V WASTEWATER MANAGEMENT PLAN

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1. Existing Condition

The Study Area of KMUP (Kotamadya Ujung Pandang - Municipality of Ujung Pandang) is comprised of eleven (11) Kecamatans. Its total area is about 176 sq•km.

The area bounded by the Jongaya - Sinrijala canal and the coast of Makassar Strait is highly urbanized and called as the old town area. This urban area essentially covers the following seven (7) Kecamatans of KMUP, namely, Mariso, Mamajang, Makassar, Ujung Pandang, Wajo, Bontoala and Ujung Tanah.

The remaining nonurban areas are located to the east of the old city area, and referred to as suburban area. This suburban area in fact encompasses some of the fast developing areas, including the future city area of Panakkukang Mass, located adjacent to the old town area. In an overall sense, this suburban area covers the four (4) Kecamatans of Tallo, Panakkukang, Tamalate and Bringkanaya.

The fast developing area of the suburban area, essentially covers a portion of Kec. Panakkukang and Kec. Tamalate, adjacent to the old town area (urban area). This area is referred to as suburban development area and the remaining fringe area to the east essentially remains rural area with low population. This rural area is referred to as suburban fringe area.

Accordingly, based on the present development stage, the Suburban Area is further sub-divided into Suburban Development Area and Suburban Fringe Area.

The present development stage of the Study Area delineated as urban area, suburban development area and suburban fringe area is shown in *Fig.* 5.1.

The environmental and sanitary condition between the urban and suburban areas is quite different, mainly due to their difference in the stage of development and population density.

The sanitation and environmental conditions of the urban area and the suburban area, referring to the existing sanitation systems in these areas, are delineated in the subsequent sections.

1.1 Sanitation System

The existing sanitation systems in both the urban and suburban areas of the Study Area treat only blackwater (toilet waste). Graywater arising from miscellaneous activities are discharged to nearby ditches and drains with no treatment. This is the case with individual houses as well as commercial and institutional entities.

1.1.1 Urban area

The urban city centre (old town area) is the hub of all major commercial and institutional activities of KMUP. Moreover, it has a highly concentrated population that could be classified into two (2) distinct categories of residential population (living in built-up area) and slum population (living in slum area). The existing population density of this urban area exceeds 200 person/ha.

(1) Slum area

A slum area is also a residential area in the basic sense. However it is differentiated from a built-up area principally due to its nature of housing, lack of amenity and extremely high population density.

In this regard, a slum area is defined as a congested area with temporary housing that lacks basic sanitary facilities.

The locations of slum area are also shown in *Fig.* 5.1. The existing population in these slum areas is estimated at 114,000.

Based on the JICA sampling survey results, on the existing sanitary conditions, about 98% of the residential population living in built-up area have their own individual sanitation systems of septic tank/leaching pit.

However, in a slum area about 60% of the population do not have access to sanitary disposal of toilet waste (blackwater).

This lack of access to sanitary disposal of toilet waste implies one of the following;

1) No toilet facility, hence canals, drains are either location or disposal of defecation.

2) Toilet is overhang above canal, drain or sea (helicopter toilet) that discharges directly into water body.

3) Toilet waste directly drains to nearby drain or canal with no treatment.

The above lack of basic sanitation system is widely prevalent in slum areas.

As the means to the provision of basic sanitation facilities to low income population of slum areas, which is referred to as the minimum target level (ML) of this master plan as well, a number of public toilets, known as MCK (Mandi-Cuci-Kakus), have been constructed under various programmes like KIP (Kampung Improvement Programme), LKMD and others.

Moreover, as a means to eliminate toilets with no treatment (toilet that discharge directly to nearby ditch or drain), in 1994 PLP on a pilot basis, constructed four (4) communal septic tanks, each serving about four (4) to ten (10) slum household toilets in Kel. Pannambungan (Kec. Mariso).

At present, out of these four (4) communal systems (septic tanks) one (1) is not used, but one (1) is functioning well. While the remaining two (2) malfunctioned, due to pipes connecting the toilets with septic tanks being broken.

The Study Team conducted a survey on existing public toilets and their present condition covering the whole study Area. Accordingly, it became evident that there are 204 public toilets (MCK), most being located in slum areas. Locations of these public toilets on a Kelurahan basis are shown in *Table* 5.1

It is also noted from the survey that 59 of these existing public toilets that account for about 30% malfunctioned, or not used. Moreover, 36 public toilets, out of the total number of 204, do not have any responsible management organization for users.

Accordingly, as the first step to ensure proper use of a public toilet once it is repaired, appropriate operation and maintenance (O/M) organization shall be established at basic (grass-root) level.

In this regard, the Study Team recommends an operation and maintenance system under the direct responsibility of RW chief or Kelurahan office in cooperation with Dinas Kebersihan (Cleansing Department of KMUP).

(2) Built-up area

In a typical residence, the residents generally refer to their individual sanitation system as "tanki septic" (septic tank). Still, most residents are not aware whether their system is technically a septic tank, or leaching pit or a hybrid (combination of both).

The study team, both based on interview survey as well as inspection of systems during desludging by Dinas Kebersihan, understand that most individual sanitation systems in the urban built-up area are of the hybrid type, septic tank followed with leaching pit.

A conventional septic tank system, which technically implies septic tank followed with leaching field (infiltration field) is very rare. This could also be attributed to high population density, which makes the provision of leaching field requiring more land space in comparison to that of a leaching pit, rather cumbersome.

Irrespective of the system, in the whole study area, only blackwater is disposed/treated in an individual sanitation system. Graywater arising from miscellaneous household activities of washing, bathing and cooking is discharged to nearby ditches and drains with no treatment.

This discharge of untreated graywater to nearby ditches and drains is not just confined to individual household sanitation systems but also to commercial and institutional entities that are widely prevalent in this built-up area. Untreated graywater discharge is identified as the major source of living environment as well as surface water quality deterioration in the highly urbanized old town area (built-up area).

This is evident from the high BOD levels, exceeding 100 mg/l, observed during dry season in the Panampu ~ Jongaya canal (refer to Supporting Report IV). In fact during dry weather flow conditions (in dry season) untreated graywater constitutes virtually the entire run-off in the drains and canals.

Concerning the sanitation systems of septic tank with leaching pit widely used in the residential built-up area, it has become a major source of groundwater pollution. Practically, septic tank with leaching pit is equivalent to that of leaching pit, as far as the effect on groundwater contamination is concerned.

This groundwater contamination due to leaching systems of toilet waste (blackwater) is aggravated by the shallow depth of groundwater table level in near coastal areas. The old town area (built-up area) is located adjacent to the coastal area (ref. *Fig.* 5.1).

The critical groundwater table level in the urban area including the suburban development area, other than the suburban fringe area of Kec. Panakkukang and Kec. Bringkanaya, during rainy season is less than 2m.

This is evident from the isohyets of critical groundwater table level in the Study Area, as shown in *Fig.* 5.2.

Widespread bacterial pollution of groundwater in the Study Area has been noted both from the water quality sampling results conducted by the Study Team as well as available data. Details on groundwater quality in the Study Area could be referred to in Supporting Report IV on Environmental Considerations.

1.1.2 Suburban area

The existing sanitation systems in the suburban area is essentially the same as the residential built-up area described in the foregone section. However, the virtual absence of slum area could be interpreted as the basic sanitation condition is satisfactory in the suburban area.

This suburban area is divided into two (2) areas of suburban development area and suburban fringe area as shown in *Fig.* 5.1, based on the difference in the present development stage between these two (2) areas.

(1) Suburban development area

This is the fastly developing area adjacent to the urban area (old town area) that covers portions of Kec. Panakkukang and Kec. Tamalate. This includes the Panakkukang Mass area, called as "Future City". This suburban development area as a whole is in fact the future urban area.

There are many new housing complex developments ongoing in this area. Moreover, institutional and commercial developments are also being established.

Still, concerned to wastewater management, all these ongoing development plans, continue to target only the sanitary disposal of blackwater (toilet waste) in individual simple sanitation systems of septic tank/leaching pit, on an individual household or entity basis.

Graywater is "planned" to be simply discharged to nearby ditches and drains. Hence, no consideration is given to the effect of graywater pollution to ditches and drains and the final receiving water bodies.

Essentially, the approach being adopted in this future urban area (suburban development area) concerned to wastewater management is the same that had been adopted in the past for the old town area (urban area).

Accordingly, in the near future the living environmental pollution and the resultant water environmental problems in this area would become a serious concern, similar to that of the old town area (urban area), as described in foregone section. As the mitigatory measure of living environmental deterioration, enforcement of comprehensive wastewater management of both blackwater and graywater, at least targeting significant scale of developments, during the development stage itself, need to be considered.

(2) Suburban fringe area

The suburban fringe area covers essentially the Kec. Bringkanaya and the administrative boundary areas of Kec. Panakkukang and Kec. Tamalate. This area is sparely populated, and pratically remains rural in nature. The existing population density of this area is less than 40 person/ha.

Due to the sparse population and hence the low density of pollution load generation in this area sanitary disposal of blackwater only in septic tank/leaching pit alone is adequate to maintain a sanitary living environment, at present.

Availability of vast open area in a typical housing lot in this area is often used as a home garden. Graywater is mostly reused for home gardening, inadvently resulting in its treatment. Even when graywater is disposed with no reuse, the availability of vast open area results in significant infiltration/treatment of graywater before it ends up in ditch/drain.

In such fringe areas, even in future, provided such areas remain with sparse population density, ensuring the sanitary disposal of blackwater alone would be sufficient to maintain a sanitary living environment.

Nevertheless, in order to mitigate groundwater pollution due to onsite leaching pit systems, their applicability shall be confined only to areas of deep groundwater table level. Most parts of Kec. Bringkanaya could be considered to be of deep groundwater zone (ref. *Fig*. 5.2).

Moreover, sufficient clearance between well and leaching pit need to be ensured.

It is noted during field survey in the suburban fringe area, even when sufficient land area is available to space a well and septic tank/leaching pit far apart in a housing lot, there are many housing lots where a well and septic tank/leaching pit are in fact provided close to each other.

This may be due to the apparent convenience of having a well and toilet (and hence the septic tank/leaching pit) close to each other, thereby facilitating easy access of water for toilet use.

Strict implementation of the guidelines of CIPTAKARYA to ensure a minimum distance of 10m between a well and septic tank/leaching pit (as pointed out earlier many so called septic tank may be functionally similar to leaching pit) is recommended to ensure the mitigation of potential groundwater pollution (well water pollution). A plan for a new housing lot shall be approved when such a condition is met with respect to the locations of well and toilet (septic tank/leaching pit).

1.2 Sewerage System

The only sewerage system in the Study Area exists at the KIMA industrial estate, located at north-east of the Study Area, in Kec. Bringkanaya (suburban fringe area). The location of KIMA industrial area shown in *Fig.* 5.1, is an exclusive industrial zone established to promote industrial development in Ujung Pandang, the provincial capital of South Sulawesi.

At present, this exclusive industrial area covers an area of 230 ha, which is planned to be expanded to cover a total area of 730 ha.

The present constitution of industrial classification of KIMA is as follows:

Industrial Classification	No. of Industry
Food, beverage and tobacco	22
Wood and wood products	10
Textiles	1
Industrial chemicals	8
Nonmetalic mineral products	4
Basic iron and steel industries	1
Fabricated mineral products	2
Other industries	13
Total	61

The entire industrial wastewater generated in KIMA is treated in a centralized wastewater treatment plant, located within the industrial area.

Oxidation ditch process (a form of extended aeration activated sludge process) is used for wastewater treatment, accompanied with drying bed for sludge treatment.

The details of wastewater treatment system are illustrated in *Figs.* 5.3~5.5.

The design capacity of the treatment plant is 3,000 m^3/d, while the present inflow of wastewater is about 600 m^3/d.

Performance of the treatment plant is not very satisfactory, which is attributed to improper operation and maintenance of the plant.

1.3 Existing Sanitation Management

Existing sanitation systems in the Study Area, as illustrated in the foregone chapters, are essentially of simple on-site systems of septic tank/leaching pit, provided on an individual household/entity basis.

Accordingly, these individual systems treating blackwater (toilet waste) belongs to the owner or user of the system, and hence the management of the sanitation system itself is entirely under the responsibility of the owner/user with no interaction from any government/public institution.

In fact, these simple individual systems are virtually maintenance free, other than for periodic desludging, at least once the septic tank/leaching pit has become full of septage, thereby preventing the use of toilet. Periodic desludging is the minimum inevitable maintenance requirement to ensure continued functioning of these simple on-site systems.

Dinas Kebersihan (Cleansing Department) of KMUP, in addition to that of solid waste management, is the only public institution that engaged in wastewater management in the Study Area.

Dinas Kebersihan provides desludging, transportation and disposal/treatment of septage from household septic tank/leaching pit, based on request for such service from residents. This service is delineated in the following sections.

It is worth to mention that wastewater management under present condition targets only blackwater, in the form of desludging service provided by Dinas Kebersihan.

There exists no management for the other component of wastewater, the graywater, that accounts for about 60% of the pollution load generation (blackwater accounts for about 40% of the pollution load generation).

1.3.1 Desludging and transportation

Dinas Kebersihan provides desludging service of septic tank/leaching pit for an official fee of Rp. 15,000, based on request for such service from a resident.

For the purpose of desludging, Dinas Kebersihan owns six (6) vacuum trucks, each of capacity $3m^3$. However, during recent years only four (4) trucks are in operational condition. All these vacuum trucks are very old and the fleet requires new trucks to be more effectively respond to request for desludging by residents.

The operational data of the four (4) operational vacuum trucks, during two (2) consecutive fiscal years of 1992 (April 92 to March 93) and 1993 (April 93 to March 94) are shown in *Table* 5.2. The above data, as provided by Dinas Kebersihan, shows the total number of monthly operational cycles of each of the four (4) operational vacuum trucks.

Based on the above data, the average annual operational cycle is about 2000 (actual data : 1947 in 1992 and 1885 in 1993). It is reported that about 2 ~ 3 septic tank/leaching pit (household) is served by one (1) operational cycle of vacuum truck. Assuming an average of 2.5 household is served per cycle, the total number of households (septic tanks/leaching pits) served (desludged) at present by Dinas Kebersihan is estimated to be 5000/year.

Based on interview survey as well as field inspection of the existing simple on-site systems of septic tank/leaching pit during desludging by vacuum truck, typical capacity of a residential system is determined as about one (1) m^3. Moreover, success rate of desludging an intended household by Dinas Kebersihan is estimated to be about 80%. Major reasons for failure of desludging an intended household are as follows:

(1) Inability to find the intended household due to inadequate/improper address of location.

(2) Accessibility to the location is impossible for the vacuum truck due to inadequate road.

The septage desludged is transported for treatment to the septage treatment plant located at Kel. Antang, near the south-eastern boundary of the Study Area (KMUP). The location of Antang septage treatment plant is shown in *Fig.* 5.1.

1.3.2 Septage treatment

The layout of Antang septage treatment plant is shown in *Fig.* 5.6. The treatment process consist of imhoff tank, the receiving unit of septage from vacuum truck, followed with anaerobic pond, facultative pond and maturation pond, as the stream of wastewater treatment. As the means of sludge treatment, sludge drying bed is provided.

This stabilization pond based treatment system is recently constructed in January 1995, as the improvement of the prior septage treatment system, which basically consisted of septage storage ponds. The operation and maintenance of the treatment plant is under the responsibility of Dinas Kebersihan.

This existing septage treatment system could be further improved, in consideration to the availability of additional land space as well as the inadequate treatment level noted during field inspection, with the incorporation of following measures.

(1) The sludge drying bed provided seems to be too small and not used. Instead, a sludge lagoon system in the adjacent open area, where sludge is actually disposed at present, is recommended. Such a sludge lagoon system could be easily constructed by enclosing this open area, where sludge is disposed, with earthen embankments.

(2) Even though, the last pond of the treatment system is referred to as maturation pond, as the high algal concentration in the pond indicates, it is functionally a facultative pond rather than maturation pond. Accordingly, one (1) additional pond in series is recommended, which could also be constructed only with earthen embankments. There is sufficient land space to create one more pond in series beyond the last maturation pond of the existing treatment system.

Still, the most important problem with the septage treatment plant is the unpaved road that makes the accessibility of vacuum truck to the treatment plant very difficult. The final approach road of about 2km in length that remains unpaved, requires urgent improvement.

1.4 Issues of Environmental Sanitation

The major issues and concerns of environmental sanitation as identified based on the existing condition of wastewater management in the Study Area are summarized below.

(1) The population in slum area lack basic sanitation facility of toilet with adequate treatment. It is very necessary to eliminate such a hazardous public health condition, from the view point of basic human needs.

(2) Discharge of untreated graywater into ditches and drains, which is not yet a concern for wastewater management for any organization, especially in the highly urbanized old town area, has become the major source of living environment as well as surface water quality deterioration.

(3) The existing on-site leaching systems of blackwater treatment is suspected as the major cause of groundwater quality deterioration. This groundwater quality deterioration is exacerbated by the shallow depth of groundwater table level in the old town area and its surroundings.

(4) At present there is no responsible organization for comprehensive wastewater management. Other than the periodic desludging service provided by Dinas Kebersihan based on request for such service from residents, there exists no significant activity of wastewater management. The major part of wastewater management, in fact blackwater management, is left to the owners of sanitation system with no instruction or guidance from civil authorities.

(5) The present septage collection service and treatment is quite insufficient and requires further improvement.

2. Technical Options

2.1 Terminology

In the field of wastewater management, some technical terms have been used without distinct definition. For example the definition of "On-site" is not so clear even though this word is very popular.

In order to avoid confusion about terminology, definition of technical terms are made as listed below.

(1) On-site system

The system treating wastewater within each building lot.

(2) Off-site system

The system collecting and treating wastewater from multiple number of building lots.

(3) Combined system

The collection system receiving both wastewater and storm water.

(4) Separate system

The collection system consisting of sanitary sewer that receives wastewater only.

(5) Septic tank

The treatment system consisting of one or more water-tight chambers. The treatment process is sedimentation and anaerobic digestion of settleable solid in wastewater.

(6) Package wastewater treatment plant (PWTP)

Package wastewater treatment plant (PWTP) is a compact blackwater and graywater treatment system which can obtain high BOD removal efficiency. The popular treatment processes of this system in Japan are anaerobic filter-contact aeration process and separate contact aeration process. Both these processes could be classified as anaerobic aerobic contact process.

Such a PWTP utilizing anaerobic aerobic contact process is generally referred to as "Johkasou" in Japan. Johkasou literally means "Purification Tank".

(7) Small modular system (B)

The system consisting of collection system, septic tank and leaching bed to collect and treat blackwater from about 20 households.

(8) Small modular system (B/G)

The off-site system that serves about 1 RT (250 people) with collection and treatment system for both blackwater and graywater. The treatment system will be abandoned after integration into conventional sewerage system.

(9) Large modular system

The off-site system that serves about 10,000 ~ 50,000 people with collection and treatment system for both blackwater and graywater. The treatment system will be abandoned after integration into conventional sewerage system.

(10) Developer modular system

The off-site system with collection and treatment system for both blackwater and graywater covering a housing complex constructed by developer.

(11) Small scale sewer

The separate collection system from each household to main sewer constructed under foot path or housing lot at a shallow depth less than 1.0 m.

(12) Interceptor sewer

The collection system that receives graywater from road side ditch during dry weather.

2.2 Alternative Collection System

Available technical options of alternative wastewater collection systems are described below.

(1) Ordinary sewer

Ordinary sewer is a separate or combined collection system which is constructed under roads at more than 1 m depth to protect sewer pipe from external loading. Wastewater is basically collected and conveyed by gravity, therefore if topography is flat the depth would increase with distance. In order to limit the depth of sewers (excavation) lift pump needs to be employed, periodically.

(2) Small bore sewer

Small bore sewer is a separate wastewater collection system consisting of septic tank and relatively small diameter sewer pipe. Solid matter is separated in septic tank and small diameter pipe can be used and the flexibility of slope is high. As a result construction cost of sewer pipe can be reduced. However, without well-functioning septic tanks this system is not recommendable. In fact this system is intended to collect and treat effluent from septic tanks.

(3) Shallow sewer

Shallow sewer is a separate wastewater collection system consisting of relative small diameter sewer pipe constructed at comparatively shallow depth. In order to construct at shallow depth, sewer pipe is constructed under foot path and in accordance with ground surface slope. In the case of lack of slope to maintain the minimum velocity, flushing is necessary.

This system can reduce construction cost, but operation and maintenance is difficult if flushing is required.

(4) Small scale sewer

Small scale sewer is a separate wastewater collection system from each household to main sewer constructed under foot path or housing lot at a shallow depth less than 1.0 m. This system can reduce construction cost, especially for tertiary sewers.

This system can be applied for an area where houses have enough space, with width between the front of houses and the road is more than 3m.

(5) Pressured sewer

Pressured sewer is a separate wastewater collection system consisting of a small submerged pump and rather small bore sewer pipes.

There are two method to remove solid; one is using grinder pump and another is using septic tank before ordinal pump.

This system can reduce construction cost of sewer pipe owing to small diameter and shallow depth. Construction cost of pump and rather high operation and maintenance cost are significant disadvantages of this system.

(6) Vacuum sewer

Vacuum sewer is a separate wastewater collection system consisting of vacuum valve unit which mix wastewater and air using small bore sewer pipes and vacuum pump stations. When wastewater level in the vacuum valve unit reach certain height, a water level monitor automatically function and the vacuum valve open, and as a result mixed wastewater and air is sucked into a sewer pipe.

This system can reduce construction cost of sewer pipe owing to small diameter and shallow depth. Also there in less possibility for leakage of wastewater from sewer pipe.

However, construction cost of vacuum pump and vacuum valve unit and rather high operation and maintenance cost are significant disadvantages of this system.

(7) Interceptor sewer

Interceptor sewer is a collection system that receives graywater from road side ditch during dry weather. This system is equivalent to ordinary sewer without house connection, therefore construction cost can be reduced. However it may be difficult to collect service charge from beneficiaries.

This system is suited for an area with temporary housing, an area of potential redevelopment or an area of poor accessibility (road width less than 3m).

A preliminary evaluation of the alternative wastewater collection systems illustrated in the foregone section is shown in *Table* 5.3.

Three (3) collection systems are selected as appropriate for application in this project study. They are small scale sewer collection system, ordinary sewer collection system and interceptor collection system.

Technical criteria of demarcation for applicability of these three (3) collection systems are illustrated in *Figs.* 5.7 ~ 5.9.

2.3 Alternative Treatment System

Characteristics of various alternatives of treatment system are listed below. These are considered as the available technical options for wastewater treatment.

(1) Leaching pit

Leaching pit is a natural soil treatment system typically consisting of two (2) pits (twin pit system) designed to facilitate wastewater infiltration into natural soil.

This system is very simple, cheap and maintenance free, and widely used as a simple on-site facility of blackwater treatment. However, there is possibility of groundwater contamination in a high groundwater table area. Moreover, a minimum distance between leaching pit and well needs to be ensured (at least 10m).

(2) Septic tank

Septic tank is a treatment system consisting of one or more water-tight chambers. The treatment process is sedimentation and anaerobic digestion of settleable solid in wastewater.

This system is simple, rather cheap and easy for operation and maintenance, but BOD removal efficiency is quite low, usually less than 50%, as a result effluent quality is not good. Moreover, bacterial removal efficiency is very low. To keep good function of septic tank, periodical desludging is required.

(3) Septic tank with leaching pit

Septic tank with leaching pit is the treatment facility consisting of septic tank and leaching pit. This system is widely used in Indonesia as a simple on-site blackwater treatment facility.

This system is relatively cheap and easy for operation and maintenance. However, there is some possibility for groundwater contamination in a high groundwater table area. Also periodical desludging is required to keep good function of septic tank.

(4) Septic tank with leaching field

Septic tank with leaching field is a treatment facility consisting of septic tank and leaching/infiltration field.

This system is simple and easy for operation and maintenance, and is applicable even for high groundwater table area. But this system requires quite bigger space than a leaching pit, and also periodical desludging is required to keep good function of septic tank. Required space for leaching field is about $10m^2$ for blackwater treatment and about $100m^2$ for both blackwater and graywater treatment of a typical household.

(5) Septic tank with upflow filter

Septic tank with upflow filter is a treatment facility consisting of septic tank and upflow filter through which the effluent of septic tank is filtrated for further treatment.

This system is simple and applicable even for high groundwater table area as the effluent is discharged to surface waters.

However this system has the disadvantage of potential clogging in the upflow filter. Periodical desludging is required to keep good function of septic tank.

(6) Imhoff tank

Imhoff tank is a treatment system consisting of a two-story tank in which sedimentation is accomplished in an upper compartment and digestion is accomplished in a lower compartment.

This system is functionally very similar to a septic tank, but structurally more complicated and suitable for larger scale installation.

(7) Anaerobic filter

Anaerobic filter is an anaerobic treatment system consisting of a column filled with various types of solid media on which anaerobic bacteria is grown and retained for treatment.

This system, a relatively recent development in the field of wastewater treatment, can be used for the treatment of low-strength soluble wastewater at ambient temperature.

(8) UASB (Upflow anaerobic sludge blanket)

UASB is an anaerobic treatment system consisting of a two-story tank. Wastewater is introduced from the bottom of the tank and pass through a sludge blanket of anaerobic bacteria retained at second story.

This system can obtain high BOD removal efficiency, especially for high-strength wastewater, but for a low-strength waste like domestic wastewater UASB has not yet been well demonstrated in practice.

(9) Anaerobic aerobic contact process

Anaerobic aerobic contact process is a treatment system consisting of an anaerobic chamber and a contact aeration chamber. This system is widely used in Japan as Johkasou. In effect, Johkasou is a package wastewater treatment plant (PWTP).

This system can obtain high BOD removal efficiency, but it is quite expensive to construct, and to operate also because of using electric power for aeration. Periodical maintenance service by certified expert is also required to ensure its high performance.

(10) Trickling filter

Trickling filter is an aerobic treatment system consisting of a wastewater distributor and a filter bed of highly permeable media to which microorganism are attached and through which wastewater is trickled.

This system is relatively simple and dependable that could produce an effluent of consistent quality with an influent of varying strength, but relatively large space is required. Operation of this system is relatively easy, but once it fails or malfunctions recovery is difficult.

(11) Rotating biological contactor

Rotating biological contactor is an aerobic treatment system consisting of a series of closely spaced circular disks which are partially submerged in wastewater and rotated slowly through it.

This system is relatively simple and dependable that produces an effluent of consistent quality with an influent of varying strength. Operation of this system is relatively easy, but once it fails or malfunctions recovery is difficult.

(12) Stabilization pond

A stabilization pond is a treatment system in which wastewater is retained in rectangular earthen basins for a relatively long retention time. Stabilization ponds are classified as anaerobic ponds, facultative ponds and maturation ponds, and a combination of these types can obtain high BOD removal efficiency of about 80 ~ 90%.

This system is simple and easy for construction, operation and maintenance, though large space is required. If enough land area is available, this system can be recommended as the most suitable technical option for wastewater treatment plant of even large scale off-site systems.

(13) Aerated lagoon

Aerated lagoon is a treatment system in which mechanical surface aeration is used. In all other aspects it is similar to a stabilization pond. Still, compared with stabilization pond, smaller space is sufficient but construction and O&M cost is relatively higher.

When available land area is not adequate for stabilization pond or as the means of upgrading the existing stabilization pond, this system could be recommended as the most suitable technical option.

(14) Activated sludge process

Activated sludge process is an aerobic treatment system consisting of an aeration tank and settling tank. Conventional process consists of a plug-flow aeration reactor followed by sedimentation tank and a sludge recycling line. Aeration time is usually about 6 to 8 hours.

This system has been very widely used for wastewater treatment plant because it is very flexible and can produce high BOD removal efficiency in a limited space. Its significant disadvantages are high construction and O&M cost, and high generation of excess sludge requiring proper sludge handling/treatment facility.

(15) Step aeration

Step aeration is a kind of modified activated sludge process. The wastewater is introduced at several points in the aeration tank, and it can be used with higher BOD loading per unit of aeration-tank volume.

Its significant disadvantages are the same as activated sludge process.

(16) Pure oxygen activated sludge process

Pure oxygen activated sludge process is a kind of modified activated sludge process. Pure oxygen is used for aeration instead of air.

Smaller facility size is sufficient, and it is bearable to wider fluctuation of organic loading. Its disadvantages are same, in fact of much higher order, as the activated sludge process.

(17) Contact stabilization

Contact stabilization process is a kind of modified activated sludge process. Two aeration tanks are used as a sludge reaeration tank and a contact tank. Influent is introduced to a contact tank (second tank), and excess sludge is returned to a sludge reaeration tank (first tank).

This system can reduce aeration volume requirement to about 50% of those of conventional process. This system is suitable for domestic wastewater. It also has the same disadvantages as activated sludge process.

(18) Extended aeration

Extended aeration is a kind of modified activated sludge process. This process operates under relative long hydraulic and solids retention time.

This system is relatively simple and suited for small and medium scale system.

(19) Oxidation ditch

Oxidation ditch is a modification of extended aeration process which consists of a ring-shaped channel about 1 to 1.5m deep and aeration rotor. The system is simple and suited for small and medium scale system.

A preliminary evaluation of the alternative treatment systems illustrated in the foregone section is shown in *Table* 5.4. The following five (5) alternative treatment systems are selected as most appropriate for this project study.

- Leaching pit
- Septic tank
- Septic tank with leaching field

- Stabilization pond
- Aerated lagoon

However the specific technical applicability will depend on local conditions like groundwater table level, population density and the type of system (on-site/off-site system).

3. Master Plan

3.1 Planning Condition

3.1.1 Water consumption

(1) Domestic water

The present domestic water consumption is estimated based on the sampling and interview surveys conducted by the Study Team. The result of survey is shown in *Table* 5.5. These surveys show that the per capita water consumption of the residents who are served with house connection is much larger than those without house connection. So the difference per capita water consumption were estimated.

The estimation of future per capita water consumption of the residents who are served with house connection is based on the estimation of domestic water use by purpose from Water Supply Development Plan (PDAM, 1985). The break down of this estimation is shown in *Fig.* 5.10. According to this, water use for toilet flushing will be increasing. On the other hand, the per capita water consumption of people without house connection is assumed to be constant, considering labor of carrying water, and toilet flushing water is assumed to be constant also.

The present and future per capita water consumption are shown in *Table* 5.6.

The existing number of house connection by Kecamatan is estimated based on the existing water supply data of PDAM by wilayah (service district). The future number of house connection by Kecamatan is estimated based on Water Supply Development Plan (PDAM, 1991). Transition of number of house connection by Kecamatan is shown in *Fig.* 5.11. The present and future house connection coverage ratios by Kecamatan are also shown in *Fig.* 5.11.

(2) Commercial water

Since the portion of well water seems to be negligible for the commercial use, this water consumption is estimated to be in proportion of PDAM domestic water supply. The present ratio of commercial water consumption to the domestic one is 14.7% based on the PDAM existing data shown in *Table* 5.7, and is assumed to be constant in the future.

(3) Institutional water

Same assumption as commercial water is applied to estimation of institutional water. The present ratio of institutional water consumption to the domestic one is 15.3% based on the PDAM existing data shown in *Table* 5.7, and is assumed to be constant in the future.

(4) Industrial water

The city of Ujung Pandang is now promoting big industries to be centralized into the KIMA industrial estate. KIMA has its own wastewater treatment plant and this plant will treat all the industrial wastewater generated inside KIMA. Taking this into account, the industrial wastewater generated inside KIMA would be better excluded from this Study. Other industrial wastewater consumption is estimated not to exceed the present amount because of large scale industries moving into KIMA.

The estimation of present industrial water consumption is based on the PDAM existing data shown in *Table* 5.7, and this amount is assumed to remain the same even in future.

3.1.2 Wastewater generation

Generally speaking wastewater generation is some portion of water consumption and this figure is usually from 80% to 100%, decided by condition. This study adopts 100% considering that lost water like sprinkling water seems to be negligible according to the observation of the Study Team.

The total present and future wastewater generation by Kelurahan is shown in *Table* 5.8 through *Table* 5.10.

3.1.3 Unit pollution load

(1) Domestic wastewater

Domestic wastewater includes toilet wastewater (blackwater) and gray water from kitchen, bathing and laundry.

The present unit pollution load of toilet wastewater is estimated 10.5g based on previous studies in Indonesia, and is assumed to be constant in the future.

The present wastewater quality of gray water is estimated at 168 mgBOD/ℓ based on the pollution load survey conducted by the Study Team. The result of this survey is shown in *Table* 5.11. The future unit pollution load from gray water is estimated to be in the proportion to wastewater generation increasing. As a result, the quality of gray water is assumed to be constant.

(2) Commercial wastewater

The present water quality of commercial wastewater is estimated at 266 mgBOD/ℓ, based on the pollution load survey shown in *Table* 5.11.

The future unit pollution load from commercial wastewater is estimated to be in proportion with increasing wastewater generation. As a result, the quality of commercial wastewater is assumed to be constant.

(3) Institutional wastewater

The present water quality of institutional wastewater is estimated at 142 mgBOD/ℓ, based on the pollution load survey shown in *Table* 5.11.

The future unit pollution load from institutional wastewater is estimated to be in proportion with increasing wastewater generation. As a result, the quality of institutional wastewater is assumed to be constant in the future.

(4) Industrial wastewater

Water quality of industrial wastewater can vary depending on the industrial characteristics. The present and future water quality of industrial wastewater are assumed to be same as those in Jakarta. The data of industrial wastewater quality in Jakarta is shown in *Table* 5.12.

The present and future pollution load are obtained by multiplying the average water quality with the amount of industrial wastewater generation. The existing data of sales amount of the respective classifications shown in *Table* 5.13.

3.1.4 Pollution load generation

Present and future pollution load generation are estimated by multiplying wastewater generation with unit pollution load.

The total present and future pollution load generation by Kelurahan are shown in *Table* 5.14 through *Table* 5.16.

3.2 Short Term Plan up to 2005

3.2.1 Basic strategy

Short term wastewater management plan up to the year 2005 shall be formulated based on urgent demand, quickness of benefit generation and practicability of implementation.

The most urgent demand of wastewater management shall be elimination of no-toilet population considering Basic Human Needs. Therefore the highest priority shall be given to provision of basic toilet facilities for no-toilet people living in slum areas.

Consequently basic strategy for formulating short term wastewater management plan consists of following five (5) steps.

i) To identify the no-toilet areas and find out appropriate schemes for providing basic toilet facilities for such areas.

ii) To demarcate the most recommendable technical options according to the characteristics of each area.

iii) To find out schemes for each area to be served by the most recommendable technical option.

iv) To optimize public sector project schemes so as to maximize private sector participation.

v) To determine the priority projects which will be completed until 2005 as public sector project schemes.

3.2.2 Demarcation of Study Area

(1) Slum area

All the slum areas in the Study Area are delineated where basic sanitation system is inadequate.

The locations of slum areas are shown in *Fig.* 5.1.

For these areas Small Modular System (B)/public toilet is most recommendable considering extremely low affordability of residents. If the physical condition is suitable for installing house connection sewer, SMS(B) could be recommendable on the condition that user could provide ones own water closet, otherwise public toilet shall be recommended.

(2) Leaching pit area

The criteria for leaching pit are that population density is less than 100 persons/ha and critical groundwater table level is deeper than 4 m from ground level based on design standard of Cipta Karya as follows.

Required Minimum Distance between Leaching Pit and Shallow Well

Soil Type		Sand	Clay
Distance between Groundwater Table and the Bottom of Leaching Pit	Deeper than 2 m	10 m	5 m
	Shallower than 2 m	15 m	10 m

Source : Pedoman Pembuangan Limbah Manusia Program Pelaksanaan Sanitasi, Cipta Karya

Groundwater table of the Study Area is shown in *Fig.* 5.2.

(3) Septic tank with leaching field area

The criteria for septic tank with leaching field are established based on the required water quality level. From the viewpoint of quickness of benefit generation and practicability of implementation, a septic tank with leaching field for blackwater treatment is recommendable because of easiness of installation and relatively low construction cost. On the other hand, this system can not contribute to mitigate heavy water pollution in highly urbanized and densely populated areas.

The correlation between water quality and specific pollution load discharge is obtained by the result of surface water quality survey as shown in *Fig.* 5.12.

The correlation is given by following equation.

$y = 7.52 \times 2.15^{x}$
($r = 0.9603$ based on logarithmic expression given by; $\ln y = x \times \ln 2.15 + \ln 7.52$)

where,

y : water quality (mgBOD/l)

x : specific pollution load discharge (kgBOD/day/ha)

r : correlation coefficient

Based on this correlation, in the area with the specific pollution load discharged into water bodies less than 2.7 kgBOD/d/ha, water quality level of 60 mgBOD/ℓ can be obtained with only blackwater treatment by septic tank with leaching field. Water quality level of 60 mgBOD/ℓ does not satisfy the minimum standard of water quality of 30 mgBOD/ℓ, however, considering existing water quality of most of main canals that exceed 100 mgBOD/ℓ, 60 mgBOD/ℓ seems reasonable as an intermediate target.

It is noted that the rapid increase of population in suburban area will be caused by development of large scale housing estates. In other words, most of population in such an area will be confined to large scale housing estates. As already mentioned in short term plan, large scale housing estates shall be covered with developer modular systems, which treat both blackwater and graywater to secondary treatment level. Accordingly, demarcation of areas suited for leaching pit and septic tank with leaching field can be based on the data excluding the estimated large scale housing estates.

Specific pollution load discharge by Kelurahan in 2005 excluding the estimated large scale housing estates is shown in *Table* 5.17.

Distribution of specific pollution load discharge excluding the estimated large scale housing estates is shown in *Fig.* 5.13.

(4) Off-site system area

In the area where neither leaching pit nor septic tank with leaching field can be applied, it is necessary to treat not only blackwater but also graywater. For this purpose off-site system is more suitable than on-site systems because septic tank with leaching field requires 100 m^2 per household to treat both blackwater and graywater and Package Wastewater Treatment Plant is too expensive to introduce in full scale. At the same time secondary treatment level is required to avoid negative impact of effluent. Accordingly, off-site system with secondary treatment is the most recommendable technical option considering the difficulty of land acquisition and necessity of mitigating heavy water pollution.

The result of demarcation of the most recommendable technical option is shown in *Fig.* 5.14.

3.2.3 Schemes for each area

Provision of SMS(B)/public toilet for the slum areas will be completed by public sector urgently until the year 2000.

In order to apply the most recommendable technical options for each area, it would be crucial to maximize the role of private sector considering the existing financial condition of KMUP and lack of wastewater management institution.

Concerning the new construction of on-site facilities, residents' self-support could be expected because the benefit is clear. Actually almost all people except for slum residents have already installed their own toilet by themselves. Therefore for the on-site system development area utilization of self-support of residents to provide ones own treatment system (septic tank/leaching pit) accompanied with appropriate guidelines and stimulants like a public campaign and legal enforcement shall be relied upon.

Installation of off-site system can be done by public sector or private developer, in other words, utilization of private sector is possible only for housing estates.

Replacing or improving existing system is very difficult not only due to the difficulty in identifying malfunctioning systems but also the benefit will be not so clear for residents. Consequently, improved desludging at regular frequency shall be conducted by public sector.

The area located beyond housing estates and needs to be covered by off-site systems is the most difficult area to be improved. Moreover, it is obvious that pollution load generation in such an area causes heavy water quality deterioration. Therefore it is very important to find out the implementable solution for improving environmental condition in this area up to 2005. For this purpose it is necessary to study this area in more detail. Accordingly, hereafter this area is called as the priority area.

The priority area is shown in *Fig.* 5.14.

3.2.4 Demarcation of the priority area

(1) Strategy for the priority area

Following (3) systems are selected as technical options for the priority area.

a. Small Modular System (B/G) using PWTP (hereinafter called as SMS (B/G) using PWTP)

b. Large Modular System using stabilization pond (hereinafter called as LMS)

c. Conventional Sewerage System using stabilization pond (hereinafter called as CSS)

Among these three (3) technical options, SMS (B/G) using PWTP is very unique in the sense of quick benefit generation and high flexibility of selecting service area. However some disadvantages of this system, like lack of sufficient experiences in Indonesia, high unit cost for both construction and O&M, requirement of high level maintenance service to keep its high performance, difficulty of cross subsidy and the requirement of enormous number of units make it difficult to be applied as a principal countermeasure for the priority area.

On the other hands, large scale off-site systems, equivalent to LMS or CSS, can be regarded as optimum countermeasure for this area from the socio-economic, financial and technical aspects in spite of its disadvantages like the necessity of large initial investment, relative long construction period and low flexibility of selecting service area. To illustrate in detail, the advantages of LMS/CSS are as follows.

- Socio-economic aspect
  Cross-subsidy is possible.

- Financial aspect
  Per capita unit construction cost is cheaper than SMS(B/G) using PWTP.

- Technical aspect
  Practicability of this system has been well demonstrated.

Cost comparison between CSS and SMS (B/G) using PWTP is shown in *Fig. 5.15.*

With careful consideration to the potential problems that include house connection and cost recovery, LMS/CSS are selected as optimum countermeasures for the priority area. Nevertheless, according to experiences of off-site system development in many countries and considering the financial condition of KMUP, it seems to be infeasible to cover the entire priority area with large scale off-site systems completely by the target year 2005.

As a conclusion the strategies for the priority area are as follows.

i) To determine the optimum LMS/CSS development plan based on the result of prioritizing and consideration of topographic condition and cross-subsidy

ii) To introduce SMS (B/G) using PWTP in pilot scale as an effort to investigate its practicability, especially with respect of O&M requirement

iii) To improve O&M of existing sanitation facilities for the non-served area of off-site system

(2) Methodology of demarcation

Basically the priority of environmental sanitation improvement has to be determined by the demand, and this principle is exactly applied to select the priority area. But in order to determine the priority of LMS/CSS development inside the priority area, other two (2) factors, affordability of residents and accessibility to treatment facility, have to be considered. Affordability of residents is crucial factor to evaluate the financial feasibility and accessibility to treatment facility is important factor to evaluate the quickness of benefit generation.

The prioritizing method consists of following steps.

i) Selecting data for ranking of each Kelurahans

The data which are selected for ranking of each Kelurahans are as follows.

a. Population density
b. Public land use ratio (commercial and institutional)
c. Average income level
d. Average distance from potential site of treatment facility

note)
For calculating average income level, households with monthly income level less than Rp. 200,000 are excluded, because cost recovery from such low income households is considered infeasible.

ii) Classifying each data for ranking

The classification of each data along with the score of ranking is determined based on the deviation from mean for standardizing different data. Deviation from mean is given by following equation.

$$u_i = (X_i - M) / \sigma$$

where,

ui :	deviation of datum from mean
Xi :	datum
M :	mean of distribution
σ :	standard deviation of distribution

Deviation from mean of each data is shown in *Table* 5.18.

The classification of each data along with the score of ranking is shown in *Table* 5.19.

Each Kelurahan's scores of each data are shown in *Fig*.5.16 through *Fig*. 5.19.

iii) Setting coefficients of weighting to integrate each score of ranking

Weighting coefficients are set as follows.

10% Population density
10% Public land use ratio (commercial and institutional)
50% Average income level
30% Average distance from potential site of treatment facility

The heaviest weight is given to income level to secure feasibility of implementation, and second heaviest weight is given to distance from treatment facility to shorten the construction period.

(3) Demarcation

The result of prioritizing is shown in *Fig*.5.20.

Selection of LMS/CSS service area is based on result of prioritizing, topographic condition and the possibility of cross-subsidy. In addition to these factors, maximum pipe length for avoiding pumping station is also considered as a selection factor of LMS service area.

As a result, LMS/CSS service area is determined as shown in *Fig*.5.20.

In short term plan cross-subsidy is pursued with applying interceptor sewer for low income area from which cost recovery can not be expected.

3.2.5 Zoning of wastewater management in 2005

As a conclusion of this section, *Fig*.5.21 shows the zoning for short term wastewater management plan until the year 2005.

3.2.6 Sanitation improvement plan for slum area

(1) Utilization of existing facilities

Based on the result of field survey conducted by the study team, there are about a total of 200 public toilets. Most of these public toilets are located in the slum areas. Moreover, it became evident from the survey that about 30 % of these public toilets malfunctioned, or not used and about 50% of public toilets did not have any organization for users. Major reason for malfunctioning of public toilets is as follows:

a. No responsible organization (60%)
b. Broken (15%)
c. Clogged (15%)
d. Dirty (10%)

Accordingly, as the first step to ensure proper use of public toilets once repaired, an appropriate operation and maintenance (O/M) organization shall be established at basic level. In this regard, it is recommended that an operation and maintenance system shall be established under the direct responsibility of RW or Kelurahan in cooperation with Dinas Kebersihan.

(2) Provision of small modular system (B) / public toilet for no-toilet people

Considering very low affodability of slum residents and the fact that they do not have any toilet facilities at present, it is infeasible to expect no-toilet people constructing individual toilets with adequate facility by themselves. Accordingly provision of basic toilet facility by public sector becomes essential to eliminate the risk of direct defecation into public water bodies. Then following two (2) technical options are recommended as appropriate basic toilet facilities.

a. Small modular system (B) (hereafter called as SMS (B))
b. Public toilet

Both systems employ septic tank with leaching bed designed for 20 households. The difference is whether with house connection from individual toilet or not. SMS (B) is more recommendable than public toilet because the user of SMS (B) can enjoy the convenience of individual private toilet located within ones housing. However, applicability of SMS(B) is restricted by physical conditions like topographic elevation. For example, if the elevation of available space for treatment facility is higher than housings to be connected, SMS (B) can not be regarded as an appropriate solution.

On the other hand, it is to be noted that once the feasibility of SMS (B) is guaranteed physically, residents can choose between either systems based on their affordability to provide their own water closets and connection pipes to treatment facility.

From the viewpoint of public sector that provides these systems, there is no necessity for separate plans since the difference between the two (2) systems is insignificant.

Based on Kelurahan interview results conducted by the study team, 66 SMS (B) / public toilets were requested, where the site area is prepared by Kelurahan. Accordingly, 66 SMS (B) / public toilets are planned to be constructed within the next two (2) years.

Many experiences of public toilets shows that responsible organization for O/M is crucial for well functioning of public toilets. In this regard, following organization is recommended.

(a) Responsible person shall be selected from among the users. The administrative management is under Kelurahan office.

(b) User shall pay a fixed amount for using the public toilet. One (1) caretaker will work between 5am ~ 11pm as payment collector, cleaner and manager. The door of the toilet be locked at night time. The key is kept by responsible person or neighbor of the public toilet between 11pm ~ 5am.

(c) The organization is responsible for both O/M and collection of revenue user charge. The cost of O/M include caretaker wage, desludging cost and repair cost.

(d) The user hold a meeting, in case of any matters to be discussed.
In the case of SMS (B), caretaker and key holder are not necessary, hence the required organization for O/M is very simple. Still, service charge and the organization responsible for overall management of the septic tank and its desludging shall be established.

(3) Software measures

The role of software measure is important to eliminate the risk of direct defecation into public water bodies. Without public health education or campaign about the risk of direct defecation into public water bodies, it is no wonder if people prefer open defecation to public toilet. In addition, it is required to make regulation to discourage direct discharge of human wastes into public water bodies and the effectiveness of this regulation shall be endorsed by the proper monitoring system.

For the purpose of establishing responsible organization for O/M of SMS (B) / public toilet, explanation of these system is also important for users or community in order to ensure their effective cooperation.

3.2.7 Improvement and development plan of on-site system

(1) Establishment of monitoring system

For improvement of on-site facilities, it is essential to estabish monitoring system. The database of on-site facilities developed by the JICA Study Team can be applied for the purpose. As a short term plan up to 2005, this monitoring system shall cover at least the priority area.

At the same time, a certain monitoring effort shall be given to illegal or undesirable facilities and actions. The authority in charge with wastewater management shall have meetings with those residents using such facilities, and educate or propagate the necessity of adequate sanitation facilities.

(2) Improvement of septage collection

It is recommended to introduce new system for septage collection, called as visiting system, instead of existing system called as request system in which dispatching vacuum truck is based on the user's request. In the request system residents will use the facilities until to the last moment, and this may spread the contamination to environment. In visiting system responsible organization for desludging will make a plan of septage collection service based on the record of all previous desludgings. The database of on-site facilities can be applied to make the plan for visiting system of desludging.

With applying visiting system, the volume of septage to be desludged will increase due to both the increase in desludging frequency and population toward the short term planning frame of the year 2005.

Estimated volume of septage and required number of vacuum trucks including procurement schedule are described in chapter 4 : Feasibility Study.

(3) Improvement of septage management

The wastewater treatment plants of sewerage system constructed under the short term plan could be used for septage treatment, in addition to the existing septage treatment plant in Antang. This would economize the septage collection and transportation.

Moreover, improvement of access road of existing Antang septage treatment plant is recommended in order to facilitate efficient transportation of septage.

(4) On-site system development plan

In leaching pit development area, following guidelines shall be effective for all new houses and any renovation of on-site facilities.

a. Twin leaching pit shall be provided instead of single leaching pit.
b. A minimum distance of 10 m between leaching pit and well shall be ensured.
c. Leaching trench or irrigation usage shall be introduced as the means of graywater disposal.

In septic tank with leaching field development area, following guidelines shall be effective for all new houses and any renovation of on-site facilities.

a. Septic tank which has water tight structure with leaching field shall be provided.
b. The area of leaching field shall be at least 10 m^2 for blackwater only and 100 m^2 for blackwater and graywater treatment.
c. Graywater shall be treated in leaching trench or used for irrigation, so far as conditions permit, if septic tank treats only blackwater.

3.2.8 Developer modular system development plan

The necessary guidelines for the provision of communal wastewater treatment system by housing developer (developer modular system) is described in this section.

This guidelines is divided into three (3) parts as follows :

PART-1: Conditions to be Followed by a Housing Developer

PART-2: Evaluation and Monitoring Checklist for the concerned Government Agency of KMUP

PART-3: Promotion Measures of Communal Treatment System

It is noted that the provision of communal (modular) treatment system to treat together both blackwater and graywater by all newly developing housing complexes, is an important aspect of the Master Plan, requiring urgent enforcement.

PART-1: Conditions to be Followed by a Housing Developer

This Part-1 describes the conditions to be followed by a housing developer with respect to treatment requirement of the wastewater generated in a housing complex and other related aspects.

A. Basic Consideration

1) For the purpose of this Guideline, a housing estate developer is defined as the planner or owner of a housing complex to be inhabited by a population of at least 100 persons (or 15 households).

2) All housing estate developers including PERUMNAS shall provide communal wastewater treatment system to treat together both blackwater and graywater.

3) Provision of more than one wastewater treatment plant for a single housing complex is permissible. However, individual treatment system for each houses is not permitted. Moreover, provision of more than one treatment system for a single housing complex would not be interpreted as an alteration to the scale of a housing complex as defined in Section B.

4) The location of wastewater treatment plant shall be easily accessible from a public road.

B. Wastewater Treatment Criteria

B.1 Treated Effluent Quality

The required treated effluent quality and hence the respective wastewater treatment system, is based on the scale of a housing complex development. The scale of a housing complex is divided into two categories of large scale and small scale, based on the intended population inhabited, as defined below.

a. *Large scale housing complex* : Intended population inhabited is more than 300 persons (or 50 households)

b. *Small scale housing complex* : Intended population inhabited is not more than 300 persons (or 50 households)

The required treated effluent quality for both of these cases of housing complexes are delineated below:

1) Large scale housing complex

For a large scale housing complex, the treated effluent quality shall conform to a secondary treatment level as follows:

BOD - not to exceed 30 mg/l
SS - not to exceed 30 mg/l
FC (fecal coliform) - not to exceed 1000 No./100 ml

2) Small scale housing complex

For a small scale housing complex, an effluent quality with intermediate treatment level would be admissible as follows:

BOD - not to exceed 80 mg/l (or COD-chromate - not to exceed 160 mg/l)
SS - not to exceed 60 mg/l
FC (fecal coliform) - not to exceed 2000 No./100 ml

B.2 Treatment System

The recommended alternative wastewater treatment systems for both these cases of housing complex are given below:

(1) Large scale housing complex

One of the following wastewater treatment system alternatives is proposed to achieve a secondary treatment level.

a. Extended aeration activated sludge process including its variations such as oxidation ditch process
b. Rotating biological contactor (RBC) process
c. Anaerobic-aerobic contact process
d. Aerated lagoon
e. Stabilization pond

(2) Small scale housing complex

In addition to those wastewater treatment systems of the above for a large scale housing complex, the following are proposed as other suitable treatment system alternatives.

a. UASB (Up flow anaerobic sludge blanket)
b. Septic tank with leaching/infiltration field

Note: For an anaerobic wastewater treatment system like UASB, the treated effluent quality as COD, instead of BOD, is applicable (refer to Section B.1).

(3) Other significant aspects

1) In case of the wastewater treatment option of septic tank with leaching/infiltration field, which would be limited to a small scale housing complex only, in order to mitigate potential groundwater pollution due to leaching/infiltration field, a minimum clearance of 2m between the groundwater table level, under the critical condition of rainy season, and the base of the leaching/infiltration field shall be provided.

2) A developer is permitted to use any other alternative wastewater treatment system as appropriate, provided the technical effectiveness of such a system to meet the required effluent quality could be justified by the developer himself. Nevertheless, the proposed system shall not involve frequent separation of primary solids (sludge), and hence primary sedimentation as utilized in a typical conventional activated sludge process would not be permitted. This is to simplify the biosolids handling and its subsequent treatment requirement.

3) In principle, a wastewater treatment system that discharges treated effluent to receiving waters would require disinfection to meet the above effluent criteria concerned to FC. The possible exception to disinfection requirement is when a maturation pond is provided as the final treatment prior to disposal to receiving waters. Hypochlorite of chlorine (NaOCl or Ca(OCl)2) is recommended as the disinfectant. Due to safety consideration and small scale of the treatment system, gaseous chlorine would not be permitted as the disinfectant.

B.3 Waste Solids Management

Proper management of waste solids from a wastewater treatment plant to ensure its sanitary disposal is equally important as producing a treated effluent conforming the criteria illustrated above.

The following waste solids management methods shall be adopted:

(1) Solid waste from an inlet screen to the wastewater treatment system shall be periodically removed and disposed sanitarily. Disposal along with municipal solid waste or controlled incineration is permissible.

(2) A wastewater treatment system requiring frequent wasting of biosolids (sludge), such as the extended aeration activated sludge system, shall be provided with drying bed or storage tank as a temporary storage facility. Any such temporarily stored biosolids shall be regularly transported and disposed in a septage treatment plant. Potential reuse of biosolids as fertilizer or soil conditioner is recommended to be given due consideration.

C. Operation and Maintenance and Monitoring (OMM)

The requirement for operation and maintenance as well as monitoring (OMM) of the wastewater treatment system is under the sole responsibility of the owner of the housing complex. In fact such requirement of OMM much depends on the type of treatment system used. For example, extended aeration activated sludge process has a high OMM requirement, while a septic tank with infiltration field requires least OMM.

The OMM of the treatment system shall incorporate, in addition to ensure the proper functioning of the treatment system, regular self monitoring of the treated effluent quality at least with respect to the three water quality parameters of BOD (COD), SS, and FC, as illustrated in Section B.1. The frequency (time interval) of water quality monitoring shall be at least once in two months.

Septic tank with leaching/infiltration field is exempted from the requirement of effluent quality monitoring, as the effluent is infiltrated into natural soil.

PART-2: Evaluation and Monitoring Checklist for the concerned Government Agency of KMUP

This Part-2 describes the required action programme and the related aspects to be followed by the concerned government agency in charge of approval and the subsequent monitoring of wastewater treatment system constructed and operated by a private housing developer.

Item-1: Ensure technical effectiveness of the proposed wastewater treatment system by the housing developer.

The required activity of Item-1 would involve confirmation of the proposed wastewater treatment to meet the required effluent quality as of Section 2 of Part-1, by reviewing the design report.

In case of a standardized package treatment system by an equipment manufacturer, the required activity would involve review of relevant catalogue of manufacturer and/or receipt of certification of performance provided by the manufacturer.

Item-2: Ensure an operation and maintenance and monitoring (OMM) plan for the proposed wastewater treatment system is provided by the housing developer.

The required activity of Item-2 is an overall review of the proposed OMM and to ensure that the plan incorporates the self effluent quality monitoring programme as of Section C of Part-1.

Accomplishment of Item-1 and Item-2 will be a prerequisite for allowing the construction works of the wastewater treatment system to begin.

Item-3: Formulate a monitoring programme to inspect the functioning wastewater treatment systems at a frequency conforming the available resource limitation of the agency.

The inspection activity of this Item-3, as far as possible, be planned to be in coincident with the water quality sampling time of treated effluent, as per the self monitoring requirement of Section C of Part-1. Moreover, the agency is recommended to designate certain laboratories with proven record as approved ones for conducting the analysis of the water quality samples, whenever such a designation is practicable.

A large scale housing complex be assigned higher priority than that of a small scale one in formulating such a monitoring (inspection) programme.

Item-4: Formulate and execute an environmental water quality monitoring programme.

The agency is strongly recommended to initiate a water quality monitoring programme targeting the major water bodies of canals and rivers in KMUP, at designated locations with regular sampling frequency.

A minimum sampling frequency of two (2) times a year, once each in dry season (September) and rainy season (February), is recommended.

The parameters monitored shall include among others, pH, DO, BOD, COD (chromate), and FC.

Such an environmental water quality monitoring programme, would help very much in assessing the change in environmental quality as a result of implementation of wastewater treatment by housing developers and others. It would also serve as the tool for any future revision of the treated effluent water quality standards, proposed in Section B of Part-1.

PART-3: Promotion Measures of Communal Treatment System

This Part-3 illustrates the possible implementation measures, so that newly developing housing complexes could provide their own communal wastewater treatment system to treat together both blackwater and graywater.

A. Enforcement at basic site plan

At present TATA KOTA of Tk-II is the agency responsible for assessing the basic site plan of a housing complex.

Accordingly it is appropriate for TATA KOTA be the agency, primarily responsible for assessing the provision of communal wastewater treatment system by a housing complex developer.

TATA KOTA shall ensure that the layout plan of a housing complex incorporates communal treatment system. Inclusion of such a communal wastewater treatment system, in the overall layout plan itself, shall be a prerequisite for gaining approval of any housing complex development.

B. Campaign on quality of life

TATA KOTA, as the representative organization of KMUP, shall organize and conduct public campaign targeting both housing developers and prospective tenants, the living environmental improvement and hence the enhancement in quality of life, that could be realized with the provision of communal treatment system treating both blackwater and graywater, instead of simple individual systems treating only blackwater.

Such a campaign shall specifically emphasize the graywater pollution, and its unfavorable effect on the cleanness of ditches and surface drains. The resultant environmental pollution to receiving waters, and the subsequent damage to beneficial uses of such receiving waters shall also be elaborated.

More over, the intended purpose of ditches and surface drains as facilities to convey storm water (rain fall) run-off to mitigate flooding, in other words an urban drainage facility, rather than to convey untreated graywater shall be emphasized.

3.2.9 Sewerage system development plan

The short term sewerage development plan consists of two (2) conventional sewerage systems in central and southern area of the old city, and one (1) large modular system in northern area of the old city as shown in *Fig.* 5.22.

The measure to promote house connection of sewerage system plays very significant part and is included in this plan.

(1) Central sewerage system

The central city area that covers the major commercial and institutional development of the city of Ujung Pandang is targeted as the service area. The location of treatment plant is in Pampang.

In principle, the sewerage service area will be covered by three (3) sewerage collection system, namely small scale sewer system, ordinary sewer system and interceptor sewer system. Technical criteria of applicability of collection system is shown below.

- Small scale sewer system

The area where houses have enough space, with width between the front of houses and road is more than 3 m or the road has pedestrian walkway of at least 1 m width.

- Interceptor sewer system

Area with temporary housing, area of potential redevelopment or area of poor accessibility (road width less than 3 m).

In addition, interceptor service area is not expected to contribute to cost recovery.

The existing land use of the proposed site for treatment plant is fish pond. Accordingly, stabilization pond system is adopted as the simple appropriate wastewater treatment technology.

(2) Southern sewerage system

The service area of this sewerage system in the southern portion of the priority area with predominant residential developments. The coastal part of this area is planned to be developed as a large scale commercial area.

Wastewater collection system would be simple with no pump facility.

The location of treatment plant is in Maccini Sombala. At present, the proposed treatment plant site remains as a wetland (swampy area). Accordingly, similar to that of central sewerage system, stabilization pond is adopted.

(3) Northern sewerage system

Wastewater collection system of this area is also simple with no pump facility. The capacity of Lembo wastewater treatment plant is very limited and consequently this plant will be abondoned with the expansion of service area according to the master plan. Therefore this system is regarded as a large modular system and integation into central sewerage system would be required beyond the year 2005. With this integration the land used as the treatment plant in Lembo will be relieved for other uses like residential /commercial development. Still, it is necessary to install a pump facility in this treatment plant location in Lembo.

As the simple appropriate wastewater treatment method and also with due consideration to the temporary nature of the treatment plant, stabilization pond system is adopted.

(4) Measure to promote house connection

Experiences of sewerage development in other Indonesian cities shows that the number of house connection to sewerage system is still far from satisfactory inspite the strenuous efforts of responsible organization including interest free loan scheme. To avoid this undesirable situation house connection sewers will be implemented by the public sector as a direct project component. In parallel with this hardware measure, campaign and enforcement for promotion of house connection shall be executed in order to get consensus of construction work inside housing lot.

3.2.10 Introduction of small modular system (B/G)

About 50 households comprising about 250 people is planned to be served by this small modular system (B/G) (hereafter called as SMS (B/G)). Blackwater and graywater from households are carried through small scale sewer collection system to a septic tank or Package Wastewater Treatment Plant treatment plant.

Installation of SMS (B/G) can be faster way in wastewater management, comparing large modular system or conventional sewerage system, though the service area is limited. The system seems an attractive option for wastewater management, however, it has not yet been introduced and demonstrated in Indonesia. Therefore introduction of the system shall be first conducted as a pilot project. The result will be studied in both technical and managerial aspects including operation and maintenance. If it could be well organized and operated successfully, introduction of SMS (B/G) project in a wider scale could be promoted.

(1) Pilot project of SMS (B/G) using septic tank

SMS (B/G) using septic tank will be studied for installation at five (5) sites as shown in *Fig.* 5.22.

Required area for septic tank is about 10 m x 20 m.

Organization in charge of operation and maintenance shall be ascertained with agreement before the implementation of this pilot project. Service charge of beneficiary and responsible organization for operation and maintenance shall be established and the agreement shall be contracted. The responsible organization for O/M may be the beneficiaries in cooperation with LKMD and/or NGO.

(2) Pilot project of SMS (B/G) using Package Wastewater Treatment Plant

SMS (B/G) using Package Wastewater Treatment Plant will be studied for installation at one (1) site as shown in *Fig.* 5.22.

Required area for Package Wastewater Treatment Plant is about 4 m x 15 m.

The conditions related to organization responsible for O/M are same as SMS (B/G) using septic tank.

The system is planned in a high income residential area and the Package Wastewater Treatment Plant treatment system is planned to be placed at Tamang Safari park. The treated effluent (a secondary treatment level) can be reused at the park for irrigation or other non portable uses.

It would serve as a good demonstration for not only wastewater treatment but also reuse of treated wastewater.

3.3 Master Plan up to 2015

3.3.1 Basic strategy

Master Plan for wastewater management up to the year 2015 shall be formulated to achieve CL in the whole Study Area.

Since short term wastewater management plan up to 2005 is determined and described in foregone section, this section describes wastewater management plan from the year 2006 until 2015 as a second stage plan.

Based on the correlation between water quality and specific pollution load discharge shown in *Fig*.5.12, required water quality standard for CL, 30 mg/ℓ as BOD, can be obtained where specific pollution load discharge is less than 1.8 kg BOD/day/ha.

Consequently basic strategy for formulating master plan for wastewater management consists of following three (3) steps.

i) To demarcate the most recommendable technical options, based on the characteristics of each area, which can reduce pollution load discharged to environment to a level less than 1.8 kg BOD/day/ha.

ii) To find out schemes for each area to be served by the most recommendable technical option.

iii) To optimize public sector project schemes so as to maximize private sector participation.

3.3.2 Demarcation of Study Area

The criteria for demarcation of short term plan can still be applied to formulate Master Plan with the inclusion of additional criterion that the specific pollution load discharge shall be less than 1.8 kg BOD/day/ha. Accordingly, even with proper treatment of blackwater in on-site system of leachng pit/septic tank with leaching field, this criteria of achieving CL can only be met when the generated pollution load density from all sources other than blackwater less than 1.8 kg BOD/day/ha. For those areas exceeding the sepecific pollution load generation of 1.8 kg

BOD/day/ha form all sources other than blackwater, in principle, further treatment of this wastewater is necessary. Such further treatment can be practicallly achieved with secondary treatment of whole wastewater.

It is noted that the rapid increase of population in suburban area will be caused by development of large scale housing estates. In other words, most of population in such an area will be confined to large scale housing estates. As already mentioned in short term plan, large scale housing estates shall be covered with developer modular systems, which treat both blackwater and graywater to secondary treatment level. Accordingly, demarcation of areas suited for leaching pit and septic tank with leaching field can be based on the data excluding the estimated large scale housing estates.

Based on the estimation of pollution load generation as BOD in 2015 and the considerations mentioned above, leaching pit or septic tank with leaching field treating only blackwater can be applied in quite large part of suburban area.

Specific pollution load discharge by Kelurahan in 2015 excluding the estimated large scale housing estates is shown in *Table* 5.20.

Distribution of specific pollution load discharge by Kelurahan in 2015 excluding the estimated large scale housing estates is shown in *Fig.* 5.23.

It is noted that in such a suburban area with specific pollution load generation from all sources other than blackwater is less than 1.8 kg BOD/day/ha, the population density is less than 100 persons/ha.

Correlation between population density and specific pollution load discharge in 2015 is shown in *Fig.* 5.24.

Accordingly, demarcation of the area between leaching pit and septic tank with leaching field could be made entirely based on the critical depth of groundwater table level, as per the short term plan described in section 3.2.2.

On the other hand, remaining area shall be served with off-site system to obtain a secondary treatment level thereby attaining the CL.

3.3.3 Schemes for each area

Basically the schemes of master plan are continuous development of the short term plan. The short term plan has already provided the basis of wastewater management like a responsible institution, necessary guidelines and regulations and wastewater treatment plant which is applicable even in long term.

The entirely new scheme is the integration of modular system into conventional sewerage system. This integration will be necessary for all modular systems located within the conventional sewerage system development area.

3.3.4 Zoning of wastewater management in 2015

The proposed off-site system development area is determined considering land use and geographical and topographical conditions in addition to demarcation mentioned above.

As a conclusion of this section, *Fig.* 5.25 shows the zoning for wastewater management master plan.

3.3.5 Improvement plan of on-site system

(1) Monitoring system

As a second stage of master plan, the monitoring system introduced in the priority area of short term plan shall be extended to the whole Study Area.

(2) Septage collection

Required number of operational vacuum trucks, each of capacity 3 m^3, is estimated as follows, based on the quantity of septage to be desludged. Frequency of operation is assumed to be five (5) days/week. The rate of depreciation of a truck is assumed to be once in five (5) years.

- 21 units in year 2010
- 17 units in year 2015

(3) Septage treatment

All wastewater treatment plants for conventional sewerage systems and Antang septage treatment plant can treat desludged septage.

(4) Development of on-site system

For leaching pit development area and septic tank with leaching field development area, the guidelines same as short term plan shall be still effective for all new houses and any renovation of on-site facilities.

3.3.6 Developer modular system development plan

Basically, same guidelines as short term plan shall be still effective. Nevertheless, if there is a network of conventional sewerage system in the vicinity, developer shall directly dispose the entire wastewater (blackwater and graywater). Hence the installation of ones own treatment plant is not necessary.

To facilitate integration of developer modular system with conventional sewerage, it is recommended that responsible institution of wastewater management shall show the total facility plan of conventional sewerage system to a developer before the approval of construction of housing estate. Approval of the developer modular system shall be made only when the proposed modular system is in conformity with the sewerage development plan.

3.3.7 Sewerage system development plan

(1) Preparation of Alternatives

The objective sewerage development area for the year 2015 covers 5,564 ha located in the western part of Ujung Pandang city.The objective area is shown in *Fig. 5.25.*

The Existing population and wastewater generation of the objective area are 866,200 persons and 64,400 m^3/day, and in the year 2015 are estimated at 1,340,600 persons and 238,000 m^3/day, respectively. The basic design information in the objective area is shown below and details are shown in *Table 5.21.*

Sewerage Zone	Service	Wastewater Generation (m^3/day)	Groundwater Infiltration (m^3/day)	Design Flow (m^3/day)
Northern Zone	1,104	48,700	4,900	53,600
Central Zone	867	57,600	5,800	63,400
E-Northern Zone	880	23,900	2,400	26,300
Southern Zone	571	37,300	3,700	41,000
E-Southern Zone	2,142	70,600	7,100	77,700
Total	5,564	238,100	23,900	262,000

The objective area is divided into five (5) zones, which could be covered with independent sewer networks. Based on combination with these five (5) zone and three (3) potential site for treatment plant, the following three (3) alternatives are established as possible sewer networks. These alternatives are as follows.

Alternative - 1 : The single large scale system (One (1) treatment plant)

The whole off-site area to be served with the Pampang wastewater treatment plant (Potential site No.3).

Alternative - 2 : The medium scale system (Two (2) treatment plants)

Northern, Central and East-Northern Zone to be served with the Pampang wastewater treatment plant (Potential site No.3)

Southern and East-southern zone to be served with the Maccini Sombala treatment plant (Potential site No.2).

Alternative - 3 : The medium and small scale system (Three (3) Treatment plants)

Northern, Central and East-Northern Zone to be served with the Pampang wastewater treatment plant (Potential site No.3)

Southern zone to be served with the Maccini Sombala treatment plant (Potential site No.2).

East-Southern zone to be served with the Bagun Sari treatment plant (Potential site No.5).

These alternative sewer systems are shown in *Fig.* 5.26 ~ 5.28.

(2) Design Criteria

Sewerage system is composed of collection system and treatment plant.

1) Collection System

Sewer networks are designed based on following criteria;

i) Peak Flow Factor

The following formula is adopted to estimate peak flow factor to daily average wastewater discharge.

$$F = 4.02\,(0.0864Q)^{-0.154}$$

where,

F : Peak flow factor to daily average wastewater discharge excluding groundwater infiltration

Q : Daily average wastewater discharge in l/s

ii) Groundwater Infiltration

Groundwater infiltration including unexpected surface water intrusion is assumed to be 10% of daily average wastewater discharge.

The proposed criteria of this Study considers a groundwater infiltration of 10% of daily average wastewater discharge into sewer system.

iii) Flow Velocity

In calculation of flow velocity, the Manning's Formula is applied for gravity flow . The minimum velocity is 0.6 m/s and maximum velocity is 3.0 m/s.

The Manning's Formula is shown below.

$$V = \frac{1}{n} R^{2/3} I^{1/2}$$

where,

V	:	Mean velocity
n	:	Roughness coefficient
R	:	Hydraulic radius
I	:	Hydraulic gradient

iv) Allowance of Sewer Pipe Capacity

Allowance of sewer pipe capacity to design peak discharge is determined as follows.

Sewer Diameter (mm)	Allowance (%)
ø 100 -300	100
ø 350 - 800	50
Larger than ø 900	30

v) Depth of Sewer Pipe Laying

The minimum earth cover depth for laying sewer pipe is 1.0 m and the maximum is approximately 6.0 m.

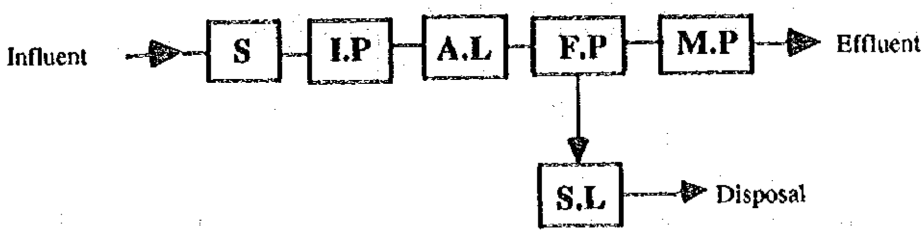
2) Treatment Plant

i) Proposed Treatment Process

The proposed treatment system is adopted to consider the following viewpoints;

- Low cost of construction and operation/maintenance
- Simple operation/maintenance
- Low sludge production (flexible sludge management)
- Low impact for environment

The flow diagram of the proposed treatment process is shown below.



S	:	Screen
I.P	:	Inflow Pump
A.L	:	Aerated Lagoon
F.P	:	Facultative Pond
M.P	:	Maturation Pond
S.L	:	Sludge Lagoon

The treatment facilities size are calculated based on below formulas;

ii) Aerated Lagoon

a) <u>Effluent BOD5</u>

$$Le = \frac{Li}{1 + k \cdot t} + 0.95 \cdot x$$

where

$$X = \frac{Y(Li-Le)}{1 + kb \cdot t}$$

Le	:	effluent BOD5 in mg/l
Li	:	influent BOD5 in mg/l
k	:	first order rate constant for soluble BOD5 reduction in day^{-1}
t	:	retention time in day (minimum retention time is 2 days)
X	:	concentration of microorganism in reactor (mg/l)
Y	:	yield coefficient of microorganism
kb	:	death rate coefficient of microorganism in day^{-1}

b) First Order Rate

$$k = 5 \times (1.035)^{T-20}$$

where

k	:	first order rate in day^{-1}
T	:	design temperature °C; (25°C)

$$k = 5 \times (1.035)^{25-20} = 5.9 \text{ day}^{-1}$$

iii) Facultative Pond

Two (2) formulas of required surface area for facultative pond are applied to calculation by effluent BOD and by BOD loading. Based on the results of calculation by two formulas, the wider required surface area is adopted.

a) Required Surface Area by effluent BOD

$$A = \frac{Qi(Li-Le)}{18D(1.05)^{T-20}}$$

where

A	:	required surface area in m^2; wanted
Qi	:	design inflow in m^3/day; given
Li	:	inflow BOD5 in mg/l given
Le	:	effluent BOD5 in mg/l ; (50 mg/l)
D	:	depth of pond in m; (1.5 m)
T	:	design temperature in °C; (25°C) given

b) <u>Required Surface Area by BOD Loading</u>

$$A = \frac{Qi \times Li}{ls}$$

$$ls = 20T - 120$$

where

A	:	required surface area in m^2; wanted
Qi	:	design inflow in m^3/day; given
Li	:	inflow BOD_5 in mg/l given
ls	:	design BOD loading in kg/day/ha
T	:	design temperature in °C; (25°C)

ls = 20 x 25 - 120 - 380 kg/day/ha

iv) Maturation Pond

Minimum 2 ponds and each with retention time of 2 days.

v) Sludge Lagoon

a) <u>Required Surface Area</u>

$$N = \frac{Qs}{D} \quad (m^2)$$

where

A	:	required surface area in m^2
Qs	:	design desludging quantity in m^3/year
D	:	depth of pond in m; (2.0 m)

b) <u>Design Desludging Quantity</u>

$$Qs = Us \times Sp$$

where

Us	:	annual per capita sludge accumulation (0.04 m^3/capita/year)
Sp	:	served population (person)

(3) Cost Estimation

Cost estimation for comparative evaluation of alternatives is composed of Construction cost and operation/maintenance cost. Construction and operation/maintenance cost are estimated as follow.

1) Construction Cost

Total construction cost for three (3) alternatives is estimated , the break-down of which is shown below.

Alternative - 1 (The single large scale system)		(Unit : Rp. billion)
Collection sewer	:	556.4
Main sewer	:	55.1
Lift pump station	:	9.7
Treatment plant	:	43.1
Total		664.3

Alternative - 2 (The medium scale system)		(Unit : Rp. billion)
Collection sewer	:	556.4
Main sewer	:	55.6
Lift pump station	:	7.5
Treatment plant	:	49.5
Total		669.0

Alternative - 3 (the medium & small scale system)		(Unit : Rp. billion)
Collection sewer	:	556.4
Main sewer	:	54.0
Lift pump station	:	4.5
Treatment plant	:	52.7
Total		667.6

The details of construction cost by each sewerage zone is shown in *Table* 5.22, 5.24.

2) Operation and Maintenance Cost

Annual opretion/maintenance cost is estimated by 2 % of construction costs, and Annual opretion/maintenance cost is as follows.

Operation and Maintenance Cost		(Unit : Rp. billion/year)
Alternative - 1	:	13.3
Alternative - 2	:	13.4
Alternative - 2	:	13.4

(4) Comparison of alternatives

The construction and annual operation/maintenance cost of the three (3) alternative systems are compared as follows.

Alternative system	Construction (Rp. billion)	Annual O&M (Rp. billion/year)
Alternative -1 (The single large scale system)	664.3	13.3
Alternative -2 (The medium scale system)	669.0	13.4
Alternative -3 (the medium & small scale system)	667.6	13.4

The above results of cost estimation indicates no significant cost difference among the three (3) alternatives. Consequently, Alternative -3 is proposed as the sewerage system for in this area based on the following reasons.

- Compatibility with the short term sewerage development plan
- Advantage of sewer networks (from the viewpoint of lower earth covering depth and smaller number of lift pump stations)

4. Feasibility Study

4.1 Planning Frame

All project components identified for feasibility study are located within the priority area, that covers the highly urbanized old town area and its surroundings. The location of priority area along with the identified project components of feasibility study, based on the Master Plan until the year 2015 delineated in the foregone chapter, are shown in *Fig.* 5.22.

The basic planning frame of the priority area with respect to population, population density and wastewater and pollution load generation as delineated between existing and planning frame (until the feasibility target year of 2005) is tabulated below.

Planning Frame of Priority Area (Area : 2542 ha)

Item	Existing Condition	Planning Frame (2005)
Population	587,800	725,300
Population density (porson/ha)	231	285
Wastewater generation (m^3/d)	45,200	119,100
Pollution load generation (kg/d)	13,900	27,820

4.2 Feasibility Project Components

The project components of wastewater management for feasibility study until the year 2005 is comprised of both on-site sanitation improvement as well as off-site sewerage development including pilot projects.

These feasibility projects are categorized into three (3) major sectors as given below.

(1) Sanitation improvement project

(2) Sewerage development project

(3) Pilot project

The Sanitation Improvement Project, which will be accomplished until the year 2000, has two (2) project components as briefed below.

(1) Provision of accessible toilet facility to no toilet population living in slum areas. As the means of providing accessible basic sanitation facility (toilet), small modular system treating blackwater (SMS (B) /communal septic tank) or public toilet (MCK) is adopted. Moreover, rehabilitation of existing but malfunctioning public toilets is also included.

(2) Improvement of existing septage management system with the procurement of additional vacuum trucks for desludging and improvement of access road to the Antang septage treatment plant.

The Sewerage Development Project has three (3) independent project components as delineated below (ref. *Fig.* 5.22).

(1) Large modular sewerage development project with its service area at northern part of the Priority Area, the Northern Service Area. The location of treatment plant is near Planampu Canal in Kel. Lembo. This system is referred to as "Northern Sewerage System".

(2) Conventional sewerage development project with its service area at central part of the Priority Area, the Central Service Area. The location of treatment plant is near Sinasara-Tallo River in Kel. Pampang. This system is referred to as "Central Sewerage System".

(3) Conventional sewerage development project with its service area at southern part of the Priority Area, the Southern Service Area. The location of treatment plant is near Jongaya Canal in Kel. Maccini Sombala. This system is referred to as "Southern Sewerage System".

The Pilot Project is to develop on a pilot scale, small scale sewerage systems at six (6) locations in the Priority Area. The locations of pilot project area shown in *Fig.* 5.22. Population served with each component of pilot project varies in the range of about 300 and 900 persons, with an average of about 500 persons (90 households).

All the above project components, delineated on the sectoral basis of sanitation improvement project, sewerage development project and pilot project, including their technical considerations, preliminary design details and project cost are elaborated in the subsequent sections.

4.3 Sanitation Improvement Project

The two (2) project components, namely, provision of accessible basic sanitation (toilet) facility in slum areas and improvement of septage management, that are slated for urgent implementation until the year 2000, as appropriate, are delineated below.

4.3.1 Basic sanitation facility for slum area

The project works include both rehabilitation of existing, but malfunctioning pubic toilets (MCK) and the provision of new public toilets.

It is emphasized that both the rehabilitation and provision of new public toilets is subjected to the condition that a responsible organization to ensure proper operation and maintenance of a system, comprising of intended users of the system (public toilet), could be established, as the prerequisite.

(1) Rehabilitation of malfunctioned public toilets (MCK)

At present, based on survey conducted by the Study Team as described in section 1.1.1, there exists a total of 204 public toilets (MCK) in the Study Area. Most of these public toilets are located in slum areas. Moreover 59 of these public toilets malfunctioned (ref. *Table* 5.1).

The proposed urgent project that would be accomplished until the year 1998 includes the rehabilitation of these 59 malfunctioned public toilets (MCK).

(2) Provision of new public toilets (MCK)

As the means of elimination of population with no access to sanitation facility (toilet) a total of 66 public toilets (MCK) will be constructed, in principle, until the year 1998 in slum areas.

Number of these new public toilets according to the respective Kelurahans are shown in *Table* 5.26. Selection of these Kelurahans for the provision of new public toilets (MCK) was made based on interview survey conducted by the Study Team, concerning both the requirement and availability of land space for the provision public toilets (MCK), targeting the heads of Kelurahan (Lurahs).

Typical public toilet (MCK) proposed as new sanitation facility is shown in *Fig.* 5.29. One public toilet is intended to serve 20 households.

It is noted that communal septic tank, denoted as small modular system treating blackwater (SMS (B)), instead of public toilet (MCK) is strongly recommended, provided the following conditions are satisfied at a selected location.

1) Intended slum residents have their own toilets, but with no treatment, or they have the willingness and affordability to construct ones own toilet. In other words, provision of ones own toilet could be guaranteed.

2) The proposed location of the communal septic tank, which shall be provided with leaching field as far as the local conditions permit, is topographically favorable, so that the wastewater (toilet waste/blackwater) from all the intended houses could be conveyed through pipes by gravity to the septic tank.

3) An agreement could be reached with the intended slum residents concerning the financing and layout alignment of conveyance pipes from household toilets to septic tank.

It is recommended that every effort shall be made to the provision of SMS (B) (communal septic tank) instead of public toilet (MCK). This is due to the fact that users of SMS (B) can enjoy the convenience of having their own private toilets in the housing lots, thereby ensuring the effectiveness of the usage of provided facility.

4.3.2 Improvement of septage management

The project works of septage management improvement is comprised of two (2) segments. They are as follows.

(1) Procurement of additional vacuum trucks on regular basis conforming the variation in the quantity of desludging with time, until the entire planning frame of Master Plan up to the year 2015. This is to ensure the continuation of improved desludging service not only until the feasibility project frame of the year 2005, but also the entire planning frame of Master Plan.

(2) Improvement of the access road to the existing Antang septage treatment plant, as the urgent project to be accomplished until the year 1998.

l) Procurement of additional vacuum trucks

It is proposed to improve the management of desludging service from the present practice of user request based desludging (request system) to planned desludging at regular interval (visit system).

Accordingly, the requirement of vacuum trucks is estimated based on the following basic assumptions.

i) Rate of septage accumulation is 18 liter/person/year, assuming only blackwater is treated in an on-site facility (septic tank/leacling pit).

ii) Capacity of typical septic tank/leaching pit of a household is $1 m^3$.

iii) Number of inhabitants in a typical household is 5.5 persons on an average.

iv) An on-site facility will be desludged completely once the accumulation of septage reached 50% of the capacity of the facility ($0.5 m^3$).

v) Capacity of a vacuum truck is $3 m^3$, same as the present ones.

vi) Operational cycle (frequency of operation) of a vacuum truck to treatment plant is three (3) cycles in a working day, on average. Moreover, during each cycle of operation three (3) on-site facilities (households) are desludged. In other words, service level of a vacuum truck is 9 households/day.

vii) A five (5) day work week is the operational requirement of desludging service (operation of vacuum trucks). Accordingly, the annual working days would be 260 days.

viii) Stand-by allowance of vacuum trucks is 20%.

Under the above basic assumptions and also with due consideration to the decrease in population requiring desludging service in tandem with the provision of conventional sewerage service with direct house connection sewers, according to the sewerage development plan of the Master Plan, the requirement of vacuum trucks for desluding service for the whole study area is estimated as shown in the Table below.

Requirement of vacuum trucks (1995 ~ 2015)

capacity of truck : $3m^3$

Year	1995	2000	2005	2010	2015
Total population	1,090,000	1,270,000	1,520,000	1,870,000	2,200,000
Population of desludging	1,090,000	1,122,800	1,363,000	1,088,000	859,000
Quantity of desludging (m^3/annum)	39,780	42,120	49,140	39,780	32,760
No. of vacuum trucks	20	22	25	20	17

As evident from the above table, the required vacuum trucks of $3m^3$ capacity in 1995 becomes 20, which is much higher than existing vacuum trucks under operation of only four (4). It is also noted that the above estimation is valid only if the existing desludging system, the request system is altered to visit system of regular desludging.

Accordingly, it is assumed that the implementation of visit system could be fully implemented by the year 2006. Then a more realistic procurement plan of vacuum trucks, so that the number of trucks in operation by the year 2006 becomes 25 is proposed as shown below. This procurement plan assumes a depreciation period of 5 years for vacuum trucks.

The proposed procurement plan for new vacuum trucks on on annual basis (1995~2015) is tabulate below.

Year	New trucks/annum	Total No. of Trucks
1995~1996	0 (4 : Existing trucks)	0
1997~2001	3	15
2002~2006	5	25
2007~2011	4	20
2012	3	3
2013	4	4
2014~2015	3	6
Grand Total (Until the year 2015)		73

Conforming the above procurement plan, the number of vacuum trucks in operation on an annual basis separated between the initial ten (10) year period and final ten (10) year period, until the year 2015 is shown below.

Vacuum Trucks in Operation - (1995~2005)

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
No. of Trucks	4	4	6	8	10	12	15	17	19	21	23

Vacuum Trucks in Operation - (2006~2015)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
No. of Trucks	25	24	23	22	21	20	19	19	18	17

It is noted that the above number of vacuum trucks in operation is computed on the assumption that the existing four (4) trucks would depreciate one by one from the year 1997, thereby being phased out completely with new trucks by the year 2000. The depreciation of newly procured vacuum trucks, as already mentioned, is 5 years.

2) Improvement of access road to Antang STP

The final 1.8 km length of the access road to the Antang septage treatment plant (STP), the layout of which is shown in *Fig*. 5.6, remains unpaved. This unpaved condition of the road makes the access of vacuum trucks to the STP very cumbersome.

Accordingly this 1.8 km length of the access road, shown in *Fig*. 5.30, will be improved to asphalt type pavement as an urgent project until the year 1988.

The effective road width will be expanded to 6m, in order to be in conformity with the existing 6m width of the paved road, that lies beyond at the 1.8 km distance from the STP.

It is noted that until the year 2000, Antang STP will be the only system available for the receipt of desludged septage. However, from the year 2001, three (3) wastewater treatment plants, located at Lembo, Pampang and Maccini Sombala will commence operation, in accordance with the sewerage development project delineated in the subsequent section.

Of these three (3) wastewater treatment plants, the two (2) treatment plants of conventional sewerage system, Pampang and Maccini Sombala treatment plants would receive desludged septage as well.

Accordingly, since the year 2001 a total of three (3) treatment plants would be available for treatment of desludged septage. They are as follows :

i) Antang septage treatment plant
ii) Pampang wastewater treatment plant
iii) Maccini Sombala wastewater treatment plant

These three (3) plants would continue to receive desludged septage throughout the entire planning frame of Master Plan.

The proposed wastewater treatment plant at Gunung Sari, planned for operation by the year 2016, is not considered for the receipt of desludged septage, since its commencement of operation is beyond the planning frame of Master Plan (2015).

Demarcation of service area among the three (3) treatment plants, for the receipt of desludged septage since the year 2001, is proposed as given below. This demarcation is made so that the distance of hauling and transportation of desludging vacuum trucks could be optimized.

i) Antang septage treatment plant

The service areas are Kec. Bringkanaya and the nearer area of Kec. Panakkukang.

ii) Pampang wastewater treatment plant

The service areas are Kec. Tallo, nearer area of Kec. Panakkukang, Kec. Ujung Tanah, Kec. Wajo, Kec. Bontoala, Kec. Makassar and Kec. Ujung Pandang.

iii) Maccini Sombala treatment plant

The service areas are Kec. Mariso, Kec. Mamajang and Kec. Tamalate.

4.4 Sewerage Development Project

4.4.1 Project components

The three (3) sewerage project components are, namely, northern sewerage system, central sewerage system and southern sewerage system.

The basic design information concerned to each of these three (3) sewerage service area, including the Kelurahans served along with their respective present and planned population in the year 2005 and the corresponding quantity of wastewater and pollution load generation (as BOD), are shown in *Table* 5.27.

The significant features common to all three (3) sewerage systems are given below.

(1) The collection system is comprised of a combination small scale sewers, ordinary sewers and interceptor sewers (ref. *Fig.* 5.7 ~ *Fig.* 5.9). Small scale sewer is applied as the tertiary sewer prior to house connection sewer when the width between the front of houses and road is at least 3m, or the road has pedestrian walkway of at least 1m width. Interceptor sewers with no direct house connection is used in areas of poor accessibility and congested areas like slum areas.

(2) Stabilization (Oxidation) pond system consisting of facultative pond followed with maturation pond is adopted as the simple wastewater treatment system. Important advantages of stabilization pond are the ease and economics of construction, operation and maintenance and the insignificance of mechanical and electrical installations.

The salient features, including the preliminary design and cost of facilities, of each sewerage system are delineated in the subsequent sections.

4.4.2 Design consideration

Sewerage system is composed of wastewater collection system and treatment plant.

(1) Collection system

Sewer network is designed based on following criteria;

i) Peak Flow Factor

The following formula is adopted to estimate peak flow factor with respect to daily average wastewater discharge.

$$F = 4.02\ (0.0864Q)^{-0.154}$$

where,

F :Peak flow factor to daily average wastewater discharge excluding groundwater infiltration

Q :Daily average wastewater discharge in l/s

ii) Groundwater infiltration

Groundwater infiltration including unexpected surface water intrusion is assumed to be 10% of daily average wastewater discharge.

The proposed criteria of this Study considers a groundwater infiltration of 10% with respect to daily average wastewater discharge into sewer system.

iii) Flow velocity

In calculation of flow velocity, the Manning's Formula is applied for gravity flow and Hazen-Williams' Formula for pressure flow. The minimum velocity is 0.6 m/s and maximum velocity is 3.0 m/s.

The Manning's Formula is shown below.

$$V = \frac{1}{n} R^{2/3} I^{1/2}$$

where,

V : Mean velocity
N : Roughness coefficient
R : Hydraulic radius
I : Hydraulic gradient

Roughness coefficient (n) is assumed as follows:

Pipe Material	Roughness coefficient
RC Pipe	0.013
PVC Pipe	0.010

The Hazen-Williams' Formula is as follows.

$$V = 0.84935\, C\, R^{0.63}\, I^{0.54}$$

where,

V : Mean velocity (m/s)
C : Coefficient (C=110)
R : Hydraulic radius
I : Hydraulic gradient

The minimum velocity of 0.6 m/s is determined to prevent sediment deposition and to minimize sulfide formation in sewer pipes. The maximum velocity of 3.0 m/s is adopted to prevent erosion of the pipe material.

iv) Allowance of sewer pipe capacity

Allowance of sewer pipe capacity to design peak discharge is determined as follows.

Sewer Diameter (mm)	Allowance (%)
ø 150 - 300	100
ø 350 - 800	50
Larger than ø 900	30

v) Depth of sewer pipe laying

The minimum earth cover depth for laying sewer pipe is 1.0 m and the maximum is approximately 6.0 m.

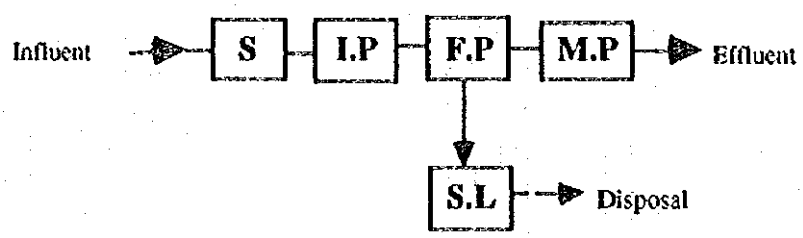
(2) Treatment plant

1) Treatment process

Stabilization pond is adopted as the wastewater treatment process with due consideration to the following aspects.

- Low cost of construction and operation/maintenance
- Simple operation/maintenance
- Low sludge production (simple/flexible sludge management)
- Minimum impact on environment (in harmony with natural environment)

The flow diagram of the stabilization pond treatment process adopted is shown below.



S	:	Screen
I.P	:	Inflow Pump
F.P	:	Facultative Pond
M.P	:	Maturation Pond (minimum of two ponds in series)

S.L : Sludge Lagoon (minimum of two cells)

The capacity of treatment facilities are determined based on the following formulas;

i) Facultative pond

Two (2) formulas to determine independently the required surface area for facultative pond are applied. One formula is based on the required effluent BOD, while the other is based on the allowable surface BOD loading. Based on the results of both formulas, higher value is adopted as the required surface area.

a) Required surface area based on effluent BOD

$$A = \frac{Qi(Li - Le)}{18D(1.05)^{T-20}}$$

where

A	:	required surface area in m^2; to be determined
Qi	:	design inflow in m^3/day; given
Li	:	inflow BOD_5 in mg/l given
Le	:	effluent BOD_5 in mg/l ; (50 mg/l)
D	:	depth of pond in m; (1.5 m)
T	:	design temperature in °C; (25°C) given

b) Required surface area based on allowable BOD loading

$$A = \frac{Qi \times Li}{ls}$$

$$ls = 20T - 120$$

where

A	:	required surface area in m^2; to be determined
Qi	:	design inflow in m^3/day; given
Li	:	inflow BOD_5 in mg/l given
ls	:	allowable BOD_5 loading in kg/day/ha
T	:	design temperature in °C; (25°C)

ls = 20 x 25 - 120 = 380 kg/day/ha

ii) Maturation pond

The design of maturation pond is based on the required bacterial treated effluent quality as fecal coliforms.

a) Retention time in facultative pond

$$tf = \frac{Qo}{Qi}$$

where

tf	:	retention time in days
Qo	:	volume of facultative pond in m^3
Qi	:	design inflow in m^3/day

b) Number of fecal coliforms in effluent

$$N = \frac{Ni}{(1+Kb \cdot tf)(1+Kb \cdot tm)^n}$$

where

N	:	number of Fecal coliform colonies in effluent in N/100 ml ; (required 2×10^3 : Source - River quality standards of DKI Jakarta (Governor's Decree No. 1608,1988))
Ni	:	number of fecal coliform colonies in influent in N/100 ml ; (4×10^7)
Kb	:	first order rate constant for coliform reduction $Kb = 2.6 \times (1.19)^{25-20} = 6.2$
tf	:	retention time in facultative pond in days
tm	:	retention time in maturation pond in days
n	:	numbers of maturation pond (2)

c) Required surface area

$$A = \frac{Qi \cdot tm}{D} \quad (m^2)$$

where

A	:	required surface area in m^2
Qi	:	design flow in m^3/day
tm	:	retention time in maturation pond in day

iii) Sludge lagoon

a) Design sludge accumulation in facultative pond

$$Qs = Us \times Sp$$

where

Us : annual per capita sludge accumulation (0.04 cu.m/capita/year)

Sp : served population (person)

b) Capacity of sludge lagoon

Design capacity of sludge lagoon is based on the following aspects.

- Minimum of two (2) cells will be provided
- A lagoon will be loaded only once in a year
- Sludge drying period in a lagoon is 4 months, during dry season only
- Effective depth of sludge in the lagoon in 2m

4.4.3 Northern sewerage system

Large scale modular sewerage development is planned in the northern part of the priority area with its treatment plant at Lembo. This is a temporary system, and planned to be incorporated into the Central Sewerage System with its treatment plant in Pampamg, as per the master plan, in future.

(1) Sewerage service area

1) Service area and served population

The service area of this large scale modular sewerage development covers an area of 73 ha. This sewerage system is shown in *Fig*. 5.31.

The sewerage development area covers 4 Kelurahan as follows;

Kel. Mampu, Kel. Malimongan Tua, Kel. Malimongan and Kel. Totake

The existing population in the sewerage service area in 1992 is 21,100 persons, and the served population in 2005 is 22,900 persons.

The existing population density of the sewerage service area in 1992 ranges from 120 person/ha in Kel. Totake to 399 person/ha in Kel Mampu with an average of 289 person/ha. The population density in 2005 is estimated at 313 person/ha on average.

The sewerage service area and served population of each Kelurahan are shown in *Table* 5.27.

2) Wastewater and pollution load generation

The existing wastewater generation in the sewerage service area is 1,700 cu.m/day, and in the year 2005 is 5,000 cu.m/day.

The existing pollution load generation in the sewerage service area is 612 kg/day as BOD and in the year 2005 is 1,133 kg/day.

The wastewater and pollution load generation of each Kelurahan are shown in *Table* 5.27.

(2) Collection system

The wastewater collection system consists of ordinary collection sewer, small scale collection sewer and interceptor sewer, and their shares in the service area are 20.8 %, 66.3 % and 12.9 %, respectively.

The total length of collection sewer network is about 2700m, with its diameter in the range of 350 ~ 700 mm. The earth covering depth is mostly in the range of 2 ~ 4 m. The relevant details could be referred to in *Table* 5.28.

There is no lift pump in the collection system. In other words the collected wastewater is conveyed through gravity only up to the treatment plant.

(3) Treatment plant

1) Existing condition

The existing condition of treatment plant site is as follows:

i) Location

The proposed treatment plant site is pond area, located in Kel. Lembo of Kec. Tallo. The west side of treatment site borders Canal Panampu, and the north side is at about 600 m distance from Jl. Tinumba (ref. *Fig.* 5.31).

ii) Land use

The existing land use of treatment site is wetland (swampy area).

iii) Land elevation

The existing land elevation is as follows:

Highest elevation	:	+ 3.0 m MSL
Lowest elevation	:	+ 0.5 m MSL
Average elevation	:	+ 1.5 m MSL

The crown elevation of Canal Panampu in this area is + 1.9 m MSL. The high tide of Makassar Port is + 1.0 m MSL and the design high water level of Canal Panampu is + 0.56 m MSL (source : Proyek Drainasi Kota Ujung Pandang, Nov. 1989).

iv) Sub-soil characteristics

The profile of bore logs at two (2) locations of the treatment plant site, drilled to a depth of 30m, is shown in *Fig.* 5.32. Based on this bore log data the sub-soil characteristics are as follows:

- Poorly graded fine sand of loose to medium dense, in the top layer between ground surface and 4m to 8m depth.
- High plasticity clay ranging from very soft to hard, in the medium layer between about 6m and 20m depth.
- Low plasticity hard and cemented silt in the base layer of more than 20m depth. (up to 30m).

v) Condition of the discharge river/canal

The treated wastewater is discharged to Canal Panampu. The design drainage capacity of Canal Panampu is 30 cu.m/sec.

Existing condition of water quality in this canal is highly polluted as shown below.

BOD	52 mg/l
Fecal Coliform	4.3×10^4 /100ml

(source : Water quality sampling by JICA at Jl. Mesjid Raya, Aug.1994.)

2) Design wastewater quantity and quality

The design wastewater quantity of influent to treatment plant is determined by wastewater generation in 2005 along with groundwater infiltration into sewer system. Groundwater infiltration is assumed as 10% of design wastewater discharge into sewer system.

Design wastewater generation in 2005	:	5,000 m^3/d
Groundwater infiltration (10 %)	:	500 m^3/d
Inflow to treatment plant	:	5,500 m^3/d

The influent wastewater quality to treatment plant is estimated as 210 mg/l in BOD5, while the effluent water quality requirement is 30 mg/l as BOD5.

3) Treatment system

The design of treatment plant structures are categorized into two(2) systems of inflow pump station and stabilization pond treatment system.

The required area for the treatment plant, as per the feasibility project until the year 2005 is about 6 ha.

The capacity of treatment facilities are determined based on formulas as illustrated under design considerations of Section 4.4.2 The design capacities and other relevant details are summarized in *Table* 5.29.

i) Inflow pump station

The inflow pump station of treatment plant consists of initial bar screen followed with the pump facilities.

Pump type : Vertical Axial Centrifuge Pump
The design hydraulic pump head: 5.8 m

ii) Stabilization pond treatment system

a) Facultative pond

Design treatment capacity is 5500 m^3/d.
Design volume of ponds is 44,800 m^3.
(required surface area is determined based on allowable BOD loading)
Detention time : 8.2 day
Effective depth : 1.5 m
(with additional 0.5 m depth for digested sludge storage)
Effective dimension of ponds (2 No. ponds in parallel):
250 m(L) x 65 m(W) x 1.5 m(D) x 2
Side slope: 1: 2

b) Maturation pond

Design volume of ponds is 17,400 m^3.

Detention time :	3.16 day
Effective depth :	1.5 m

Effective dimension of ponds (2 sets in parallel)

82 m(L) x 29 m(W) x 1.5 m(D) 2 sets x 3 pond series

Side slope:	1: 2

Sludge treatment facility is not installed in this treatment plant. When necessary, sludge removal in the facultative pond shall be executed by vacuum truck and transported for treatment in the Pampang treatment plant of central sewerage system.

The layout of treatment facilities designed is shown in *Fig*. 5.33.

4.4.4 Central sewerage system

Conventional sewerage development for central area is planned in the central part of the priority area.

(1) Sewerage service area

1) Sewerage service area and served population

The sewerage development system for central area in the year 2005, shown in *Fig*. 5.34, covers an area of 435 ha.

The sewerage development area covers 19 Kelurahan as followsP;

- Kel. Lanang Banggi, Kel. Barona, Kel. Baru, Kel. Bulo Gading, Kel. Pisang Utara, Kel. Pattunuang, Kel. Endeh, Kel. Melayu Baru, Kel. Bontoala, Kel. Bontoala Tua, Kel. Gaddong, Kel. Bontala Parang, Kel. Wajo Baru, Kel. Tompo balang, Kel. Baraya, Kel. Maccini, Kel. Maccini Gusung, Kel. Mal Baru, Kel. Timungan Lompoa.

The existing population in the sewerage service area is 107,200 persons, and served poplation in 2005 is 130,600 persons.

The existing population density of the sewerage service area in 1992 ranges from 69 person/ha in Kel. Baru to 529 person/ha in Kel Barona with an average of 246 person/ha. The population density in 2005 is estimated at 300 person/ha on average.

The sewerage service area and served population of each Kelurahan are shown in *Table* 5.27.

2) Wastewater and pollution load generation

The existing wastewater generation in the sewerage service area is 9,600 cu.m/day, and in the year 2005 is 26,000 cu.m/day.

The existing pollution load generation in the sewerage service area is 2,791 kg/day as BOD and in the year 2005 is 5,815 kg/day.

The wastewater and pollution load generation of each Kelurahan are shown in *Table* 5.27.

(2) Collection system

The collection system consists of ordinary collection sewer, small scale collection sewer and interceptor sewer, and their shares in the service area are 10.6 %, 75.6 % and 13.7 %, respectively.

The total length of collection sewer network is about 11870 m, with its diameter in the range of 350 ~ 1100 mm. The earth covering depth is mostly in the range of 2 ~ 6 m. The relevant details could be referred to in *Table* 5.28.

There is one lift pump station in the collection system located in Kel. Karuwisi Utara (Kebun Binatang, Jl. Urip Sumaharjo).

The proposed lift pump facility is shown in *Fig.* 5.35. The pump facility proposed is comprised of four (4) units as follows.

- 2 units of 300kw
- 2 units of 400kw

(3) Treatment plant

1) Existing condition

The existing condition of treatment plant site is as follows:

i) Location

The proposed treatment plant site is fish pond area, located in Kel. Pampang of Kec. Panakkukang. The east and north side of treatment site borders Sinasara river (Pampang river) and the west side is at about 800 m distance from inner road(ref. *Fig* .5.34).

ii) Land use

The existing land use of treatment site is fish pond and Nippa plantation.

iii) Land elevation

The existing land elevation is as follow:

Highest elevation	:	+ 3.0 m MSL
Lowest elevation	:	+ 0.5 m MSL
Average elevation	:	+ 1.5 m MSL

The highest water level of Pampang river at the discharged point is +1.25 m MSL (Source : Pampang River Improvement Project, Jan. 1994)

iv) Sub-soil characteristics

The profiles of bore logs at two (2) locations of treatment plant site, drilled to a depth of 30m, are shown in *Fig*. 5.36. Based on this bore log data, the sub-soil characteristics are noted as variable with respect to depth, as follows :

- the top most layer consists of high plasticity very soft clay (8 ~ 14m depth)
- the medium layer consists of low plasticity silt (8 ~ 26m depth)
- the base layer consists of sand stone rock (14 ~ 30m depth)

v) Condition of discharge river/canal

The treated wastewater is discharged to Sinassara river. The design discharge capacity at the junction of Pampang river and Sinassara river is 92 cu.m/sec as per the Pampang River Improvement Project.

Existing condition of water quality in this canal is good as shown below.

BOD	3 mg/l
Fecal Coliform	1×10^3/100ml

(Source : JICA sampling from Jun. 29 to 30, 1995)

2) Design wastewater quantity and quality

The design wastewater quantity of influent to treatment plant is determined by wastewater generation in 2005 along with groundwater infiltration into sewer system. Groundwater infiltration is assumed as 10% of design wastewater discharge into sewer system.

Design wastewater generation in 2005	:	26,000 m^3/d
Groundwater infiltration (10 %)	:	2,600 m^3/d
Inflow to treatment plant	:	28,600 m^3/d

The influent wastewater quality to treatment plant is estimated as 220 mg/l in BOD5, while the effluent water quality requirement is 30 mg/l as BOD5.

3) Treatment system

The design of treatment plant structures are categorized into three (3) systems of inflow pump station, stabilization pond treatment system and sludge treatment system.

The capacity of treatment facilities are determined based on formulas as illustrated under design considerations of section 4.4.2 The design capacities and other relevant details are summarized in *Table* 5.30.

The required area for the treatment plant, as the short term feasibility project until the year 2005 is about 44 ha.

i) Inflow pump station

The inflow pump station of treatment plant consists of initial bar screen followed with the pump facilities.

Pump type :	Vertical Axial Centrifuge Pump
The design hydraulic pump head:	8.6 m

ii) Stabilization pond treatment system

a) Facultative pond

Design treatment capacity is 28,600 m^3/d.
Design volume of ponds is 230,000 m^3.
(required surface area is determined based on allowable BOD loading)

Detention time : 8.0 day

Effective depth : 1.5 m

(with additional 0.5 m depth for digested sludge storage)

Effective dimension of ponds (6 No. ponds in parallel)

320 m(L) x 85 m(W) x 1.5 m(D) x 6

Side slope: 1: 2

b) Maturation pond

Design volume ofponds is 175,000 m^3.

Detention time : 6.1 day

Effective depth : 1.5 m

Effective dimension of ponds (12 sets in parallel)

130 m(L) x 42 m(W) x 1.5 m(D) x 12 set x2 pond series

Side slope: 1: 2

c) Sludge lagoon

The quantity of desludging from facultative pond is determined considering an annual per capita sludge accumulation of 0.04 cu.m.

The total annual accumulation of sludge in facultative pond becomes 5,230 m^3/year.

Frequency of desludging:	once in 2 years
Depth of sludge storage	2.0 m
Effective dimension:	30 m(L) x 42 m(W) x 2 m(D) x 3 ponds

The layout of treatment facilities designed is shown in *Fig*.5.37.

4.4.5 Southern sewerage system

Conventional sewerage development for southern area is planned in the southern part of the priority area.

(1) Sewerage service area

1) Service area and served population

The sewerage development system for southern area in the year 2005, shown in *Fig*. 5.38, covers an area of 162 ha.

The sewerage development area covers 8 Kelurahan as follows;

- Kel. Mario, Kel. Mattoanging, Kel. Kampung Buyang, Kel. Banto Rannu, Kel. Mariso, Kel. Lette, Kel. Pannambungan, Kel. Pa'Batang.

The existing population in the sewerage service area is 57,600 persons, and the served population in 2005 is 70,800 persons.

The existing population density of the sewerage service area in 1992 ranges from 143 person/ha in Kel. Mattoanging to 620 person/ha in Kel. Mariso with an average of 356 person/ha. The population density in 2005 is estimated at 437 person/ha on average.

The sewerage service area and served population of each Kelurahan are shown in *Table* 5.27.

2) Wastewater and pollution load generation

The existing wastewater generation in the sewerage service area is 4,000 cu.m/day, and in the year 2005 is 10,000 cu.m/day.

The existing pollution load generation in the sewerage service area is 1251 kg/day as BOD and in the year 2005 is 2394 kg/day.

The wastewater and pollution load generation of each Kelurahan are shown in *Table* 5.27.

(2) Collection system

The collection system consists of ordinary collection sewer, small scale collection sewer and interceptor sewer and their shares in the service area are 2.3 %, 31.6 % and 66.1 %, respectively.

The total length of collection sewer network is about 5,580 m, with its diameter in the range of 350 ~ 800 mm. The earth covering depth is mostly in the range of 2 ~ 4 m. The relevant in formation could be referred to in *Table* 5.28.

There is no lift pump facility in the collection system, similar to that of the northern sewerage system.

(3) Treatment plant

1) Existing condition

The existing condition of treatment plant site is as follows:

i) Location

The proposed treatment plant site is fish pond area, located in Kel. Maccini Sombala of Kec. Tamalate. The northeast side of treatment site borders Canal Jongaya and the southeast side is at about 250 m distance from Jl. Nuri (ref. *Fig.* 5.38).

ii) Land use

The existing land use of treatment site is fish and agar weed pond.

iii) Land elevation

The existing land elevation is as follow:

Highest elevation	:	+ 1.5 m MSL
Lowest elevation	:	+ 0.0 m MSL
Average elevation	:	+ 0.5 m MSL

The high tide of Makassar Port is + 1.0 m MSL and the design high water level of Canal Jongaya is +0.56 m MSL (Source : Proyek Drainasi Kota Ujung Pandang, Nov. 1989).

iv) Sob-soil characteristics

The profiles of bore logs at two (2) locations of treatment plant site, drilled to a depth of 30m, are shown in *Fig.* 5.39. Based on this bore log data, the sub-soil characteristics are noted as variable with respect to depth as follows :

- the top most layer consists of poorly graded fine sand of loose to medium dense sandwiched with silt (10 ~15m depth)
- the second layer consists of high plasticity very soft clay (10 ~18 depth)
- the third layer consists of low plasticity hard silt (15 ~ 23m depth)
- the base layer consists of sand stone rock (23 ~ 30m depth)

v) Condition of the discharge river/canal

The treated wastewater is discharged to Canal Jongaya. The design flow capacity of Canal Jongaya is 30 cu.m/sec (Source : Proyek Drainasi Kota Ujung Pandang, Nov. 1989).

Existing condition of water quality in this canal is quite polluted as below.

BOD	40 mg/l
Fecal Coliform	1 x 10^4 /100ml

(Source : JICA sampling from Jul. 2 to 3, 1995)

2) Design wastewater quantity and quality

The design wastewater quantity of influent to treatment plant is determined by wastewater generation in 2005 along with groundwater infiltration into sewer system. Groundwater infiltration is assumed as 10% of design wastewater discharge into sewer system.

Design wastewater generation in 2005	:	10,000 m^3/d
Groundwater infiltration (10 %)	:	1,000 m^3/d
Inflow to treatment plant	:	11,000 m^3/d

The influent wastewater quality to treatment plant is estimated as 220 mg/l in BOD5, while the effluent water quality requirement is 30 mg/l as BOD5.

3) Treatment system

The design of treatment plant structures are categorized into three (3) systems of inflow pump station, stabilization pond treatment system and sludge treatment system.

The capacity of treatment facilities are determined based on formulas as illustrated under design considerations of section 4.4.2. The design capacities and other relevant details are summarized in *Table* 5.31.

The required area for the treatment plant, as the short term feasibility project until the year 2005 is about 29 ha.

i) Inflow pump station

The inflow pump station of treatment plant consists of initial bar screen followed with the pump facilities.

Pump type : Vertical Axial Centrifuge Pump
The design hydraulic pump head: 6.9 m

ii) Stabilization pond treatment system

a) Facultative pond

Design treatment capacity is 11,000 m^3/d.
Design volume of ponds is 126,000 m^3.
(required surface area is determined based on allowable BOD loading)
Detention time : 11.5 day
Effective depth : 1.5 m
(with additional 0.5 m depth for digested sludge storage)
Effective dimension of ponds (4 No. ponds in parallel)
265 m(L) x 85 m(W) x 1.5 m(D) x 4
Side slope: 1: 2

b) Maturation pond

Design volume of ponds is 68,800 m^3.
Detention time : 6.3 day
Effective depth : 1.5 m
Effective dimension of ponds (8 sets in parallel)
80 m(L) x 42 m(W) x 1.5 m(D) x 8 sets x 2pond series
Side slope: 1: 2

c) Sludge lagoon

The quantity of desludging from facultative pond is determined considering an annual per capita sludge accumulation of 0.04 cu.m.

The total annual accumulation of sludge in facultative pond becomes 2,800 m^3/year.

Frequency of desludging: once in 2 years
Depth of sludge storage 2.0 m
Effective dimension: 20 m(L) x 30 m(W) x 2 m(D) x 3 ponds

The layout of treatment facilities designed is shown in *Fig*. 5.40.

4.5 Pilot Project

4.5.1 Project Components

In principle, about 60 to 90 households comprising about 300 to 500 people in one(1) to two (2) hectare is planned to be served with small modular system treating together both blackwater and graywater (SMS(B/G)). Wastewater from households are carried through sewer collection system to wastewater treatment plant.

Installation of small modular system (B/G) can be faster way in wastewater management, compared to large modular system or conventional sewerage system, though the service area is limited. The system looks attractive for wastewater management but is has not yet been introduced and demonstrated in Indonesia.

So the system introduction shall be first conducted as a pilot project. The result will be studied both technically and managerially including operation and maintenance aspects. If it could be well organized and operated successfully, introduction of a wider scale SMS(B/G) project could be promoted.

This system is planned as simple system for sanitation improvement. Accordingly, in principle, the system is designed without pump facility and septic tank as the treatment system. Service area and the site of treatment system are constrained to meet these conditions. In addition to the service area limitation of 2 ha, space of at least about 10 m x 20 m (200m2) for septic tank and drainage depth of at least 1 meter below ground level should be permissible near the space for the septic tank.

The above conditions are necessary to ensure a smooth gravitational flow throughout the system. Available sites to satisfy these conditions are very limited due to flat topography and low ground elevation of the priority area (old city of Ujung Pandang).

Accordingly six (6) potential sites are selected as follows (ref. *Fig.*5.22).

No	Treatmentsite	Treatment Process	Service Area (ha)	Served Household (No)	Kelurahan	Kecamatan
1	Field near canal	Septictank	1.2	77	SambungJawa	Mamajang
2	Puskesmas/Mardekaya	Septictank	1.3	92	Bara-Baraya Selatan	Makassar
3	SD / Kip Bara-Baraya II	Septictank	1.5	75	Bara-Baraya Timur	Makassar
4	SD / Neg. Bertingkat Tabaringan SD / Inp. Tabaingan	Septictank	1.8	62	Totake	Ujung Tanah
5	Field at harbor	Septictank	1.3	70	Gusung	Ujung Tanah
6	Tamang Safari	Package wastewater treatment plant (PWTP)	5.2	170	Losari	Ujung Pandang

It is noted that among six (6) sites, Losari site is planned with package wastewater treatment plant (PWTP) instead of septic tank. Losari is a high income residential area and the treatment plant is planned to be placed at Tamang Safari Park. The treated effluent (to a secondary treatment level) can be reused at the park for irrigation or other non portable uses.

It would serve as a good demonstration (advertisement) for not only wastewater treatment but also reuse of treated wastewater (integrated wastewater management).

It is also noted that due to the provision of PWTP, that requires elaborate management in comparison to septic tank, the service area is much larger (5.2 ha). Moreover, inflow pump facility is provided at the location of PWTP (Tamang Safari Park).

4.5.2 Design Considerations

(1) Wastewater treatment plant

1) Septic tank

Capacity of septic tank is calculated with following conditions.

Wastewater flow : 215 litter/capita/day
Sludge accumulation : 40 litter/capita/year
Retention time : 3 days at start up
Factor of sludge volume rate prior to desludging

: 1 / 3 of empty septic tank

Desludging interval : 5 years

Design procedure of septic tank is shown in *Table* 5.32.

The layout of typical septic tank is shown in *Fig.* 5.41.

2) Package wastewater treatment plant

The treated effluent(to a secondary treatment level) could be reused at the park for irrigation or other non portable uses. Accordingly, the following condition shall be wet.

Effluent water quality as BOD : 20 mg/l

(2) Collection system

In principle small scale sewer system at shallow depth is planned as collection system. If external loading is anticipated, reinforcement of pipes or installation of pipes at deeper depth shall be considered.

In general following conditions shall be met :

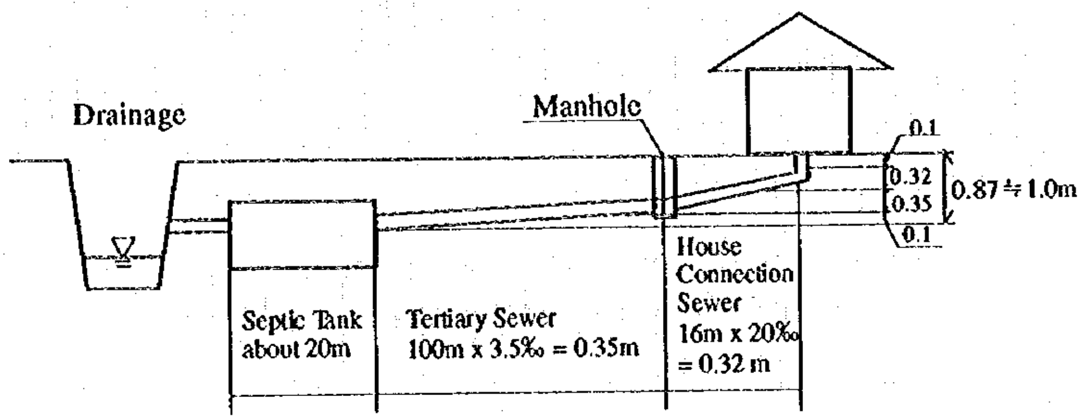
- Minimum diameter of sewer : 100 mm
- Minimum velocity in pipe : 0.6 m/sec
- Maximum velocity in pipe : 2 m/sec
- Maximum allowable head loss in the whole system : 1 m

However, in case of house connection sewer, in addition to the above, the following condition shall be met.

- Minimum slope : 2%
- Minimum earth covering depth : 10 cm

Moreover, manhole shall be installed at connection points of sewer or bending points.

Typical profile of the sewerage system (SMS (B/G)) is shown below.



The above typical profile assumes a service area of aobut one (1) to two (2) ha.

4.5.3 Design of facilities

The five (5) septic tank treatment based modular systems are Sambung Jawa, Bara-Baraya Selatan, Bara-Baraya Timur, Totake and Gusung. The package wastewater treatment plant (PWTP) based system is Losari.

Of these systems, the design layout and profil of the one (1) septic tank based system at Totake is shown in *Fig.* 5.42 and *Fig.* 5.43. The corresponding design procedure of septic tanks are shown in *Table* 5.32.

The layout of PWTP based system at Losari is shown in *Fig.* 5.44. The PWTP proposed is shown in *Fig.* 5.45.

4.5.4 Operation and Maintenance

Organization in charge of O/M(operation and maintenance) shall be ascertained with agreement before the implementation of this pilot project. Service charge of beneficiary, responsible organization for operation and maintenance shall be determined and agreement shall be contracted. The responsible organization for O/M may be the beneficiaries in cooperation with LKMD and/or NGO.

5 Cost Estimation

Cost estimation in this section elaborates the cost of master plan described in foregone Chapter 3 and the feasibility projects described in foregone Chapter 4.

It is to be noted that the cost of feasibility projects infact accounts for the initial ten (10) year (1996 ~ 2005) portion of the overall cost of the master plan.

5.1 Sanitation Improvement Project

Sanitation improvement projects of feasibility study as described in Section 4.3 are provision of basic sanitation for slum area and improvement of septage management. Construction cost due to both these projects would be borne by the public sector (Government). However, the cost of provision of individual sanitation system of septic tank/leaching pit would be borne by individual households.

The relevant estimations are determined below.

5.1.1 Basic sanitation for slum area

(1) Rehabilitation of malfunctioned public toilets (MCK)

Unit construction cost of public toilet is 5million Rp.

There are 59 malfunctioned public toilets to be repaired (ref. *Table* 5.1).
The unit repair cost is estimated at 10 % of the unit construction cost. Accordingly, total rehabilitation cost is as follows:
59 x 0.5 million/pc = 30 million Rp.

(2) Provision of new public toilets (MCK)

A total of 66 public toilets will be constructed (ref. *Table* 5.26). The total construction cost is as follows:
66 x 5 million Rp = 330 million Rp.

(3) Operation and maintenance cost

Appropriate organization is required for public toilets to maintain good function of the system. Construction and repair of the mentioned public toilets will be commenced after the organization system is ascertained.

The organization is responsible for both operation and maintenance(O/M) and collection of user charge. The cost of O/M include caretaker wage, desludging cost, repair cost and others. User charge would cover a portion of O/M cost. The remaining would be paid by public sector as a cross subsidy.

Typical O/M cost of an MCK(public toilet) and the relevant revenue from users, including the required contribution from public sector as O/M subsidy, are given below.

O/M cost	for caretaker(5am ~ 11pm)	= 150,000 Rp/month
	Key holder at night (11pm ~ 5am)	= 30,000 Rp/month
	Repair cost/desludging	= 10,000 Rp/month
	sub-total	= 190,000 Rp/month

Relevant revenue

Condition			
No. of users	20 households x 5.5 person/household = 110 person		
Fee charge	5 Rp/person/day		
Revenue	110 x 1 x 5	=	550 Rp/day
	550 Rp/day x 30	=	16,500 Rp/month
Balance		=	-173,500 Rp/month
		=	2 million Rp/year

Outlay of household			
	5.5 x 1 x 5	=	27.5 Rp/day/H.
	55 x 30	=	825 Rp/month/H.
		=	800 Rp/month/H.

The tariff of public toilet users is about 800 Rp/month/household. Such a tariff system is considered affordable for a typical slum household.

The subsidy of operation and maintenance for one (1) public toilet is 2million Rp/year/MCK.

Total number of public toilets is 270.

The required annual subsidy of operation and maintenance is 270 x 2 million/year/pc = 540 million Rp.

5.1.2 Improvement of septage management

(1) Procurement of vacuum trucks and desludging

The proposed procurement plan of vacuum trucks for improved desludging is described in Section 4.3.2.

Investment cost for the procurement of 20 vacuum trucks until the year 2002 is 1,540 million Rp.

Annual O/M cost that includes operation and maintenance including depreciation of vacuum trucks and personnel expenditure is 766 million Rp in 2005.

The breakdown of investment cost and O/M cost is shown in at *Table* 5.33.

(2) Improvement of access road to Antang STP

About 1.8 km length of the final access road to Antang STP requires improvement (ref. *Fig.* 5.30).

The unit construction cost of road improvement is 50,000 Rp./m^2

The cost of road improvement : 1800m length x 6m width x 50,000 Rp./m^2 = 540 million Rp.

(3) Adequate operation and maintenance at Antang STP

The level of staffing in the Antang septage treatment plant (STP) at present, is very inadequate for effective O/M of the STP. About 8 staff including director, workers and security personnel are proposed for proper O/M of Antang STP. The annual O/M cost of 766 million Rp in 2005, mentioned above, includes this personnel requirement of Antang STP.

5.1.3 Individual sanitation system

Present simple sanitation system of an individual household is septic tank and leaching pit. Newly developing households will continue to install such simple systems by themselves.

In fact, such cost of sanitation system could be considered as a portion of housing development cost.

The unit cost of sanitation system is given below.

facility	Unit cost (Rp)
Septic tank (for 1 household)	250,000
Leaching pit (for 1 household)	200,000
Septic tank with leaching bed (for 1 household)	400,000
Toilet room (1 household)	350,000

5.2 Sewerage Development Project

5.2.1 Basis of cost estimation

Based on the facility plans, the project costs are estimated under the following condition.

(1) All base costs are expressed under the economic conditions that prevailed in August, 1995.

(2) Overhead is assumed at 20 % of the total cost of equipment and civil works and incorporated in the direct construction cost.

(3) Engineering service and administration costs are assumed respectively at 12 % and 2 % of the total direct construction cost.

5.2.2 Unit construction cost

There are three items of unit construction cost concerning the sewerage development projects, namely, sewer network, pump station and treatment plant. These unit costs are delineated below.

(1) Cost of sewer network

Unit construction cost of collection sewer is shown in *Table* 5.34.

Breakdown of this unit construction cost is shown in *Table* 5.35. There are four types of Tables expressing this breakdown of unit collection sewer construction cost per meter.

Table 5.35(1) shows the unit cost breakdown of RC pipe with diameter in the range of 350mm and 2200mm. *Table* 5.35(2) shows that of PVC pipe with diameter in the range of 100mm and 300mm. These unit cost breakdown are for a sewer laid under paved road with an earth covering depth of 3m.

Table 5.35(3) also shows the unit cost breakdown for PVC pipe similar to *Table* 5.35(2), but cheaper than the former one, as the sewer is laid at household area where ground surface is not much paved. In this project 50 % of the sewer length is considered to be laid under unpaved area.

Table 5.35(4) also shows the unit cost breakdown for PVC pipe, but is much more cheaper than that of *Table* 5.35 (3) . This sewer is for house connection with and average earth covering depth of 0.5 meter and 50 % of which is considered to be laid under unpaved area.

Unit pipelaying cost of house connection sewer and tertiary/secondary sewer is estimated on a per hectare basis. This estimation is made based on typical house connection sewer installation at 6 model sites using the above unit cost shown in *Table* 5.34.

The estimated unit pipe laying cost in the six (6) model areas is shown in *Table* 5.36.

It is noted that there are three kinds of sewer systems, namely, ordinary collection system, small scale collection system and interceptor system used in this project.

The summary of unit costs of ordinary collection system and small scale collection system as extracted from *Table* 5.36 are shown below.

unit : million Rp/ha.

	House connection sewer	Tertiary/secondary sewer	Total
Ordinary collection system	36	64	100
Small scale collection system	23	40	63

It is also noted that the unit cost of interceptor system is the cost of tertiary/secondary sewer without house connection sewer.

(2) Pump station

Unit construction cost of pump station used in the sewer collection network is estimated based on the formula shown below.

$C = 10^{2.286} \times Q^{0.64}$

C : Typical pump station construction cost (million Rp)

Q : Design flow (m^3/min.)

(3) Treatment plant

Unit construction cost of the treatment plant includes the inflow pump facility in addition to treatment facility.

Unit construction cost of secondary treatment process is estimated based on the following formula.

$C = 10^{C1} \times Q^{C2}$

C : Typical unit construction cost (million Rp)

Q : Design flow (1,000 m^3/day)

Process		Stabilization pond	Aerated lagoon	Oxidation ditch	Activated sludge
Coefficient	C1	2.2	2.7	3.2	3.4
	C2	0.9	0.8	0.75	0.7

Source : Previous JICA studies in Indonesia

5.2.3 Construction cost

The total construction cost of sewerage development projects of feasibility study (2005) and Master Plan (2015) is estimated below. Sewerage development cost of master plan is the summation of feasibility project cost and the additional sewerage project cost incurred during 2006 ~2015.

(1) F/S construction cost

The project components are northern sewerage system, central sewerage system and southern sewerage system (ref. *Fig.* 5.31, *Fig.* 5.34 and *Fig.* 5.38). The cost of relevant project components are delineated below.

1) House connection sewer and tertiary/secondary sewer

Total construction cost of house connection sewer and tertiary/secondary sewer becomes 12,184 million Rp. and 26,832 million Rp., respectively.

The cost breakdown is shown in *Table* 5.37 (1).

2) Main sewer

Total construction cost of main sewer becomes 9,369 million Rp.

The cost breakdown is shown in *Table* 5.38 (1).

3) Pump station

Total construction cost of pump station at Karuwisi Utara becomes 1,939 million Rp.

This pump construction cost is estimated using M/P design flow, as the M/P design flow is only slightly higher than F/S design flow. (M/P and F/S design flows are 36.7m3/min and 35.9 m3/min respectively.)

The cost breakdown is shown in *Table* 5.39.

4) Treatment plant

Total construction cost of all three (3) treatment plants becomes 5,359 million Rp.

The cost breakdown is shown in *Table* 5.40.

5) Land acquisition cost

Total land acquisition cost becomes 8,160 million Rp.

The cost breakdown is shown in *Table* 5.41.

6) Total construction cost

The total construction cost of sewerage development project becomes 71,639 million Rp (feasibility project).

The cost breakdown is shown in *Table* 5.42

(2) M/P construction cost

The sewerage development plan of Master Plan has three (3) independent conventional sewerage systems (CSS) with their treatment plants at Pampang (northern area), Maccini Sombala (southern area) and Gunung Sari (south eastern area). The cost is delineated below.

1) House connection sewer and tertiary/secondary sewer

Total construction cost of house connection sewer and tertiary/secondary sewer is 124,911 million Rp. and 231,104 million Rp., respectively.

The cost breakdown is shown in *Table* 5.37.

2) Main sewer

Total construction cost of main sewer becomes 43,644 million Rp.

The cost breakdown is shown in *Table* 5.38.