inland area.

(2) Revetment

The side slopes of the drainage channels are protected by revetment works with wet masonry, excluding the channel stretches where concrete lined stretches, namely stretches of an open culvert, concrete ditches and concrete L-type walls, are provided. The slope of the wet masonry is 1:0.5.

Drainage channel	Revetment length (m)			Remarks
	Left bank	Right bank	Total	
Kamal (main)	1,315	1,580	2,895	
Kamal (branch)	1,869	1,474	3,343	
Tanjungan	204	143	347	
Saluran Cengkareng	1,341	1,435	2,776	
Gede/Bor	1,183	1,183	2.366	

The typical cross section of the revetment is given in Fig. 4.3.4.

(3) Other channel structures

(a) Open culvert with mesh cover and screen

The open culvert is applied to the 390 m long channel stretch from the outlet of the Saluran Cengkareng drainage channel. The open culvert is divided cross-sectionally into 3 lanes and is provided with mesh cover at the top over the whole stretch in order to prevent dust and garbage from being thrown into the drainage channel. A screen made of I-type steel members is provided at the upstream end of the open culvert to prevent dust and garbage from flowing into the culvert. The open culvert is designed as shown in Fig. 4.3.5.

(b) Open U- type concrete ditch

The open U-type concrete ditch was adopted for the Kamal (branch) and the Tanjungan drainage channels and the Meruya area.

Drainage channel	Concrete ditch length (m)	Remarks
Kamal (branch)	452	upstream stretch
PIK Junction	765	whole stretch
Meruya area	1,477	

(4) Inspection road

Each drainage channel needs an inspection road on one side. The inspection road is aligned in the crest of the earth type levee or in the area along the channel, except for the channel stretches where the existing public roads will be available for the inspection roads.

Drainage channel	Length of inspection road(m)			Remarks
	Left bank	Right bank	Total	
Kamal (main)	2,264	632	2,896	
Kamal (branch)	0	1,357	1,357	
Tanjungan	0	495	495	
Saluran Cengkareng	2,602	1,338	3,940	
Gede/Bor	265	0	265	

4.3.3 Drainage facilities

The channel improvement works bring about the following negative effects, due to construction of levees, revetments and other channel structures:

(i) to close outlets of existing drainage canals which discharge domestic waste water and inland rain water to the drainage channels, and

(ii) to confine inland rain water into locally low land areas along the drainage channels.

To solve these negative effects, it is necessary to provide drainage facilities such as sluiceway and/or drain-ditch structures at the existing drainage canal and the locally low land areas. The sluiceways will be equipped with slide or flap gates and inland rain water will be discharged at each sluiceway to the drainage channel through the gates when the water level in the drainage channel is lower than that in the inland water level at the sluiceway.

(1) Design discharge

A 10-year runoff discharge in the inland area is used for the design of the sluiceway and drain-ditch structures. The 10-year runoff discharge was calculated by the Rational Formula, as in the case of the design discharge calculation of the drainage channels. The formula used in this calculation is as follows:

$$Qp = f \times ra \times A/3.6$$

where,

Qp :Peak discharge (m3/s)

f :Run-off coefficient (0.5 for residential area, 0.7 for industrial area)

A :Drainage area (km^2) of sluiceway/drain-ditch site

ra :Basin average rainfall intensity during concentration time (mm/h)

$ra = a \times rp = a \times 8571/(t^{1/1.02} + 50.1)$ ($t \leq 180min$)

$ra = a \times rp = a \times 8973/(t^{1/1.02} + 68.0)$ ($180min < t$)

rp :Point rainfall intensity (mm/h)

a :Reduction coefficient

t :Concentration time (min)

The locations of sluiceway and drain-ditch sites are shown in Fig. 4.3.6, together with their drainage areas. The computed design discharges are in the wide range from 0.06 m3/sec to 7.5 m3/sec, as referred to in Table 4.3.2.

(2) Construction site

Conceivable sites of the sluiceway/drain-ditch facilities were thoroughly examined through extensive site reconnaissance along the drainage channels from topographic, geotechnical and hydraulic viewpoints to minimize the number of the facilities and to realize effective drainage. Consequently, 51 and 13 sites are determined for construction of the sluiceways and drain-ditches repectively, as shown in the following table. The present outlet sites of major drainage canals are included in the sites.

(Unit : site)

Drainage channel	Left bank		Right bank		Total
	S	D	S	D	
Kamal (main channel)	8	2	7	-	17
Kamal (branch channel)	5	3	3	1	12
Tanjungan	4	-	3	-	7
Gede/Bor	3	3	2	3	11
Saluran Cengkareng	8	-	7	1	16
PIC drainage channel	-	-	1	-	1
Total	28	8	23	5	64

Notes: S = Sluiceway, D = Drain-ditch

The location of the above sites is illustrated in Fig. 4.3.6.

The drain-ditch structure is employed at the site where a drain-ditch is currently provided and the inland elevation is higher than the design high water level (HWL) of the drainage channel, because the inland area will have no inundation from the drainage channel during floods and gate facilities are not required.

(3) Design of structure

(a) Size of sluiceway conduit and drain-ditch

The conduit size of sluiceway is determined so that the design discharge may be safely drained through the conduit without overtopping from the levee even in the case that flood water in the drainage channel reaches the HWL at the sluiceway site. The drain-ditches are also designed so as to safely drain inland waters in their drainage basins up to the design discharges

(b) Sluiceway gate

Slide and flap gates are used for the sluiceways. The flap gate is selected, at the site that meets the following requirements:

(i) Design discharge $\leqq$ 0.2 m^3/sec

(ii) EL1-EL2 $\geqq$ 0.6 m

where, EL1 = Outlet sill elevation of sluiceway conduit

EL2 = Drainage channel bed elevation

Consequently, the sluiceways will be equipped with 50 slide gates and 5 flap gates in total, as referred to in Table. 4.3.3. The general features of the gates are as shown in Fig. 4.3.7.

(c) Foundation

According to the geotechnical investigation conducted in this project, the N values (SPT values) of sluiceway foundation, composed mainly of clayey/silty material, are in the low range of 2 ~ 8 blows, and the allowable bearing capacity is estimated to be as low as 3.5 t/m^2. In view of these results, all sluiceways are provided with the pile foundation with R.C. friction piles of 250 mm x 250 mm, as the estimated allowable bearing capacity was assessed to be insufficient to sustain the total loads to be transmitted from the sluiceway body.

(d) Cut-off wall

To ensure safety against piping by seepage water around the conduit due to the difference in water level between the sluiceway inlet and outlet during floods, sheet piling cut-off walls of 2 m ~ 2.5 m deep are provided at the inlet and outlet bottoms.

(e) Main features of sluiceways

Main features of the sluiceways and drain-ditch structures are compiled in Table 4.3.3.

4.3.4 Gate and related structures

(1) Kind of gates and location to be adopted

Two types of gate; namely, slide gate and flap gate types are adopted in this design.

Characteristics of these two types of gate are as follows:

a) The flap gate tends to malfunction due to clogging by water drift and trash.
b) The slide gate has higher reliability of operation performance, though it is operated manually.

In view of the above, each type of gate was applied to the following locations:

Gate Type	Location
(a) Slide gate	- at inlet and outlet of the Saluran Cengkareng drainage channel
	- at sluiceways having design discharges of more than 0.2 m^3/s
(b) Flap gate	- at sluiceways having design discharges of equal to or less than 0.2 m^3/s

(2) Design of gate and related structure

1) Type of gates and related structures

The following metal equipment are proposed to provide at the each drainage channels:

Type of Gate	Dimension		Type of Gate or Metal Works	Dimension	
	Width(m)	Height(m)		Width(m)	Height(m)
1.Slide Gate			2.Flap Gate		
Type-1	2.3	2.3	Type-1	0.4	0.4
Type-2	1.5	1.5			
Type-3	1.4	1.4			
Type-4	1.3	1.3			
Type-5	1.2	1.2			
Type-6	1.1	1.1			
Type-7	1	1			
Type-8	0.9	0.9	3.Stop log		
Type-9	0.8	0.8	Type-1	2.3	2.7
Type-10	0.7	0.7	Type-2	2.3	3.4
Type-11	0.6	0.6	4.Trashrack	10	2.403
Type-12	0.5	0.5	5.Mesh Cover	10	400(length)

2) Standard to be applied

The design and fabrication of gates, in principle, conform to the applicable provisions of the Technical Standards for Gates and Penstocks published by the Hydraulic Gate and Penstock Association of Japan. The Japanese Industrial Standards (JIS) and the American Society for Testing and Materials (ASTM) are mainly adopted for the materials to be used and workmanship of the works. In addition, the Indonesian National Standards are applied as much as possible.

3) Gate

Twelve (12) sizes of steel-made slide gates and one (1) size of steel-made flap gate are designed at the inlet or outlets of the drainage channels for draining the water from inland area and for preventing the adverse flow of flood water from the river or main drainage.

(a) Slide gates

Type of gate shall be determined from the view points of the required purpose, functions, frequency of operation, safety, convenience of operation and maintenance, installed location and circumstances, civil structure, etc., and also from the economical view point. Slide gate or roller (fixed wheel) gate is generally adopted to the inlet or outlet gates in vertical lift type gate. The slide gate is of plate girder construction and is simple structure compared with the roller gate because no rollers exist. While, the operating load is larger than that of roller gate due to the friction force of bearing plates. Thus, the slide gate is used for small span gate and small operating head as described hereunder, but shall not be limited to:

Item	Slide Gate	Roller Gate
Clear span	less than 2.30 m	more than 2.30 m
Operating load	less than 5.0 tf	more than 5.0 tf

The vertical lift slide gate is selected as the inlet or outlet gate in due consideration of :

i) The gate size is relatively small, i.e., the largest one is 2.30 m width x 2.30 m height

ii) The gate is operated under the water head difference of 1.0 m, i.e, the gate is operated with small operating load.

iii) The gate cost is cheaper due to simple structure.

iv) The maintenance is easy, i.e., the lubrication is not required for the gate.

v) The gate is kept at fully opened position in dry season and the gate is operated to close at the time of flood, i.e., the frequency of operation is a relatively low.

Each gate consists of skin plate, main horizontal beams, vertical beams, bearing cum seal clamp plates, rubber seals, side guides, front wedges, lifting lug and all other necessary components, and the gate is capable of overcoming all loads at any water level up to H.W.L.

The skin plate and rubber seals are provided at the land side (anti-pressure side) of gate leaf because of requirement of perfect water tightness at flood.

The guide frame consists of the sealing frames, inter beam, sill beam, track frames, front frames, side guide frames and all other components necessary for the complete and satisfactory installation of the guide frame. The corrosion - resisting steel plates are attached to the sealing frame surfaces to avoid excessive wear of rubber seals.

The loads on the guide frame are the bearing load and all other loads due to the most adverse operation of the gate by the hoist. The guide frame and anchors are capable of transferring all the loads of bearing plate, side guides and rubber seals of the gate to the concrete structure.

The power source will not be supplied for the gate operation in principle. Accordingly, the gate should be operated by the man power within the limited operating force which a operator can operate the hoist continuously.

A manually driven single stem screwed spindle hoist was selected as the operation device for each slide gate because of:

- small lifting load
- limited space
- availability of forcible lowering force by the hoist
- enough lead time for gate operation
- simple and compact construction
- easy maintenance and operation
- reliability and durability of the hoist
- small span (Normally two stem spindle hoist is used for the gate having span of 2.5 m or more)

- a few time operation of gate throughout a year and
- low cost.

Each hoist consists of screwed spindle with its supports and cover, gear reducer unit with gear cover, bearings manual operating device and other necessary components for safe, proper and efficient operation. The hoist should be established on the concrete deck or structural steel base frame works. The spindle is made of corrosion-resisting steel.

If necessary the spindle supports are provided at proper positions with a interval to avoid the buckling of spindle due to over-lowering force when the gate is jammed or closed. The operation force on the manual operating device is less than 10 kg force under normal design condition. The operation force is given by the 300 to 600 mm in diameter handle which is located at approximately 800 mm in height from the operation deck.

The design data of the slide gates are summarized as follows:

Type	: Square steel made slide gate
- Clear span	500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500 and 2300 mm
- Clear height	500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500 and 2300 mm
- Design head	Hydrostatic pressure of HWL + 1.0m - Sill EL.
- Operation head	Water head difference of 1.0 m
- Sealing method	4 edges rubber seal at land side
- Maximum deflection of main beams:	1/800 of supporting span
- Corrosion allowance	1.0 mm for water contact face members
- Type of hoist	Manually driven single stem screwed spindle hoist
- Hoisting height	Clear height + 5 cm in normal operation
- Maximum operation force of handle	10 kgf

Note: The design water level (H.W.L.+1.0m) is determined in account of land subsidence which is caused in the future.

(b) Flap gates

The flap gates are provided at the outlets having the small size culvert (0.4 m width by 0.4 m height) which are located at the junction of tributary. The flap gate can be operated automatically by a water head difference between upstream and downstream sides of the gate without operator. The circular type flap gate is normally provided for the circular type culvert, but the square type flap gate is provided for the circular type culvert because of easy manufacturing and water tightness thereof. The circular type flap gate is normally made in one piece by the mould with gray iron or spheroidal graphite iron casting or other alloy castings. The guide is also made in one piece as well as the gate. After moulding the gate and guide, the precise manufacturing, for example mechanical processing is required to get enough water tightness of the gate.

While, the square type flap gate is made of steel plates and sections. The guide frame is also made of steel plates and sections as well as gate. Therefore, steel-made gate can be comparatively easily reformed, and manufacturing is very easy compared with the circular type gate. The metal seal or rubber seal is generally used for the sealing method of the flap gate. The former water tightness of the gate is seriously affected by accuracy of manufacturing while, the latter elasticity of the rubber can absorb the distortion of manufacture. Flap gate is sometimes made from aluminum alloy. The comparison of the steel flap gate and aluminum ally flap gate is as follows:

Item	Steel flap gate	Aluminium alloy flap gate
-Manufacturing	Easy	There are few factory which have facilities for aluminium welding in Indonesia in comparison with steel gate
-Durability	Good Repainting is needed every 3 to 5 years	Poor Body of flap gate has enough durability as well steel flap gate. However, stainless steel is used at the part of by reason of strength. As a result, the part of aluminium alloy which is closed to the stainless steel is concentratively damaged by galvanic corrosion. Therfore, total durability becomes poor.

As a result, the square type steel made flap gate having rubber seal is: supplied by the low cost, expected for perfect water tightness and high durability, and easily manufactured compared with the circular type flap gate.

The rectangular type flap gate is sometimes made of timber with combination steel plates and bolts. The comparison of steel flap gate and timber flap gate is as follows:

Item	Steel flap gate	Timber flap gate
- Structure	Simple because of welded steel girder provided with	Complecate since first class wood reinforced by steel plate,bolts and
- Water tightness	Good	Poor due to uneven contact between timber block and seating frame, timber warp in the dry season.
- Construction cost		Same level
- Reliability of operation by head	Good	Poor
	Repainting is needed every 3 to 5 years	Replacement of timber is needed
- Garbage problem		Same level
- Installation		Same level
- Manufacturing difficulty		Same level

It is recommended from the above comparison that the steel made flap gate with rubber seal shall be used for the project.

The flap gate consists of skin plate, main beams, edge beams, side hinges, supporting arms and other necessary components and the gate is capable of overcoming all loads at any water level up to HWL. The skin plate is provided at the river side (pressure side) of gate leaf, but the rubber seal is provided at the land side of gate leaf for the complete water tightness at flood. The side hinge and supporting arm are provided on both side of gate to support the gate and to turn the gate to outward or inward. The material of the pin is corrosion-resisting steel.

The guide frame consists of upper, bottom and side frames, hinge brackets and other components necessary for the complete and satisfactory installation of the guide frame. The corrosion-resisting steel plates are attached to four edge frames to avoid excessive wear thereof. The guide frame and anchors are capable of transferring the load of the metal seals of the gate to the concrete structure. The hinge brackets are rigidly fixed by the anchors to perfectly support the gate and no binding occurs when the gate is opened and closed.

The design data of the flap gates are summarized as follows:

Type	Square steel made flap gate
- Clear span	400 mm
- Clear height	400 mm
- Design head	Hydrostatic pressure of HWL - bottom seal EL
- Inclined angle	4°
- Operation	Automatically operated by water pressure difference
- Sealing method	4 edges rubber seal at land side
- Maximum deflection of main beam	1/800 of supporting span
- Corrosion allowance	1.0 mm for water contact face members

The detailed design calculation results are given in ANNEX-II, Design and Structural Calculation.

4) Design of stoplog

To maintain the gate leaf, guide slots and piers, stoplog are installed at the upside and downside of the Saluran Cengkareng drainage channel. Since the H.W.L. is +1.30 and elevation of the drain is EL. -2.1, the design head of 3.4 m was applied for the structural calculation of the stoplog.

(a) Selection of gate type

The timber stoplog is selected because of:

- The span and water head is comparatively small,
- The stoplog is dealt by man power, therefore light material is profitable,
- Considering the providing object of stoplog, perfect water tightness is not requested, and
- Low cost

(b) Gate details

The stoplog shall consist of wooden timber of class I (pkk-1), bottom and side seal rubbers with their clamping plate, sealing plates and lifting lugs and all other necessary components. The guide frames shall consist of guide frames and sill beams. The guide frames shall be all welded construction excepting field joint between guide frames and sill beams and all other components necessary for the complete and satisfactory installation of the guide frame.

(c) Portable hanger

The portable hanger shall be provided on the slab of drain for easy handling the timber stoplogs. The portable hanger shall consist of a hanger support, required number of stands and a handling tools with slings and hooks. The hanger support shall be of a steel pipe construction with a U-hook for suspending a handling tool. The stand for hanger shall be adequate for removing the hanger. The handling tool shall be of manually operated chain block type

5) Design of trashrack

To prevent the garbage which shall obstruct the smooth flow in the drain, fixed type trashrack is installed at the each drain separated by concrete partition of Saluran Cengkareng drainage channel. Each trashrack having 3.333m, 3.334m width by 2.402m vertical height is inclined at an angle of 16.7° to the vertical plane. The above dimension and inclination are decided so as to keep the water velocity of 0.9 m/sec under the maximum discharge of 18.8 m^3/sec, considering head losses at the trashracks and convenience of cleaning on their surface by manual.

Each trashrack comprises screen panels, top and bottom embedded beams etc. The screen panels consist of rectangular bar elements, tie rods with nuts and spacing pipes, and they are fixed to the embedded beams.

The trashracks are designed to have a sufficient strength and suitable structure against the impact force, static and all other loads, and vibration phenomena which would likely occur due to the inflow of water.

The design head of the trashracks shall be determined to consider the head loss at the trashracks and the head difference between upstream side and downstream side. The flow velocity in this drain is small, therefore the head loss which is obtained by the calculation is very small. The quantity of the garbage in this drain is large, so head loss is mainly affected with obstruction caused by the trash at the screen. However it is very difficult to estimate the amount of the debris in this drain, since it is owe to the maintenance frequency and its interval. Therefore at the upper stream side design water level of trashrack shall be adopted to be H.W.L. and at the down stream side, bottom elevation of the drainage channel shall be adopted. Consequently the design head of the trashrafck of this project is determined to be 2.057m of water head difference.

The pitch of bar elements is decided as 75mm to prevent flowing down and accumulating the dumped plastic goods, thrown empty juice cans and many dumped trash which maybe obstruct the smooth flow in the drain.

The design data of the trashracks are summarized as follows:

-	Type	:	Slant type fixed trashrack
-	Quantity	:	Two (2) sets, One (1) set
-	Clear span	:	3.333 m, 3.334 m
-	Concrete deck elevation	:	EL.1.734 m
-	Sill elevation	:	EL. -0.668 m
-	Vertical height	:	2.403 m
-	Gradient	:	1:0.3
-	Slant length	:	2.867 m
-	Bar pitch	:	75 mm (Center to Center)
-	Design head	:	Water head of 2.057 m
-	Corrosion allowance	:	1.0 mm for water contact face members

6) Design of mesh cover

The mesh cover is provided at the part of the open culvert of Saluran Cengkareng drainage channel to prevent thrown away the garbage. Expanded metals (JIS G 3351 XS-type) should be used as the mesh cover because of lightness and comparative strength. The mesh size is determined to be 50 mm square so as the relatively large garbage not to be dumped. The panel size of mesh cover is determined to be 2.0 m width x3.5 m length for easy handling. The edge of mesh cover should be fixed with angle steel by welding. The angle steel is designed to consider the self weight of mesh cover panel and the garbage load of 10 kg/m^2. The mesh cover panel should be fixed with anchor bolts on the concrete of the drain.

4.3.5 Shifting of related structures

High tension electric lines, water supply pipe lines and telephone lines crossing the existing drainage channels and several structures such as concrete structures with gates, road signs, signals, etc. were planned to be shifted due to expansion of the existing drainage channels. For these treatments, only cost necessary for shifting works was estimated under the condition that planning, designing, land and house compensation and shifting works are performed by the authorities concerned.