CHAPTER 4: DEVELOPMENT STRATEGY FOR KAMPOT

4.1 Issues in the Present Conditions of Kampot

4.1.1 Socio Economic Condition

According to the 2008 Census, the total population in the Kampot province was 585,850, of which only 8.2% of population was living in urban area. Population density of the province was 120/km^2, which was considerably higher than the national average of 56/km^2. In Kampot, 36.4% of the population (225,039) was under 15 years of age. Working age population (age between 15 and 64) was 377,315 or 61.0% of the population.

Labor force participation rate[1] of Kampot (81.5%) in 2008 was higher than that of the national average (76.9%) and the Study area average (76.4%). About 85% of labor force in the province was engaged in agriculture. The high labor force participation rate in Kampot is considered to be a result from extensive self-employed agricultural activities. The economically active segment of the population (employed population + unemployed population) was 309,098, which accounted for 49.9% of the total population in the province.

Population of the Kampot province has increased by 1.0% per annum between 1998 and 2008. During the same period, the number of labor force in the Study area has increased more rapidly from 230,411 to 309,093 with annual average increase rate of 3.0%.

Table 4.1.1 Change in Population and Number of Labor Force in Kampot Province

	Population			Labor Force
	Urban	Rural	Total	
1998 Census	45,240	483,165	528,405	230,411
2008 Census	48,274	537,576	585,850	309,093
Annual Growth Rate (98-08)	0.7%	1.1%	1.0%	3.0%

Source: CENSUS 1998 and 2008, NIS

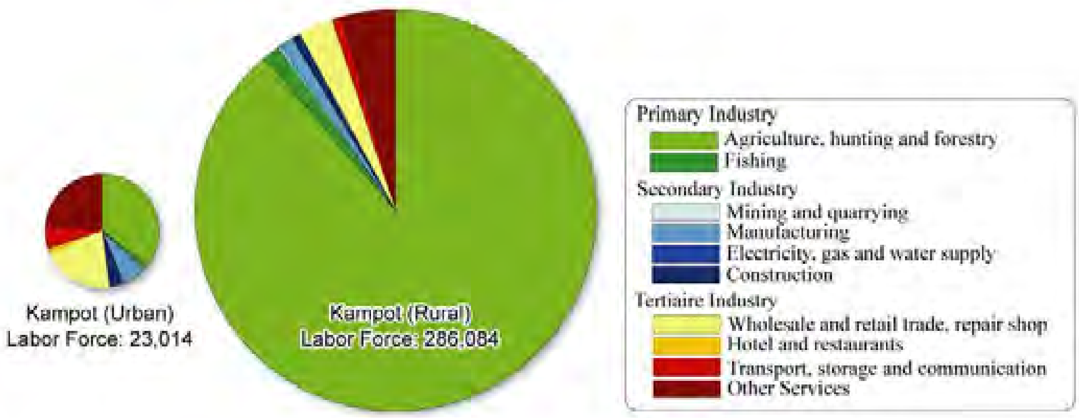
Such a rapid increase in labor force was attributed to 4 main factors; namely 1) increase in the total population, 2) increase in the percentage of working age population to total population (51.6% -> 61.0%), 3) increase in the labor force participation rate (75.4% -> 81.5%), and 4) decrease in the crude unemployment rate (3.7% -> 1.4%).

Figure 4.1.1 illustrates labor force of the urban and rural areas of Kampot provinces by industry in 1998. The size of the circle indicates the relative size of labor force. The agriculture sector plays a vital roll in the Study area, which absorb 88.7% of labor force in rural area and 84.7% of the total

[1] Labor force participation rate refer to the ratio of labor for aged more than 15 to the total population of the same age group.

labor force in the province. When fishery sector is added, labor force engaged in the primary sector occupied 90.0% of labor force in the province.

The secondary and tertiary industry absorbed only 2.7% and 11.2% of labor force of the province, respectively. In the urban area of the province, tertiary sector absorbed a majority of labor force (52.2%). However, even in the urban area, secondary sector absorbed laboronly in selected locations with factories, secondary sector's labor force accounted only for 11.1% of the total labor force. Labor force of wearing apparel sector (1,491) and that of food products sector (1,219) occupied 31.0% and 25.3% of the total manufacturing sector's labor force in the province (4,809). Manufacture of furniture (325), manufacture of non-metallic mineral products (439), and manufacture of wood and wood products (288) were absorbed relatively many labor force.



Source: 2008 Population Census, NIS

Figure 4.1.1 Labor Force of Urban and Rural Area of Kampot Province, by Industry in 2008

4.1.2 Urban Planning

(1) Early History of Kampot

The town of Kampot appeared in historical documents as early as in the latter part of 18th century, but the growth of Kampot came during the French era, when Kampot became one of the regional administrative centers for the coastal area, and a colonial resort.

In 1889, the French started the construction of buildings for their *Résidence*, or settlement. Installation of the *Résidence* and the new route to Phnom-Penh stimulated urban growth of Kampot in the first decade of 1900's. In 1905, a new market was built. The boulevard of the urban center was accomplished and connected to the Route of Phnom Penh–Kampot in February 1907. Thus the present shape of Kampot city was completed in those days.

(2) Kampot City Today

Today the city houses the provincial hall of Kampot Province. Still the colonial style architecture are widely seen in the central part of the city. Kampot City is located on the Kampot river bank, and is served by NR No.3, about 200 km from Phnom Penh. Also, Kampot City is close to the Vietnamese border along the coast served by NR No. 33 and 31.

Source: Kampot Province

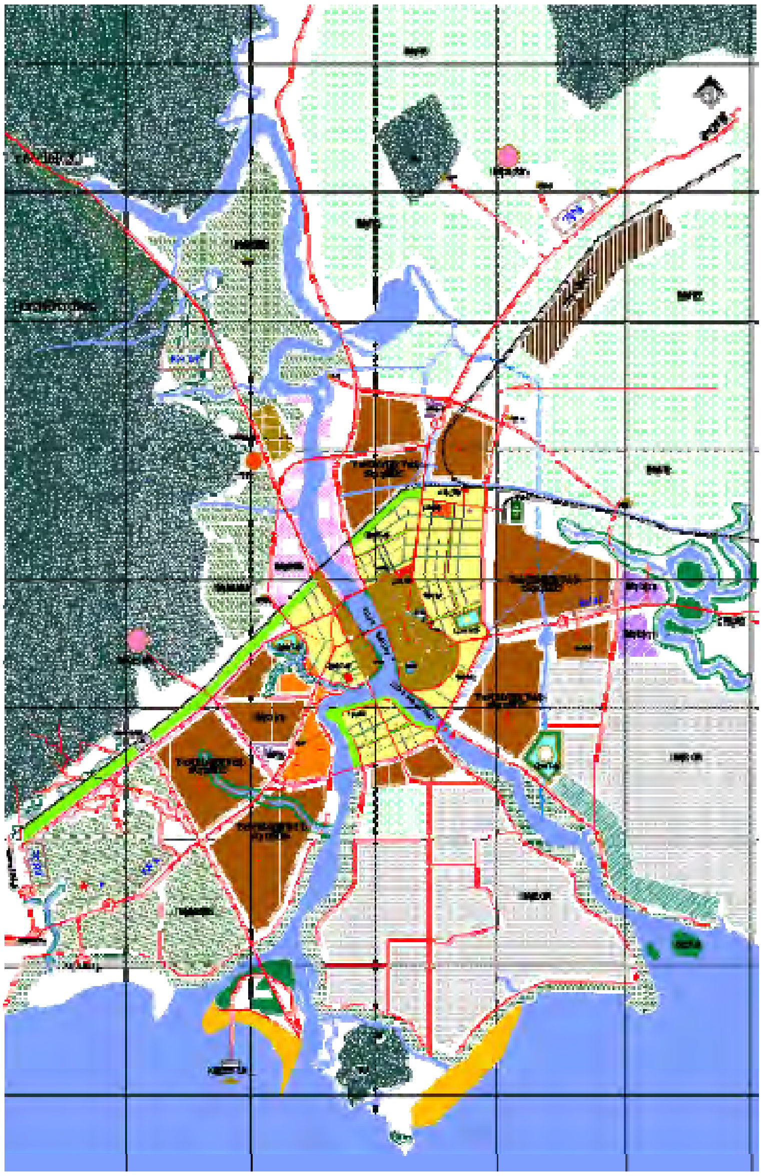
Figure 4.1.2 Central part of Kampot City and the Old Buildings form the French Era

(3) Master Plan Efforts for Kampot DLMUPCC[2]

Kampot became the provincial capital city after the independence of Cambodia, but the atmosphere as a resort town continues to date. Also, because of the history, the city of Kampot has a lot of historical architecture mostly within the old city area near the river.

In 1992, DLMUPCC of Kampot Province has formulated a draft master plan for the Kampot City with GTZ assistance, as shown in Figure 4.1.3.

2 A power point document prepared by DMLUPC of Kampot is referenced.



Source: Kampot Province

Figure 4.1.3 Draft Urban Master Plan by DLMUPCC

The land use contains two categories, land use before 2015 and after 2015.

Proposed Plan Before 2015 are the following.

- Existing urban area - Green space area
- Light industry area - Farming area
- Recreation area - Commercial zone
- Salt evaporator - Dumping area

- Water treatment area
- Complex residential development area
- New stadium
- Proposed Plan After 2015 include the following.:
- Industrial area
- Tourist port
- High building - Proposed residential development area

Based on the draft Master Plan, DLMUPCC have started the renovation project in the city center as following;

- Moving provincial traffic circle to the center of ax

Source: DLMUPCC Kampot

Figure 4.1.4 Image of Renovated Provincial Traffic Circle

- Improvement Project for the East Side of Kampot River

Source: DLMUPCC Kampot

Figure 4.1.5 Image of Improved East Side of Kampot River

(4) Issues in Urban Planning for Kampot

1) Segmented city center by river

Kampot city is divided into three parts by Kampot River. The city center is located east bank of the river, but urban area is spreading out its area into other parts. Existing bridges across the river are only three. Two of these bridges are deteriorated temporary structure. Connectivity of three areas is weakness of its urbanization.

2) Sprawl along national road no.3 & 33

Urbanized area of Kampot city is sprawling along road radiating outward from the city center. The resource for infrastructure development is limited to follow uncontrolled urbanization. Compact urbanization is important for Kampot city.

3) Irruption of through traffic into city center

The old city area located on the eastern bank of the Kampot River is expanding on the outskirts, and beyond the river to the western bank of the river. However, there are only two bridges across the river; one is newly constructed but the other is quite old and decrepit, and cannot be used by heavy vehicles. Strengthen the road network is important in the urban planning of Kampot city.

Because of the network, all regional traffic passes in the city center of Kampot from/to Phnom Penh, Preah Sihanouk, Kep and Kampong Trach causing a serious problem in the city center.

New route of NR3 is passing next to the city market and traffic to/from NR33 is mixed into the city center. Detour route is necessary for the safety of the city center.

DLMUPCC of Kampot Province has been trying to upgrade the road network of Master Plan, but in an effort to evade resettlement, the planned detour route of NR3 is twisting and turning.

4) Protection of historical architecture

Historical architecture of the French coronial era characterizes the townscape of the city. Conservation and utilization of the historical buildings is essential for tourism development of the city.

4.1.3 Infrastructure

(1) Road Network

1) Delay of road rehabilitation

In Kampot province, a few road rehabilitation projects either have been implemented and are planned. But the progress of the rehabilitation projects have be delayed from the schedule. NR3 is substantially deteriorated and is often not used for going form Kampot to Phnom Penh because it takes more time to travel in comparison with other roads.

The rehabilitation of a part of NR3, NR31 and NR33 have been delayed and the road surface has been deteriorated. At last, they have been commenced in 2009 and will be completed in 2012.

Table 4.1.2 Rehabilitation Projects for the Southern Coastal Corridor

No.	Route Description	Cost (USD million)	Financial Source	Status
1	NR. 3 (Veal Renh – Trapang Ropaou) : 32.5 km	6.50	World Bank	Completed (in 2004)
2	NR. 3 (Trapang Ropao – Kompot) : 33.0 km	21.30	Korean Loan	Completed (in 2007)
3	NR. 3 (Kompot – Chaoam Chav) : 137.5 km	41.88	Korean Loan	Started (up to 2011)
4	NR. 31 (Thnol Bek Kus－Kompong Track), NR. 33 (Kompong Trach－Kampot) and Kampot City Detour (Kanthor－Ton Hon) : 97.0 km	30	Korean Loan	Planed to complete in 2012
5	NR. 33 (Kompong Trach – Lork : 16.0 km and Cross Border Facilities (Koh Kong (Cham Yeam) and Lork (Prek Chak)	18.7	Asian Development Bank	Planed to complete in 2012

Source: JICA Study Team, Kingdom of Cambodia Ministry of Public Works and Transport and Overview on Transport Infrastructure Sectors in the Kingdom of Cambodia

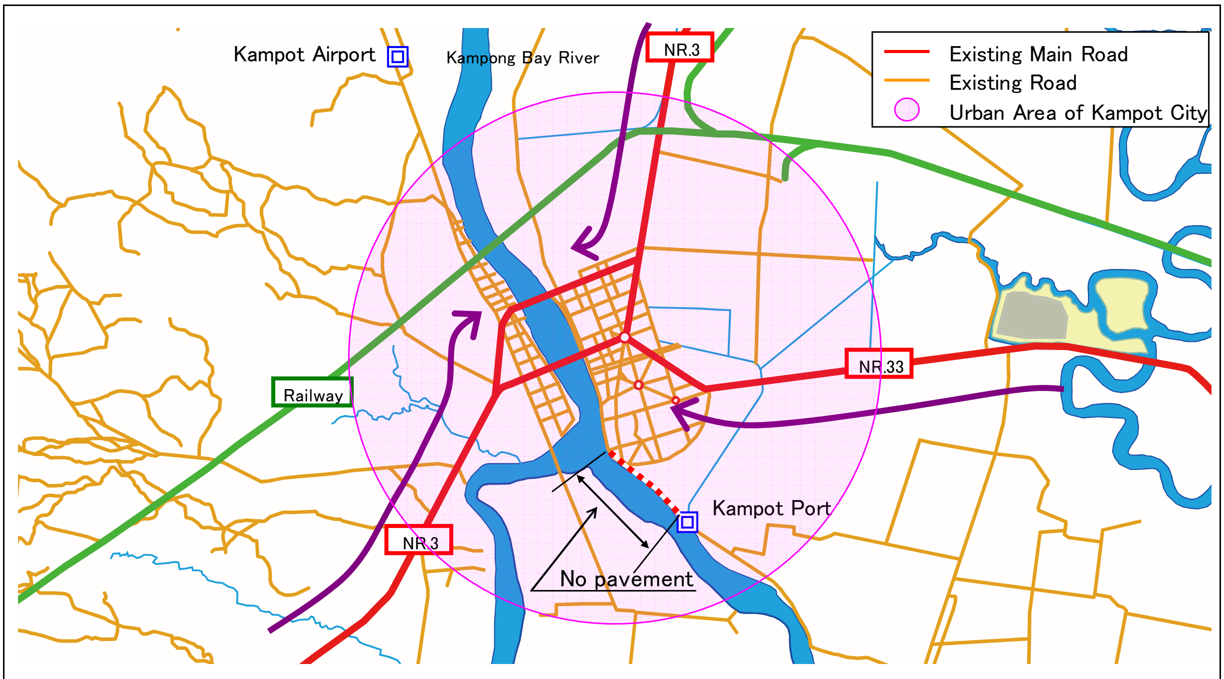
Table 4.1.3 Present Road Condition of NR.3, NR.33

		
Road Condition of NR.3 (Sameakki – Tuek Lak)	Road Condition of NR. 33	Road Condition of NR. 3 (near Kampot City)

Source: JICA Study Team

2) No pavement of the access road to Kampot port and small space for truck parking

At present, the access road to Kampot port is not paved despite the traffic of heavy vehicles. The road is very narrow and truck parking is too small. Main commodity is sugar dealt with in Kampot port. Heavy vehicles frequently come to Kampot port in order to bring sugar or other foods to the border of Vietnam. An efficient road network also has not been developed from Kampot port. Considering the present road situation around Kampot port, the improvement of the access road is needed. The situation of truck parking of Kampot port is shown below.



Source: JICA Study Team

Figure 4.1.6 Existing Road Network (Kampot City)

Table 4.1.4 Present Condition Kampot Port and Parking Space

		
Parking Space in front of Port (1)	Parking Space in front of Port (2)	Parking Space in front of Port (3)
		
Parking Space in front of Port (4)	Parking Space in front of Port (5)	Access Road to Port

Source: JICA Study Team

3) No provision of an efficient road network in Kampot City

Kampot city is located at the junction for three routes, NR3 (from Phnom Penh to Kampot), NR3 (from Preah Sihanouk to Kampot) and NR33 (from Kep to Kampot). Though three routes come into Kampot city, all vehicles have to pass through the center of the city. The road network in Kampot city is not suitable for heavy vehicles. Kampot city is devided by Kampong Bay River and thre is only one bridge for all vehicles to be able to pass through. Though there is one more bridge, it is too old and deteriorated and there is restriction for vehicle to over the bridge. The old bridge has not functioned as a part of the road network in Kampot city. If a road network is prepared around Kampot City, there is possibility for Kampot City to be bottle neck in the future traffic fllow.

Source: JICA Study Team

Figure 4.1.7 Non Networked Existing Road around Kampot City

Table 4.1.5 Present Condition of Old Bridge in Kampot City

		
Old Bridge Photo 1	Old Bridge Photo 2	Old Bridge Photo 3 (Traffic Control for Heavy Vehicles)
		
Old Bridge Photo 4 (Deteriorated Sidewalk)	Bridge Photo 5 (Deteriorated Sidewalk)	Bridge Photo 6 (Wooden Sue: temporary)

Source: JICA Study Team

(2) Railway

Though a signaling system and a level crossing are indispensable for a safe railway system, the provision of these facilities has not planned in any development project. Even if the rahabilitation projects of railway is completed, the lack of safety facilities will remain in the railway system.

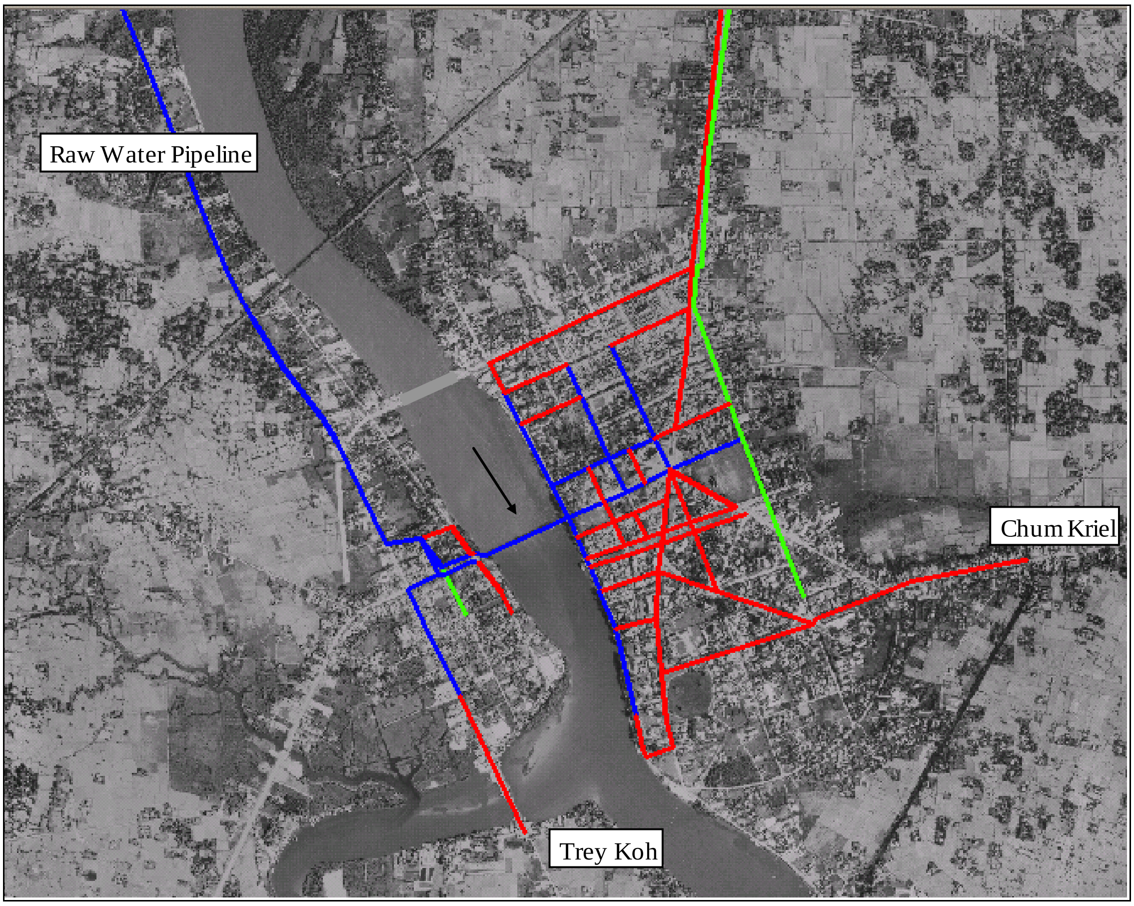
It is needed that the procurement of a signaling system and a level crossing should be discussed and implemented.

4.1.4 Water Supply

(1) Existing Condition

1) Service Area

The Kampot water system supplies approximately 18,320 customers within the urban boundaries of Kampong Bay district. The service extent of the distribution network is shown in Figure 4.1.8.



Source: JICA Study Team

Figure 4.1.8 Existing Water Supply Network

The water supply authority is currently extending the network to the east along NR33 to service the village of Chum Kriel. This project is being funded in part by the AIMF (Association Internationale des Municipalités Francophones)

Water supply on the west bank extends to the Fish Island to fill a small cistern serving villagers living in Trey Koh commune.

2) Supply

Kampot obtains its water supply from Tek Chhou River which originates in the Bokor Mountains. Table 4.1.6 summarizes the Kampot water supply sources.

Table 4.1.6 Existing Water Supply Sources

Source name	Capacity (m3/day)	Annual Production Potential(1) (MCM)
Tek Chou River	5,875	1.93

Note: (1) Based on 90% capacity factor for the raw water pump station (10% allowance for down time)
Source: JICA Study Team

There is no information on the available safe yield of the River. A dam is being constructed about 5 km upstream by Sinohydro but details are unavailable. It is not clear what impact the dam will have on downstream flows however the reservoir upstream of the dam could provide a reliable source of water for the city.

3) Treatment

The city's water treatment plant, built in the 1950s, was last refurbished in 2003-04 under the ADB Towns Improvement Project. The treatment plant is located near the old bridge on the west bank of the river.

The treatment plant is a conventional filtration plant with a design capacity of 5,750 m3/day.

The plant has 4 rapid sand filter cells with an air scour backwash system. The plant is also equipped with initial chlorine injection and chemical flocculation with small mixing basins prior to filtration.

4) Storage

Kampot has two ground storage reservoirs an done elevated tank providing a total capacity of 1410 cubic meters.

Table 4.1.7 summarizes information related to these facilities. Reservoir # 3 is located in close proximity to the public water treatment but at a lower ground elevation.

Table 4.1.7 Storage Facilities

Name	Location	Capacity (m3)	Elevations (m)
Reservoir #1	Ground level storage at treatment plant	460	8.8
Reservoir #2	Ground level storage at treatment plant	500	8.8
Reservoir #3	Elevated storage tank at treatment plant	450	29
	TOTAL	1,410	

Source: JICA Study Team

5) Transmission and distribution mains

<u>Pipe classification</u>

Transmission mains are larger diameter pipes that carry water between major components of the water supply system. They include raw water mains from the source to the treatment plant, and treated water mains from the treatment plant to service reservoirs and booster stations.

Distribution mains are smaller in diameter than transmission mains and distribute water to service reservoirs and booster pump stations.

Reticulation mains are the smaller diameter pipes that serve individual customer areas.

Raw Water Transmission

Raw water for the public water treatment plant is pumped from the Tek Chhou River to a grit chamber located at the treatment plant. The raw water pumping station was refurbished in 2003 under the ADB Provincial Towns Improvement Project. It is equipped with 3 pumps (1 standby) with discharge capacity of 34 liter/sec and pumping head of 37 m. A new 8.1 km raw water main (350 mm diameter ductile iron) was also constructed in 2003.

Treated Water Transmission

Treated water is pumped into the distribution system from a pump station located at the treatment plant. The pumps are controlled by pre-set timers and water levels in the ground storage reservoirs and elevated tank.

The pumping station is equipped with 3 pumps (1 standby) rated 34 liter/sec with a pumping head of 45 m. The distribution pumps can provide a peak flow of 245 m3/ hour.

The transmission main is connected to the elevated tank which effectively floats on the system, filling up during low demand periods. The transmission main crosses the River along the old bridge to supply the center core of the City.

Distribution

The Kampot water distribution system includes pipelines from 63 mm to 250 mm in diameter, totaling approximately 20,000 linear meters of pipe. These are summarized by type of material in Table 4.1.8.

Table 4.1.8 Summary of Distribution Piping

Material	Length (m)	Age (years)
DI	2,888	6
HDPE	2,760	5
AC	14,375	58
Total	20,023	

Source: JICA Study Team

The distribution system is supplied by the distribution pumping station at the treatment plant and by gravity from the elevated reservoir when the distribution pumps are off.

(2) Water Demand

Detailed explanation for the water demand projection is given in Appendix attached at the end of Book II report. The following is the summary of the projection.

1) Population forecast

The urban population in Kampot province is growing at a relatively slow pace. The urban population has grown from 45,240 in 1998 to 48,310 in 2008, an increase of 0.7% percent per annum. Future growth is expected to be stronger and will occur mainly to the East along

NR3 and North of the urban center. This study estimates that the urban population will be 57,200 by the year 2030. Population history and projections for Kampot are shown in Table 4.1.9.

Table 4.1.9 Population History and Projections

Year	Urban Population
1998	45,240 [a]
2008	48,310 [a]/ 32,300 [b]
2020	43,700 [b]
2030	57,200 [b]

Source: a : Census for whole of Kampot Province
b : JICA study team estimates, October 2009

2) Population served by the water supply system

The water supply system serves 57% of the urban population (2008).

The GOC's millennium goal is to provide service to 80% of the urban population by the year 2015. This goal is considered unachievable in Kampot because there isn't enough time to implement the infrastructure required. This planning study will assume a more realistic implementation scenario whereby service coverage will increase gradually to 80% by the year 2030.

Domestic water use per capita in Kampot is similar to that found in other coastal towns in Southeast Asia therefore appears to be reasonable.

Domestic per capita water demands used for planning in this study are indicated in Table 4.1.10:

Table 4.1.10 Domestic Water Demand

Year	Domestic Consumption (liter per person per day)
2020	140
2030	150

Source: JICA Study Team

These values are the same as those adopted by the water supply authority in Kampot and are consistent with unit water consumption values adopted for planning in Vietnam and other Southeast Asian countries.

Per capita consumption is assumed to increase over time to reflect an improved living standard and improved service levels.

3) Commercial and Institutional Water Consumption

There is at present no single large consumer of water and the water supply estimates that the commercial/institutional demand is quite small. The tourism industry consists of a few small guesthouses scattered throughout the urban area. The town has a strong tourism potential with a good selection of local attractions but will never be a resort destination. This study adds a moderate factor of 15% to the domestic demand as an allowance for future increases in the commercial and institutional demand.

4) Industrial demand

There is no industrial demand and this study does not foresee the development of any large industries within the urban area that would impose a unusual demand on water supply.

5) Unaccounted for Water

Unaccounted for water (UFW) represents the difference between "net production" (volume of water delivered into a network) and "consumption" (the volume of water that can be accounted for by legitimate consumption, whether metered or not). UFW falls into two categories:

i. Non physical Loss which is water consumed but not recorded by the consumer's meters or otherwise accounted for by government or other public use. It is reflected as a loss of revenue. It includes water consumed through illegal connections.

ii. Physical loss which is water lost through leakage

The current (2008) figure for UFW in Kampot is 31% which is normal relative to the average value of 28% reported in a survey of 40 utilities in Southeast Asia (SEAWUN 2005). It is assumed that most of the UFW is due to leakage in the old asbestos cement pipes. The percentage of UFW water is expected to decrease when the old pipes are replaced. This study assumes a typical planning value of 20%.

6) Peaking Factors

Water use varies with the time of year and the time of day. To account for these variations, peaking factors are commonly used in evaluating water system operating characteristics. Peaking factors are multipliers that are applied to the average day demand to approximate other peak water demands. Peaking factors are often estimated because of the lack of detailed water use data. Peak water demands and associated peaking factors that are important in evaluating water system performance are discussed below.

The average day demand (ADD) is the total volume of water used during a year divided by 365 days, usually expressed in terms of cubic meters per day (m3/day). In order to estimate future demands based on population growth, ADD is also expressed in terms of liters per capita per day (lpcd). Peaking factors are applied to the ADD to estimate the other peak demands.

The maximum day demand (MDD) is the highest daily water use rate during the year. The MDD peaking factor is the ratio of MDD to ADD and normally occurs during the dry season. Records maintained by the Sihanoukville water supply authority indicate a MDD factor of 1.25.

The peak hour flow (PHF) is the highest hourly water use rate during the day. The hourly peaking factor is the ratio of PHF to ADD. This factor is usually estimated based on engineering judgment, since it is difficult to determine the actual maximum hour demand in the system. The water supply authority in Kampot and Phnom Penh have adopted a MHD peaking factor of 1.8 and this is considered appropriate for planning purposes..

7) Water Demands for Existing and future conditions

For the purposes this study, water demands for the existing and future conditions are defined as shown in Table 4.1.11.

Table 4.1.11 Water demands for existing and future conditions

Parameter	Units	2008	2020	2030
Population		18,382	30,970	51,644
Domestic Demand	lpcd	121	140	150
	m3/day	2,224	4,336	7,747
	m3/hour	93	181	323
Tourism/commercial demand	multiplier	0.15	0.15	0.15
	m3/day	Included in domestic demand-	650	1,162
	m3/hour		27	48
Leakage	ratio	31%	20%	20%
	m3/day	684	997	1,782
	m3/hour	29	42	74
Average Day Demand	m3/day	3,213	5,983	10,690
	m3/hour	134	249	445
Maximum Day Demand	multiplier	1.25	1.25	1.25
	m3/day	4,404	7,479	13,363
	m3/hour	184	312	557
Maximum Hour Demand	multiplier	1.80	1.80	1.80
	m3/hour	330	561	1,002
	liter/sec	92	156	278
Total Annual Demand	million m3	1.2	2.3	4.1

Source: JICA Study Team

(3) Evaluation

1) Supply Capacity

Criteria

The water system source should have the ability to:

i. meet the maximum day demand, and

ii. provide one year's supply of water.

These criteria are used to evaluate the adequacy of Kampot’s water supply.

Existing and Future Conditions

Table 4.1.12 summarizes the evaluation of Kampot’s water supply for existing and future conditions under the criteria described above.

Table 4.1.12 Summary of Maximum Day Treatment Capacity Evaluation

m^3/day	2008	2020	2030
Maximum Day Demand [1]	4,624	7,853	14,031
Total Current Supply [2]	5,760	5,760	5,760
Surplus (+) / Shortage (-)	1,136	(-2,093)	(-8,271)

[1] maximum day demand + 5% for treatment plant losses
[2] based on treatment plant capacity

Table 4.1.12 is presented graphically in Figure 4.1.9.

Conclusions and Recommendations

Kampot's current water supply will meet the maximum day demand until the year 2015. Kampot will need an additional 8,000 m3/day to meet the maximum day demand in the year 2030.

It is recommended that 5,000 m3/day of additional treatment capacity be provided by the year 2015. This will meet maximum day demands until the year 2025 when a second 5,000 m3/day expansion will be required.

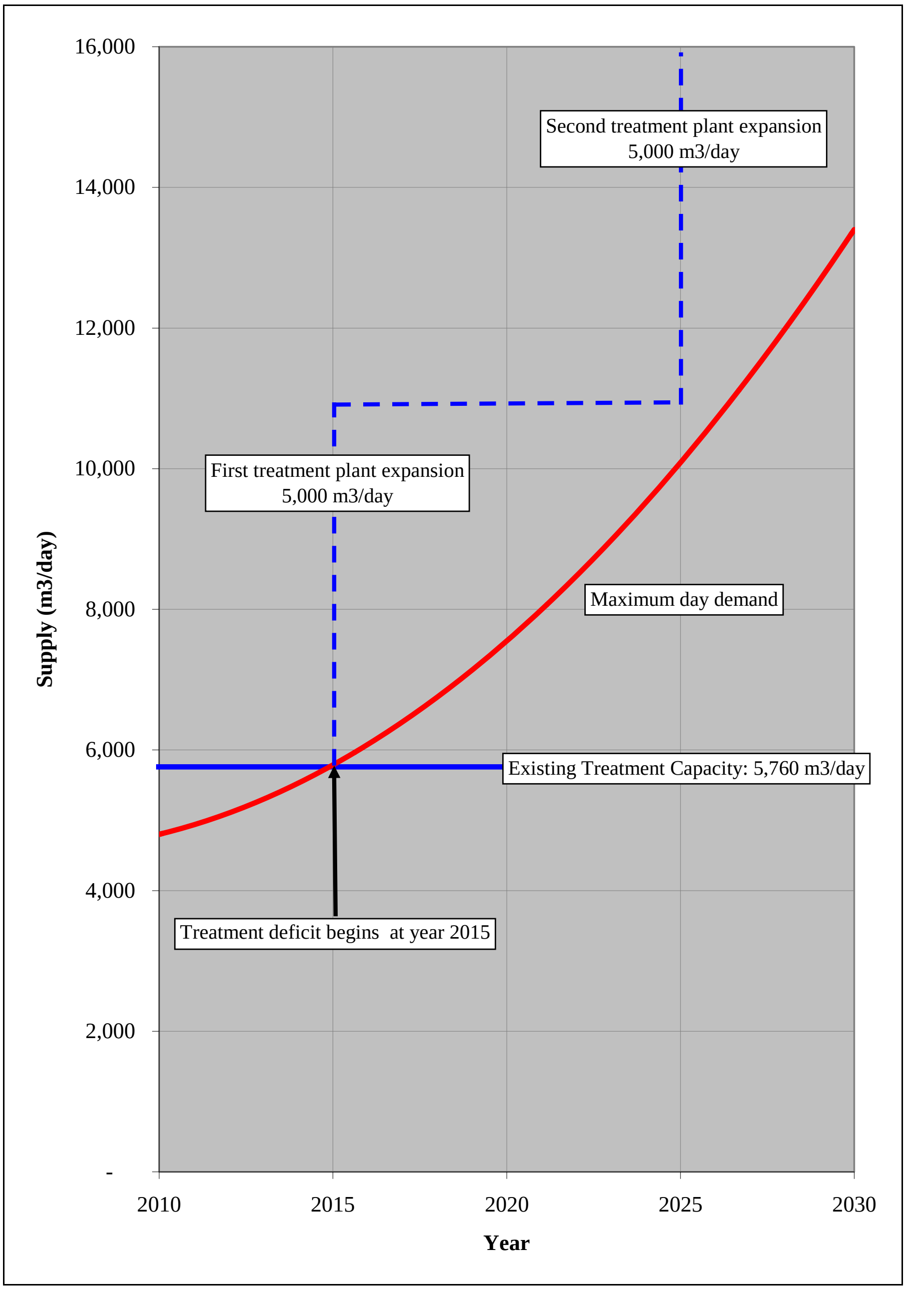
Kampot should begin now to identify and evaluate options to increase its daily water supply capacity. In general, Kampot could increase its water supply by one or more of the following:

i. Increasing treatment capacity at the existing treatment plant and augmenting conveyance capacity for raw water.

ii. Conveying raw water to a new public treatment plant strategically located near the source with sufficient space for future expansions.

Kampot city can easily find a site for a new treatment plant somewhere along the route of the existing raw water pipeline which is sparsely populated.

The demand forecast indicates an annual water resources requirement of 2.2 MCM by the year 2020 and 3.9 MCM by the year 2030. This study assumes that the river can supply this amount with a reliability of more than 90%. However a hydro power development in the upstream catchment may affect the amounts available for abstraction downstream. Raw water should be taken from the reservoir to supply the city's water needs. Details of the hydro scheme, size of reservoir and intended use are not public at this time and must be confirmed before proceeding with water supply improvements.



Source: JICA Study Team

Figure 4.1.9 Maximum Day Demand vs. Supply

2) Treatment

<u>Evaluation</u>

The evaluation of the City's public water treatment plant is based on information provided by City staff. The plant was rehabilitated in 2003-04, is generally in good condition and has historically operated as designed. There are no problems to report except that raw water quality is affected by construction of hydro dam.

Conclusions and Recommendations

The electro-mechanical equipment at the treatment plant is relatively new and in good condition and should not need to be replaced until the year 2020. The plant can probably continue to operate beyond 2020 with suitable program of preventive maintenance, annual repairs and eventual replacement of electro-mechanical equipment.

3) Raw water intake and transmission

The raw water intake is located just upstream of the Tek Chou rapids. The difference in elevation between tidal back water and upstream water levels is relatively small and the water supply authority indicates that it is possible for salt water to intrude under certain conditions.

Raw water pumps and transmission pipeline are matched to the capacity of the existing treatment plant. Any expansion of treatment capacity will require the additional pumping and transmission facilities. The existing pup house does not have space for future expansion.

4) Storage

Criteria

Water systems including those in developing countries are normally required to have storage facilities sufficient to provide:

i. operational storage,

ii. fire suppression storage and

iii. emergency storage.

Operational Storage.

Operational storage is the volume of water needed to supply the system for periods when demands exceed the supply. Storage is usually sized on the basis of a 24 demand fluctuation curve which in most systems works out to be 5-6 hours of supply at maximum day. In the absence of data the rule of thumb is to provide 20-30% of the maximum day demand for gravity fed scheme and 15% for a pump supplied scheme.

Fire Suppression Storage.

Fire suppression storage is the volume of water needed to provide a required fire flow for specified period of time. There is currently no standard or regulatory requirement for fire suppression storage in Cambodia. The guideline in Vietnam is to provide a minimum of 250 m3 at each storage reservoir for fire fighting. JICA's design standards for water supply facilities requires a minimum amount of water based on population as indicated in Table 4.1.13.

Table 4.1.13 Fire-fighting Storage Requirements

Population (10,000 persons)	Amount of water for firefighting (m3)
1	100
2	200
3	300
4	350
5	400

Source: JICA Study Team

Fire suppression storage for planning purposes will be based on JICA's standard.

Emergency Storage

Emergency storage is the volume of water required to meet water demand during an emergency situation.

An emergency storage volume of at least 1 day at the maximum demand is desirable for gravity schemes.

Pumped schemes require emergency storage that reflects the risk of pump failure (or broken pipeline). In general the greater the number of pumps the lower the risk. The transmission pipelines are quite vulnerable to external damage therefore this study assumes that the worst case scenario will occur when a pipeline is broken. It is assumed that a broken pressure main can be repaired within 8 hours therefore an emergency storage equivalent to 8 consecutive peak periods (max day) will be considered for planning purposes.

Existing and Future Conditions

The evaluation of the City water storage facilities for existing and future conditions is summarized in Table 4.1.14.

Table 4.1.14 Summary of Storage Evaluation

Storage	2008	2020	2030
Equalization [1]	1,101	1,870	3,341
Fire Suppression	250	300	400
Emergency [4]	2,374	4,033	7,205
Total Required	3,725	6,202	10,946
Total Existing	1,410	1,410	1,410
Surplus (+) / Shortage (-)	-2,315	-4,792	-9,536

[1] Based on estimated demand pattern. Equivalent to 6 hour at maximum day.
[2] 250 m3 per Vietnamese MOP.
[3] 300 m3 for 30,000 persons, 400 for 50,000, per JICA design criteria
[4] 1 assuming loss of transmission main for 8 consecutive hours during peak flow periods at max day
Source: JICA Study Team

<u>*Conclusions and Recommendations*</u>

The City currently has a shortage of water storage facilities. The current deficit is almost 2,500m3. As the population and the water demand in Kampot continue to grow, it is projected that in the year 2020 the City will have a storage requirement of about 9,500 m3.

It is recommended that the City construct additional reservoir storage as soon as possible. Alternatives for storage include

i. ground level tanks

ii. elevated storage tanks

iii. combination of both

The topography is flat therefore a combination of both is recommended. Location and sizing of storage reservoirs is discussed in section 5.

5) Distribution

<u>*Operating Criteria*</u>

This study evaluates the performance of the existing water distribution system and proposes improvements to meet future design flow rates. There are no guidelines for water supply in Cambodia therefore evaluation is based on supplying design flows while simultaneously meeting the following criteria:

i. The system should have sufficient capacity to refill all reservoirs from empty to full within 5 days of continuous operation at average day demand

ii. The system should be capable of continuous operation under maximum day demands and each reservoir in the system should have a positive net inflow at this demand

iii. During 3 consecutive days of maximum day demand, reservoirs within the system should not empty

iv. During peak hour demands, all sections of the system should receive a pressure of at least 12 meters. Where an elevated storage serves an area of reticulation, this pressure should be maintained at the lowest operating level of the reservoir. The total system should be capable of supplying water for 6 consecutive maximum hours

v. Pressures in the distribution system should not exceed 80 meters to limit leakage from the mains and minimize problems with consumer plumbing fixtures.

vi. Flow velocity should not exceed 2 m/s anywhere in the system.

<u>*Distribution System Model*</u>

When planning the expansion of an existing scheme it is necessary to evaluate the operation of the system as a whole. The modeling program known as EPANET is used for this study to simulate operating conditions and evaluate proposed alternatives for improvement. The model is also used to determine the required size trunk mains to meet future demands.

The data used to create the model were obtained from the Kampot water supply authority. The data compiled and used to construct the hydraulic model included:

i. Pipeline locations and diameters

ii. Land use maps developed by this study on the basis of satellite images

iii. Elevation contour data from topographic maps developed in 2002

iv. Water demand data

v. Pipe roughness coefficients

vi. Node elevations

vii. Pumps, valve settings, wells and reservoirs.

viii. An EPANET model developed in 2004 to design the water supply improvements implemented by the World Bank project

Head loss

Head losses in the system as calculated using the Hazen Williams C values identified in Table 4.1.15.

Table 4.1.15 Hazen Williams C values for distribution

Material	Maximum C value
Existing Ductile iron	100
Existing Asbestos cement	115
Existing HDPE	130
Proposed new pipe	110

Source: JICA Study Team

These values make allowance for the effect of ageing, losses in fittings such as bends, tees and valves. New pipe is assumed to be cement lined ductile iron because it represents the worse case in terms of system head losses.

Design Flow and Distribution System Capacity

Design flows used in this study are indicated in Table 4.1.16.

Table 4.1.16 Distribution Capacity

Scheme element	Capacity criteria
Trunk mains gravity supply	MDD over 24 hours
Trunk mains pumped supply	MDD over 20 hours
Distribution	Peak hourly flow = 1.8 x MDD

Source: JICA Study Team

The average day demand was distributed to various nodes in the distribution network according to information provided by the water supply authority and population estimates of new areas to be served.

Simulation of system performance was carried out over an extended 72 hour period. A demand multiplier of 1.25 was applied to obtain maximum day demands at each node. Demands were subjected to a 24 hour fluctuation pattern including peak hourly demand factor of 1.8.The demand pattern is presented in Figure 4.1.10.

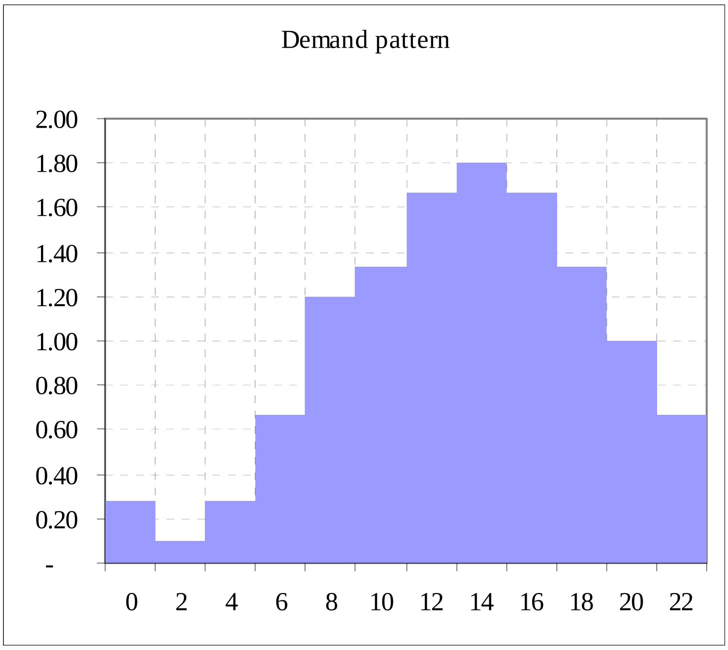


Figure 4.1.10 Water Demand Hourly Fluctuation Pattern

Existing Conditions

The distribution system model was used to simulate existing conditions with maximum hour demand. Water demand rates for each of these scenarios are described in Section 2.

The modeling results for this scenario indicate the following problems:

i. System pressures are just below 20 m at several nodes during peak hour demand.

ii. Distribution pumps cannot meet peak hour demands and the elevated storage is insufficient to balance the difference.

Other Problems and Needs

The City's water distribution system includes approximately 14,500 meters of asbestos cement (AC) pipe also known as transit pipe. This pipe was installed when the system was originally constructed in 1951. The asbestos cement pipe is in poor condition and is the source of significant leakage in the system. It is difficult to repair and difficult to tap when providing new service connections because it is brittle. The pipe is unable to sustain the higher pressures that will be imposed by proposed system improvements.

AC pipe may also present a potential health risks:

i. Asbestos may enter drinking water as a result of internal corrosive action on AC pipe. This is dependent upon several factors, including the corrosiveness of the water. Sampling and testing can be done to determine if asbestos is present in the water system. If asbestos is present at hazardous levels, the AC pipe should be replaced.

ii. When working with AC pipe, such as tapping or making repairs, asbestos can be released into the air as dust, creating a health hazard for maintenance workers. Appropriate safety precautions can be taken to protect workers from exposure to asbestos in these situations.

The water supply authority has indicated that it would like to replace all AC pipe. The mains identified for replacement are shown in red in Figure 4.1.9 and a summary of the length for each diameter is provided in Table 4.1.17.

Table 4.1.17 Asbestos Cement Pipe Identified for replacement

Diameter (mm)	Length (m)
75	980
10	4,605
150	1,160
200	330
250	7,300
Total	14,375

Source: JICA Study Team

Conclusions and Recommendations

a) Low pressures

Distribution pumps cannot meet peak hourly demands. This problem can most effectively be addressed by providing elevated storage facilities to balance demands and boost system wide pressures.

The system has been extended to serve several outlying communities. In most cases the diameter of the pipeline is too small to provide adequate service pressure and cannot accommodate any future growth. This problem can be solved by installing larger diameter feeder mains around the perimeter of the existing service area which can be extended into future growth areas.

b) Asbestos cement pipes

Most of these pipes should be replaced with larger diameters to improve system performance and handle increased flows. Proposed pipe sizes based on preliminary modeling of future demand and proposed reconfiguration of the system are identified in section 5.

4.1.5 Wastewater Disposal

There is no existing sewerage system in Kampot. As the city is located in the strategic juncture connecting Phnom Penh, Sihanoukville and Vietnam, and the possesses a large hinterland rich in agricultural potential, the city of Kampot is expected to grow fast in size in future. With the expected urban growth, the lack of sewerage system shall pose a serious issue in future.

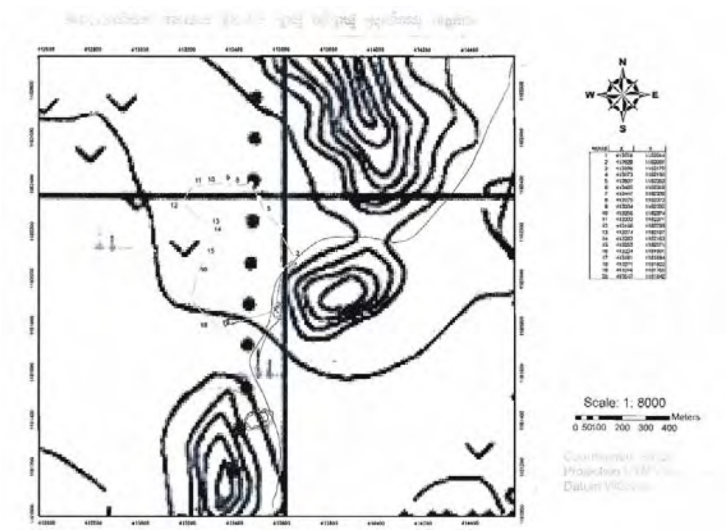
4.1.6 Solid Waste Management

(1) Present Conditions of Solid Waste Management in Kampot Province

In Kampot Province there is one authorized dumping site and five unauthorized dumping sites. The only authorized dumping site is for Krong Kampot (central town) and Tuek Chhou district, but it has been already closed in consideration of a concern about negative environmental impact. The province is planning a new landfill site to receive waste from Krong Kampot (central town) and Tuek Chhou district. The province has proceeded with determination of location for the new landfill site. The proposed site is forest land of 19.4ha. Establishment of the new landfill site is urgent because sharp increase in the amount of household waste and commercial waste in urban areas is projected in accordance with the increase in population and tourists. The province also has a plan to authorize two unauthorized dumping sites in Chhouk district and Kampong Trach district.

Source: JICA study team and MLMUPC

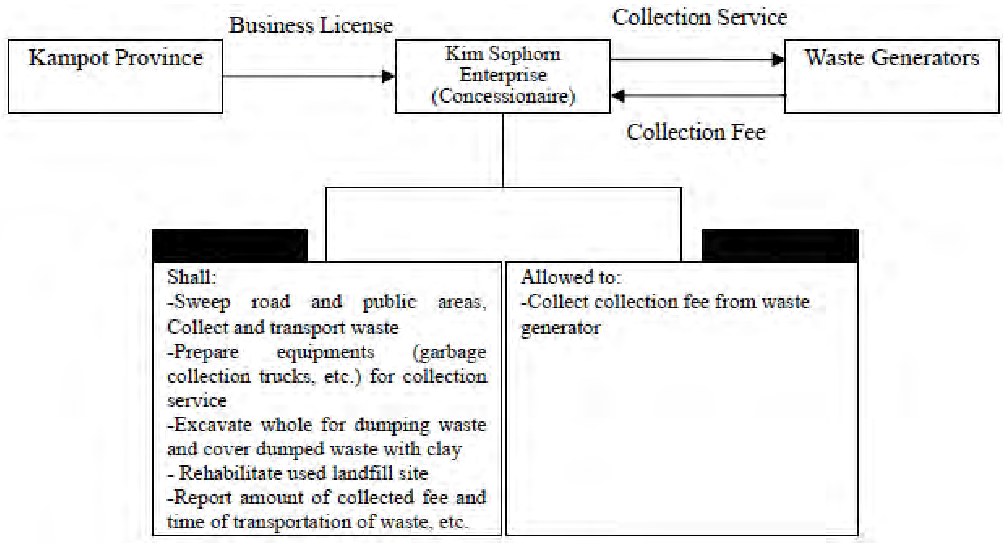
Figure 4.1.11 Location of Current Dumping Site and Proposed Site for Future Dumping Site in Kampot



Source: Kampot Province

Figure4.1.12 Proposed Sites for the New Dumping Sites in Kampot

The province is planning to terminate the contract with a private company in terms of collection service for Krong Kampot (central town) and Tuek Chhou district before the end of the contract term because the contractor does not properly provide the collection service stipulated in the contract. The contract of garbage collection service is concession for 12 years from 2007 to 2019. The province is seeking for another private company.



Source: JICA Study Team (based on the contact document)

Figure 4.1.13 Structure of Contract of Garbage Collection Service in Kampot

The province is interested in Community-based SWM in a village of Preah Sihanouk Province that has introduced primary collection service by community. Kampot Province is planning to organize primary collection service by the community.

The province promotes activities to improve SWM, including model projects of Community-based SWM, with two budget sources. The detail activities by financial source are shown in the following table.

Table 4.1.18 Projected Activities on SWM in Kampot

Financial Sources	Provincial investment fund for departments of the province sourced from Royal Governmental budget based on the National Committee Decentralization and Deconcentration Program (2008) (NCDD)	District Fund of SWM which was established by coordination by the Province
Amount	The royal government annually provides provinces with budget for five years, from 2010 to 2014. Budget for Kampot Province in 2010 is as follows: Natural Resources Management: 10,600USD Solid Waste Management: 4,725USD	There three districts, Teuk Chhou, Banteay Meas and Chum Kiri, which set the fund of SWM. Each of the districts prepared the budget, 4,000 to 2,000 USD in 2010.
Target Areas	Chhuk district, Tuek Chhou district and Kampot central town	Teuk Chhou district, Banteay Meas district and Chum Kir district
Activities	4,725USD for SWM will be appropriated to 1,000 of rubbish bins placed along public road and areas in three districts (Chhuk, Tuek Chhou and Krong Kampot) Education for 8 primary and secondary schools	Purchase of handcarts and rubbish bins for primary collection service managed by communities as model projects.
Remarks	In the process of budgeting, the province estimated costs for the budget based on plans from communes collected through districts, discussed the priority in the province and proposed the budget plan to the royal government with approval from the provincial governor.	Preparing a guidelines on SWM DoE of the province prepares a guideline to encourage districts to introduce Community-based SWM. According to DoE, they need knowledge and information on SWM introduced in other countries to draft and finalize the guidelines.

Source: JICA Study Team (based on the hearing from the province)

(2) Key Issues to Establish the Future Solid Waste Management in Kampot Province

Based on the current conditions of SWM in Kampot Province, the following are key issues.

- Establishment of a new sanitary landfill site to receive waste from Krong Kampot (central town) and Tuek Chhou district is urgent because the existing dumping site has bee already closed. The present situation would be a bottleneck to develop tourism and economy of Kampot.

- It is indispensable to enhance administration of private concessionaire in order to achieve proper level of service even though the province changes the concessionaire. The province needs to not only administrate the private concessionaire but also prepare conditions to exert a market mechanism that private sector would make effort to reduce costs and could make profit based on the concept of PPP (Public-Private Partnerships).

- It is desirable to introduce community-based SWM to other areas in harmony with 3R concept.

4.2 Socio Economic and Spatial Planning Framework for Kampot City

4.2.1 Population

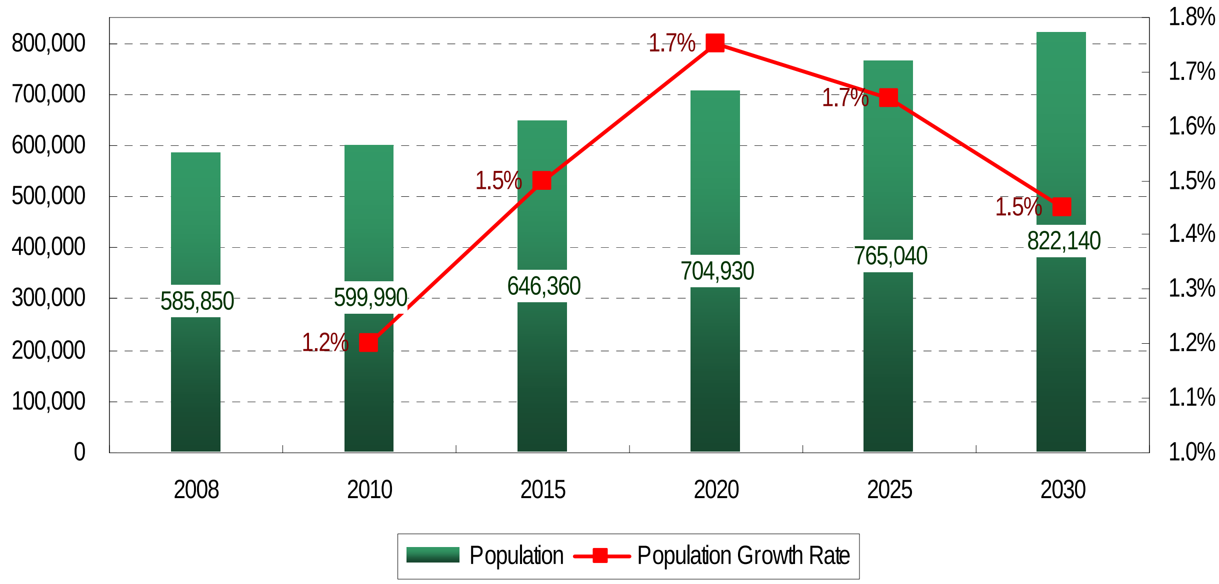
(1) Population Projection for Kampot Province

The population projection of Kampot province has been prepared as shown in Table 4.2.1, and Figure 4.2.1, based upon the current demographic analysis via NIS census 2008 as well as the NIS 2004 population projection.

Table 4.2.1 Population Projection and Growth Rate for Kampot Province

	2008*	2010	2015	2020	2025	2030
Population	585,850	599,990	646,360	704,930	765,040	822,140
Urban	48,274	56,070	58,390	70,080	97,860	145,690
Rural	537,576	543,920	587,970	634,850	667,180	676,450
Population Growth (%)	--	1.2%	1.5%	1.7%	1.7%	1.5%

Note: *Final results for Census 2008.

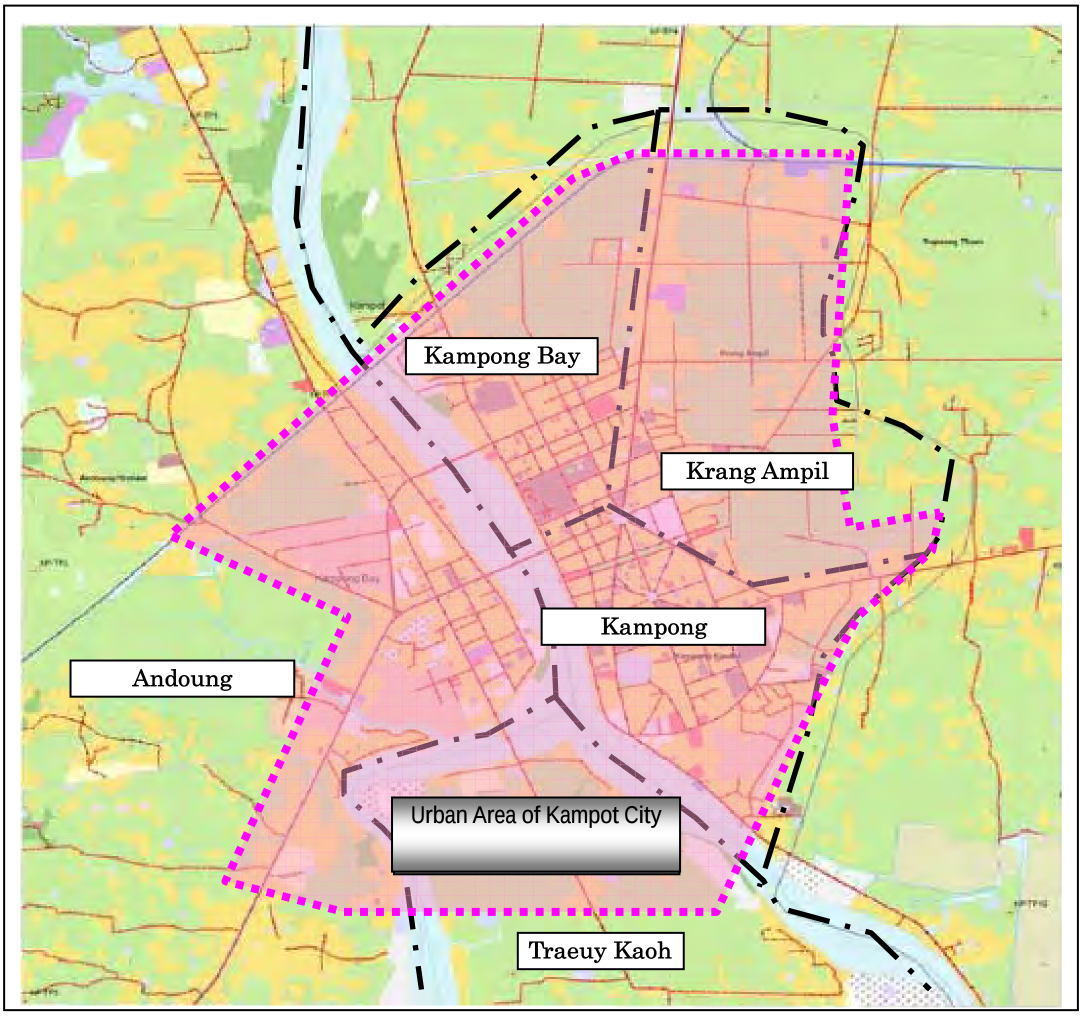


Source: JICA Study Team

Figure 4.2.1 Population Projection and Growth Rate for Kampot Province

(2) Population Projection for the Urban Area (Kampot City)

As shown in the Figure 4.2.2, the target area for Development Strategy for Kampot City covers five (5) communes, which are categorized as urban area. Based upon the provincial population growth prospects and migration factors from surrounding rural communes, population projection for the urban area was prepared, as shown in Table S4.01.



Source: JICA Study Team

Figure 4.2.2 Boundary of Urban Area for Development Strategy of Kampot City

As the center of Kampot Province, future population growth rate of the Study Area is expected to exceed the provincial average population growth rate. Kampot is located at the junction of three roads with a hinterland rich in agriculture. As the only urban center, Kampot shall grow as the center of trading and goods movement and services. Industrial development and structural shift may create redundant labor force especially for the agriculture in rural areas, and therefore, these workers move to live in the urban area to seek the working opportunities. Also the Department of Land Management, Urban Planning, Construction and Cadastre (DLMUPCC), Kampot Province has already prepared the draft land use plan of the Kampot City, which depicts the plentiful lands for the housing area in the city, based upon the very strong estimate for its future population growth[1].

[1] DLMUPCC, Kampot employs their own population census data, which estimates to be much higher than the national population census data provided by NIS, for population projection. They also projected that annual population growth rate of the province in 2009 would be three (3) percent, which nearly triples the annual population growth rate of the province during the past decade.

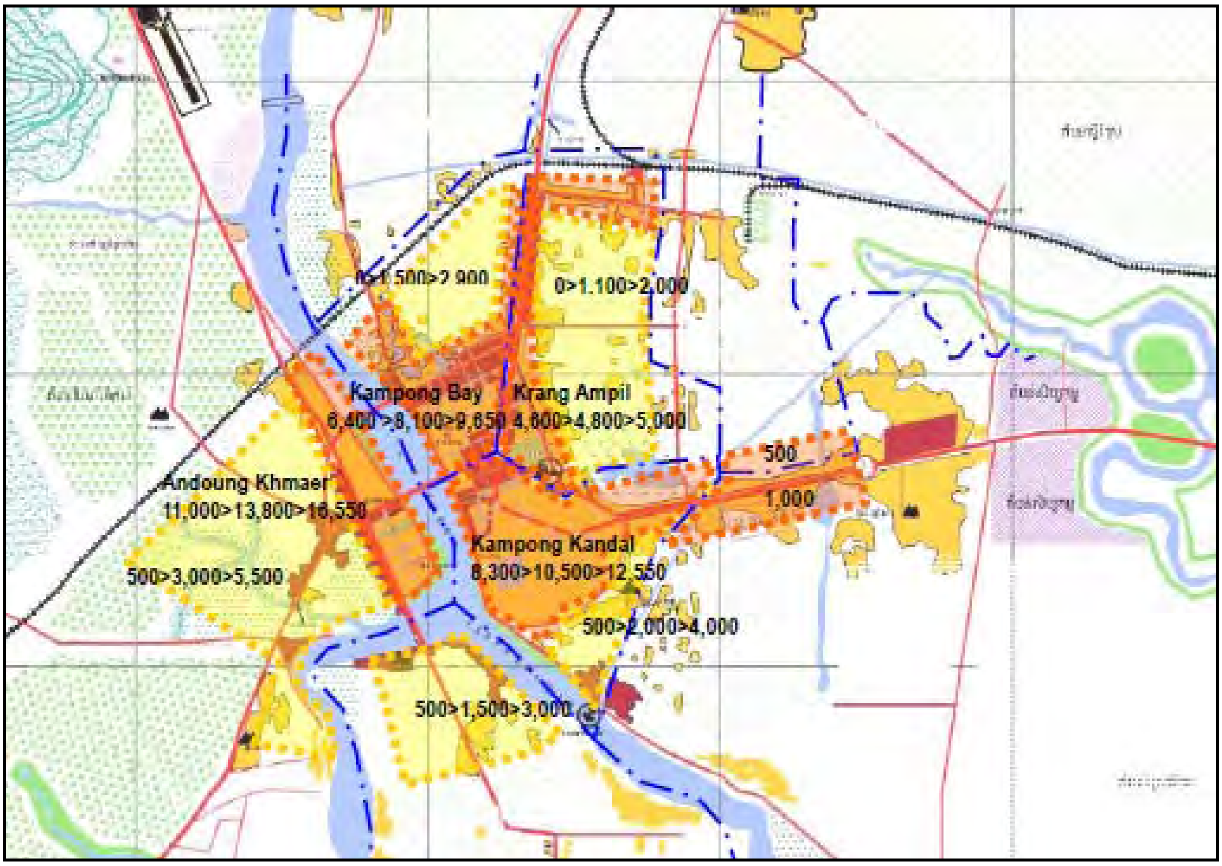
Based upon the assumptions, JICA Study Team has projected the long term population projection for the urban area. The Team's scenario expects the rather higher population growth rate than the provincial average.

Table 4.2.2 Population Projection and Annual Growth Rate for each Commune of Urban Area

	2008*	2010		2020		2030	
		No.	G/R (%)	No.	G/R (%)	No.	G/R (%)
Kampong Kandal	8,285	8,550	1.6%	10,500	2.1%	12,550	1.8%
Kampong Ampil	4,632	4,800	1.8%	5,950	2.2%	7,100	1.8%
Kampong Bay	6,376	6,600	1.7%	8,100	2.1%	9,650	1.8%
Andoung Khmaer	10,923	11,250	1.5%	13,800	2.1%	16,550	1.8%
Traeuy Kaoh	6,151	6,350	1.6%	7,850	2.1%	9,400	1.8%
Study Area	36,367	37,550	1.6%	46,200	2.1%	55,250	1.8%

Note: *Final results for Census 2008.
Source: JICA Study Team

The following Figure 4.2.3 displays the future population growth for the mid scenario among the above mentioned communes.



Source: JICA Study Team

Figure 4.2.3 Shift of the Population among the Urban Communes

4.2.2 Employment

Based on the population above age 15, as well as the abovementioned figures regarding labor force participation rate and proportion of labor force by industrial sector, the forecasted labor force of has been acquired (please refer to the Table 4.2.3, and the Figure 4.2.4)

According to the Team's calculation, the total labor force of Kampot Province will increase from 30,900 in 2008, 379,000 in 2020, and 438,500 in 2030. Labor force in Kampot province is projected to grow 1.6% from 2008 to 2030 (5.4% per annum in urban area and 1.1% in rural area).

Table 4.2.3 Forecasted Number of Labor Force in Kampot Province

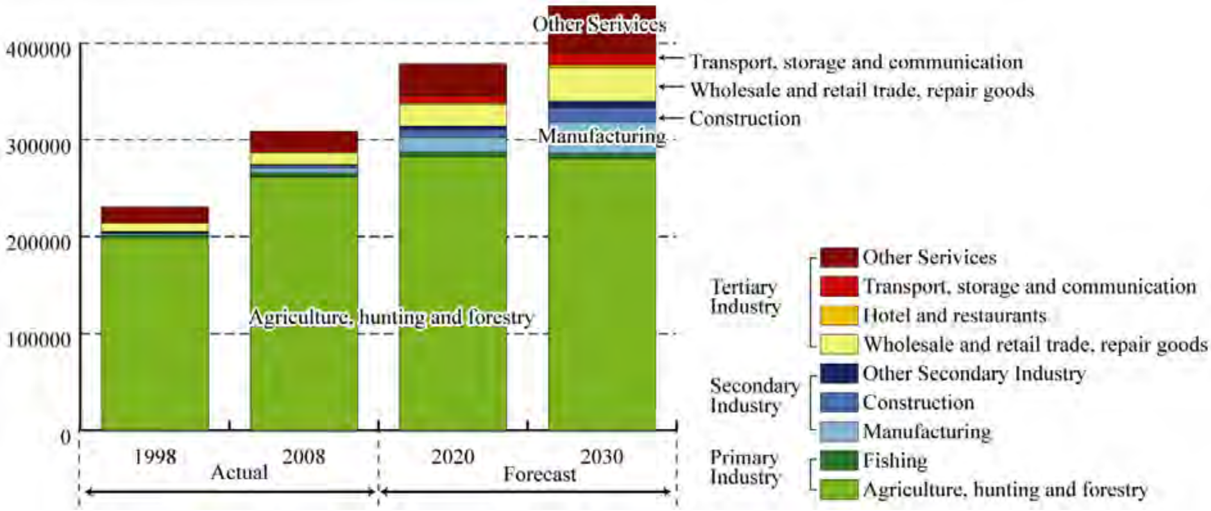
	2008 (actual)			2020 (forecasted)			2030 (forecasted)		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Agriculture, hunting and forestry	8,125	253,637	261,762	6,890	276,050	282,940	9,900	271,430	281,330
Fishing	312	3,939	266,013	260	4,290	287,490	380	4,220	285,930
Manufacturing	1,555	3,281	9,087	4,370	11,150	20,070	14,190	18,380	37,170
Construction	810	1,765	7,411	2,150	5,650	23,320	5,490	9,310	47,370
Other Secondary Industry	199	738	3,512	530	2,840	11,170	1,350	5,680	21,830
Wholesale and retail trade, repair goods	4,655	7,748	13,340	7,520	15,110	26,000	14,900	19,320	41,250
Hotel and restaurants	421	411	13,235	770	900	24,300	1,710	1,300	37,230
Transport, storage and communication	1,488	2,250	4,570	2,710	4,390	8,770	6,050	5,610	14,670
Other Services	5,449	12,310	21,497	9,340	24,010	40,450	18,520	30,700	60,880
Total	23,014	286,079	326,852	34,530	344,400	412,280	72,500	365,960	487,680

Source: JICA Study Team

Currently, Kampot province heavily depends on agriculture in terms of economy as well as employment. According to the 2008 Census agricultural sector absorbed 84.7% of the total labor force in the province. Kampot province is expected to be core of "regional agriculture". While agriculture sector will play vital roll in the economy in the future, percentage distribution of employment of agricultural is expected to decline moderately, reflecting the agriculture industry's ability to produce more with fewer workers overall. Percentage distribution of agricultural sector's labor force was projected to reduce from 75.1% in 2008 to 49.5% in 2030. Since total number of labor force in Kampot province is expected to increase, labor force engaged in agricultural sector will be also increased slightly. Most of incremental labor force is expected to absorb by the secondary and tertiary sector.

The fundamental industrial activities using agricultural products as raw materials are expected to be located in the province. Given assumptions, labor force engaged in the secondary industries in the province is forecasted to grow 9.0% per annum, and will be accounted for 12.7% of total labor force in 2030. Labor force engaged in manufacturing sector is expected to grow 9.1% per annum, and will absorb 32,600 labor forces in 2030. Labor force of manufacturing sector in urban area of Kampot province in 2030 (14,200) will be occupied 19.6% of total labor force in urban area of the province.

Population growth, subsequent urbanization and an expanding economy are expected to boost the demand for tertiary industries, contributing to job growth. Labor force of the tertiary industries in the province is projected to grow 4.96% per annum. Among the industries in the tertiary sector, transport sector is projected to grow more rapidly from 3,738 in 2008 to 11,700 with 5.31% of annual increase.



Source: JICA Study Team and CENSUS 1998, 2008

Table 4.2.4 Forecasted Number of Labor Force by Industrial Activities in Kampot Province

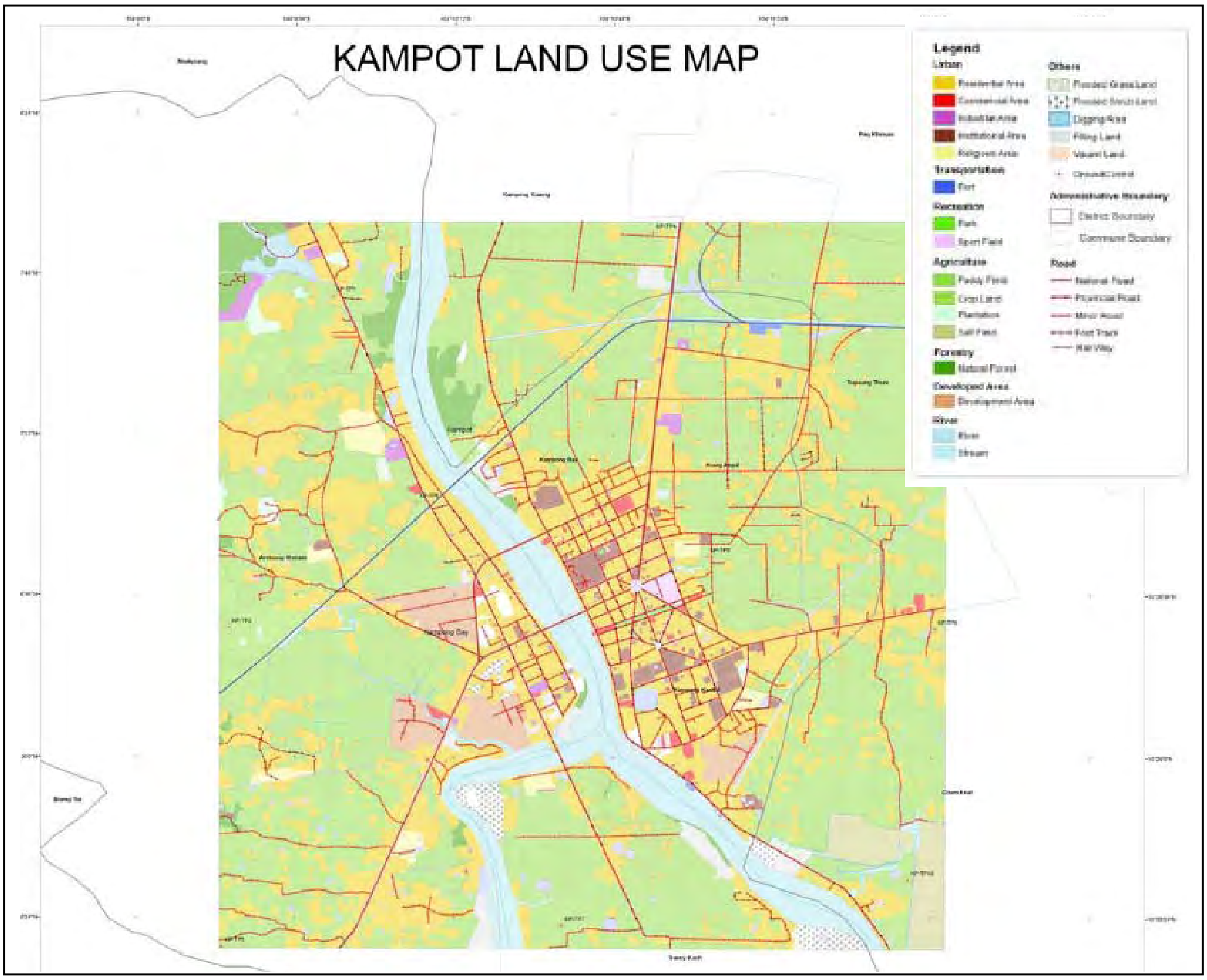
4.2.3 Urban Planning and Land Use

This sector describes the summary of land use analysis based on the result of detailed Land Use Survey by the Team.

(1) Existing Land Use

A detailed mapping using satellite imagery of urbanized areas of Kampot Cities ($25km^2$) was carried out for this Study with the mapping scale of one to ten thousand (1:10,000).

The existing land use map shown below is drawn by GIS combining a series of information such as the aerial photo interpretations together with ground surveys for confirmation. Relevant geographical information such as the road network, administrative boundaries has also been imposed.



Source: JICA Study Team

Figure 4.2.5 Kampot Land Use Map

(2) Land Use Area by Commune

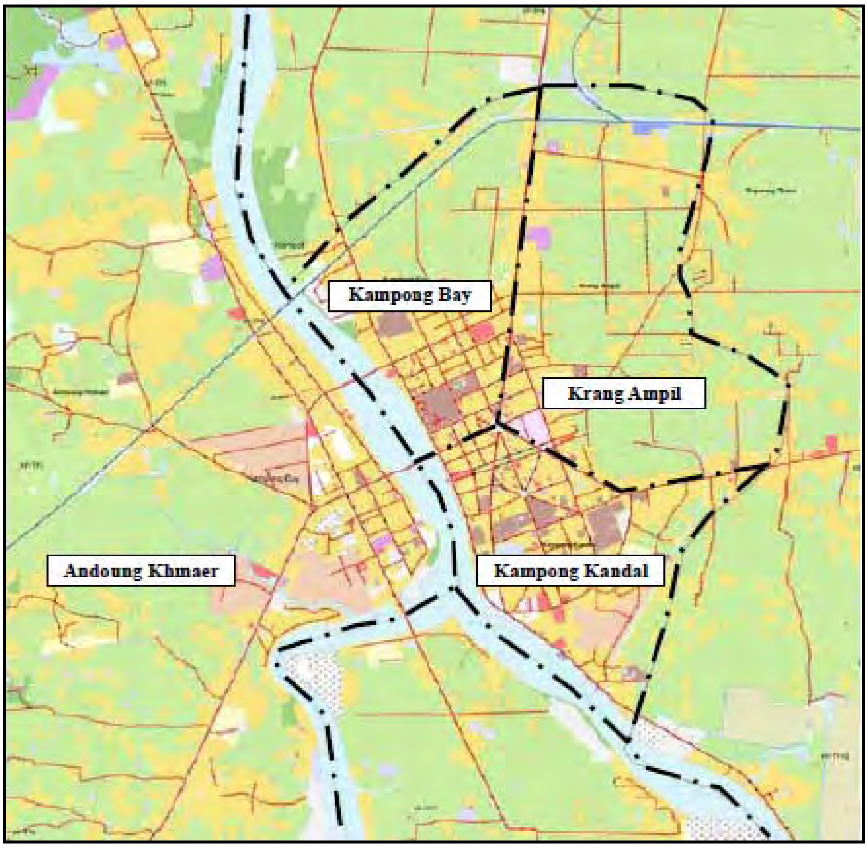
The land use area of Urban Commune in Kampot Province is estimated from the satellite image mapping and ground surveys. The result of the estimation is shown below.

Kampong Kandal, Krang Ampil and Kampong Bay Communes cover the existing urbanized area located on the eastern bank of the Kampon Bay River. Andoung Khmaer Commune is located on the western bank of the river.

Table 4.2.4 Land Use Area of some of Urban Communes in Kampot Province

Class	Kampong Kandal		Krang Ampil		Kampong Bay		Andoung Khmaer	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Residential Area	94.2	47.0	86.0	34.7	68.9	39.2	280.1	30.3
Commercial Area	2.9	1.5	0.5	0.2	2.0	1.1	2.1	0.2
Industrial Area	0.1	0.1	2.5	1.0	0.3	0.2	7.8	0.8
Institutional Area	15.6	7.8	2.0	0.8	9.5	5.4	2.9	0.3
Religious Area	2.6	1.3	2.1	0.9	0.1	0.1	15.0	1.6
Port	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Park	1.2	0.6	0.0	0.0	0.1	0.1	0.0	0.0
Sport Field	0.1	0.1	3.1	1.3	0.1	0.1	0.0	0.0
Development Area	8.6	4.3	0.0	0.0	0.0	0.0	39.6	4.3
Paddy Field - Irrigated Paddy	26.9	13.4	136.4	55.0	57.6	32.7	374.8	40.6
Crop Land Total	0.0	0.0	1.3	0.5	1.8	1.0	42.7	4.6
Crop Land - Maize	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.8*	*0.1*
Crop Land - Jack Fruit	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.2*	*0.1*
Crop Land - Mango	*0.0*	*0.0*	*0.7*	*0.3*	*1.1*	*0.6*	*12.6*	*1.4*
Crop Land - Mixed	*0.0*	*0.0*	*0.0*	*0.0*	*0.7*	*0.4*	*25.8*	*2.8*
Crop Land - Durian	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.4*	*0.2*
Crop Land - Orange	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.0*	*0.1*
Crop Land - Coconut	*0.0*	*0.0*	*0.6*	*0.2*	*0.0*	*0.0*	*0.0*	*0.0*
Plantation	0.0	0.0	0.0	0.0	0.9	0.5	8.1	0.9
Natural Forest	0.0	0.0	0.0	0.0	1.3	0.7	28.7	3.1
Salt Field	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
River	22.0	11.0	0.0	0.0	17.4	9.9	62.4	6.8
Stream	3.6	1.8	3.6	1.4	1.0	0.6	2.9	0.3
Pond	3.5	1.8	2.2	0.9	0.9	0.5	8.6	0.9
Bridge	0.2	0.1	0.0	0.0	0.3	0.2	0.6	0.1
Rail Way	0.0	0.0	3.0	1.2	2.1	1.2	1.9	0.2
High Way	0.0	0.0	0.7	0.3	1.8	1.0	6.0	0.7
Major Road	16.2	8.1	3.1	1.2	6.1	3.5	14.1	1.5
Minor Road	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Bus and Taxi Station	0.0	0.0	0.7	0.3	0.0	0.0	0.0	0.0
Digging Area	0.0	0.0	0.0	0.0	0.0	0.0	8.4	0.9
Filling Land	0.9	0.5	0.0	0.0	3.1	1.7	9.4	1.0
Vacant Land	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.4
Flooded Grass Land	0.8	0.4	0.6	0.2	0.7	0.4	1.5	0.2
Flooded Shrub Land	0.5	0.2	0.0	0.0	0.0	0.0	2.3	0.2
Total	**200.2**	**100.0**	**247.8**	**100.0**	**175.9**	**100.0**	**923.5**	**100.0**

Source: JICA Study Team



Source: JICA Study Team

Figure 4.2.6 Location of Urban Communes in Kampot

(3) Urban Land Use Expansion

The expansion of the urban land use in the central part of Kampot Province could be estimated with commune base population forecast and planned population density.

1) Existing Residential Land Use Area by Commune

Existing residential land use area is calculated as the sum of the residential area and commercial area, as shown below. The existing residential land use areas in urban communes are about 97 ha in Kampong Kandal, 87 ha in Krang Ampil, 71 ha in Kampong Bay and 282 ha in Andoung Khmaer Commune, respectively.

Table 4.2.5 Residential Land Use Area of Urban Communes in Kampot Province

Land Use	Kampong Kandal		Krang Ampil		Kampong Bay		Andoung Khmaer		Total
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	
Residential Area	94.2	47.0	86.0	34.7	68.9	39.2	280.1	30.3	529.2
Commercial Area	2.9	1.5	0.5	0.2	2.0	1.1	2.1	0.2	7.5
Residential Land Use Total	97.1	48.5	86.5	34.9	70.9	40.3	282.2	30.5	536.7

Source: JICA Study Team

2) Existing Available Land for Development by Commune

The available land for development is expandable area defined as the sum of the development area and vacant land. Based on the GIS data, the habitable area in 2008 may be about 8.6 ha in Kampong Kanda, 43 ha in Andoung Khmaer Commune respectively. In Krang Ampil and Kampong Bay Commune, there is no sizable available land area.

But other land use area such as paddy field can be transformed to land for urban area development which covers 596 ha of the area.

Table 4.2.6 Existing Available Land Area of Urban Communes

Land Use	Kampong Kandal		Krang Ampil		Kampong Bay		Andoung Khmaer		Total
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	
Development Area	8.6	4.3	0.0	0.0	0.0	0.0	39.6	4.3	48.2
Vacant Land	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.4	3.5
Total Land Area	8.6	4.3	0.0	0.0	0.0	0.0	43.1	4.7	51.7
Paddy Field	26.9	13.4	136.4	55.0	57.6	32.7	374.8	40.6	595.7
Total Available Land	35.5	17.7	136.4	55.0	57.6	32.7	417.9	45.3	647.4

Source: JICA Study Team

3) Provisional Residential Land Use Area Expansion

Based on the provisional population of urban communes in Kampot city in 2008 Census and projected future population is shown below. To calculate the expansion area, the Team used 80 persons/ha as a gross population density of residential land use for expansion in urban area.

The expansion areas thus calculated in Table 4.2.7 are 53 ha in Kampong Kandal, 30 ha in Krang Ampil, 30 ha in Kampong Bay and 68 ha in Andoung Khmaer Commune, respectively. Available land area of Kampong Kandal is smaller than estimated residential land use expansion area. The gap is 17.5ha, but other neighbor communes, such as Krang Ampil, have enough land to be utilized for residential land use.

Table 4.2.7 Provisional Residential Land Use Area Expansion of Urban Communes

Commune	Population 2008	Population 2030	Population Increased	Residential Land Use Expansion Area (ha)	Available Land Area (ha)
Kampong Kandal	8,200	12,400	4,200	53	35.5
Krang Ampil	4,600	7,000	2,400	30	136.4
Kampong Bay	6,500	9,700	3,200	40	57.6
Andoung Khmaer	11,000	16,400	5,400	68	417.9
Total	30,300	45,500	15,200	190	647.4

Source: JICA Study Team

4) Urbanization Promotion Area and Urbanization Control Area

Based on the above analysis, the Team recommends adopting the urbanization area defined in the existing master plan (not yet approved by central government) as a "Urbanization Promotion Area (UPA)" for the new Master Plan to accommodate increasing population until 2030.

Following discussion with DLMUPCC in Kampot, it was known that people in Kampot prefer to live in south-west area of Kampot city because of high ground to prevent flood and location of general hospital. So the UPA should be expanded toward south-west.

Outside the urbanization promotion area, a new zone called "Urbanization Control Area (UCA)" is proposed, where development activities should be carefully controlled by provincial government.

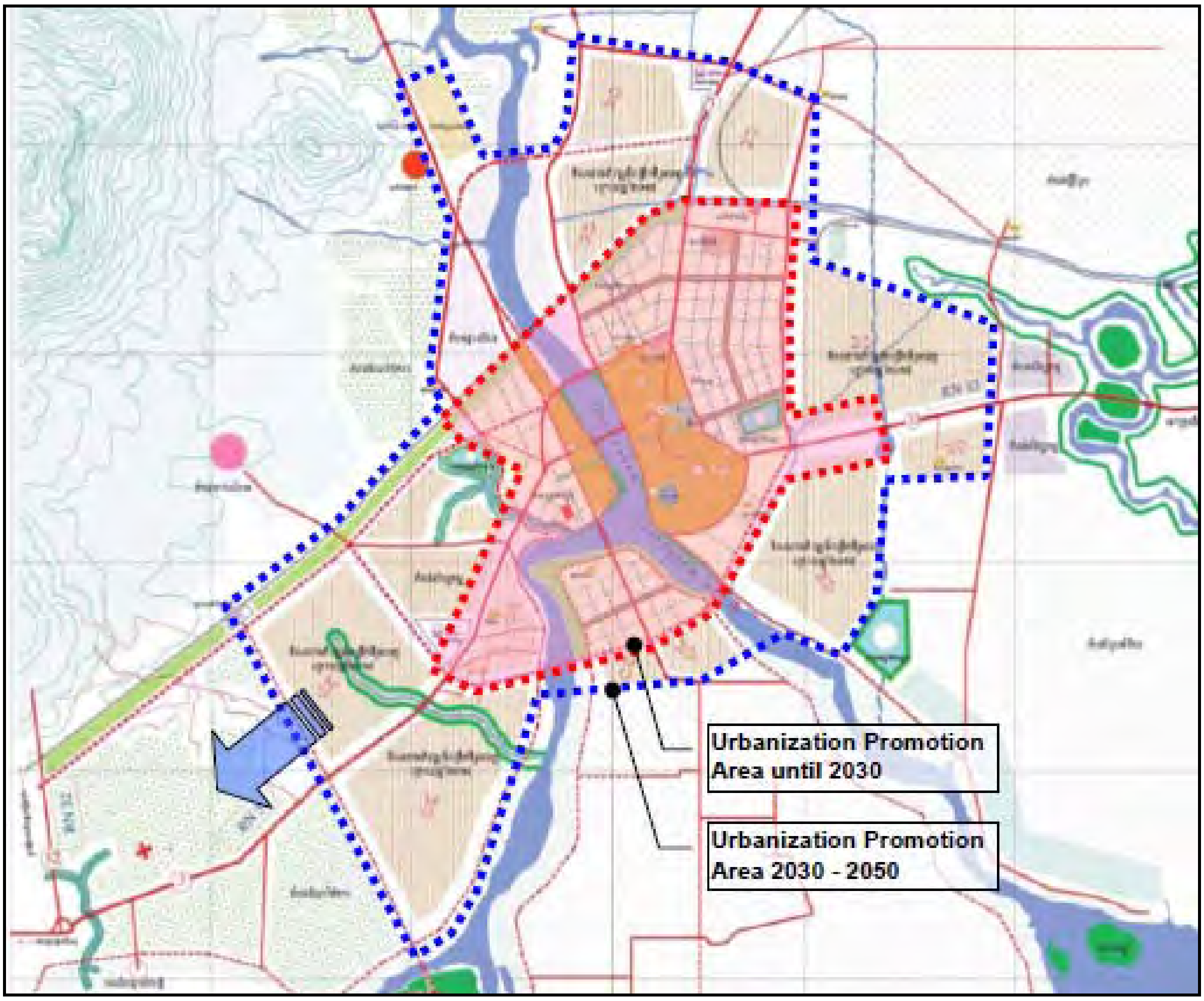
4.2.4 Land Use Concept

This section describes the summary of land use concept. The proposal here basically accommodates main points of the existing Kampot Provincial Center Development Plan prepared by DLMUPCC of Kampot Province with GTZ.

(1) Concept of "Compact City"

Existing Development Master Plan is targeted for 2015. But urbanization speed is still slow to fill up the proposed urbanization area of existing master plan. Based on the Study Team's analysis on population projection in section 4.2.3 of Book II, existing urbanization area can accommodate the population increase until 2030 in this city.

The Team recommends the concept of "Compact City" for Kampot City to concentrate the investment for development to improve the attractiveness of the city center for tourism development and also investment for infrastructure such as tapped water distribution and sewage water collection network.



Source: JICA Study Team

Figure 4.2.7 Urbanization Promotion Area

(2) Land Use Zoning

Basically existing land use zoning is followed in new master plan. Though, Building Code have not defined yet. MLMUPC have been drafting sub decree on land use master plan to define building code for each land use zones.

It is recommended DLMUPCC to discuss detail building code with MLMUPC.

4.2.5 Urban Road

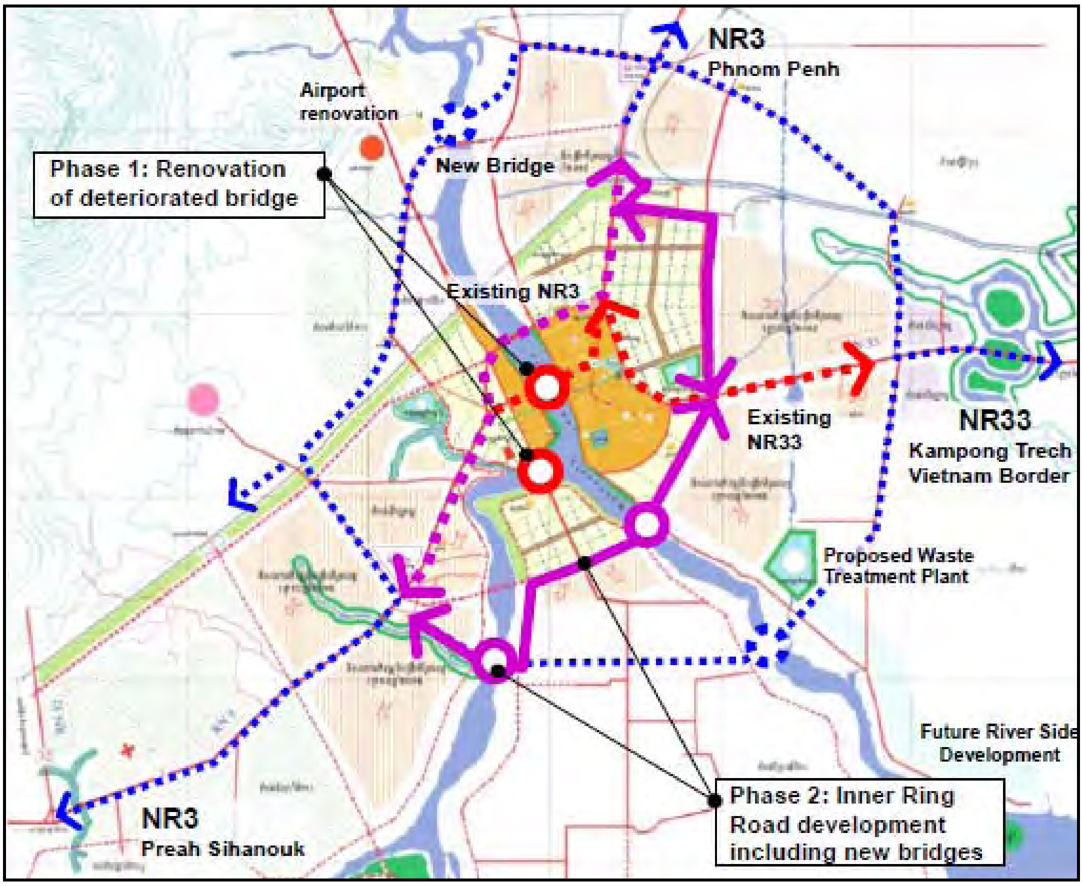
Urban area of Kampot city is expanding toward suburban along the roads radiating from city center. It is because existing road network around the city center is not planed and constructed properly.

The Team proposed road network in Kampot city to strengthen its urban structure and minimize inefficient urban area sprawl of the city.

(1) Inner Ring Road

In the short term, renovation of existing deteriorated bridges in the city is crucial to improve connectivity among divided city areas by river. One is called "old bridge" which was main bridge before completion of new bridge to connect both banks of the Kampon Bay River. Others are temporally constructed steel bridge and wooden narrow bridge at south of the city center.

In the middle term development, construction of inner ring road is important to strengthen road structure of the city. This route can be detour route between NR3 and NR33 to minimize unnecessary through traffic and to set down urbanization promotion area.



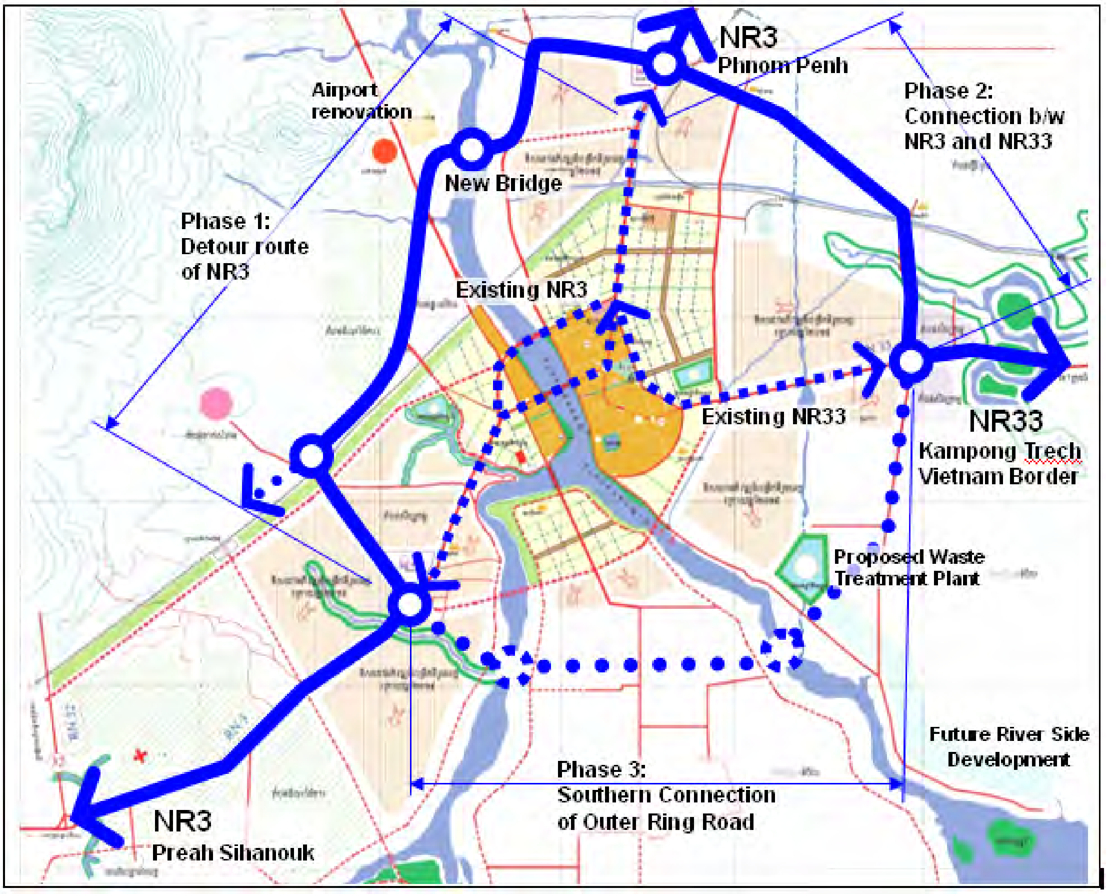
Source: JICA Study Team

Figure 4.2.8 Proposed Inner Ring Road

(2) Outer Ring Road

To avoid traffic mix in the city center and traffic accidents along the existing NR3 and NR33, new detour route called "Outer Ring Road" should be constructed at the next phase. Heavy loaded vehicles and unnecessary through traffic should be avoided to enter inside of the New Outer Ring Road.

This route also intends to connect future development area around the Kampot City. Proposed specifications of the ring road are 50m of road width, 3 x 3 lanes, planted median strip and pedestrian sidewalk.



Source: JICA Study Team

Figure 4.2.9 Proposed Outer Ring Road

The implementation of Outer Ring Road is divided into three (3) phases as follows;

i) Phase 1: Detour route of NR3 (Western section)

This phase is the most important part of New Outer Ring Road to avoid unnecessary traffic into city center. And also it aims to connect the airport into regional transport network.

This route includes construction of new bridge on Kompong Bei River.

ii) Phase 2: Connection between NR3 and NR33 (Eastern section)

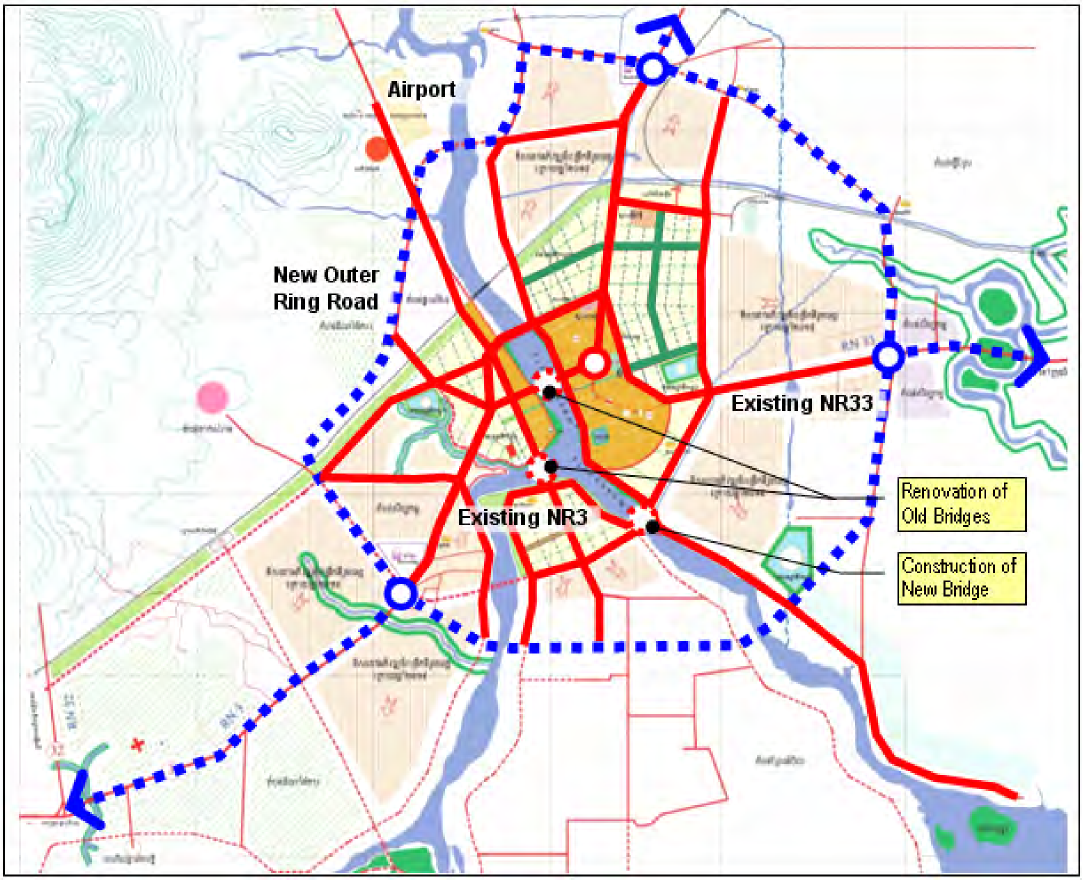
This phase route intends to avoid traffic mix in the city center by NR33.

iii) Phase 3: Southern Connection between NR3 and NR33 (Southern section)

Phase 3 connects between NR3 and NR33 in the south of Kampot City which includes two (2) new bridge constructions on Kampong Bei River. This route aims to improve accessibility to seaside and riverside development projects.

(3) Approval of Planned Road Network

To secure the land for Planned Road Network, alignment and width of the Planned Road Network should be approved by the provincial and the central government. The Expropriation Law is now on the process of approval in the National Assembly which regulates to have right to reserve or to expropriate land for infrastructure development by governmental authority.



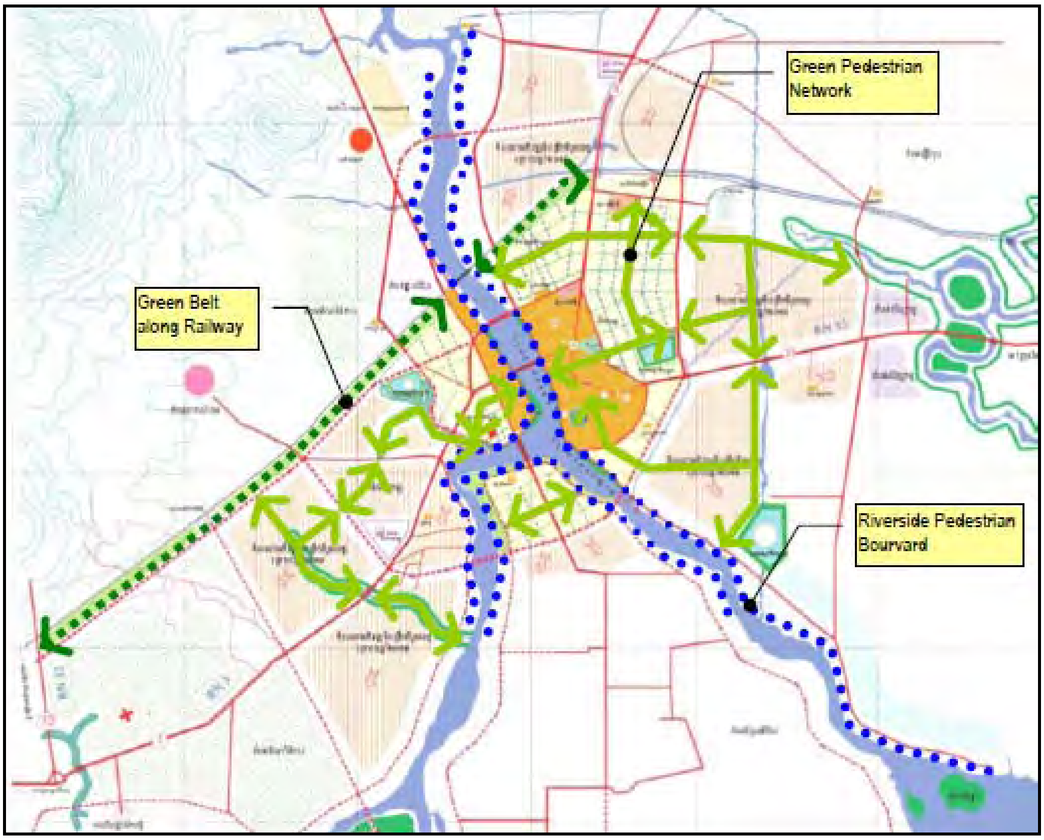
Source: JICA Study Team

Figure 4.2.10 Proposed Arterial and Collector Road Network

The Planned Road Network contains "arterial road" and "collector road". Arterial roads formulate urban structure and major road network of the city. Collector roads tend to lead traffic from local roads or sections of neighborhoods to activity areas within communities, arterial roads.

(4) Pedestrian and Open Space Network

As a historical and waterside tourism destination, pedestrian and open space network is key structure of urban land use in Kampot City. The riverside landscape along Kampong Bei River is one of the typical image of Kampot. Connecting network to/from Riverside Pedestrian Boulevard activates both tourists and residents to walk around the city center.



Source: JICA Study Team

Figure 4.2.11 Proposed Open Space and Pedestrian Network

Proposed specifications of the arterial road are 30m of road width, 2 x 2 lanes with parking lane and pedestrian sidewalk.

4.3 Infrastructure Development Concept

4.3.1 Water Supply

This section presents the basic concept for the water supply system development in Sihanoukville following from the evaluation of the present conditions of water sources and water demand as given in Section 2.3.3 (3).

Water supply areas proposed in the master plan cover the urban area that has been defined by the study. The urban area typically has higher population densities (in the order of 70-80 persons per hectare). Peri-urban areas outside the proposed service areas have lower population densities and tend to be more rural in nature. Extending piped water services into these sparsely populated peri-urban areas is generally not cost effective or financially viable because the small customer base makes it difficult to recover investment and operating costs.

Peri-urban areas will continue to obtain water from groundwater sources. Supply is typically from individually owned wells or community based small scale schemes. Well yields are typically low but sufficient for small scale schemes with low water demands. Rural areas typically use surface water sources supplemented with rainwater collection.

Special economic zones and industrial estates located outside the Sihanoukville urban area have developed their own groundwater schemes and the master plan presumed that the private sector development schemes such as SEZ will consider its own supply of water to the tenants of development. Integration of this kind of water demand to the public sector water supply is too early to make for the time being, as the maturity and sustainability of such development is not clear.

(1) Overview

Proposed modifications to water supply system are presented schematically in Figure 4.3.1.

District no.1 serves the largest part of the city on the East bank of the river. A new treatment plant including raw water intake and pump station is proposed to supply district no.1. Pressure in the distribution system to be maintained by a new 1600 m3 elevated water tower located centrally. Additional storage is provided at ground level next to the elevated tank. Treated water will pumped from the new treatment plant to the ground storage reservoir via a new transmission pipeline that crosses the river along the recently constructed bridge.

Raw water from the treatment plant can be obtained by gravity from the new dam or can be abstracted from the river if it the maintenance flow released from the dam is sufficient.

District no.2 serves the smaller part of the city on the West bank of the river. This district will be supplied by the existing treatment plant whose capacity matches the projected demand. Pressure to be maintained by the existing water distribution pump station and water tower.

The feeder main crossing the old bridge is kept in place but only used in case of emergency to transfer water between districts.

(2) Demand by District

The max day demand for each supply district is provided in Table 4.3.1.

Table 4.3.1 Future Water Demand by Distribution District

	2020		2030	
District 1	Pop	m3/day	Pop	m3/day
Chum Kriel	650	137	1,600	360
Krang Ampil	4,720	991	5,600	1,260
Kampong Bay	6,560	1,837	7,840	2,584
Kampong Kandal	9,440	2,499	13,120	3,875
Kampong Kraeh			3,564	802
Sub-total	21,370	5,463	31,724	8,881
District 2				
Andoung Khmer	8,400	1,764	17,520	3,942
Traeuy Kaoh	1,200	252	2,400	540
Sub-total	9,600	2,016	19,920	4,482
Total	30,970	7,479	51,644	13,363

Note: Includes allowance for non-revenue water
Source: JICA Study team

(3) Storage

Proposed new storage facilities are identified in Table 4.3.2. The location of proposed storage is shown in Figure 4.3.2.

Table 4.3.2 Proposed Storage Facilities

ID No.	Type	Initial Volume 2020 (m3)	Incremental Volume 2030 (m3)	Ground Elevation (m)	Top Water level (m)	Bottom Water Level (m)
SR-1	Ground	3,000	3,000	8	10	7
T-1	Elevated	1,600	0	8	33	30

Source: JICA Study Team

1) District 1:

The proposed ground storage reservoir will be supplied by treated water pumping station located at the proposed treatment plant. An evaluation of the required storage volume for district no.1 is provided in Table 4.3.3 assuming the treated water pumps operate 20 hours per day at constant flow.

Table 4.3.3 Total storage requirements district no.1

Combined storage District 1	2020	2030
Population	21,370	31,724
Equalization [1]	1,365	2,218
Fire Suppression [2]	300	300
Emergency [3]	2,943	4,783
Total Required	4,608	7,301
Total Existing	0	4,600
Surplus (+) / Shortage (-)	-4,608	-2,701
Proposed Tower	1,600	
Proposed ground storage	3,000	3,000

[1] Based on demand pattern, and assumed 20 hours per day pumped supply
[2] 300 m3 for first 30,000 persons.
[3] 8 consecutive hours at peak period during max day.
Source: JICA Study Team

The water tower and ground storage capacity are combined to meet the total storage requirement for district no.1.

Elevated storage is proposed instead of a booster pumping station to simplify operation. This choice also reduces the size of the ground storage tank. Variable speed pumping from ground storage is proposed to reduce the size of the elevated storage tank.

Elevated storage is usually sized on the basis of balancing fluctuations in hourly demand but the storage should be sufficient to supply 3 to preferably 6 consecutive hours during peak periods. A fire fighting reserve of 150 m3 is desirable. Emergency storage is normally not provided in elevated tanks because of the costs. An evaluation of the required storage volume for the elevated tank is provided in Table 4.3.4

Table 4.3.4 Storage requirements for Elevated Tank in District no.1

Elevated Storage T1	2020	2030
Equalization [1]	942	1,530
Fire Suppression [2]	150	150
Total Required	1,092	1,680
Total Existing	0	1,600
Surplus (+) / Shortage (-)	-1,092	-80
Proposed	1600	0

Note: (1) assumes variable speed pumping from ground storage reservoir
Source: JICA Study Team

2) District 2:

The amount of storage at the existing treatment plant is presently sufficient to balance fluctuations in demand for district no.2. Additional storage should be provided after 2020 as an emergency reserve in case of mechanical breakdown such as loss of a distribution pump or loss of standby power during power outage. An evaluation of the required storage volume for district no.2 is provided in Table 4.3.5.

Table 4.3.5 Total storage requirements district no.2

Combined storage District 1	2020	2030
Population	9,600	19,920
Equalization [1]	504	1,121
Fire Suppression [2]	250	250
Emergency [3]	864	1,920
Total Required	1,618	3,290
Total Existing	1,410	1,410
Surplus (+) / Shortage (-)	-208	-1,880
Proposed ground storage	0	2,000

[1] Based on demand pattern, and assumed 20 hours per day pumped supply
[2] 250 m3 minimum requirement per Vietnamese MOP
[3] 6 consecutive hours at peak period during max day.
Source: JICA Study Team

The site at the existing treatment plant has sufficient space to accommodate the proposed storage in the form of a ground reservoir however it is recommended that the existing elevated tower be replaced by a larger tank at higher elevation. The new tank would supply the distribution system directly thereby simplifying pump operations and pressure control.

(4) Transmission Pipelines and Pumps

1) District 1.

Treated water will be pumped from the clear well at the treatment plant to the proposed ground storage reservoir SR-1. Pump and pipeline requirements are based on the assumption that the pumps will operate 20 hours per day delivering a constant flow. It is also assumed that the site of the proposed treatment plant will be near the existing raw water intake.

A new 400 mm diameter transmission main is proposed. The size is selected based on the comparison of the net present value of investment and operating costs for different pipe diameters shown in Table 4.3.6.

Table 4.3.6 Selection of pipeline diameter for transmission to S-1

Dia. of transmission main	Average flow [1] 2030	Head loss in pressure main L=7500m	Minor losses 10%	Static head	Total head	Net Present Value [3]
mm	m3/hr	m	m	m	m	$ million
400 DIP	500	30.18	3.02	2.00	35.20	2.7
600 DIP	500	4.19	0.42	2.00	6.61	3.8

(1) maximum day divided by 20 hours
(2) unit cost of electricity $0.25 per kwH
(3) 15 years of operation to 2030
Source: JICA Study Team

The 400 mm diameter pipe has a higher energy cost but a significantly lower investment cost and therefore provides the lowest cost option.

Preliminary requirements for transmission pumps are identified in Table 4.3.7. The size of the pumps and the relative times of pumping will be very dependant on the actual hourly demands and the amount of storage that can actually be provided at the treatment plant.

Table 4.3.7 Pump requirements for transmission to S-1

Parameter	Units		2020	2030
No of pumps		duty	2	4
		standby	1	1
Flow[2]	(lps)	Per pump	35	35
Operating Head	(m)		40	40
Motor power	(kw)	Per pump	5	16
Power consumption	(kwH)	per day	205	1286
Energy cost [1]	USD	Per day	51	321

(1) unit cost of electricity $0.25 / kwH, assuming a single 350 mm dia. pipeline
(2) The flow rate is based on constant pumping for 20 hours per day
Source: JICA Study Team

(5) Distribution Piping

New feeder mains and secondary distribution piping are required to meet increased demand and distribute flow from the proposed storage facilities. Proposed feeder mains are shown in Figure 4.3.1. Sizes are based on preliminary modeling of demands for 2030 using EPAnet. A summary of pipe diameters is presented in Table 4.3.8.

Table 4.3.8 Proposed Feeder Mains

Diameter (mm)	150	200	250	Total
Feeder ID	Length (m)			
A	-	999	4,122	5,121
A1	-	730	1,154	1,884
B	-	4711.95	1,968	6,680
B1	-	3203.23	-	3,203

B2		1100		1,100
C	-	3,342	-	3,342
D	1,001	2,449	-	3,450
E	-	1,902	-	1,902
F	-	3,948	2,068	6,016
G	990	2,040	465	3,495
Total	1,991	24,426	9,778	36,195

Source: JICA Study Team

Some of the proposed feeder mains will replace the old asbestos cement distribution piping. New distribution piping is required throughout the existing service area to replace remaining asbestos cement pipes and improve system performance. A rough estimate of the quantities of replacement piping is identified in Table 4.3.9. Actual quantities and diameters should be confirmed at the feasibility study and detailed design stages.

Table 4.3.9 Replacement of Asbestos Cement Piping

Diameter (mm)	100	150	Total
Length	3,007-	4,658	7,655

Source: JICA Study Team

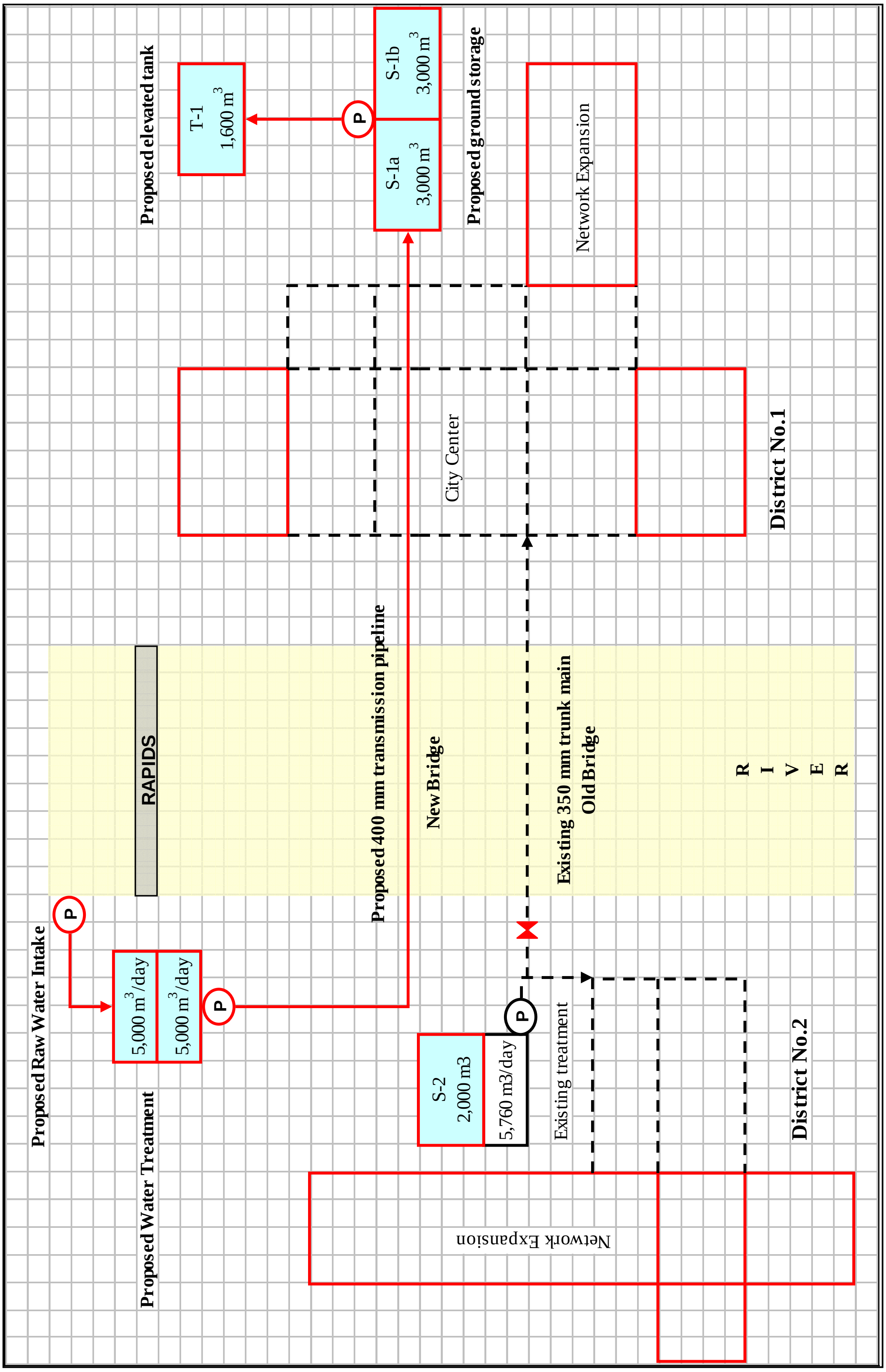
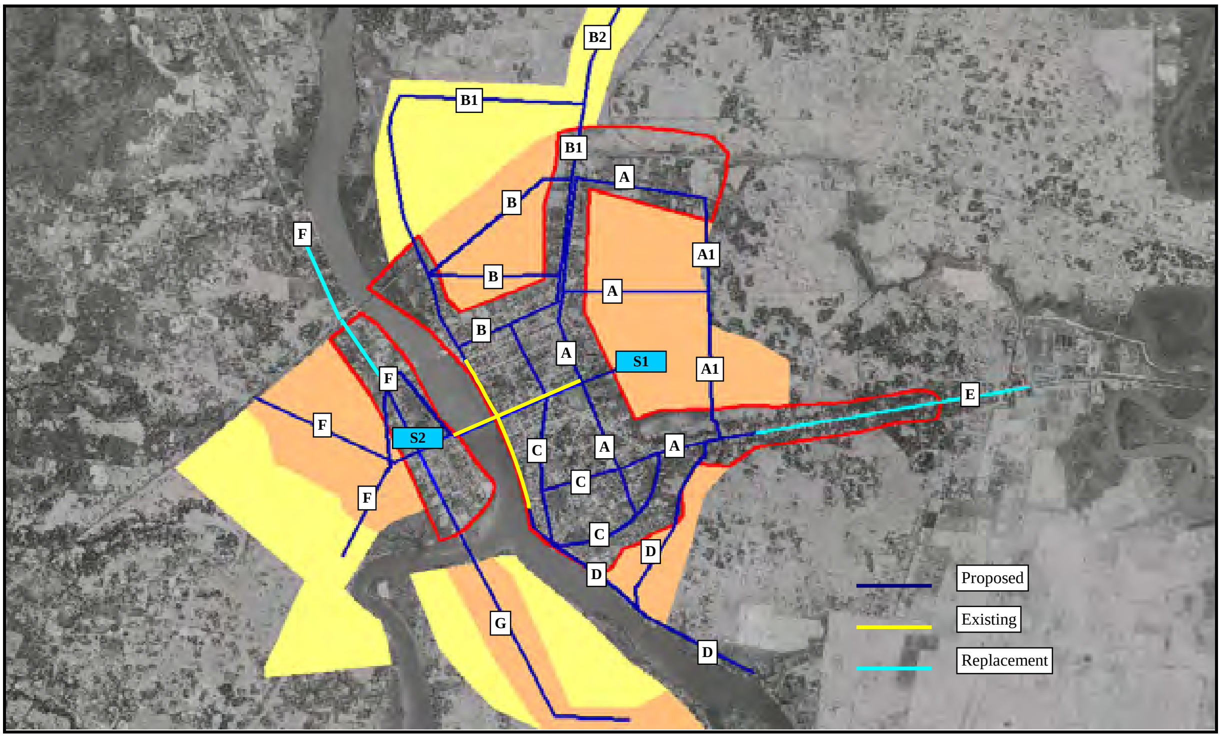


Figure 4.3.1 Proposed Water Supply Improvement Scheme



Source: JICA Study Team

Figure 4.3.2 Proposed Feeder Mains

4.3.2 Wastewater Disposal

(1) Wastewater Quantities

1) Service Area and Service Criteria

For planning purposes it is assumed that wastewater will in general be collected by a separate pipe system in urbanized areas where water supply is provided and where population densities will be at least 70 persons per hectare. Servicing areas with lower population densities is usually not financially viable. Areas with lower population densities can dispose of wastewater to septic tanks.

Proposed wastewater collection areas are shown in Figure 4.3.3. The initial service area should be implemented in a phase 1 project by 2020 to collect wastewater from the central core of the City. Service would be extended to other growth areas by 2030 or sooner depending on how development proceeds.

Table 4.3.10 Populations Served by Sewerage System

District	Catchment	2008	2020	2030
West	Andoung Khmer	4,110	5,880	8,760
East	Kampong Bay	4,742	6,560	7,840
East	Kampong Kandal	6,618	9,440	13,120
East	Krang Ampil	2,910	4,720	5,600
East	Kampong Kraeh			4,455
Subtotal East		14,270	20,720	31,015
Total	Total	18,380	26,600	39,775

Source: JICA Study Team

The collection area on the east bank encompasses the communes of Kampong Bay, Kampong Kandal and part of Krang Ampil. The initial service area is bounded to the north by the railway line. The system would be extended further north past the railway line sometime after 2020.

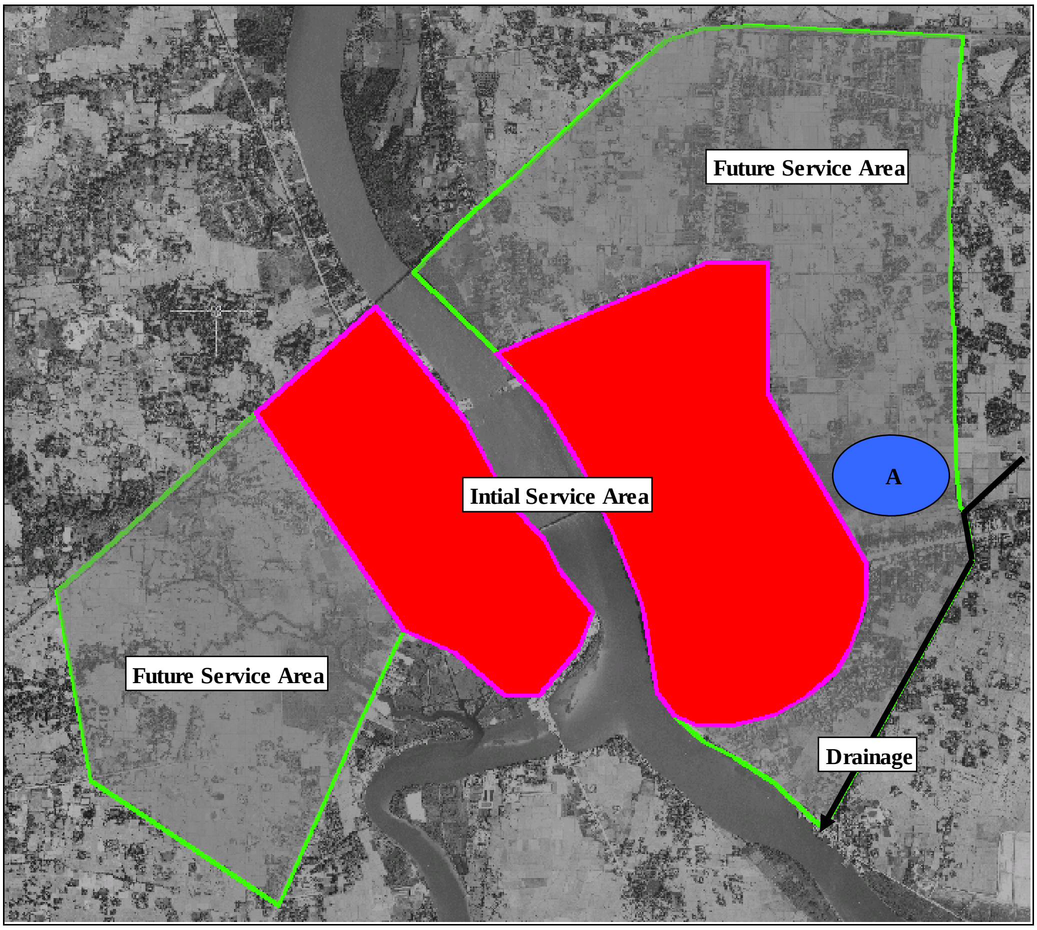
The collection area on the west bank includes most of the commune of Krang Ampil. The initial service area will remain to the east of the main drain. The system would then be extended gradually further west after 2020 to match the pace of growth.

2) Natural Drainage

The natural gradient in Kampot is about 1:1000 with natural drainage flowing from north to south.

The core of the City is located on the East bank and drains towards the river. A low lying area north east of NR33 also collects drainage from the city. This is the site proposed by the City for a wastewater lagoon identified as "A" in Figure 4.3.3. This low lying area discharges via a drainage canal which angles back to the river just south of the urban area.

The urban area on the west bank drains toward the river to the east and towards low lying areas to the south and west. A natural drain runs north South through the Andoung Khmer commune. This drain will naturally become a major collector or wastewater in the future as urban growth expands in this area.



Source: JICA Study Team

Figure 4.3.3 Sewer Service Area

3) Wastewater Generation Rates

Wastewater generation is a function of the water that is consumed however not all water is returned as wastewater. Some portion will be consumed for drinking and cooking or may be used for watering gardens or washing cars. The wastewater return factor generally ranges between 0.70 and 0.85. Higher return factors are typical for low to middle income households or high density urban areas whereas lower return factors are typical for high income households or lower density sub-urban areas with larger plots.

A return factor of 0.85 will be used for calculating wastewater quantities in Kampot.

4) Infiltration factor

Calculations for the amount of sewage collected during dry weather must include a factor for the groundwater that enters the system through leaking pipe joints and manholes. A factor of 15% is added to the total projected sewage flow to calculate the average daily wastewater flow. The factor reflects relatively high groundwater tables and poor surface drainage.

5) Wastewater Quantities for Existing and Future Conditions

The average daily wastewater amounts for dry weather are defined in Table 4.3.11.

Table 4.3.11 Average Daily Wastewater Flow (dry weather)

	Drainage Catchment	2008 m^3/day	2020 m^3/day	2030 m^3/day
West	Andoung Khmer	490	925	1,477
East	Kampong Bay	565	1,032	1,322
East	Kampong Kandal	788	1,486	2,212
East	Krang Ampil	347	743	944
East	Kampong Kraeh	-	-	751
	Total	2,189	4,186	6,707

Note: Includes infiltration factor
Source: JICA Study Team

6) Wet Weather Inflow factor

A separate wastewater collection system should not be receiving storm water flows since it will only be collecting wastewater from household connections. Nevertheless extraneous inflow of surface water does normally occur during wet weather typically through manhole covers. The hydraulic capacity of sewer pipes, pumping stations and treatment plants must therefore be based on these larger wet weather flows. Average daily wastewater flows should be increased by a typical factor of 1.2.

(2) Proposed Sewerage System

1) System Configuration

The physical layout of the collection system will depend on topography and to a very large extent on the location and number of the treatment plants. The natural gradient in Kampot is about 1:1000 with natural drainage flowing from north to south. The collection system must where possible take advantage of this natural gradient and should therefore be arranged from North to South with the treatment plants located downstream of the City. The natural gradient is quite low therefore wastewater collection by gravity will only be possible for shorter distances of about 2 km to limit the depth of the collection system to less than 3 m. Longer distances are technically possible but the cost of the trunk sewers and pumping stations but deeper sewers will significantly increase the construction costs. Pumping stations will therefore be required at intermediate and terminal points to relay wastewater to the treatment site.

There are three options for the configuration of the sewerage system. These are shown in Figure 2-1.

i) Option 1a: convey all the wastewater to a single WSP located on the east side.

ii) Option 1b: convey all the wastewater to a single WSP located on Trey Keoh Island.

iii) Option 2: two treatment plants i.e. one for each collection district (East and West).

Option 1a is less desirable because it requires pumping across the river which complicates construction of the pressure pipeline and adds to the cost.

Option 1b is rejected because it requires larger main pumping stations (higher capital and operating costs) than Option 1a.

Option 2 is the preferred option because it offers several significant advantages:

- Smaller pumping stations (easier to operate and maintain, lower capital costs)
- Smaller trunk sewers to main pumping station (lower capital costs)
- Fewer pumping stations (lower O&M and capital costs)
- No river crossings (lower capital costs)
- Smaller diameter of pressure pipe (lower capital cost)
- Land requirement for separate WSP is smaller and therefore easier to acquire than a single big site
- More flexibility for implementation and operation because each side is separate.

For planning purposes this study recommends the implementation of two separate treatment plants and sewage collection districts.

2) Wastewater

Wastewater composition differs from one situation to the other and is dependant on the level of sanitation, water usage, type of collection system, retention time in sewers and infiltration. Wastewater characteristics will influence the choice of treatment method, extent of treatment and quantities of solids produced.

Average Biological Oxygen Demand (BOD) is one of the most important factors that determines the design and performance of waste stabilization ponds. The other is hydraulic flow rate.

Wastewater strength (BOD) is estimated by assuming an organic loading of 40 grams/person/day which is a typical value for domestic wastewater in South/East Asian countries. Strength is used in calculating treatment requirements.

Table 4.3.12 Wastewater BOD characteristics

Wastewater characteristic	**2020**	**2030**
Wastewater average litre/capita	137	126
grams BOD per capita per day	40	40
Wastewater BOD[1] (mg/l)	292	319

Note: includes allowance for infiltration
Source: JICA Study Team

3) Required level of treatment

The national effluent standard for discharges to water courses covering many a long list of parameters including many chemicals. The parameters of primary interest for the selection of the sewage treatment process are identified in Table 4.3.13.

Table 4.3.13 Effluent Standards Affecting Design of Wastewater Treatment Process

Nº	Parameters	Unit	Allowable limits for pollutant substance Discharging to:
			Protected public water area
3	BOD_5 (5 days at 20^0 C)	mg/l	< 30
4	COD	mg/l	< 50
5	Total Suspended Solids	mg/l	< 50
10	Nitrate (NO_3)	mg/l	< 10
15	Phosphate (PO_4)	mg/l	< 3.0
34	Ammonia (NH_3)	mg/l	< 5.0
35	DO	mg/l	>2.0
	Total coliform	MPN per 100ml	Not specified

From sub-decree on water pollution control (council of ministers No. ANRK.BK 06 April 1999), Annex 2
Source: JICA Study Team

The national water quality standards for conservation of biodiversity in coastal water requires that total coliform be less than 1000 per 100 ml. The effluent from the treatment plant will be discharged to a coastal estuary and regardless of any beneficial dilution effect should be disinfected to this level in order to lower the risk of contamination. This level of treatment also meets the WHO standards for unrestricted irrigation which means the effluent could be safely used to irrigate crops during the dry season.

4) Selection of a treatment method

Simple, reliable operation and low operating costs are the primary criteria for selecting a wastewater treatment system in developing countries. The cost of electricity in Cambodia is high therefore the selected treatment process should have the lowest possible energy requirement. Three technologies most commonly used in developing countries are compared in Table 4.3.14.

i) Waste stabilization ponds (WSP)

ii) Aerated lagoons

iii) Extended aeration process using oxidation ditch

Planning in this study is based on WSP technology because it has a significantly lower energy requirement and is simple to operate. Waste stabilization ponds (WSP) are shallow man-made basins into which wastewater flows and from which, after a retention time of several days (rather than several hours in conventional treatment processes), a well-treated effluent is discharged. WSP systems comprise a series of ponds – anaerobic, facultative and several maturation ponds. The use of maturation ponds provides natural disinfection without the use of chemicals.

WSP are simple to construct: earthmoving is the principal activity; other civil works are minimal – preliminary treatment, inlets and outlets, pond embankment protection and, if necessary, pond lining.

The major disadvantage of WSP is that significant areas of land, typically about 2.25 ha per 1000 m3, are needed for treatment therefore the initial capital costs may be higher than other forms of treatment.

Table 4.3.14 Comparison of potential treatment technologies

	Key Features	Advantages	Disadvantages
Waste Stabilization Ponds (WSP)	• Large surface-area, shallow ponds. • Treatment is essentially by action of sunlight, encouraging algal growth which provides the oxygen requirement for bacteria to oxidize the organic waste.	• Simple to operate • Low operating cost with minimum energy requirement • High level of pathogen removal • Reliable effluent quality because of long retention times	• Requires significant land area approximately 2.25 ha per 1000 m3 • Effluent has a higher BOD caused by algae in the effluent.
Aerated lagoons	• Like WSPs but deeper and with mechanical aeration. Sedimentation ponds and sludge removal are required downstream of aerated lagoons.	• Less land required than for WSP due to pond depths • Higher organic loading than WSP • Simple to operate • Simpler operation and lower cost than oxidation ditch	• Higher energy costs compared to WSP • Mechanical failure of aerators is common • Effluent quality is general not as good as oxidation ditch or WSP • Would require maturation ponds for disinfection prior to agricultural reuse, thereby increasing land requirement
Oxidation ditch	• Oval shaped aeration lanes with horizontal paddles used to circulate and aerate the wastewater.	• Relatively low sludge production • Reduced land requirement compared to ponds and aerated lagoons.	• Very high energy costs • Complex operation and maintenance • Almost total treatment failure during power cuts • Would require maturation ponds for disinfection prior to agricultural reuse, thereby increasing land requirement

Source: JICA Study Team

5) Treatment capacity and land requirements

Preliminary land requirements have been calculated with reference to the methods outlined in “Design Manual for WSP in India” Duncan Mara 1987. This reference is well recognized and used extensively in the design of ponds in countries with tropical climates.Land requirements are identified in Table 4.3.15.

Table 4.3.15 Capacity and Land Requirements for Wastewater Treatment Ponds

Contributing catchment	2020	2030	2030	
	Avg. wet weather flow		Land	Dimensions (m)
	m3/day	m3/day	ha	W x L Ratio 1: 3
East	3,545	5,685	10.5	190 x 550
West	1,110	1,610	3.0	100 x 300
Single Facility	4,186	6,707	13.5	210 x 640

Land includes a 20% allowance for civil works such as embankments, access roads, screening and grit removal facilities
Source: JICA Study Team

Calculation of pond areas and land requirements are based on configuration and parameters identified in Table 4.3.16:

Table 4.3.16 Physical Arrangement of Ponds

WSP process	West	East	Retention time	Depth
Anaerobic ponds	2 In parallel	3 In parallel	1 day	4 m
Facultative ponds	2 In parallel	3 In parallel	4 days	1.5 m
Maturation ponds	2 in series	2 in series	4 days each	1.5 m

Source: JICA Study Team

6) Treatment Plant sites

The 5 hectare site that was initially identified by City is not large enough to accommodate future wastewater flows in the east district. It is also too close to the urban area and would interfere with future growth of the City therefore two new sites are proposed.

Two potential WSP sites (one East and one West) are identified in Figure 2-.2.

East: the site is located in an area of salt drying flats located near the east branch of the estuary south of the city. The 10.5 ha site can be acquired without resettlement. Wastewater collected to a main pumping station and conveyed to the treatment plant under pressure. Treated effluent can be discharged by gravity to the estuary or can be pumped for irrigation in rice growing areas adjacent to the site and further to the north of NR3.

West: the site is located in an area used for rice cultivation located near the west branch of estuary south of the proposed service area.. The 3 ha site can be acquired without resettlement. Wastewater collected to a main pumping station and conveyed to the treatment plant under pressure. Treated effluent can be discharged by gravity to the estuary or can be pumped for irrigation in rice growing areas adjacent to the site and further to the north of NR3.

7) Collection system

The proposed arrangement of trunk sewer and pumping stations is shown diagrammatically in Figure 2-3. A preliminary estimate of main pumping station capacities has been carried out to provide a basis for preliminary cost estimates and project formulation. Preliminary criteria used in this study such as peak factors should be re-evaluated during subsequent feasibility studies and detail design stages.

The capacity of pumping stations is based on the following criteria:

Design flow :average wastewater + infiltration + wet weather inflow

Peak factor: :2.0

Number of pumps: : 50% standby capacity at peak hour

: 100% standby capacity at non-peak

Hydraulic design for pressure pipe:

Hazen Williams $V= 0.85\ C\ R^{0.63}\ S^{0.54}$

Roughness factor C= 100 ductile iron pipe
Minimum velocity 0.6 m/s at average flow

Maximum velocity 3.0 m/s

Screening and grit removal facilities would be provided at the head of the treatment plant to reduce the size and complexity of the pumping stations and facilitate the removal and disposal of waste materials. The size of the pumps and the number of pumps will be very dependant on the actual diurnal pattern and the amount of storage that can be provided in the wet well at the pump station.

East district

Wastewater generated on the side will be collected by gravity to a main pumping station located near the outlet of the drainage canal to the south. The main trunk sewer would run in the north south direction roughly parallel to the river with a secondary branch reaching north along the road to Kampong Kraeh. The distance travelled exceeds 3,000 m so an intermediate pumping station will be required midway to reduce the depth of the trunk sewer and main pumping station at the terminal end.

Sewage will be pumped from the main pumping station to the treatment plant via a 350 mm diameter pressure main.

Preliminary pump requirements are identified in Table 4.3.17

Table 4.3.17 Pump requirements for main pumping station East

Parameter	Units		2020	2030
No of pumps		duty	3	3
		standby	1	1
Pump capacity	(lps)	each	35	55
Operating Head	(m)	peak flow	11.5	17.5
Motor power	(kw)	peak flow	6	13
Power consumption	(kwH)	per day	133	287
Energy cost [1]	USD	Per day	33	72

Note: (1) unit cost of electricity $0.25 / kwH,

Source: JICA Study Team

West district

Wastewater generated on the west side will be collected by gravity to a main pumping station. Located by NR3 near the stream. This is a low point in the catchment area. The pump station will collect flows from trunk sewers running along the stream, along NR3 and parallel to the river. The main pumping station is centrally located within a 2,000 m radius of the service area perimeter therefore intermediate pumping station will not be required. Sewage will be pumped from the main pumping station to the treatment plant via a 200 mm diameter pressure main.

Preliminary pump requirements are identified in Table 4.3.18.

Table 4.3.18 Pump requirements for main pumping station West

Parameter	Units		2020	2030
No of pumps		duty	3	3
		standby	1	1
Pump capacity	(lps)	each	10	15
Operating Head	(m)	peak flow	28	48
Motor power	(kw)	peak flow	4	10
Power consumption	(kwH)	per day	82	210
Energy cost [1]	USD	Per day	21	53

Note: (1) unit cost of electricity $0.25 / kwH,
Source: JICA Study Team

Trunk sewers and Branch sewers

There is insufficient information on topography and location of dwellings to layout and size trunk sewers at this time. Preliminary alignments for trunk sewers are shown on Figure 2-3.

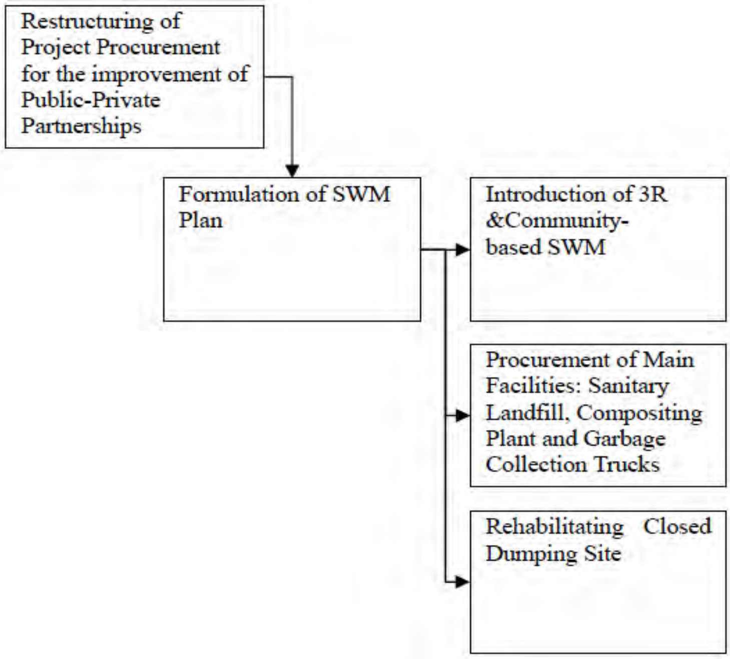
4.3.3 Solid Waste Management

The infrastructure development Plan will be designed in consideration of the common strategies of SWM in the Coastal Area and issues of SWM in Kampot Province.

The following activities are necessary in order to efficiently establish and utilize infrastructures of SWM.

(1) Present Conditions of Solid Waste Management in Kampot Province

Framework and components of a plan of SWM in Kampot is led based on the key issues of SWM in Kampot. It is shown in the following figure. Project procurement of SWM should be reconsidered and restructured prior to the other activities in order to make private sector and public sector function for SWM from waste reduction at source to collection, transportation and management of landfill in consideration of marketability of SWM and affordability and willingness to pay of waste generators. Formulation of SWM plan should be followed by introduction of 3R and Community-based SWM and procurement of main facilities and rehabilitating closed dumping site.



Source: JICA Study Team

Figure 4.3.4 Framework and Components of Infrastructural Development Plan in Kampot

Description of activities of each component is shown below.

(2) Restructuring of Project Procurement

To restructure the project procurement of SWM, the qeustion who should be the owner, operator and financer should be studied and reconsidered. Risks and responsibilities of SWM shared between the private sector and public sector should be clear. The following studies and surveys are necessary.

- Affordability and Willingness to Pay Surveys: Affordability of waste generators and Willingness to Pay (WTP) of waste generators
- Financial Analysis Surveys: Affordability of Province and Districts, including central towns
- Cost estimation by type of technology and project: Type of garbage collection truck, composting plant and sanitary landfill site
- Marketability and Feasibility Study
- Study on Type of Project: BOT, DBFO, BOO, including types shown in the Law on Concessions
- Study on monitoring system of performance of private sector and performance-based payment
- Main conditions that should be mentioned in contract with private company

These studies should be done in collaboration with MOE because it is difficult for the province alone to conduct it.

(3) Making of SWM Plan

SWM plan should be made in accordance with the sub-decree on Solid Waste Management. At present there are no guidelines on making of SWM plan given by the Royal Government, however, the following components should be described in the SWM plan at least.

- Purposes and targets, including numerical target of waste reduction
- Policies of countermeasures, including policy on project procurement
- Main countermeasures to realize purposes and targets
- System of monitoring and evaluation on progress and achievements of the plan

In addition, action plan showing schedule and financial sources should be made.

To make SWM plan, the following actual conditions survey are necessary.

- Waste quantity survey
- Waste composition survey
- Time and motion survey on collection of waste
- Public awareness survey

(4) Introduction of 3R and Community-based SWM

Based on the results of the studies on project procurement, roles of province, districts, communes and villages should be clear, and 3R and Community-based SWM should be implemented. Especially the following points should be clarified.

- How to/ who collect and manage garbage collection fee
- How to/ who decide unit price of garbage collection fee
- How to share the garbage collection fee between communities and private company who provide secondary collection service
- How to/ who monitor secondary collection service after primary service by communities
- How to/ who assist communities in implementing 3R and Community-based SWM

(5) Procurement of Main Facilities of SWM

The following are considered as main facilities of SWM.

- Sanitary landfill with leachette and gas control system
- Composting plant
- Garbage collection truck

The above facilities should be prepared for Krong Kamopt (central town) and Tuek Chhou district prior to the other areas because they are urban areas where amount of waste would sharply increase, and the province has already have a proposed site for a new landfill for the areas. However, the proposed site should be carefully decided in consideration of future zoning plans in the province, and environmental and social sustainability. Site surveys are necessary for establishment of landfill and composting plant. Examples of surveys are as follows:

- Topographic Survey
- Geological Survey
- Environmental Survey
- Desk Study, including Conceptual Design

(6) Rehabilitation of the Closed Dumping Site

Kampot province closed its dumping site in consideration of the environmental impact. Closed dumping site should be rehabilitated in proper way to prevent environmental impact. The following site surveys are required to rehabilitate the closed dumping site.

- Topographic Survey
- Geological Survey
- Environmental Survey
- Desk Study, including technical options