Number of Samples Surveyed by AFD Survey

Category	Number		
	Urban	Suburban	Total
Household	312	104	416
Shop	89	32	121
Factory, Warehouse, Office	37	0	37
School	16	1	17
Hospital	9	0	9
Farm	30	72	102
Livestock Operator	0	30	30
Fish Pond Operator	0	20	20
District/Sub-district Office	12	3	15
Total	505	262	767

4.4.5 Socioeconomic Surveys

The Kop Srov and Tompun dikes are located on the northwest and southwest side of Phnom Penh City with communities along both sides of the dike. During the construction period, the residents who live along the dikes may be relocated and construction activities will disturb the living conditions of people who live near the dikes. The socio-economic survey along Kop Srov and Tompun dikes focused on persons who would be affected by the project implementation. The study includes collecting information of their attitudes and their perceptions of the project, as well as their problems and necessary assistance for the relocation, and their opinions, suggestions, and recommendations for mitigation measures for the project.

(1) Objectives

There are 3 major objectives for this study as follows:

- To obtain information on existing socio-economic conditions of the affected people in the study area.
- To evaluate negative and positive impacts of the project on the people and communities in the project vicinity.
- To analyze opinions and attitude of the affected people towards the project.

(2) Scope of Study

The socio-economic survey covers the area within 100 m on each side of Kop Srov and Tompun dikes.

(3) Methods of the Study

Two methods of study were applied, i.e., collecting information from secondary data to present the overall picture of the study area, primary socio-economic study and field survey to collect an update and in-depth information of affected households and related organization / agencies.

Secondary data collection refers to IEE documents and research reports relating to socio-economic condition of the area including village, local area profiles. These data were reviewed and analyzed.

The primary data will be obtained from field surveys in some locations of the study area that are elaborated below:

(a) The Questionnaire Structure and Administration

The questionnaire utilized in this study covers 4 main components for 'head of household interviews'.

- General information of respondents and their family, e.g., age, sex, education, religious, population structure and family size, employment / unemployment of family member.
- Economic structure of family, e.g., occupation, expenditure, details of expenditure and distance of work place from their resident.
- Assets owned by family, e.g., house condition, land owned / occupied by family, and other assets ownership.
- Resettlement issue, e.g., opinion on the existing environment, community awareness, and attitude toward the project, willingness to relocate, problems in relocation and other suggestions/ recommendations toward the project.

(b) Population and Sample

The socio-economic survey was undertaken along Kop Srov and Tompun dikes by interviewing the villagers from 3 districts namely Tompun, Russey Kao, and Sork Dong Ko. The number of households and population within 100 m on each side of Kop Srov and Tompun dikes were derived from the compensation survey investigations. The respondents were selected by random sampling method totaling 20% of all household numbers. The sample distribution is shown in Table G4-7.

(c) The Field Survey

Before the actual field survey was conducted, the enumerators were trained to administer the questionnaire properly. Among various topics discussed were the background of the project, objectives of the socio-economic study, goals of the questionnaire, techniques in interviewing people to ensure that data to be collected will be reliable and accurate data. After sufficient training, enumerators and field supervisors started the interviews in the study area.

(d) Data Tabulation and Analysis

Statistic computer programs SPSS processed data from field surveys for Windows. The result describes the socio-economic condition at household level and attitude towards the project implementation.

(4) Study Results

(a) General Condition of Study Area

(i) Kop Srov Dike

Kop Srov Dike is located on the northern part of Phnom Penh, in 3 sangkats namely Svay Pak, Khamou, Khan Russey Keo, and Sangkat Kok

Kokar, Khan Dong Kor. It was reported that housing was dense near highway No.5, and along Kop Srov road. Most of the houses are small wooden houses, ground floor is at or higher than the water level.

(ii) Tompun Dike

Located on the southern side of Phnom Penh City, this road is actually a flood protection dike with one pumping station. Boeng Tompun is under the administration of Sangkat Stoeng Meanchey and Sangkat Boeng Tompun, Srok Meanchey. Houses are situated along the road. Fresh market is located at the center of the dike road. Most of the houses are made of wood, level of living floor is equal to the road level or lower. Ground floor is used for hog raising. The occupations of the residents in this area are gardening, pig and duck raisings, trading and wage earning in the factories. All residents are Khmers.

(iii) Svay Pak Drainage Sluiceway

Svay Pak drainage sluiceway site is located under NR-5 about 2 km southward from the intersection to Kop Srov Road. Housing is situated besides the existing sluiceway in the southern part. In the northern part, there are lots of factories, but buildings or structures are away from the sluiceway.

(b) Infrastructure and Public Facilities

(i) Kop Srov Dike

Kop Srov Dike is suburban area with rather poor public facilities and infrastructure system. Electricity supply is available only at the first 1.5 km of the Kop Srov Dike from the junction of national road No.5. Almost all of households still use batteries, lamps, and private electric generating engine. Most of the households have domestic water from Trapeang Reang Lake which is closed to the road, and some household buy water from private water supply.

Regarding public facilities, there is only one primary school namely Trapeang Reang school, 2 private clinics and 3 buddhist temples Wat Suwan Maniwong, Wat Trapeang Veng, and Wat Kop Srov are all located along the dike.

(ii) Tompun Dike

The infrastructure and public facility conditions along Tompun Dike are summarized as follows:

Infrastructure	Public Facilities
• Electricity supply is available along this road. • Telephone is available only near the junction between Tompun Dike and road No.271. • Sources of water for household consumption consist of connected pipeline from water supply system of private sector, groundwater well and rain. • Access to city via road No.271 and Monireth road.	• Thapol Pous school. • Wat Thapok Pous and Wat An Pothignen. • 5 clinics.

(iii) Svay Pak Drainage Sluiceway

Svay Pak drainage sluiceway is along the NR-5. Electricity supply is available.

(c) Results of Head of Household Interview

(i) Household Family and Structure

General Information of Household and Family Structure is presented in Table G4-8. Some characteristics are as follows:

The average age of the respondents is 44.73 years, the largest group is 30-40 years (29.75%), followed by 41-50 years (28.51%), males outnumber the females female (67.36% and 32.64% respectively). The vast majority of them (82.64%) being household head and 7.85 % of them are parents of household head. About 40.91% and 34.30% have finished secondary and primary education respectively, 8.26 % have attended high school, and only 2.48 % have studied beyond high school. Majority (99.59%) is reported to be Buddhists.

The average household size of the respondents is 6.17 persons per household, the largest group is 5-7 person per household (47.93%), followed by less than 5 persons (26.86%). Male members are a little less than female members with a ratio of 1:1.06 (male:female). About 39.37% of family members are between 21-60 years old, about 25.41 % are 6-13 years old, 18.29 % are 14-20 years old, 12.11% are lower than 6 years old and 4.92% higher than 60 years old. Concerning education level of family, one-third of family members (31.57%) are students, about 24.95% and 15.83% of family members completed primary school and secondary school respectively. The proportion of employed member and unemployed member is 1.77 and 4.39 persons per family respectively or 1:2.48 which is a very high dependency ratio.

(ii) Economic Structure of Household

Occupation

Among 242 households interviewed, many occupations were reported. The highest percentage among the main occupation was in the service sector (22.73%), shop owner or merchant (21.90%), and labour (20.25%) followed by farmer (18.18%), and government officer (16.94%). About 45.04 % of respondents reported having supplementary occupation, the highest percentage (17.36%) being shop owners followed by government officers (15.29%) and service sectors (8.26%). Types of occupation can be described as follows:

Shop owner or merchant: Shop owner is an important occupation in Tompun dike. Various types of shops were found, i.e., grocery shop, fruit / vegetable stalls (fresh market), timber shop, restaurant and cloth shop. Near the junction of Kop Srov road and Highway No.5 many shops are located.

Labor: The main occupation of respondents living in both Tompun and Kop Srov is labour. The highest number among laborers were factory workers (63.27%) followed by construction workers (26.53%) and general workers (10.20%).

Service Sector: Service is one of main occupations of respondents. Motorcycle drivers were found all over the area. Carpenters are in Svay Pak because in this area there are a lot of lumber yards and a saw mill nearby. Other types in small number are private water supplier, taxi driver, rental house owner, and maker of thatch products.

Farmer: Agriculture is very important for respondents living in Sangkat Khamou, Kok-Kokar and Tompun dikes. Agricultural activities found are morning glory cropping, paddy rice, vegetable cropping, animal raising (swine), fishing, and lotus product collection. This occupation generates much lower income than other occupation since cropping is limited by size of cropping area, and yield of cropping is also low.

Government / Private sector employee: People practising this occupation were found in every area. This type of occupation includes policemen, solider, doctor and company employees.

Income and Expenditure

It is found that there is great difference in level of family income. The average annual household income is US$ 1,397.69. The group with the highest income live in Tompun dike (US$ 1,482.22 per household) while Kop Srov dike earn the lowest income (approx. US$ 1,258.35 per household). This group consists mostly of farmers with lower income than other groups. Considering rank of annual household income, almost one-third of them has income in the range of US$ 500 to 1,000 per household (33.88%).

Concerning the expenditure, it is found that those in Kop Srov have lower expenses than those in Tompun.

Distance from Residence to School and to Work Place

The average distance from residence to the school is about 2.34km. About 27.69 % of them are between 3-5 km to school and 27.27 % have no student in their family.

Concerning about distance between residence to work place, it can be categorized into 3 groups as follows:

- Unable to indicate the distance (16.94%) because of temporary work place such as general wage labor, construction labor, fishermen, motorcycle driver, and taxi driver.
- Working at the home or the resident is close to the work place (35.12%), i.e., animal raising, grocery, business, restaurant and wood / timber.
- Those who have permanent work place (47.94%) i.e., trading at the fresh market, government employee, factory worker, company employee lotus product collection, paddy rice cultivation.

The average distance between residence and work place is approximately 4.15 km.

(iii) Information on House, Assets Owned, and Land Occupied by the Family

House Condition

Majority of the respondents (96.29%) have their own house or building, 2.48% are tenants and only 1.24% occupies housing free of charge. The average value of building (92.98%) is about US$ 5,954 per house, purchase house (3.31%) is about US$ 6,250 per house, and rental house is charged about US$ 14 per month.

Average floor area is about 80.79 sq.metres per house, two-third of the houses (64.46%) are traditional style, 30.58 % of them are modern style, and only 4.13 % of them are row house. Roof of house is metal (64.46%), tile (15.29%), thatch (9.50%), or concrete (3.31%). Majority of houses (86.78%) has wooden walls followed by thatch (5.79%) and concrete (5.37%). The vast majority of houses (93.80%) are single storey house (the floor over the ground).

Land Owned / Occupied by the Family

According to data analysis, it is found that every household occupies a plot of land for house and residence. The average residential land is 537 sq.m per households, about 52.48% of them have land holding certificate. About 43 families (17.77 % of respondents) utilize their land for agricultural purposes. These are classified into 3 type of uses: cropping land (paddy rice, horticulture), fishpond, and water body (lotus). The

average land sizes of those are 4,501 m^2, 1,637 m^2, and 10,300 m^2 respectively per household.

Assets and Utilities

The properties that most of the families owns are motorcycle (67.77%) and television set (64.46%). The next rank are radio, bicycle, and bed/table/cabinet (19.01%, 14.05% and 13.64%, respectively). Other properties found in some household are car, boat, and machine / engine / equipment.

(iv) Information on Settlement

In the past 10 years, about 40.08 % of respondents have never moved. The rest of them have just migrated. In the latter group, 53.10% have migrated within these area, 28.28 % from other provinces, and 18.62% were from other districts within Phnom Penh. Only 7 families have moved two times within the past 10 years.

(v) Reason for Current Settlement and Problems Experienced

When asked about their satisfaction with the community, reasons in order of priority are; good neighbour (35.54%), no other places to choose (25.21%), close to school (13.64%), water availability for crops (9.09%), and close to work place (7.02%). Reasons of dissatisfaction with community are; inadequate water supply (26.61%), too many mosquitoes/insects (24.77%), inconvenient transport to work place (11.93%), and very bad smell from polluted water (8.26%). The conclusion on satisfactory condition of present living and dissatisfaction or problems can be summarized in the order of important as follows:

Reason for Satisfaction in Present Location	N = 92(%)	Reason for Dissatisfaction	N = 92(%)
First Priority		First Priority	
-Good neighbor	35.54	-Inadequate / no water supply	26.61
-No other place to choose	25.21	-Too much mosquitoes / insects	24.77
-Close to school/wat/temple	13.64	-Inconvenient transport to work place	11.93
-Available water for crop	9.09	-Very bad smell from polluted water	8.26
		-Flood every year	7.34
Second Priority		Second Priority	
-Close to work place	31.19	-Too much mosquitoes / insects	23.85
-Good neighbor	24.31	-Inadequate / no water supply	16.06
-Close to school	13.76	-Inconvenient transport to wore place	15.60
Third Priority		Third Priority	
-Good neighbor	22.02	-Too much mosquitoes / insects	22.02
-Close to school	20.64	-Inconvenient transport to work place	14.68
-Available water for crop	11.47	-Inadequate/no water supply	11.01
-Convenient on other utility	11.47	-Very bad smell from polluted water	11.01

(vi) Awareness and Attitude Towards the Project

The vast majority of respondents (73.35%) know about the drainage improvement and flood control project. Only 26.45% of them have never

know about the project. Source of information are mostly from project staff (JICA Team and research team), government officer and neighbor (76.97%, 14.04% and 8.99%, respectively).

Considering overall project implementation, almost all of respondents agree with the necessity of the project (87.60%).

The reason to agree with necessity of the project was not much different. The major reasons were that i) improve national economy, ii) improve living conditions in the area, iii) prevent flood, and iv) convenient access to this area. Reason given for disagreeing is an unwillingness to relocate.

(vii) Opinion on the Relocation and Assistance from the Project

Cooperation and Relocation

Majority of respondents (92.56%) showed their willingness to relocate during project implementation while only 3.31% disagree and 4.13% gave no opinion on this aspect.

Problem of Relocation

About 19.83 % of them said that they had no problem in relocating while the rest of them (80.17%) have some problem to relocate. The most important problem perceived is transportation to the relocated site (49.59%), followed by lost of appropriate site for business or cropping (25.62%), no money to move and construction the new house (10.33%), far from work place and school (9.92%), and hard to find place to relocate (4.13%).

Expected Assistance for Relocation

In term of expected assistance for relocation, provision of finance for relocation of houses and assets to new place, provision of new land for residential area, provision of supporting facilities in the new place and assistance in food supplies during relocation are required.

(viii) Requirement on Proposed Relocation Area and Other Suggestions for Project Implementation

Requirement on Proposed Relocation Area

Result of interview showed that suggestions on proposed relocation area were given by 28.10% of respondents i.e., 19.83% suggested to relocate within this area (close to Kop Srov and Tompun dikes), 5.79% requested the area close to downtown (near market and commercial area), and 2.07% suggested relocation to other provinces (outside Phnom Penh City).

Other Suggestion for Project Implementation

About 9.50 % of respondents had some suggestions. They suggested that the project should provide appropriate compensation and a good place for business or support new occupation for affected people.

4.4.6 Compensation / Resettlement Survey and Study

The compensation and resettlement aspects are important concerns of all development projects. Infrastructure improvement may cause loss of properties and in some case require relocation of the inhabitants. Thus, it is necessary to establish a fair compensation scheme and if necessary, to provide a proper resettlement program to the affected families and to ensure that their quality of life will not worsen due to the project implementation.

(1) Study Methodology

The compensation and resettlement study comprised the following steps:

- data / information collection and review
- field investigation on affected households / properties and potential resettlement sites
- preliminary planning for compensation / resettlement program and cost estimates

(a) Data Collection and Review

The concerned secondary data including topographic maps, aerial photo, reports, etc., were reviewed and pertinent information was extracted and tabulated for further analysis. Information gaps were identified and field survey programs were designed to fill up such gaps.

(b) Field Investigation and Additional Data Collection

Field survey was conducted between December 1998 - January 1999 to collect necessary data for resettlement planning and compensation cost estimations. Field activities included:

- Collection of household and population data of the affected families.
- Collection of local cost of construction material, labor, transportation, etc.
- Inventory of private structural properties.
- Field survey of existing land use and condition around the potential resettlement site.
- Collection of land price.

(c) Data Analysis and Evaluation

Data and information collected from related office and surveys were analyzed, and evaluated to delineate the actual condition of the affected inhabitants, their properties and other related aspects.

(d) Preliminary Planning for Compensation / Resettlement Program and Cost Estimates

Criteria for compensation payment and resettlement program were established considering previous practices implemented for similar projects. Unit

compensation cost for each type of property was calculated. Suitability of each potential resettlement site was evaluated and most suitable site with related development was recommended.

(2) Compensation Estimates for Affected Properties

(a) Affected Area

The area to be affected by Kop Srov and Tompun dikes reinforcement will be on the northern side of Kop Srov dike (water side) and along Tompun dike. The total improvement length will be about 7.65 km. A total of 51 households from Kop Srov and Tompun dikes to be relocated respectively. This development excluded development activities on the eastern most part of the dike near Highway No.5 due to very dense housing present there.

(b) Criteria for Compensation Payment

The compensation payment for properties to be affected by the construction of the proposed Kop Srov dike improvement includes the following items:

(i) Land compensation for each piece of affected land with ownership document or proven evidence of ownership.

(ii) Compensation cost for structural properties in the project affected area

The compensation cost will include the following basic cost items:

- dismantling cost
- cost of damaged material due to dismantling
- transportation cost of dismantled material to new home plot
- cost for labor for reconstruction

Unit cost for all of the above items were proposed based on local cost of construction material, labor and transportation.

(iii) Administrative costs

The administrative costs will be added to the compensation cost estimates are expenses for detailed survey of the affected properties, cost for compensation payment, administration, and contingency.

(c) Estimation of Compensation Cost

(i) Cost for Structural Compensation

The estimation for cost of structural compensation was based on the result of structural inventories performed in December 1998. The type, size, quantity, and quality of construction material for each type of affected structure were recorded and grouped into the type of typical structure. Detailed information on typical structures is presented in the TEAM EIA Report (TEAM, April 1999).

The compensation cost for each type of typical structure was then calculated to include the following items:

- Cost for dismantling
- Cost of damaged material due to dismantling
- Cost for transportation of dismantled construction material to new place
- Cost for reconstruction at new place

By application of this unit compensation cost criteria, the total compensation cost of each structure was calculated and is presented in **Table G4-9 and G4-10**.

(ii) Cost for Land Compensation

No land acquisition is necessary for Kop Srov and Tompun dike improvement.

(iii) Summary of Compensation Cost

The total compensation cost for Kop Srov dike improvement can be summarized as follows:

Structural Properties

- Number of structure to be dismantled 54
- Compensation cost (1) US$ 74,248

(3) Resettlement Scheme

(a) Description of Potential Sites for Resettlement Development

Suitable resettlement site was to be identified to accommodate 54 families from Kop Srov who will to be relocated from their present residence due to the dike improvement. In general, the preferable site should possess the following characteristics:

- The land should be located not far from the previous residential area in the same khan.
- The land should have suitable topography with relatively flat terrain.
- The land should have potential for infrastructure development.
- Good water sources for cultivation and consumption is available.

Potential resettlement areas with the above requirements were identified from 1:50,000 topographic maps and 1:2,000 aerial photos. Field reconnaissance was undertaken of the potential areas to observe the actual conditions with particular emphasis on:

- Topography
- Existing land use and land occupancy
- Water resources availability
- Accessibility and available supporting facilities and infrastructure

The investigated areas including two sites in the vicinity of Kop Srov dike. Description of each investigated site is as follows:

(i) Site 1: Existing resettlement site at Kop Srov dike (UNBRO relocation site: km 1+900 to km.4+000) (For Kop Srov Area)

Location

Adjacent to Kop Srov dike Km.1+900 to Km.4+000 on the southern side of the dike.

Accessibility

The site can be directly reached from Kop Srov dike at km.2+400 via lateritic road.

Topography

This alternative site is located on flat terrain.

Land Use

This site, with area of 33.28 ha, was initially developed in 1992 by a non-profit organization founded by Thai and foreign developers to serve residents from Km.6 of Kop Srov road and Wat Salawan. This plot was developed for 600 families but only 300 families moved in. Currently, only 78 household reside in their allocated homelot. There are still 344 vacant homelots available. This area is under the supervision of Russey Keo Khan office.

Water Sources

Major source of water is from Trapeany Reong Lake and buying drinking water from private sector.

(ii) Site 2: Public land along the road to Wat Sawan Monivong (For Kop Srov Area)

Location

Adjacent to the road leading to Wat Sawan Monivong on the southern part of Kop Srov dike.

Accessibility

The site can be reached by lateritic road leading to Wat Suwan Monivong branching from Kop Srov dike at Km.1+600.

Topography

This site is a flat land on the flood plain.

Land Use

The area is currently being utilized for agricultural purposes with very few houses.

Water Sources

Major source of water for agriculture is from Trapeang Reong Lake.

(b) Assessment of Site Suitability

All alternative sites were assessed in terms of site suitability based on the following factors:

(i) Physical factors; topography, land use, water sources, and distance from the present Khan.

(ii) Social and legal factors; administrative location, acquisition process.

(iii) Size of land available.

With respect to the above criteria, in the Kop Srov area, Site 1 has some advantages due to the availability of basic infrastructures, e.g., embankment around the resettlement site, availability of vacant homelots, existing roads within the communities, and the land being already acquired. Site 1 and 2 are very similar in other aspects (topography, water source, distances from Khan and administration location). Thus, it is recommended that site 1 is to be selected for further development as the resettlement site.

(c) Description of the Selected Resettlement Scheme

(i) Number of Household to be Resettled and their Occupation

The household profile survey described earlier revealed that major occupations of 54 households that need to be relocated are as follows:

Farmer	42.50%
Small business / service	25.00%
Governmental officer	15.00%
Labor	17.50%

(ii) Development of the proposed resettlement area

The resettlement area for this group of persons is proposed to be in the northern corner of the existing Kop Srov resettlement site. The size of land allocation for each family is proposed to be 145 m^2 (based on the ADB funded Boeng Trabek relocation project), thus, the total area required will be about 1 ha for those 54 families to be resettled.

All land plot can be reached by village road. Provision of water supply and electrical distribution to this new community and the nearby household is strongly recommended.

4.5 Environmental Impacts

Construction and operation of the proposed project may initiate both positive and negative impacts on the surrounding environment. Thus, it is essential to assess the overall potential impacts prior to the development, and to effectively minimize the adverse effects with appropriate mitigation measures. The environmental impacts are assessed for both construction and operation periods. Information presented in earlier sections of this report concerning Project Description and Existing Environmental Conditions are used to predict possible impacts during construction and operation stage of the project.

4.5.1 Criteria for Assessment

Assessment criteria will be based on the following definitions.

a. Impact: A project - derived effect on physical resources, biological resources, human use values, and quality of life values. It can be a direct or indirect effect and can be either positive or negative.

b. Mitigation- An action that prevents, eliminates, reduces, or compensates a negative impact.

Impacts have been evaluated with respect to geographic scope, level of impact and duration as shown in the following table:

Geographic Scope	Level of Impact	Duration
Local Regional	High Moderate Low No impact	Short-term Long-term

a. Geographic Scope

- Local: Impacts restricted within the 100-m strips from the center line of the embankment, impacts concern one's communities/areas along the embankment.
- Regional: Impacts that extend beyond the local areas or impacts extending to other provinces.

b. Level of Impact

- High Impact: A high level of impact would result if the proposed project causes a substantial adverse change or stress to an environmental resource.
- Medium Impact: A moderate impact would result if the proposed project causes a moderate degree of adverse change or stress to an environmental resource.
- Low Impact: A low impact would result if the proposed project causes a minimal adverse change or stress to an environmental resource.
- No Impact: No impact would be indicated where no measurable impact would occur to the specific resource under investigation.

c. Duration

- Short-term: Impacts of short duration during the construction phase.
- Long-term: Impacts significance over longer periods during the construction phase or throughout the life of the embankment.

4.5.2 Physical Resources

(1) Hydrology

(a) Construction Period

During the improvement of Kop Srov dike, the major activities will include improvement of mobilization of heavy equipment, filling / shaping embankment with construction material, slope adjustment, and pavement of the Kop Srov

road. All of the above activities except the pavement will be confined to the waterside (north side) of the existing dike. Currently, this construction site is part of the existing embankment slope, a low lying area, or water body. The existing crossings at location (pipe and box culverts) on the drainage channel or waterways will remain functional throughout the construction period. Concerning the fill up of water body on the north of Kop Srov dike, the area to be disturbed by construction activities will be small, in comparison with the vast area of low lying area and water body. Therefore, these will have no significant adverse impact on the hydrological regime of the area.

For Tompun dike, the construction activities will be similar to Kop Srov dike and the affected area will be limited to within Tompun road ROW. All of the crossing infrastructure (pipe and box culverts) will remain functional. Thus, potential impacts on hydrology is evaluated as short term, very low and very localized.

For Svay Pak drainage sluiceway, temporary coffer dams will be constructed on the creak at both sides of the NR-5. Hydrological condition will be slightly changed but it will be only for one rainy season and no serious damage is expected.

(b) Operation Period

The proposed reinforcement of Kop Srov and Tompun dikes is intended to alleviate the flood damage to the city of Phnom Penh and its environs. The improvement will increase the height of the existing Kop Srov dike by 1.1 m at maximum. Therefore, no new structures will be built to obstruct the current hydrological pattern of the area. Thus, no significant adverse impact on hydrological pattern is expected.

The proposed Svay Pak drainage sluiceway has the better function than the existing one, because the existing structure is heavily deteriorated and water tightness is very low. Thus no adverse impact is expected, and high positive impact, rather, is expected.

(2) Water Quality

(a) Construction Period

The improvement works of Kop Srov and Tompun dikes will occur over a period of about 3 years. During this period, the ground surface could be affected by the following activities:

- ROW clearing and leveling
- Mobilization of heavy equipment for soil transportation and compaction
- Foundation preparation
- Dike surface preparation
- Wastewater from construction camps / site office
- Wastewater from maintenance workshop

The section of Kop Srov dike and Tompun dike to be reinforced are parallel to large low-lying swampy area throughout the length. For Kop Srov dike, the

large water body serves as the primary source of water for domestic and agricultural purposes. The current practice is to boil water prior to consumption. It can be expected that some of the runoff from the construction site of Kop Srov dike will drain into this waterbody during the rainy season.

Concerning Tompun dike, the receiving waterbody is also a low-lying area and serves as a source of water for agricultural purposes. The additional suspended solids from the runoff can add turbidity to the water body.

Svay Pak drainage sluiceway has a similar condition. The additional suspended solids during construction can add turbidity to the water body only adjacent to the site. But it is limited to local effect, and it will not flow to the Tonle Sap river because of existence of coffer dams.

Suspended solids from existing dikes are being washed into the waterways every year due to the unpaved condition of the dike roads and lack of sodding along the dike slope. Potential impact of the additional suspended solids from dike construction activities is evaluated to be short term, localized and relatively minor.

The main sources of waste water will be from the construction camps, the site office and the workshop. At this stage of feasibility study, the exact locations of the related facilities cannot be identified. However, with strict application of the following criteria, expected impacts on water quality will be short term and have low impact. The criteria for selection of workers camp site, site office and workshop are as follows:

- To be located at least 50m from waterbody.
- To be adequately equipment with sanitary toilets.
- To be equipped with retention basin(s) to collect domestic wastewater prior to overflow into nearby waterbody.
- Workers will be provided with clean water for domestic purposes.
- Maintenance activities will be conducted only within the designated areas with proper oil reception and treatment facilities.

Construction activities will require a large number of heavy equipment that have to be regularly maintained. The oil changing, lubricating and other related maintenance activities have to be performed only in the designated workshop facilities. These facilities also have to be equipped with containers for waste oil. In addition, this area needs to have proper shelter to prevent any surface runoff contaminated with oil from washing into the water body. With these provisions as recommended, the potential impact on water quality will be very low.

(b) Operation Period

During the operation period of Kop Srov and Tompun dikes, there will be no negative impact on water quality. After the dike is improved, paved and sodded, the suspended solids in runoff from the dikes will be reduced which has a long term positive impact on the area. Svay Pak drainage sluiceway will have positive impact on water quality.

(3) Soil

(a) Construction Period

It is expected that soil for embankment will be borrowed from the existing borrow area outside the Study Area. No impact cab be evaluated.

On the other hand, excavated soil will be used as filling in the proposed resettlement area (25ha). The area is currently low-lying area with some agricultural activities. Thus, the impact is evaluated as local, low level and short term in duration.

(b) Operation Period

There will be no impact on soil during operation period.

4.5.3 Human Use Values

(1) Land Use

(a) Construction Period

(i) Current situation

The total area within 20m strip on both sides of the whole section of Kop Srov road is about 304,000 m^2. The major land use types are Idle land (45.77%), followed by water bodies (40.44%) and residential land (7.03%). There is about 6,972 m^2 of agricultural land including paddy field, orchards and idle land. There are some environmental problems in the resettlement site (Phum Trapeang Reang with an area of 0.335 km^2 comprising fish pond and housing area). The problems are annual flooding, contaminated water and poor operation of pumping station during floods. There is an area under preparation as fish pond in front of the 3K Battery factory.

For Tompun dike, the study area within a 20 m strip (17.7ha) is mostly housing area (48.87%) and idle land (24.31%). The remaining portions are agricultural areas (aquatic plants/orchards) and factories.

(ii) Effects on land use at project's construction area

During the construction period, the land use types within the construction area will change. Table below shows the land use types affected comprising housing area with 54 houses. These will be replaced by the construction of structures of the dike. After completion project construction, the land use will change to flood protection structures. Thus impacts are significant but unavoidable due to requirement of land for the construction.

The other side of Kop Srov road (non-water front) will not be affected by project construction activities. The road surface will also be improved for local transportation. There will be no impact on land use.

For Tompun dike, all improvement works will be confined within the existing road ROW, with no requirements of land acquisition. Thus, there will be no impact on land use along Tompun dike ROW.

Land Use Types to be Affected by Kop Srov Reinforcement

Land Use Types	Existing Area (m^2)	Changes	
		Area (m^2)	%
- Residential Area	21,354	2,453	11.49
- Factory / Industry	13,594	No	-
- Paddy Field	754	No	-
- Orchards	252	No	-
- Idle Land	139,128	No	-
- Paddy Field / Idle Land	5,964	No	-
- Water Bodies	122,951	51,516	41.90
Total	304,000	53,969	17.75

(b) Operation Period

The project development will be operated within the right of way of the project. There will be no additional disturbance in the vicinity areas. Thus, the impacts on land use are insignificant. In addition, the residential and commercial areas are expected to be improved due to the indirect effect of the project development in terms of improved road network and other related infrastructure.

(2) Transportation

(a) Construction Period

(i) Current condition

Kop Srov and Tompun roads are the primary routes for truck transportation of various goods and trailers. The poor road surface results in delays in transportation. There is also extensive dust problem during dry season since the road surfaces are laterite. In rainy season, the road is normally flooded in some sections resulting in inconvenience for transportation.

(ii) Potential impact

The adverse effects on transportation during construction period comprise the following items;

- accident and traffic congestion near the construction site
- deterioration of road surface by heavy trucks used in the project
- dust increase due to construction vehicles
- inconvenience for local transportation

These effects can be mitigated by suitable measures such as provision of detour routes, installation of the warning signs, strict control on the loading of construction trucks and daily water spraying etc. Therefore, negative impacts can be controlled and residual impacts are expected to be minor.

(b) Operation Period

Positive impact is expected as the stability of road structure and asphalt pavement will help flow of transport vehicles more smoothly with little or no dust generation in dry season and no flooding in rainy season.

(3) Flood Control

(a) Construction Period

During the 2-year construction period, Kop Srov dike will still have the some flood protection capacity. In addition, the existing crossings at 9 locations (6 pipe culvert and 3 box culverts) will be maintained. Thus, there will be no alteration of flood condition during construction period.

(b) Operation Period

After completion of Kop Srov and Tompun dike improvements, the Kop Srov dike will be heightened with better condition and stability and Tompun dike will be strengthen maintaining the same height. Thus, the area within the dike perimeter will be improved to protect against present flood. In addition, Kop Srov and Tompun roads will also be improved which is beneficial to local community and transportation vehicles. Svay Pak drainage sluiceway is the structure for flood protection and it will give high positive impact on flood control.

4.5.4 Quality of Life Values

(1) Socio-economy

According to the result of the socio-economic survey, most of respondents understand the project benefits in terms of its contribution to economic development, prevention of flood, improvements in their community environmental conditions, and improving access to the area. However, there is anxiety about relocation and compensation schemes due to the project implementation.

(a) Pre-construction Period

(i) Relocation Problem

According to the result of field survey, it is found that the right of way (ROW) of Kop Srov and Tompun dikes has been encroached upon by many houses which need to be relocated. The house location has a very important relation with their main source of income. This is because either the house is also used for business/shop etc. or is in close proximity to their income generation activities. In addition, some people have a problem about relocation due to lack of finance, loss in income due to relocation, and problems in finding a place to be relocate to, and loss of site used for income earning like shops. Affected persons and problems are as follows:

- Approximately 54 families located along the water side of Kop Srov dike are affected and persons living here have to be relocated. No

relocation is necessary at Tompun dike and Svay Pak drainage sluiceway.

- Problem arising for children of affected families in terms of longer travel distance to school. This issue was mentioned by 14.13% of respondents and family members.
- Problems in terms of loss of income and earning potential, and increased expenditure due to commuting longer distance to appropriate site for work such as trading (far from market), fishing, lotus product collection (far from lake) and factories.

These impacts can be alleviated by implementing mitigation measures such as compensation payment for relocation, provision of acceptable relocation site and consultation as well as participation of affected persons in relocation/compensation development and implementation plan. If these measures are implemented adequately before commencement of project construction, then the negative impacts can be controlled and construction will proceed as per schedule. The impacts can then be considered to be negligible with project affected persons enjoying a quality of life which is the same or better at the new relocation site.

(ii) Disturbance on Communities

During construction, the transportation of equipment, heavy machinery and construction material will impact the communities located along both side of Kop Srov and Tompun dikes and Svay Pak drainage sluiceway in the form of dust, noise and travel inconvenience. Dust and noise will be increased due to land clearance and other construction activities. Existing air quality of this area already indicates high concentration of dust due to poor road conditions (laterite surface) and high traffic volume especially due to heavy trucks. It is recommended that construction contractors (CCS) will provide some mitigation measures for dust suppression like spraying water, traffic noise mufflers on all equipment on site management etc. It is also proposed that the measure will be outlined in an environmental management plan (EMP) by the CCS and submitted along with their tender bids. Adequate monitoring will be done by the implementing agencies to ensure implementation as per the EMP. Negative impacts can therefore be adequately managed to ensure that they are rendered insignificant.

(iii) Local Economic Impact

The construction activities will create job opportunities for local people as construction laborers and workers. Local economic activities will be stimulated during construction period through a boost trade/business in Phnom Penh Municipality particularly in construction materials, construction contract work and contracting opportunities.

(b) Operation Period

(i) Improve Quality of Life in the Communities

When the Kop Srov and Tompun dikes are improved, the road surfaces will be upgraded to asphalt. The infrastructure at the resettlement site will be developed by the project. The project affected persons will have a better place to live due to improved utilities and facilities.

(ii) Economic Impact

At present, the people in Phnom Penh municipality suffer from flood and property loss due to flood damage every year. When the project is completed, these problems will be reduced significantly. There are positive impacts for improved economic development of Phnom Penh municipality.

(2) Compensation/Resettlement

(a) Pre-construction Period

The estimation of compensation cost for the affected properties was presented in an earlier section. Proposed resettlement scheme was also outlined for the 54 affected families. If these are implemented on time with adequate consultation with the project affected persons, the negative impacts of compensation resettlement will have minimal negative impact.

(3) Archaeology and Tourism

(a) Construction Period

The area around Kop Srov dike is mostly flat, low lying area with low population density. Tompun dike is quite different with relatively dense population near the City of Phnom Penh. There are no archaeological sites or tourist attractions within or near proposed improvement facilities. Therefore, no impact on archaeological and tourism is identified.

(b) Operation Period

The indirect benefit on Archaeology and Tourism can be expected to the city of Phnom Penh in terms of flood damage reduction which can enhance the potential as tourist attraction within the city. In addition, after the Kop Srov and Tompun dike improvements with upgrading of the dike roads to asphalt, the dike can be utilized as ring road around Phnom Penh that should facilitate tourist activities around the city.

4.6 Environmental Mitigation Measures

The mitigation measures proposed herein will be elaborated in detail in an EMP to be prepared by the CCS during the design and tendering process of all construction works.

4.6.1 Physical Resources

(1) Hydrology

(a) Construction Period

- Drain ditch and small pond shall be provided to collect runoff water from construction activities.
- Any construction activities which disturb soil, such as land leveling, excavation, or piling will be done during dry season to avoid potential soil erosion during rainy season.
- Provide temporary drains at the construction site and vicinity areas.
- Strictly prohibit workers from dumping solid waste and garbage into the waterways. Make adequate arrangements for construction related waste disposal.

(b) Operation Period

- Coordinate with local Khan about gate barrage operation schedule in case of flood.
- Regularly clear up waterways prior to the rainy season.

(2) Water Quality

(a) Construction Period

- Construct all sections close to the waterways only during the dry season.
- Create buffer zones by leaving vegetation undisturbed for a minimum of 1m from the waterways.
- Do not wash equipment in the river.
- Prohibit any waste dumping into the waterways.
- Inspect machinery and equipment weekly to prevent any oil leakage.
- Store construction material at least 10m from the water course
- Install sanitary latrine for construction workers.
- Locate construction camp at least 50m from waterway.
- Construct retention basin to trap domestic wastewater from construction camps prior to overflow to nearby waterways.
- Drain ditch and a small retention pond should be constructed within the fenced compound to retain storm run offs and wastewater from construction activities.

(b) Operation Period

- Provide efficient flood warning system.
- During inundation there should be an efficient anti-disaster preparedness system to assist the affected families.
- Implement other additional flood protection measures e.g. dredging of swamps and canals.

4.6.2 Human Use Values

(1) Land Use

(a) Construction Period

- Inform local people prior to construction.
- Minimize the use of private land for construction purposes,
- Avoid construction activities during the growing season in case the construction site is in agriculture area,
- Filled up soil must be graded and compressed immediately to minimize erosion,
- Minimize construction in rainy season,
- Ditches should be dug parallel to the improved dike to collect the runoff water.

(2) Transportation

(a) Construction Period

- Avoid transporting construction machinery, equipment and materials during rush hours.
- Apply appropriate construction techniques and traffic management methods that minimize traffic problem.
- Inform road users and people in nearby communities about project construction schedules and planned activities.
- Closely cooperate with the highway police to alleviate traffic problem near the project construction site.
- Strictly enforce traffic rules within construction site.
- Install warning signs for drivers entering the construction site.

(b) Operation Period

- Install warning signs at proper sites along the road/flood protection dike.

4.6.3 Quality of Life Values

(1) Socio-Economic aspects

(a) Construction Period

- Urgently improve the existing resettlement site to accommodate affected families.
- Fairly compensate for directly affected land and properties as recommended in the section on compensation.
- Conduct construction activities only during daytime.
- Regularly check up machinery and equipment to control noise level to be within the permitted standard.
- Spray water on disturbed area or dust generating area to minimize dust dispersion.
- Not use machinery and equipment which generate soot and smoke exceeding the standard limit at the project construction sites.
- Provide temporary detour with adequate traffic signs at proper places.

- Employ local workers as often as possible to benefit local residents and improve local economic conditions.

(2) Compensation/Resettlement

(a) Pre-Construction Period

- The compensation should be fair and acceptable to affected people
- Compensation process should be completed before the start of project construction.
- The affected people should be actively consulted and informed about the compensation process.
- To compensate the private owned land and properties, the affected people should be given fair compensation and any genuine grievances should be reviewed.

4.7 Environmental Monitoring

The monitoring program to be proposed in this chapter is the follow up to ensure the effectiveness of the recommended measures. The data obtained from the monitoring program will be useful for further planning and management of the proposed project.

4.7.1 Surface Water Quality

(1) Parameter

- Depth
- Temperature
- pH
- Conductivity
- DO
- SS
- BOD

(2) Station

5 Station as follows:

- Phnou River
- Bassac River
- Sap River Downstream at Chak Tomuk
- Thnot River
- Phum Svay Pak

(3) Methodology

Standard Methods for Examination of Water and Wastewater by APHA, AWWA and WPCF; Vol.19.

(4) Frequency

- During construction activities
- Post construction activities

(5) Responsible Agency

- Contractor / DPWT

4.7.2 Transportation

(1) Parameter

- Average daily traffic by separate type of vehicle and accidental records.

(2) Location

- Kop Srov road and HW.#5.

(3) Frequency

- Once every 3 months during construction period.

(4) Methodology

- Traffic records according to type of vehicle and time of day.

(5) Responsible Agency

- Contractor / DPWT.

4.7.3 Socio-economic Aspects

(1) Parameter

(a) Construction Period

Attitude of villagers toward the project, compensation and resettlement plan issues to be considered are:

- Has consultation taken place as scheduled including meeting, groups, community activities? Have resettlement leaflets been prepared and distributed?
- How many affected peoples know their entitlements?
- How any affected peoples used the grievance redress procedures?
- What were the outcomes?
- Have conflicts been resolved?
- Was the social preparation (consultations in compensation relocation planning) phase implemented?

(b) Operation Period

- Change in patterns of occupation, production and resource use compared to the pre-project situation.
- Changes in income and expenditure patterns compared to pre-project situation, changes in cost of living compared to pre-project situation, and affected people's incomes place with these changes.
- Changes taken place in key social and cultural parameters relating to living standards.

(2) Methodology

- Independent survey of villagers attitude by questionnaire

(3) Location

- Villagers live along both side of Kop Srov Dike and resettlement area (operation) located in Khan Russey Kao and Dong Ko.

(4) Frequency

- Two times before construction period and the first year of construction.
- Once every 2 years during project operation.

(5) Responsible Agency

- Department of Public Work and Transportation.

G5. Environmental Impact Assessment of Priority Project - Tompun Watershed Drainage improvement

5.1 Project

The Project, Tompun Watershed Drainage Improvement (corresponding to Component 3 in the Master Plan), is for the drainage improvement of Tompun Watershed (17.47 km^2), the western half of the populated area of Phnom Penh City, with a scale of a 5-year return period rainfall.

The Project comprises the following 13 sub-components:

(a) Sub-component 1 : Construction of Tompun New Pumping Station and Inlet Channel with a capacity of 15 m^3/sec

(b) Sub-component 2 : Construction of Tompun Regulation Pond with a total area of 47.5 ha

(c) Sub-component 3 : Improvement of Meanchey Drainage Main, Downstream Stretch, from Tompun Regulation Pond to Meanchey Bridge with a length of 2.635 km

(d) Sub-component 4 : Improvement of Meanchey Drainage Main, Middle Stretch, from Meanchey Bridge to the junction with a branch with a length of 1.285 km

(e) Sub-component 5 : Improvement of Meanchey Drainage Main, Upstream Stretch, upstream from the junction with a length of 0.535 km

(f) Sub-component 6 : Construction of Tum Nup Toek Drainage Sluiceway with a capacity of 10 m^3/sec

(g) Sub-component 7 : Construction of Samdach Monireth Drainage Main, Downstream Stretch, between the junctions with Meanchey and Jawaharlal Nehru drainage mains with a length of 1.676 km

(h) Sub-component 8 : Construction of Samdach Monireth Drainage Main, Upstream Stretch, upstream from the junction with Jawaharlal Nehru Drainage Main with a length of 0.714 km

(i) Sub-component 9 : Construction of Jawaharlal Nehru Drainage Main with a length of 1.152 km

(j) Sub-component 10 : Improvement of Salang Drainage Main, Downstream Stretch, from the junction with Meanchey Drainage Main to a bridge with a length of 0.887 km

(k) Sub-component 11 : Improvement of Salang Drainage Main, Upstream Stretch, upstream from the bridge with a length of 0.488 km

(l) Sub-component 12 : Conservation of the north lake of Boeng Salang with dredging (5.1 ha) and providing a walkway around the lake

(m) Sub-component 13 : Preparation of Relocation Site and Spoil Area with a total area of 26 ha

The preliminary design results on the project facilities of the Tompun Watershed Drainage Improvement are briefly described in the succeeding sub-sections.

5.1.1 Tompun Pumping Station, Inlet Channel and Regulation Pond

(1) Design Discharge

The design discharge with a 5-year probability of rainfall at the downstream end of Tompun Watershed, where the above structures are proposed, is 75 m^3/sec.

The combination of a pump capacity of Tompun Pumping Station and the corresponding regulation volume of Tompun Regulation Pond are determined as follows:

- Pump capacity : 15 m^3/sec
- Regulation pond volume : 560,000 m^3

(2) Design Water Levels

The design water levels of the Tompun new pumping station, inlet channel, regulation pond are listed in the following table:

Water Levels Concerning Tompun Pumping Station and Related Structures

Water Level	Elevation (EL. m)
(1) Outer Side	
(a) Design High Water Level (HWL)	9.00
(b) Normal Water Level (NWL) in the Dry Season	4.00 to 4.50
(2) Inner Side (Regulation Pond)	
(a) Design Surcharge Water Level (SWL)	4.50
(b) Design High Water Level (HWL)	3.70
(c) Design Low Water Level (LWL)	3.30
(d) Normal Water Level (NWL) in the Dry Season	About 3.30 in future (4.00 at present)

(3) Structural Features of Tompun New Pumping Station

Main points of the structure of the pumping station are as follows:

(a) The capacity of the existing Tompun pumping station is ignored in planning, and Tompun New Pumping Station will be constructed on the west side with a total capacity of 15 m^3/sec, consisting of 5 pump units of 3 m^3/sec per each (submergible type).

(b) The main civil structure of the pumping station is designed without superstructure because submersible pumps can be installed outdoor.

(c) An operation building yard is planned to be constructed beside the main structure, to house an operating room, electric room, backup generator room, substation yard and store room.

(d) Five outlets, each made of a steel pipe, from the respective pump units will be constructed beneath Tompun Dike. A flap gate will be installed at each exit.

(e) No automatic trash removal equipment is installed at the initial stage although spaces for future installation of such equipment will be secured in the design. This is because debris would scarcely flow down to the pumping station for the time being due not only to less debris but to water hyacinth vigorously growing in the upstream channel that can considerably check flowing articles.

(4) Structure of Inlet Channel

The inlet channel connecting to Tompun New Pumping Station is designed with the same capacity of 15 m^3/sec as the pumping station. Major features of the channel are presented hereunder.

(a) Plan

The alignment of the designed channel generally follows the existing Meanchey stream. The length of the channel is 1,020 m from Tompun New Pumping Station to the upstream end of Tompun Regulation Pond.

(b) Profile

Most of the channel is within the area of Tompun Regulation Pond. The bed gradient of the designed channel is set at 1/10,000. The design bed elevation varies from EL. 0.6 m at Tompun Pumping Station and EL. 0.7 m at the upstream end.

(c) Cross-sections

Cross-sections of the inlet channel are trapezoid-shaped with side slopes of 1:2 of earth channel. Major features of the are shown below:

Major Features of Inlet Channel

Stretch	Type of Channel	Design Discharge (m^3/sec)	Design Water Depth (m)	Channel Bed Width (m)
Inlet Channel	Earth channel	15	2.6	7.0

(5) Structure of Regulation Pond

Tompun Regulation Pond is located on the existing Boeng Tompun just upstream of the new pumping station. The area is 47.5 ha, consisting of the east and west lakes sandwiching Inlet Channel. The bed elevation is 3.0 m with design water levels tabulated in Item (2) above. The regulation pond will be constructed simply of small dikes and earth banks both with a slope gradient of 1:2.

5.1.2 Meanchey Drainage Main

(1) Purpose of Improvement

Improvement of the existing Meanchey drainage channel is an essential factor in the Project. In particular, the downstream stretch of Meanchey Drainage Main is the trunk line gathering storm water not only from its own upper reaches but from Salang and Tum Nup Toek basins (the western half of City Core). It finally leads water to the complex of a pumping station and a regulation pond at the Tompun site. Without improving the stretch, no effect can be anticipated on the drainage over Tompun Watershed.

(2) Design Discharges

The design discharges along Meanchey Drainage Main, with a return period of 5-year, are as follows:

- Meanchey Drainage Main, Downstream Stretch (0+000 to 2+635) :75 m^3/sec
- Meanchey Drainage Main, Middle Stretch (2+635 to 3+920) :15 m^3/sec
- Meanchey Drainage Main, Upstream Stretch (3+920 to 4+455) :11 m^3/sec

(3) Structure of Meanchey Drainage Main

(a) Plan

The alignment of the designed channel generally follows the existing Meanchey stream. The length of the channel is 4,455 m in total comprising the downstream stretch of 2,635 m, middle stretch of 1,285 m, and upstream stretch of 535 m.

(b) Profile

The bed gradient of the designed channel in each stretch generally corresponds with the average bed gradient of the existing Meanchey channel as follows:

- 1/2,500 in the downstream stretch;
- 1/1,000 in the middle stretch; and
- 1/500 in the upstream stretch.

To enable gravity drainage to Tompun Regulation Pond, the design bed elevation varies from EL. 0.7 m at the downstream end to EL. 5.3 m at the upstream end.

(c) Cross-sections

The cross-sections of Meanchey Drainage Main are trapezoid-shaped with side slopes of 1:2 of earth channel and 1:0.3 of masonry-reveted channel. Major features of the channel resulting from hydraulic calculations are summarized below:

Major Features of Meanchey Drainage Main

Stretch	Type of Channel	Design Discharge (m^3/sec)	Design Water Depth (m)	Channel Bed Width (m)
Downstream	Earth channel	75 (at DHWL) 15 (at DSWL)	3.0	16.0
Middle	Earth channel	15	3.0	2.0
Upstream	Masonry-reveted channel	11	1.8	2.5

Note: DHWL and DSWL mean the design high water level (EL. 3.7 m) and design surcharge water level (EL. 4.5 m) of Tompun Regulation Pond, respectively.

(4) Structure of Tum Nup Toek Drainage Sluiceway

Tum Nup Toek Drainage Sluiceway is the facility provided beneath the Inner Ring Dike to drain storm water in the corresponding drainage basin to Meanchey Drainage Main by gravity.

5.1.3 Samdach Monireth and Jawaharlal Nehru Drainage Mains

(1) Purpose of Construction

The City Core portion of the Tompun Watershed (631 ha) consists of the following three areas:

- Boeng Salang Area : 275 ha
- Tum Nup Toek Area : 68 ha
- Remaining Area : 288 ha

There is no major drainage facilities furnished in the City Core within the Tompun Watershed, which condition repeatedly causes serious inundation over the area. In this case, recommended is the construction of underground drainage mains along Samdach Monireth and Jawaharlal Nehru streets because of no space for providing open channels in the house-congested area.

(2) Design Discharges

The design discharges of Samdach Monireth and Jawaharlal Nehru drainage mains are determined through hydrological analysis as follows:

- Samdach Monireth Drainage Main, Downstream Stretch : 44 m^3/sec
- Samdach Monireth Drainage Main, Upstream Stretch : 20 m^3/sec
- Jawaharlal Nehru Drainage Main : 8 m^3/sec

(3) Structure of Samdach Monireth and Jawaharlal Nehru Drainage Mains

(a) Plan

The alignments of the designed drainage mains follow Samdach Monireth and Jawaharlal Nehru streets. Most part of the drainage mains is of the underground box culvert except an open channel portion joining Meanchey Drainage Main 50 m downstream of Meanchey Bridge. The total length of Samdach Monireth Drainage Main is 2,390 m comprising the downstream stretch of 1,676 m and

upstream stretch of 714 m. The length of Jawaharlal Nehru Drainage Main is 1,152 m.

(b) Profile

The longitudinal gradient of the drainage mains is constantly 1/2,000 which generally corresponds with the average gradient of the existing road surface. The design bottom elevation varies from EL. 1.7 m at the confluence with Meanchey Drainage Main to EL. 2.9 m at the upstream end of Samdach Monireth and EL. 3.6 m at that of Jawaharlal Nehru.

(c) Cross-sections

The cross-sections of the underground culverts are rectangular-shaped with one or two lane(s) depending on the design discharges. The cross-sections of the open channel are trapezoid-shaped with side slopes of 1:2 of earth channel, and for the purposes of inspection and maintenance, roads and sidewalks are provided on both banks of the channel. Major features of the channels are summarized as below:

Major Features of Samdach Monireth and Jawaharlal Nehru Drainage Mains

Stretch	Type of Channel	Design Discharge (m^3/sec)	Design Water Depth (m)	Channel Bed Width (m)
Samdach Monireth, Outlet	Earth channel Underground box culvert	44	3.0	8.0 3.6 (2-lane)
Samdach Monireth, Downstream	Underground box culvert	44	3.0	7.20 (1-lane)
Samdach Monireth, Upstream	Underground box culvert	20	3.0	4.00 (1-lane)
Jawaharlal Nehru	Underground box culvert	8	2.5	2.50 (1-lane)

5.1.4 Salang Drainage Main

(1) Purpose of Improvement

Boeng Salang plays an important role in the retention of storm water gathering from the City Core portion of the Tompun Watershed. However, the south lake of Boeng Salang has been reclaimed in most area and encroached on by housing, resulting in diminution of its retention function although the north lake comparatively remains as it was. To compensate and control such deterioration in terms of drainage, Salang Drainage Main will be provided along the centerline of the south lake, and moreover some conservation measures are recommended to be taken in the north lake (5.1 ha).

(2) Design Discharge

The design discharge of Salang Drainage Main is 21 m^3/sec both for the upstream and downstream stretch.

(3) Structure of Salang Drainage Main

(a) Plan

The alignment of the designed channel generally follows the existing Boeng Salang south lake, and joins Meanchey Drainage Main 50 m upstream of Meanchey Bridge. The total length of the channel is 1,375 m composed of the downstream stretch of 887 m and upstream stretch of 488 m.

(b) Profile

The bed gradient of the designed channel in each stretch is as follows:

- 1/2,500 in the downstream stretch; and
- 1/1,000 in the upstream stretch.

The design bed elevation varies from EL. 1.8 m at the confluence with Meanchey Drainage Main to EL. 2.6 m at the upstream end (Boeng Salang north lake).

(c) Cross-sections

The cross-sections of Salang Drainage Main are trapezoid-shaped with side slopes of 1:2 of earth channel and 1:0.3 of masonry-reveted channel. Major features of the channel is as follows:

Major Features of Salang Drainage Main

Stretch	Type of Channel	Design Discharge (m^3/sec)	Design Water Depth (m)	Channel Bed Width (m)
Downstream Stretch	Earth channel	21	3.0	2.0
Upstream Stretch	Masonry-reveted channel	21	3.0	3.0

5.1.5 Relocation Site and Spoil Area

Land acquisition and house evacuation will probably be required for the implementation of the Project. The total land acquisition and house evacuation for Sub-components 1 to 12 are 58,400 m^2 and 460 houses. As for the relocation site, one suggested by the Study Team is the proposed spoil area (26 ha) near Tompun New Pumping Station. The proposed spoil area will be provided in two stages with the following respective dimensions:

Dimensions of Proposed Spoil Area

Stage	Corresponding Sub-component	Excess Soil Volume Approximate (m^3)	Area (ha)	Formation Height (EL. m)	Embankment Height (m)
I	1, 3, 6 and 10	250,000	10.5	6.0	2.5
II	2, 4, 5, 7, 8, 9, 11 and 12	550,000	15.5	7.0	3.5
Total	-	800,000	26.0	-	-

Note: The existing ground elevation is around 3.5 m.

A part of the spoil area, Stage I, will be used for the relocation site of the evacuated peoples, 480 households in total (above 460 plus 20 in the spoil area). The relocation site will require 48,000 m^2 of land complete with necessary infrastructures, such as roads, electricity, wells and sanitary facilities.

Finally, it is noted that right-of-way preparation and establishment of a reasonable relocation plan is an essential task of the Cambodian Government, which shall be settled prior to the actual implementation when the Government will request a foreign assistance for the Project.

5.2 Summary of Project Features

(1) Tompun New Pumping Station and Inlet Channel

(a)	Location	:	On Tompun Dike, adjoining the existing pumping station to the east
(b)	Pump capacity	:	15 m^3/sec (3 m^3/sec x 5 units)
(c)	Type of Pumps	:	Submergible pump
(d)	Structure	:	Pumping station of RC structure with foundation piles, outlets with flap gates, a control house and the inlet channel

(2) Tompun Regulation Pond

(a)	Location	:	Existing Boeng Tompun
(b)	Area	:	47.5 ha (total of East and West ponds)
(c)	Design Surcharge Water Level	:	EL. 4.5 m (at the maximum storage)
(d)	Design High Water Level	:	EL. 3.7 m (at the peak discharge of Meanchey Drainage Main)
(e)	Design Low Water Level	:	EL. 3.3 m (to be maintained through the year)
(f)	Design Bottom Height	:	EL. 3.0 m
(g)	Regulation Volume	:	560,000 m^3 by which 60 m^3/sec of the peak discharge can be regulated.

(3) Meanchey Drainage Main, Downstream Stretch

(a)	Stretch	:	From Tompun Regulation Pond to Meanchey Bridge with a length of 2.635 km
(b)	Design Discharge	:	75 m^3/sec
(c)	Channel Bed Gradient	:	1/2,500
(d)	Structure	:	Earth channel with a side slope of 1:2

(4) Meanchey Drainage Main, Middle Stretch

(a)	Stretch	:	From Meanchey Bridge to the junction with a branch with a length of 1.285 km
(b)	Design Discharge	:	15 m^3/sec
(c)	Channel Bed Gradient	:	1/2,000

(d) Structure : Earth channel with a side slope of 1: 2

(5) Meanchey Drainage Main, Upstream Stretch

(a) Stretch : Upstream from the junction with a length of 0.535 km

(b) Design Discharge : 11 m^3/sec

(c) Channel Bed Gradient : 1/1,000

(d) Structure : Masonry-riveted channel with a side slope of 1: 0.3

(6) Tum Nup Toek Drainage Sluiceway

(a) Location : On the Inner Ring Dike near the existing Tum Nup Toul Pumping Station

(b) Structure : 3.0 m wide & 3.6 m high box culvert with stoplogs

(7) Samdach Monireth Drainage Main, Downstream Stretch

(a) Stretch : Under Samdach Monireth Street between the junctions with Meanchey and Jawaharlal Nehru drainage mains with a length of 1.676 km, at the downmost of which an outlet structure, with stoplogs, will be provided

(b) Design Discharge : 44 m^3/sec

(c) Channel Bed Gradient : 1/2,000

(d) Structure : 4.25 m wide, 3.6 m high & 2 lanes

(8) Samdach Monireth Drainage Main, Upstream Stretch

(a) Stretch : Under Samdach Monireth Street upstream from the junction with Jawaharlal Nehru Drainage Main with a length of 0.714 km

(b) Design Discharge : 20 m^3/sec

(c) Channel Bed Gradient : 1/2,000

(d) Structure : 4.0 m wide & 3.6 m high

(9) Jawaharlal Nehru Drainage Main

(a) Stretch : Under Jawaharlal Nehru Street with a length of 1.152 km

(b) Design Discharge : 8 m^3/sec

(c) Channel Bed Gradient : 1/2,000

(d) Structure : Box culvert, 2.5 m wide & 3.1 m high

(10) Salang Drainage Main, Downstream Stretch

(a) Stretch : Along the existing Boeng Salang south lake from the junction with Meanchey Drainage Main to a bridge with a length of 0.887 km, at the downmost of which an outlet structure, with stoplogs, will be constructed

(b) Design Discharge : 21 m^3/sec

(c) Channel Bed Gradient : 1/3,000

(d) Structure : Earth channel with 1:2 of side slopes

(11) Salang Drainage Main, Upstream Stretch

(a) Stretch : From the bridge to the existing Boeng Salang north lake with a length of 0.488 km

(b) Design Discharge : 21 m^3/sec

(c) Channel Bed Gradient : 1/3,000

(d) Structure : Masonry-reveted channel with 1:0.3 of side slopes

(12) North Lake of Boeng Salang

(a) Location : Existing Boeng Salang north lake

(b) Structure : Dredging of 5.1 ha and provision of a walkway around the lake

(13) Relocation Site and Spoil Area

(a) Location : West side of the Tompun New Pumping Station

(b) Area : 26 ha for spoil area within which 48,000 m^2 is used as the relocation site for the Project

5.3 Environmental Surveys

5.3.1 Soil / Benthic Material – Leachate Tests

As dredging of Tompun lake is a major proposed project activity, the disposal of dredged material in a safe and appropriate location with minimal environmental risk is important. During Phase I, sediment samples were taken from various locations including Tompun lake and analyzed for common toxic pollutants. In Phase II, a limited number of samples were collected and subjected to leachate tests. This was to determine the dispersion or leaching potential of heavy metal constituents in the sediments, to evaluate a suitable disposal method and disposal site.

The results of leaching analysis are presented in Chapter G2. The results indicated that some heavy metals can be leached out by rain water or surface runoff especially Arsenic. However, the concentration found in the leachate samples were relatively low in comparison with surface water quality standard for EEC or standards proposed in Japan.

5.3.2 Land Use

Areas affected by the proposed improvement comprise Boeng Salang, Meanchey drainage channel, Tompun regulation pond and inlet-outlet of the new Tompun pumping station. The study covers the area within 20 m on both sides of the Meanchey drainage channel (744,998m^2), Boeng Salang (174,890m^2) and Tompun regulation pond (565,213 m^2).

The study was carried out in accordance with the following procedure:

- Study the existing land use patterns of the study area from various sources e.g., the related documents, aerial photo and maps (scale 1:2,000).

- Investigate current land uses by the field survey and identify areas of importance in the study area.

Tables G5-1 to G5-3 present the existing land use in the study area as obtained from maps, survey and field check conducted in December 1998.

5.3.3 Transportation

The purpose of the transportation study is to investigate the traffic condition at the concerned roads to be used for access to the construction areas. The project development may increase traffic volume at this access road or on the adjacent roads.

The information relating to transportation network and traffic volumes in the project and vicinity areas were collected. Field observation were conducted during Dec. 27-28, 1998 on the main roads Charles De Gaulle (1 station), Jawaharlal Nerhu (1 station), Monireth (2 stations), Steang Meanchey (1 station) and Tompun (1 station).

(1) Road Network

The project area comprises the main roads namely;

- Jawaharlal Nerhu road: This asphaltic concrete road connects with the Confederation de la Russia road (No.110) and Kampuchea Krom road (No.128) in the north and Charles De Gaulle, Monireth (No.217) and Sihanouk roads (No.274) in the south. The road width is approximately 15-20 m and most of pavements are in good condition. Some sections are flooded during heavy rain in the rainy season.
- Charles De Gaulle road: This road is located near the Olympic stadium and it can be used to access the Central market. This road also connects with other main roads namely, Monivong road (No.93), Tchecoslovaquic road (No.169), Jawaharlal Nerhu road (No.215), Monireth road (No.217) and Sihanouk road (No.274). The pavement is asphaltic concrete. Poor conditions can be found on some sections. In the rainy season, some parts of the road are flooded.
- Monireth road: This road connected with Charles De Gaulle, Jawaharlal Nerhu, Sihanouk, Mao Tse Toung (No.245) and the road No.271. It is about 20 m wide with asphaltic concrete pavement. Some damaged part can be found. There is a lot of dust due to poor surface in some portions.
- Road No.271: This road (10 m wide) is in poor condition with damaged pavements and a lot of dust. This road is to be the main transportation access for materials / equipment transportation to the project sites especially Meanchey drainage channel and Tompun regulation pond.

(2) Traffic volumes

The traffic counting stations comprise of 6 stations on 5 roads as described as follows;

- Station 1: This station is located on Charles De Gaulle road in front of the Olympic stadium. The total numbers of vehicles on the first and second traffic counting day were 34,506 and 52,917 vehicles respectively. Motorcycles are predominant found with 22,953 and 39,905 vehicles on the first and second day respectively, followed by car & pick-up (5,501 and 6,354 vehicles) and Bicycles/Tricycles (4,845 and 5,291 vehicles). Among trucks, Medium Truck (6 wheels) were predominant (698 and 757 vehicles on the first and second day

respectively) followed by Light Truck (4 wheels: 60 and 113 vehicles) and Heavy Truck (10 wheels: 54 and 53 vehicles). Only two trailers were found on the second day.

- Station 2: This station is on Jawaharlal Nerhu road. The total numbers of vehicle on the first day were about 24,267 vehicles and on the second day were 32,674. Motorcycle were predominant with 12,893 and 17,277 vehicles, followed by car and pick-up (6,419 and 7,146), and Bicycles and tricycles(2,035 and 2,039) on the first and second day respectively. Medium trucks (6 wheels) were found with 1,594 and 2,592, followed by light truck and heavy truck (218-514 vehicles and 140-565 vehicles respectively). Trailers were found in larger numbers than station 1 with 28 and 2 vehicles on the first day and second day respectively.
- Station 3: This station is located on Monireth road at the connection point with road No.280. The highest number of vehicles were found (on this road) both on the first and second day with 61,239 vehicles and 62,075 vehicles respectively. Motorcycle, car & pick-up and bicycle and tricycle were found in decreasing numbers as in case of station 1 and 2. Truck categories were similar to station 2. In addition, other vehicle types such as tractor, forklift and carts were found.
- Station 4: This station is located on Monireth road near the junction with road No.271. The type with largest numbers is still motorcycle, followed by car and pick-up and bicycles and tricycles. With respect to trucks, the largest numbers were found here among all stations. Medium trucks were 2,212 and 2,625 vehicles, light trucks were 1,466 and 1,571 vehicles and heavy trucks were 462 and 447 vehicles, on the first and second day respectively. Forklift was only other vehicle type found with 55 and 64 vehicles on the first and second day respectively.
- Station 5: This station is located near Meanchey bridge on Monireth road. The total vehicles on the first day and the second day were about 52,904 and 55,968 vehicles respectively. Motorcycles were predominant with 46,660 and 46,535 vehicles followed by car and pick-up (2,581 and 4,112 vehicles) and bicycles and tricycles (1,340 and 2,589 vehicles) on the first and the second day respectively. With respect to trucks the numbers were less than station 4 but trailer was found to be the highest among all stations with 174 and 140 vehicles on the first day and the second day respectively.

5.3.4 Socio-economic Surveys

The socio-economic study covers two main drainage channels improvement namely Boeng Salang, Meanchey drainage channel and Boeng Tompun. There are a lot of houses in those areas. During construction period, some households have to be relocated and construction activities will disturb peacefulness of people living around the area. Therefore the socio-economic survey was undertaken with emphasis on people who would be affected by the project implementation.

The objectives, scope, methods used and questionnaire formats of these surveys were the same as those outlined in case of Kop Srov and Tompun dike reinforcement.

The socio-economic survey was undertaken along Boeng Tompun, Boeng Salang, and Meanchey drainage channel by interviewing the local people. The data on household and population in these areas were derived from the survey results. The respondents were selected by the random sampling method (20% of household numbers). The sample distribution is shown in TableG5-4.

5.3.5 Result of Study

(1) General Condition of Study Area

The study area was classified into 3 parts, i.e., Meanchey drainage channel, Boeng Salang, and Boeng Tompun. The general conditions of each area can be described as follows:

(a) Meanchey Drainage Channel

Meanchey drainage channel has about 20 m wide connecting to Boeng Tompun. Housing in this area is very dense. Large numbers of houses were built over the drainage channel. The houses are mostly made of wood. Dominant occupations are trading and pig raising. Most people are Khmers.

(b) Boeng Salang

Boeng Salang (shaped as a drainage channel in its downstream reach) connects to Meanchey drainage channel. The houses (squatters) were built over the lake along both sides. Most of the households are one-storey houses with elevated floor. Living people are mostly Khmers with a small number of Vietnamese renting some houses in the area.

(c) Boeng Tompun

Boeng Tompun is the swamp receiving water discharged from Boeng Salang and Meanchey drainage channel. The housing density is not high around the swamp. Most of the houses are made of wood. Ground floor level is at the highest flooding level. Dominant occupation of people is wage earning in the factories and vegetable growing. All the people in this area are Khmers.

(2) Infrastructure and Public Facilities

The infrastructure and public facility conditions of each area are summarized as follows:

Area	Infrastructure	Public Facilities
Boeng Salang	• Electricity supply is available for most of the houses (connecting from large houses or landlord's houses). • Some households still use lamp and batteries. • No telephone (available only at Boeng Salang Post and Telecommunication Office, Depot market on Mao Tse Toung rd. near the junction with road No.230). • Water for household consumption is supplied from water supply system of private sector via connected pipelines. • Good road network in this area.	• 1 school, Boeng Salang school. • 3 clinics. • 1 Post and Telecommunication Office (on Monireth rd.) near Boeng Salang pumping station.
Meanchey Drainage Channel	• Most of house are supplied with electricity, some households still use batteries and lamps. • No telephone (Public telephones and private-owned telephones are available only at the shops and houses along the road No.271). • Sources of water used are groundwater well of private sector. • Good Accessibility.	• Stoeng Meanchey high school. • Wat Stoeng Meanchey.

(3) Results of the Interview with Head of the Household

(a) General Information of Household and Family Structure

(i) General Information of Respondents

The collected information from socio-economic surveys indicates that average age of respondents is 40.25 years old. Most of them (95.54%) are head of household, only 2.68% and 1.79% are son/daughter and spouse, respectively. 38.39 % of them have attended primary school and 36.61 % have attended secondary school while 15.18 % have never attended school. Most of them are Buddhists.

(ii) Family Structure

The average household size of respondents is 5.66 persons per household. The proportion of male and female is 1:1.08. 26.77 % of family members have completed primary school, 16.56% have completed secondary school, and 27.37 % are students. 48.05 % of family members are between 21-60 years old, 23.21% are between 6-13 years old, 18.57% are between 14-20 years old, 13.54% are lower than 6 years old and 2.3% higher than 60 years old. Only 27.96 % of family member has a job indicating a high dependency rate; the ratio of those employment and unemployment is 1:2.55.

(b) Economic Structure of Household

(i) Occupation

According to the field survey, occupations of households can be classified into 5 types, i.e., shop owner / merchant (33.04%), service sector (28.57%), government / private sector employee (17.86%), labor (16.07%) and farmer (4.46%). 36.61 % of respondents has supplementary occupation.

(ii) Household Income and Expenditure

Average annual income of household is approximately US$ 1,293 per household. The group with the highest income lives in Boeng Salang (US$ 1,311 per household). Households in Meanchey Drainage Channel earn the lowest income (approx. US$ 1,158 per household).

Concerning expenditure, it is found that the respondents living in Meanchey Drainage Channel have lower expenses than other groups (US$ 984.47 per household). However the overall household expenditure of respondents is smaller than income. The annual average expense is about US$ 1,011 per household or 82.30 % of the average annual household income.

(iii) Distance from Residence to School for Children and to Work Place

The average distance from residence to the school is about 1.72km. 19.64 % of them live between 0.5-1 km from school and 47.32 % of them don't have children going any school in their family.

Concerning distance between residence and work place, it can be categorized into 3 groups as follows:

- Unable to indicate the distance (26.79%) because of temporary work place such as general wage labour, construction labour, motorcycle driver, and taxi driver.
- Working at home or the residence is close to the work place (20.54%), i.e., grocery, business, restaurant, and wood / timber seller.
- Those who have permanent work place (52.67%) comprising, trading in the fresh market, government employee, factory worker, company employee, morning glory cropping, and vegetable cropping.

The average distance between residence and work place is approximately 2.61 km.

(c) Information on House, Assets Owned, and Land Occupied by the Family

(i) House Conditions

Most of respondents (87.50%) have their own house or building, while 12.50% are tenants. The average value of building a house is about US$ 2,970 per house and rentals are about US$ 21 per month.

Average floor area size is about 50.43 sq.metres per house, about 84.82 % of house are traditional style, 13.39 % of them are modern style and 1.79 % of them are cottages. Roofs of houses are metal (86.61%), pantile (4.46%) or thatch tile (3.57%). Most of houses (90.18%) have wooden walls, while the rest of them have concrete (2.68%) and thatch walls (4.46%). All houses are single storey houses.

(ii) Land Owned / Occupied by the Family

According to data analysis, it was found that each household occupies a plot of land for their house and residence, but only 17.86 % of them have land ownership document. The average residential land is 199 sq.m per household. Only 3 families living along Meanchey drainage channel utilize their land for agricultural purposes. Their average land size is 1,567 m^2. One respondent living in Meanchey Drainage Channel has idle land of 350 m^2.

(iii) Assets

The assets that most of the respondents own are television set (57.14%) and motorcycle (56.25%). Radio, bed / table / cabinet rank second. The other assets found in some households are car, bicycle and boat.

(d) Information on Settlement

In the past 10 years, about 28.57% of respondents have never moved. The rest of them have just moved. In the latter group, about 48.75% have moved from within the same district, 28.75% from other provinces (out of Phnom Penh Municipal area), and 22.50% from other districts within Phnom Penh. Only 5 families or about 4.46 % have moved two times during the past 10 years.

(e) Reason for Current Settlement Location and Problems Experienced

Reasons for settling in their present location were in the order of priority the following: good neighbors (47.32%), no other places to choose (31.25%), and convenience to other utilities (7.14%). Problems experienced were very bad smell from polluted water (48.21%), flood every year (20.54%) and too many mosquitoes / insects.

(f) Awareness and Attitude towards the Project

About 29.46 % of respondent knew about the drainage improvement and flood control project. The rest of them (70.54%) have never heard about the project. Source of information is mostly from project staff (JICA Team and research team), government officer, and neighbor (66.67%, 30.30% and 3.03% respectively).

Considering the project implementation, majority of respondents agree with the necessity of the project (59.82%), while the remaining (40.18%) were indifferent.

(g) Opinion on the Relocation and Expected Assistance from the Project

(i) Cooperation and Relocation

The vast majority of respondents (84.82%) showed their cooperation for relocation during project implementation, while only 5.36% disagreed, and 9.82% gave no opinion on this aspect. Opinions of each group are not much different since most of the houses are temporarily shelters with poor hygiene and environmental conditions, and lack proper infrastructure.

(ii) Problem of Relocation

About 16.96 % of the project affected people were willing to relocate. Remaining 83.04% expressed their anxieties concerning relocation. These include commuting (to their place of work) problems after relocation, loss of site for business or agriculture (14.29%), new location being far from work place and school (21.43%), and loss of existing house structures.

(iii) Expected Assistance of Relocation

Expected assistance for relocation include provision of finance for relocation of houses and assets to new place, provision of new land for residential area, provision of supporting facilities in the new place, and assistance in food supply.

5.3.6 Compensation / Resettlement Study

(1) Study Methodology

The compensation and resettlement study comprise the following steps:

- data / information collection and review
- field investigation on affected households / properties and potential resettlement sites
- Data analysis and evaluation
- preliminary planning for compensation / resettlement program and cost estimates

(2) Compensation Estimates for Affected Properties

(a) Affected Area

The area affected by Tompun watershed improvement works is around the New Tompun pumping station, Meanchey Drainage Main including Tum Nup Tock Drainage Sluiceway, Salang Drainage Main, and Outlet Sluiceway of Samdach Monireth Drainage Main. The overall area to be affected is about 318,400 m^2 with 480 households who need to be relocated.

(b) Criteria for Compensation Payment

The compensation payment for properties to be affected by the construction of the proposed Tompun dike and watershed improvement will require the following items:

- Land compensation for each piece of affected land with ownership document or proven evidence of ownership.
- Compensation cost for structural properties in the project affected area.

The compensation cost will include the following basic cost items:

- dismantling cost
- cost of damaged material due to dismantling
- transportation cost of dismantled material to new home plot
- cost for labor for reconstruction

Unit cost for all of the above items were estimated based on local cost of construction material, labor and transportation.

Administrative cost that will be added to the compensation cost estimates are expenses for detailed survey of the affected properties, administration costs and contingency costs.

(c) Estimation of Compensation Cost

(i) Structural Compensation Cost

The estimation for cost of structural compensation was based on the result of structural inventories was performed in December 1998. The type, size,

quantity, and quality of construction material for each type of affected structure was recorded and grouped into the type of typical structure.

The compensation cost for each type of typical structure was then calculated as per the following items:

- Cost for dismantling
- Cost of damaged material due to dismantling
- Cost for transportation of dismantled construction material to new place
- Cost for reconstruction at new place

By application of this unit compensation cost criteria, the total compensation cost of each structure with breakdown was calculated.

(ii) Cost for Land Compensation

Land compensation cost for Tompun area was assessed based on interviews of affected inhabitants in the area. The average land cost is 5 US$/m^2.

(iii) Summary of Compensation Cost

The overall compensation cost for Tompun dike improvement can be summarized as follows:

1)	Structural Properties	
•	Number of structure to be dismantled	480
•	Compensation cost	US$ 1,152,000
2)	Land Compensation	
•	Size of land to be acquired	318,400 m^2
•	Compensation cost	US$ 1,592,000
3)	Sub Total (1+2)	US$ 2,744,000
4)	Contingency (10%)	US$ 274,400
5)	Total	US$ 3,018,400

(3) Resettlement Scheme

(a) Description of Potential Sites for Resettlement Development

Suitable resettlement sites need to be identified to accommodate 480 families (450 from Tompun watershed area and 30 from Tompun pumping station) who need to be relocated due to the Tompun watershed improvement scheme. In general, the preferable site should possess the following characteristics:

- The land should be located not far from the previous residential area in the same khan.
- The land should have suitable topography with relatively flat terrain.
- The land should have potential for infrastructure development.
- Good water sources for cultivation and consumption should be available.

Potential resettlement areas with the above requirements were identified from 1:50,000 topographic map and 1:2,000 aerial photos. Field reconnaissance were

undertaken of the potential areas to investigate the actual conditions with particular emphasis on:

- Topography
- Existing land use and land occupancy
- Water resources availability
- Accessibility and availability of supporting facilities and infrastructure

The investigated areas include two sites in the vicinity of Tompun dike. Description of each site is as follows:

(i) Site 1: Proposed Spoil Bank Area

Location	Adjacent to proposed Tompun pumping station near the existing Tompun pumping station.
Accessibility	The site can be easily accessed from Tompun dike via dirt road.
Topography	This site is located on flat terrain close to regulating pond.
Land Use	This site, with the area of about 10.5 ha is currently occupied by about 25 households, with agricultural activities and farm ponds in the area. Part of the area is to be utilized as spoil bank for the sediment excavated from all concerned Tompun drainage channels. Embankment will be constructed around the spoil bank area and resettlement site can be developed on this plot.
Water Resources	Major source of water is groundwater that can be developed from nearby area.

(ii) Site 2: Reclaimed area within the regulating pond

Location	The area on the southern side of the regulating pond can be reclaimed Currently, this area is a shallow water body.
Accessibility	The area can be accessed via dirt road to Tompun dike near proposed Tompun pumping station.
Topography	This site is currently shallow water body that can be reclaimed by spoil material from channel excavation.
Land Use	The site can be utilized for dual purposes, i.e., spoil bank area and resettlement site.

(b) Assessment of Site Suitability

Both alternative sites were assessed in terms of site suitability based on the following factors:

- Physical factors; topography, land use, water sources, distance from the present Khan.
- Social and legal factors; administrative location and acquisition process.
- Size of land available.

Considering the above criteria, it can be found that Site 1 has some advantages in terms of topography and simpler construction procedure. Site 1 is recommended as the proposed relocation site.

(c) Description of the Selected Resettlement Site Scheme

(i) Number of Household to be Resettled and their Occupation

The household profile survey described earlier revealed that the major occupation of 357 households that need to be relocated are as follows :

- Shop owner / small business 22%
- Service 21%
- Labor 20%
- Government officer 10%
- Farmer 6%
- Not known 21%

(ii) Development of the Proposed Resettlement Area

The proposed resettlement is in the northern part of the proposed Tompun pumping station relocation project. Land allocation for each family is proposed to be 100 m^2. Thus, the total area required will about 4.8 ha. for those 480 families that will be resettled.

5.4 Environmental Impacts

Construction and operation of the proposed project may initiate both positive and negative impacts on the surrounding environment. Thus, it is essential to assess the overall potential impacts prior to the development, and to effectively minimize the adverse effects with appropriate mitigation measures. The environmental impacts are assessed for both construction and operation periods. Information presented in earlier sections of this report concerning Project Description and Existing Environmental Conditions are used to predict possible impacts during construction and operation stage of the project.

5.4.1 Criteria for Assessment

The same criteria for assessment with the EIA in Chapter G4.

5.4.2 Physical Resources

(1) Hydrology

(a) Construction Period

During the construction period, primary activities will include mobilization of heavy machineries, excavation of regulation pond, concerned drainage channels, removal of excavated material to designated area, slope adjustment, etc. All of

the above activities will be confined along the concerned drainage channels. The excavation of regulation pond / related channels will be conducted mainly during the dry season. These channels will be partially blocked during excavation. Thus, the hydrological regime can be disrupted. However, these channels currently are so shallow and obstructed due to garbage dumping and sediment deposition. The improvement of these waterways, therefore, will cause temporary impacts in terms of flow disruption only during the construction period. This type of impact is viewed as minor due to the implementation of channel excavation and improvement will be concentrated in dry season.

(b) Operation Period

The improvement of Tompun watershed drainage system will enhance the flow capacity within these related channels significantly. The hydrological regime of the watershed will be affected in a positive manner with removal of channel obstruction and improved capacities. Thus, the hydrological aspects will receive long term positive impact due to these improvements.

(2) Water Quality

(a) Construction Period

During the construction period of Tompun watershed drainage improvement, series of activities will be undertaken for about 2 years. Almost all construction activities will generate impacts on water quality. During the excavation period, the suspended solids in all of the concerned waterways will be temporarily increased at the excavation site and downstream. Currently, all of the concerned channels serve as wastewater collectors with deteriorated water quality. Local residents utilize groundwater or serviced pipe water for domestic consumption. Therefore, the temporary and localized impacts in terms of increased suspended solid is assessed as minor impact.

Concerning the wastewater to be generated from the construction activities, the exact location of construction camps and site office cannot be identified at this stage of study. However, the following criteria need to be applied for selection of construction camps and office:

- To be located at least 50 m. from water body.
- To be adequately equipped with sanitary toilets.
- To be equipped with retention basins(s) to collect domestic wastewater prior to overflow into nearby water body.
- Workers will be provided with clean water for domestic purpose.
- Maintenance activities will be conducted only within the designated areas with proper oil reception facilities.

The proposed Tompun watershed improvement will be utilized a number of heavy equipment that needs to be regularly maintained. All of these maintenance activities, e.g., oil changing, lubricating, engine checking, etc, need to be performed in the designated area only. The facility need to be equipped with oil separator, oil containers and proper shelters to minimize contaminated

runoff from the site. With the above measures, the potential impact on water quality will be insignificant.

(b) Operation Period

There will be no adverse impact on water quality during operation period. It is expected that the short term water quality in each channel will be improved due to excavation of polluted sediment and drainage improvement. However, long term plan for wastewater treatment facility need to be drawn up for City of Phnom Penh to sustain water quality of the channels and water body tin the area.

(3) Soil

(a) Construction Period

The concerned drainage channels e.g., Meanchey, Salang Drainage Channels will be excavated to improve the channel capacities. Soft material on the surface layer will be confined in the designated area near new Tompun pumping station. Embankment will be built around this area to confine such fine material which will take a relatively long period of time to solidified. The sediment in the deeper layer will be removed to fill up the new Tompun pumping station and proposed resettlement site for affected families from the proposed Tompun dike and watershed improvement.

However, all of the above areas are frequently affected by flood with small agricultural practices at new Tompun pumping station and proposed resettlement site. The disturbance of soil quality will be limited to the project facilities. The impact is viewed as minor. Concerning the effect of leaching from soft sediment, the analyses have confirmed that the concentration of heavy metals in leacing condition is relatively low and there will have no impact on the surrounding inhabitants due to the heavy metal from excavated sediment.

(b) Operation Period

There will be no impact on soil during operation period.

5.4.3 Human Use Values

(1) Land Use

(a) Construction Period

The land use at the construction area would be changed significantly, especially the housing area encroached in Boeng Salang and the concerned drainage channels to be excavated e.g., Meanchey drainage channel and Tompun regulation pond, suitable compensation and resettlement area will be provided for all of these resettled residents. On the other hand, the existing land use type which to be not improved and the area within the right of way will be impacted by the construction activities. Therefore, the impacts on land use will be limited.

(i) Current condition

Meanchey Drainage Channel

Most of land use in Meanchey drainage channel is water bodies (494,178.64 m^2 or 66.33%) where a lot of encroached houses can be founded (see Table G5-1). There is also 14,663.5 m^2 of cropping area (parsley). This is water quality and hydrology problems comprising water contamination and obstruction of water flow in the channel resulting from channel blockage.

Tompun regulation pond

As shown in Table G5-2, the major type of land use is water body (276,197.41 m^2). This area is always flooded during rainy season especially at the area proposed to be resettlement area (near the existing Tompun pumping station). Floods obstruct local transportation and cause damages / nuisance problems. About the agricultural land, there are parsley and morning glory patches that significantly affected by flood condition.

Boeng Salang

Normally, the major land use types is water bodies (see Table G5-3). There are a lot of houses encroached in the Boeng Salang drainage channel causing obstruction of the water flow and nuisance problem from domestic waste. At Boeng Salang, there are some houses located around water body. These houses are flooded during heavy rain. For the agricultural land, it is rarely found, since most of local people have non-agricultural occupation e.g., government officer, seller and general worker, etc.

(ii) Effects on land use during construction

Meanchey drainage channel

The construction activities in the area of Meanchey drainage channel comprise dredging of the channel and construction of the inspection road. The present land uses of area to be changed to the drainage channel improvement area and inspection road comprise 7,233 m^2 of water body, 5,240 m^2 of vegetable land and 167 housing units. The total changed land use types is in small fraction when compared to the total area. In addition, these changes of land use would be within the limited right of way of project causing no disturbance to other and use types in the vicinity, moreover suitable facilities of resettlement site will be provided. So the impacts of land use at Meanchey drainage channel will be minor.

Tompun regulation pond

According to project development plan, the construction comprises dredging of Tompun regulation pond, construction of inspection road, installation of new Tompun pumping station and provision of resettlement site. There are about 64 houses to be relocated and approximately 5,000

m^2 of agricultural land to be affected during construction period. However, the resettlement site with suitable facilities will be provided near the existing settlement site for all of relocated people. Therefore, the impacts of land use during construction period is considered as low level.

Boeng Salang

These changes on present land use in Boeng Salang area will occur within the limited right of way of project. For the relocated households, they will be provided with the suitable facilities at the resettlement site. The project impact on land use will be minor impact.

(b) Operation Period

After project construction has been completed, there will be urban communities around the project site, especially in the idle land close to the project area. If the urban plan is strictly implemented, the area at project site and its vicinity would be in good condition especially the Tompun regulation pond which will be developed to be the recreation site. Thus, there would be also positive impacts on land use.

(2) Transportation

(a) Construction Period

(i) Current condition

The concerned project routes (Jawaharlal Nehru, Samdach Monireth, and road No.271) have rather high traffic volumes. These roads in the city center with asphaltic pavement but a lot of dust can be found along the roads due to the vehicles especially the trucks. There is also dust from the shoulders and some deteriorated areas of the roads. The traffic can flow with some traffic jam even though the traffic volume is rather high.

(ii) Potential impact

During construction period, the construction activities will create short-term effect on the related roads to be utilized as access road for the project. The main impacts comprise traffic congestion from transportation of construction materials, heavy equipment, machinery or construction workers, followed by the deterioration of traffic pavement, accident, dust problem and inconvenience for local people (e.g., nuisance from noise, smoke of transportation).

For the underground drainage at Samdach Monireth and Jawaharlal Nehru road, the construction activities would be conducted on shoulders, not on the traffic lanes. The impact from transportation of construction materials / equipment would be temporary only during construction period.

The suitable measures and strict implementations will be provided during construction period. The mentioned effects would be alleviated. Therefore, impacts on transportation are expected to be minimal.

(b) Operation Period

The positive impact will be generated by the project on the related road network due to surface improvement and provision of inspection roads. It will be conveniently utilized by local people for transportation. For other aspects, there would not be any problems since project sites are concentrated in drainage channel and pond. Therefore, impacts on transportation during operation period are insignificant.

(3) Flood Control

(a) Construction Period

Current situation for drainage system in City of Phnom Penh is relatively poor which resulted in flooding after every major rainfall. During construction period, it is expected to be some inconvenience in terms of rainwater drainage due to blockage of channel system. However, the major excavation activities will be concentrated in the dry reason. Therefore, the impact on inundation condition in the city is expected to be acceptable, short term, and localized nature.

(b) Operation Period

After the improvement of Tompun watershed, the drainage efficiency will be significantly improved which will result in minimization of flood damage in the City of Phnom Penh.

5.4.4 Quality of Life Values

(1) Socioeconomy

According to the result of socioeconomic survey (see Table G5-4), most of the respondents agree with the project on the contribution to their country in terms of improvement of national economic development, prevent flood, improvement of their community to be with good environmental condition, and convenient accessibility. However, some respondents worried about relocation during project implementation. Then, considering the project construction plan and other relevant information, along with socioeconomic background, the socioeconomic impact from the drainage improvement and flood control project at Tompun Improvement area during construction and operation periods can be described as follows:

(a) Construction Period

(i) Impact on Investment and House Improvement Plan

During the project preparation stage, it will cause concerns for those who expect to expand or improve their housing / offices because they are not sure about their future particularly on land expropriation and relocation. Thus it should be better if the project provide additional information to concerned people about the project's workplan as soon as possible to relieve their worry and reduce their business opportunity cost and other anxiety.

(ii) Relocation Problem

According to the results of field survey, Boeng Salang and Meanchey drainage channel area have been occupied by house temporarily built and squatter area that need to be relocated due to the project improvement. These areas are both residence and the main source of income in terms of trading, rental house, and business. In addition, the affected people to be relocated have problem about relocation in terms of no funding, lose income during relocation, no other place to relocate, and lose appropriate site for trading. These conditions will induce problems as follows:

- Approximately 45, 133 and 167 families living in Tompun pumping station, Boeng Salang and Mean Chey Drainage Channel respectively will be relocated to resettlement site. These villagers worried about living in resettlement site concerning distance from their work place / school, and adequacy of facilities especially fresh market.
- Education problem for children of affected families in terms of longer travel distance to school. This issue was mentioned by 6.11% of respondents. According to the result of field survey, family members who are in school, is about 1.78 person per household or about 29.52 percent of family member.
- Occupation problem in terms of longer distance to appropriate site for earning money (being far from market and factory). Their expenditure will increase due to transportation cost otherwise their income is very low.
- Affected agricultural families living in Meanchey Drainage Channel (approximately 5 families) will lose cropping area (vegetable, morning glory, and fishpond).

All of the above impacts can be alleviated by appropriately mitigation measures such as compensation payment for relocation, provide appropriate relocation site and inform the relocation plan to them, etc. Then relocation problem have a low level of impact.

(iii) Lost Opportunity for Trading of Affected People

During construction, building structure, stalls, booth, and some part of shop, will be demolished, trading would temporary affected. The shop owner or businessman will lose income for those periods due to construction activities. These conditions will be serious problem at P.C. No. IV market. However, this impact will occur only near Tompun dike pumping station and be short term (only construction period). Then this impact is low level.

(iv) Disturbance on Communities

During construction, the transportation of equipment, heavy machinery, and construction material will disturb the community located along both side of Boeng Salang and Meanchey Drainage Channel, in terms of dust, noise and inconvenience in traveling. Dust and noise will be increased due to land clearance and other construction activities. However, currently

these areas have a lot of dust due to bad conditions surface of road (laterite surface) and a lot of traffic volume especially heavy truck. In addition, mitigation measures for air quality, noise, and transportation aspects can reduce those impacts to the low level, and those impacts will occur only during construction period. Then this impact is expected to be low level.

(v) Local Economic Impact

The project construction will create job opportunities for local people who are general labor and construction worker (about 17.56% of them). The wage of worker will be circulated within this area. This impact is benefits to the villagers who are merchants in terms of increasing income from trading and service including food stores, groceries, and vehicles for rent, etc. Furthermore, local economic activities will be stimulated during construction period through a boost in Phnom Penh Municipality trade / business particularly in construction materials, construction contract work, and loading. This positive impact is expected to be high level.

(b) Operation Period

(i) Improvement the Quality of Life

When the Tompun watershed areas are improved, the road surface will be in good conditions and infrastructure development of community will receive more attention from the government. In addition, the infrastructure and facility systems of resettlement site will be developed by the project, i.e., health, education, electric power, and water supply system. These will result in better quality of life for local people. These are significant positive impacts of high level.

(ii) Economic Impact

At present, the people in Phnom Penh Municipal suffer from flood and face economic loss from flood damage frequently. When the project was completed, problems on assets damage, business, transportation, and health damages will disappear. These are highly positive impacts for economic of Phnom Penh Municipal.

(2) Compensation / Resettlement

(a) Construction Period

Although the number of affected families from Tompun watershed improvement are relatively high of about 480 households, majority of them are relatively good quality houses occupied areas along drainage channel banks. It is necessary to fairly compensate for their affected properties and provide new resettlement site for this group of residents. With the provision as recommended, the expected impact will be at acceptable level.

The detail consideration on excavation schedule need to be made to minimize impact on affected families the order of excavation should be in this order:

(b) Operation Period

The necessary infrastructure, e.g., water supply, electricity, road conditions, pump facilities, etc. should be well maintained to make living condition of the affected household at the acceptable standard. With the implementation of the related measures, there will be no impact on the affected households.

(3) Archaeology and Tourism

(a) Construction Period

The archaeological and tourist attractions in City of Phnom Penh are clustered in the inner city area. Along Tompun concerned drainage channels, there is no archaeological site or tourist attraction, thus, the direct disturbances on such resources is nil. However, the project related traffic may create the adverse impact on traffic conditions in the nearby streets. The necessary measures on traffic safety need to be implemented.

(b) Operation Period

The alleviation of flood problem for the City of Phnom Penh will have indirect benefit on the enhancement of tourism activities. In addition, improvement of drainage system and control of garbage disposal will also benefit the aesthetic quality within the city.

Table G5-5 summarizes the environmental impacts. Disposal site for dredged/excavated material needs to be carefully selected during the detailed design stage. However it is recommended that suitable low cost liner material be used in the dredged material disposal site and adequate monitoring be conducted to protect nearby water resources and to take preventive action if pollution is detected.

5.5 Mitigation Measures

5.5.1 Physical Resources

(1) Hydrology

(a) Construction Period

- Drainage ditch and small pond shall be provided to collect water from construction activities.
- Any construction activities which disturb soil, such as land leveling, excavating, or piling will be concentrated during dry season to avoid the soil erosion during rainy season.
- Provide temporary gutters at the construction site and vicinity areas in order to protect flood.
- Strictly prohibit the workers to dump the solid wastes and garbages into the waterways to prevent the obstruction and shallowness of drainage channel, as well as flood problem.
- Channel excavation should be concentrated during dry season.

(b) Operation Period

- Coordinate with local Khan about gate barrage operation schedule in case of flood.
- Regularly clear up waterways prior to the rainy season.
- Enforce the regulation on garbage dumping.

(2) Water Quality

(a) Construction Period

- Construct all of sections which close to the waterways only during the dry season.
- Do not wash equipment in the river.
- Prohibit any waste dumping into the waterways.
- Inspect machinery and equipment weekly to prevent any oil leakage.
- Store construction material at least 10 m. from the water course
- Install sanitary latrine for construction workers.
- Locate construction camp at least 50 m. from waterway.
- Construct retention basin to trap domestic wastewater from construction camps prior to overflow to nearby waterways.
- Draining ditch and a small retention pond should be constructed within the fenced compound to retain waste water from spraying on construction material and from cleaning of vehicles.

(b) Operation Period

- Provide efficient flood warning system.
- During inundation there should be an efficient system to assist the affected families.
- Implement other additional flood protection measures e.g. dredging of swamps and canals.
- Provide agriculture extension program in the flood protected area.

5.5.2 Human Use Values

(1) Land Use

(a) Construction Period

- Inform local people who utilize the project development areas before starting the construction.
- Set the action plan of compensation and implementation.
- Carefully monitor the construction activities especially at Boeng Salang and Meanchey drainage channel to avoid any effects on local communities.
- Clear and return the land use pattern in construction site into its original condition as soon as possible.
- Avoid establishing worker's communities adjacent to the public lands the problem of land encroachment.
- Adequate space for infrastructure should be provided at worker's communities to avoid increase of congestion, drainage and flood problems.

(b) Operation Period

- Regularly check the land use pattern to avoid the encroachment problem.

(2) Transportation

(a) Construction Period

- Carefully schedule project transportation to avoid the rush hours.
- Speed limits and traffic regulations should be strictly enforced to minimize traffic accidents.
- Overloading of project's trucks must be avoided because it could cause accidents and damages to the roads.
- Inform the local people about the construction schedule to alleviate the congestion and accidents around the construction site.
- Provide and install good signals which are easy to be observed both during daytime and nighttime around the construction site.
- Cover the truck containing the construction materials to avoid material falling and dust dispersion.
- Closely cooperation between the contractor and traffic police is necessary to minimize traffic congestion and accident problems.

(b) Operation Period

- Install the traffic sign and project's other structures at the project site to avoid the damage problem to the inspection road and encroachment problem to the developed waterways.

5.5.3 Quality of Life Values

(1) Socioeconomy

(a) Construction Period

- Give priority to the development of resettlement site prior to major construction.
- Fairly compensate for directly affected land and properties as recommended in the section on compensation.
- Conduct construction activities only during daytime.
- Regularly check up machineries and equipment to control noise level to be within the permitted standard.
- Spray water on disturbed area or dust generating area to minimize dust dispersion.
- Not use machineries and equipment which generate soot and smoke exceeding the standard limit in the project construction.
- Provide temporary detour with adequate traffic signs at proper places.
- Employ local workers to a maximum extent to alleviate conflicts between project construction workers and local residents and improve local economic condition.
- Excavation of regulation pond first and use sediment to fill up new resettlement site.
- Emphasis the excavation activities at the channel with lower population density first.

(2) Compensation/Resettlement

(a) Construction Period

- The compensation cost should be fair and accepted by affected people.
- Compensation process should be completed before the start of project construction.
- The affected people should have proper representatives in establishing of the compensation process.
- To compensate the private owned land and properties, the affected people should be given fair compensation and any genuine conflicts should be reviewed. Compensation by using the power of justice should be the last choice.

(b) Operation Period

- Regularly maintain the infrastructure in and around the resettlement site.

(3) Archaeological and Historical Values

(a) Construction Period

- Spray water over the disturbed area at least 2 times a day to avoid dust dispersion.
- Spray water on construction material such as soil, sand or others periodically to control dust.
- Regularly check up machineries and equipment to control noise level to be within the permitted standard and not to disturb religious activities in the temples.

(4) Aesthetic and Tourism

(a) Construction Period

- Keep construction site clean and tidy.
- Dispose of wastes in the designated containers.
- Properly construct worker camps away from Aesthetic sites.

Mitigation measures recommended are the same as in case of Kop Srov dike and Tompun dike improvement. Appropriate dredge site selection during detailed design stage needs to be done. Appropriate design of the site with due consideration of appropriate cost effective liner material needs to be done. Adequate monitoring of nearby water bodies needs to be conducted especially during runoff events to ensure toxic pollutant levels in leachate overflows during storm events do not exceed harmful levels.

5.6 Environmental Monitoring

5.6.1 Surface Water Quality

(1) Parameter

- Depth
- Temperature
- pH
- Conductivity

- DO
- SS
- BOD

(2) Station

15 Stations as follows:

No.	Location Name	Remarks
1.	Bassac River	At Monyvong Bridge
2.	Kak Lake	Behind the mosque
3.	Salang Lake	At the intersection with Street 4336
4.	Meanchey Drainage Channel	Outside Salang Pumping Station
5.	Toul Sen West Drainage Channel	At the intersection with Street 310
6.	Toul Sen East Drainage Channel	At the intersection with Street 103
7.	Trabek Drainage Channel	At the intersection with Street 310
8.	Trabek Lake	Inside Trabek Pumping Station
9.	Outside Trabek Pumping Station	
10.	Tompun Lake	Inside Tompun Pumping Station
11.	Outside Tompun Pumping Station	
12.	Phum Russey Drainage Channel	At Phum Dangkao Bridge
13.	Well 1 at Phum Dangkao Village	At Phum Dangkao Village
14.	Well 2 at Thnot Chrum Village	At Thnot Chrum Village
15.	Well 3 at Phum Chak Angre Kraom Village	At Phum Chak Angre Kraom Village

(3) Methodology

Standard Methods for Examination of Water and Wastewater by APHA, AWWA and WPCF; Vol. 19.

(4) Frequency

- During construction activities
- Post construction activities

(5) Responsible Agency

- Contractor / DPWT

5.6.2 Transportation

(1) Parameter

- Average daily traffic by separate type of vehicle and accidental records.

(2) Location

- Road No.271, Monireth (217), Mao Tse Toung (245), Jawaharlal Nerhu (215) and Charles De Gaulle road.

(3) Frequency

- Every 3 months during construction period.

(4) Methodology

- Traffic count according to type of traffic and time of day.

(5) Responsible Agency

- Contractor / DPWT.

5.6.3 Socioeconomy

(1) Parameter

(a) Construction Period

Attitude of villagers toward the project, compensation and resettlement plan, list of question are as follows:

- Have consultation taken place as scheduled including meeting, groups, community activities? Have resettlement leaflets been prepared and distributed?
- How many affected peoples know their entitlements? How many know if they have been received?
- How many affected peoples used the grievance redress procedures?
- What were the outcomes?
- Have conflicts been resolved?
- Was the social preparation phase implemented?

(b) Operation Period

Attitude of villagers toward the project, compensation and resettlement plan,

- Change in patterns of occupation, production and resource use compared to the pre-project situation.
- Changes in income and expenditure patterns compared to pre-project situation, changes in cost of living compared to pre-project situation, and affected people's incomes place with these changes.
- Changes taken place in key social and cultural parameters relating to living standards.
- Changes have occurred for vulnerable groups.

(2) Methodology

- Independent survey of villagers attitude by questionnaire.

(3) Location

- Villagers live along both sides of concerned Tompun drainage channel and resettlement area (operation).

(4) Frequency

- Twice before construction period and during the first year of construction.
- Once every 2 years during project operation.

(5) Responsible Agency

- DPWT

Monitoring program of water bodies for toxic pollutants near dredged material disposal site will be determined in the detailed design stage when the dredged material site will be selected.

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Table G2-1 Existing Infrastructure in Phnom Penh

Item	Description
1. Water Supply	Core City / Town. Service : Surface water Distribution : Poor Per- Urban Area : Untreated Surface water / well.
2. Sanitation	Core City : Piped System combined with stormwater. Condition : 60% unserviceable. Per- Urban Area : Pit Laterine
3. Drainage	Core City : Piped / Caual System combined with sewage. Condition : 60% unserviceable. Per- Urban Area : Canal / Poor.
4. Roads	Core City : 270 km paved / 350 km unpaved. Condition : 60% Poor. Per- Urban Area : Unpaved and in poor condition.
5. Solid waste	Core City : Collection privatised and fair. Disposal : Privatised and poor. Per- Urban Area : None.
6. Power Supply	Core City : Generation : 60% demand. Distribution: Poor. Per- Urban Area : None (private generations).

Source : ADB Cambodia Urban Development Study (1996)

Table G2-2 Existing Water Quality Data

Item	Unit	WHO guideline values	Tonle Mekong	Tonle Sap	Tonle Bassac
pH		<8	7-8.3	6-7.8	7.2-7.5
Taste and Odor		acceptable	Nil	Nil	Nil
Turbility	NTU	5	5-22	11-16	
Alkalinity	mg / ℓ		70-80	27-63	
Hardness			84	72	7
Sulphate	mg / ℓ	250	18	12	
Iron	mg / ℓ	0.3	0-0.08	0.06-0.15	0.05-0.11
Manganese	mg / ℓ	0.1	0.0-0.1	0.0-0.1	
Zinc	mg / ℓ	3	0.01-0.04	0.0-0.1	0.01-0.02
Aluminum	mg / ℓ	0.2	0.2	0	
Copper	mg / ℓ	1	0-0.01	0-0.01	0-0.01
Arsenic	mg / ℓ	0.01	<0.004	<0.004	
Cadmium	mg / ℓ	0.003	<0.001	<0.001	
Chromium	mg / ℓ	0.05	0.05	0.05	
Cyanide	mg / ℓ	0.07	0-0.002	0-01.002	0-0.001
Lead	mg / ℓ	0.01	<0.001	<0.001	
Fluoride	mg / ℓ	1.5	0.09-0.58	0.12-0.57	0.28-0.69
Mercury	mg / ℓ	0.001	<0.005	<0.005	
Nitrate	mg / ℓ	50	0.05	0.47-0.88	
Mitrite	mg / ℓ	3	0.001-0.069	0.0-0.035	0.006-0.027
COD	mg / ℓ		3-6	5-7	5-7
$N\text{-}NH_3$	mg / ℓ		0.1-0.5	0.2-0.7	
Fecal Coliforms(100 mℓ)				2000	500
Total Coliforms (100 mℓ)			8000	4,500-12,006	1,300-6,000

Source: Interim Report and Final Report, Urban Water Supply and Sanitation Project, ADB TA No. 2280-CAM, Sogreah Ingenierie, June 1996

Table 2-3 Locations of Water Quality and Benthic Material Quality Sampling Stations

No.	Location Name	Remarks
1.	Sap River Upstream	At the confluence with Phnou River
2.	Phnou River	At the River mouth
3.	Sap River Downstream	At Chak Tomuk
4.	Bassac River	At Monyvong Bridge
5.	Thnot River	At the River mouth
6.	Phum Svay Pak	At HW # 5
7.	Kak Lake	Behind the Mosque
8.	Salang Lake	At the intersection with street 336
9.	Meanchey Drainage Channel	Outside Salang Pumping Station
10.	Toul Sen West Drainage Channel	At the intersection with street 310
11.	Toul Sen East Drainage Channel	At the intersection with street 103
12.	Trabek Drainage Channel	At the intersection with street 310
13.	Trabek Lake	Inside Trabek Pumping Station
14.	Outside Trabek Pumping Station	
15.	Tompun Lake	Inside Tompun Pumping Station
16.	Outside Tompun Pumping Station	
17.	Phum Russey Drainage Channel	At Phum Dangkao Bridge
18.	Well 1 at Phum Dangkao Village	At Phum Dangkao Village
19.	Well 2 at Thnot Chrum Village	At Thnot Chrum Village
20.	Well 3 at Phum Chak Angre Kraom Village	At Phum Chak Angre Kraom Village

Table G2-4 Results of Water Quality Analysis (April 27-28, 1998)

Parameter	Station									
	1	2	3	4	5	6	7	8	9	10
1. Depth (m)	1.9	0.2	1.3	1.6	0.4	0.6	1.4	0.5	1.0	0.5
2. Transparency (m)	1.8	0.2	0.7	0.5	0.1	0.1	0.4	0.1	0.1	0
3. Air Temp. (°C)	36.1	36.0	37.5	42.6	38.0	31.1	35.5	35.6	39.0	38.9
4. Water Temp. (°C)	32.0	30.0	32.0	33.0	34.0	30.7	32.0	34.0	31.5	32.0
5. pH	7.5	7.3	8.0	8.1	7.6	7.4	7.8	7.5	7.4	7.1
6. Conductivity ($10^{-6}\Omega$/cm)	<100	200	100	100	300	1,000	800	1,000	1,200	900
7. Dissolved Oxygen (mg/ℓ)	5.2	1.0	6.0	6.6	3.8	0.1	8.4	0.1	0.1	0.1
8. Suspended Solid (mg/ℓ)	4.0	2.0	5.5	21.0	458.0	440.0	12.0	25.0	118.0	90.0
9. BOD_5 (mg/ℓ)	a	a	a	a	a	a	a	a	a	a
10. COD (mg/ℓ)	6.3	8.4	6.1	6.7	24.2	105.2	19.6	43.9	61.1	27.5
11. Fecal Coliform Bacteria (MPN/100 mℓ)	2,493	42,625	30,360	57,167	86,000	380,600	21,560	460,600	221,600	2.E+06

Parameter	Station									
	11	12	13	14	15	16	17	18	19	20
1. Depth (m)	0.5	0.5	<1	<1	2.0	<1	0.4	~12	~36	~42
2. Transparency (m)	0	0	0	0	0	-	0.1	b	b	b
3. Air Temp. (°C)	38.9	40.8	41.0	41.0	39.0	40.8	34.0	40.8	43.0	44.2
4. Water Temp. (°C)	32.0	33.0	34.0	37.0	32.0	32.6	28.0	32.0	31.0	32.0
5. pH	7.1	7.2	7.3	7.7	7.4	7.6	7.6	7.5	7.6	8.3
6. Conductivity ($10^{-6}\Omega$/cm)	500	700	800	800	1,000	1,000	200	900	900	600
7. Dissolved Oxygen (mg/ℓ)	0.1	0.1	0.1	0.1	0.1	0.1	1.0	1.6	1.4	5.6
8. Suspended Solid (mg/ℓ)	36.0	76.0	23.3	29.0	5.5	44.0	27.0	0.8	1.0	0.0
9. BOD_5 (mg/ℓ)	a	a	a	a	a	a	a	a	a	a
10. COD (mg/ℓ)	39.8	39.0	30.3	26.7	35.7	48.4	15.6	1.3	1.4	1.5
11. Fecal Coliform Bacteria (MPN/100 mℓ)	3.E+06	462,308	232,131	384,000	570,000	530,000	32,500	352	0	178

Note:

Station 1: Tonle Sap Upstream at Prek Phnou Confluence
Station 2: Prek Phnou
Station 3: Tonle Sap Downstream at Chak Tomuk
Station 4: Tonle Bassac
Station 5: Prek Thnot
Station 6: Phum Svay Pak
Station 7: Boeng Kak
Station 8: Boeng Salang
Station 9: Meanchey Drainage Channel
Station 10: Toul Sen West Drainage Channel
Station 11: Toul Sen East Drainage Channel
Station 12: Trabek Drainage Channel
Station 13: Boeng Trabek
Station 14: Outside Trabek Pumping Station
Station 15: Boeng Tompun
Station 16: Outside Tompun Pumping Station
Station 17: Phum Russey Drainage Channel Upstream from Dangkao Bridge
Station 18: Well 1 at Phum Dangkao Village
Station 19: Well 2 at Thnot Chrum Village
Station 20: Well 3 at Phum Chak Angre Kraom Village
a: Laboratory equipment for BOD is being repaired.
b: not measured

Table G2-5 Results of Water Quality Analysis (May 20-21, 1998)

Parameter	Station									
	1	2	3	4	5	6	7	8	9	10
1. Depth (m)	2.2	0.3	1.5	1.2	0.5	0.8	2.4	0.5	1.0	0.5
2. Transparency (m)	1.0	0.1	0.3	0.5	0.1	0.1	0.4	-	0.1	0
3. Air Temp. (°C)	39.0	38.4	36.0	43.1	41.5	39.1	36.0	37.3	39.0	40.4
4. Water Temp. (°C)	32.0	30.5	32.0	33.0	34.0	32.0	31.0	34.0	31.0	33.0
5. pH	7.4	7.6	8.4	8.9	8.9	7.1	8.1	7.6	7.7	7.4
6. Conductivity ($10^{-6}\Omega$/cm)	<10.0	1,800	100	100	600	700	900	1,000	1,400	800
7. Dissolved Oxygen (mg/ℓ)	6.4	0.8	6.8	5.8	3.7	6.4	6.2	0.2	0.1	0.2
8. Suspended Solid (mg/ℓ)	2.8	4.0	12.0	1.3	260.0	62.5	4.0	128.0	28.0	46.0
9. BOD_5 (mg/ℓ) a	1.83 4.90	3.67 12.86	3.67 3.07	6.76 5.20	8.33 11.45	11.39 22.66	6.12 6.73	35.20 31.67	14.06 14.06	63.36 95.03
10. COD (mg/ℓ)	6.7	7.5	4.8	7.3	20.5	39.1	19.1	39.0	33.2	35.3
11. Fecal Coliform Bacteria (MPN/100 mℓ)	4.E+03	4.E+04	2.E+05	5.E+03	8.E+04	3.E+04	2.E+04	2.E+06	1.E+06	1.E+07

Parameter	Station									
	11	12	13	14	15	16	17	18	19	20
1. Depth (m)	0.5	0.5	<1	<1	1.0	1.0	0.5	~12	~36	~42
2. Transparency (m)	0	0	b	b	0	-	0.1	b	b	b
3. Air Temp. (°C)	40.2	44.3	39.7	41.9	39.2	38.0	41.2	41.8	38.2	42.2
4. Water Temp. (°C)	32.0	34.0	32.0	33.0	33.0	32.0	31.0	33.0	31.0	34.0
5. pH	7.6	7.6	8.0	8.0	8.0	7.9	7.8	7.6	8.0	8.7
6. Conductivity ($10^{-6}\Omega$/cm)	800	1,000	800	900	1,000	1,100	200	800	900	700
7. Dissolved Oxygen (mg/ℓ)	0.2	0.2	0.2	0.1	0.2	0.2	1.2	1.5	2.4	4.2
8. Suspended Solid (mg/ℓ)	52.0	11.0	20.0	27.0	20.0	73.0	360.0	-	0.0	0.0
9. BOD_5 (mg/ℓ) a	84.47 73.35	124.85 106.32	54.57 54.11	43.64 38.40	23.39 27.93	17.45 28.97	6.45 3.12	4.25 3.52	2.76 3.52	1.76 1.98
10. COD (mg/ℓ)	30.8	92.7	37.3	35.3	47.6	31.2	16.8	0.6	0.6	1.5
11. Fecal Coliform Bacteria (MPN/100 mℓ)	1.E+07	9.E+06	3.E+06	2.E+06	4.E+07	2.E+06	3,636	82	1	11

Note:

Station 1: Tonle Sap Upstream at Prek Phnou Confluence
Station 2: Prek Phnou
Station 3: Tonle Sap Downstream at Chak Tomuk
Station 4: Tonle Bassac
Station 5: Prek Thnot
Station 6: Phum Svay Pak
Station 7: Boeng Kak
Station 8: Boeng Salang
Station 9: Meanchey Drainage Channel
Station 10: Toul Sen West Drainage Channel
Station 11: Toul Sen East Drainage Channel
Station 12: Trabek Drainage Channel
Station 13: Boeng Trabek
Station 14: Outside Trabek Pumping Station
Station 15: Boeng Tompun
Station 16: Outside Tompun Pumping Station
Station 17: Phum Russey Drainage Channel Upstream from Dangkao Bridge
Station 18: Well 1 at Phum Dangkao Village
Station 19: Well 2 at Thnot Chrum Village
Station 20: Well 3 at Phum Chak Angre Kraom Village
a: upper column: upstream, lower column: downstream
b: not measured

Table G2-6 Results of Water Quality Analysis (19-20 October, 1998)

Parameter	Station									
	1	2	3	4	5	6	7	8	9	10
1. Depth (m)	NA*	1.0	NA*	NA*	NA*	1.5	1.3	1.2	6.0	0.7
2. Transparency (m)	0.5	0.2	0.2	0.4	0.2	0.4	0.3	0.2	0.1	0
3. Air Temp. (°C)	35.7	31.2	37.1	36.4	35.0	36.8	40.5	36.2	36.0	37.7
4. Water Temp. (°C)	30.5	29.0	31.0	30.5	29.0	30.5	31.0	29.0	32.0	29.0
5. pH	7.2	7.4	7.3	7.6	8.0	7.4	7.7	7.2	6.2	7.4
6. Conductivity ($10^{-6}\Omega$/cm)	100.0	100	100	100	100	100	100	500	300	600
7. Dissolved Oxygen (mg/ℓ)	3.6	2.8	3.4	3.2	5.6	2.0	7.0	0.2	0.2	0.2
8. Suspended Solid (mg/ℓ)	40.0	34.0	83.0	26.0	119.0	33.0	107.0	190.0	67.0	78.0
9. BOD_5 (mg/ℓ) a	13.00	14.00	12.00	8.00	35.00	9.00	15.00	30.00	25.00	44.00
10. COD (mg/ℓ)	16.0	31.0	23.0	16.0	7.0	16.0	97.0	89.0	101.0	16.0
11. Fecal Coliform Bacteria (MPN/100 mℓ)	2.4E+03	4.6E+04	1.1E+05	7.5E+04	2.4E+03	2.4E+04	4.6E+04	2.4E+07	2.1E+06	4.3E+06

Parameter	Station									
	11	12	13	14	15	16	17	18	19	20
1. Depth (m)	1.3	0.9	1.0	1.2	NA*	NA*	1.5	12.0	36.0	42.0
2. Transparency (m)	0.1	0.1	0.1	0.2	0.2	0.1	0.1	NA	NA	NA
3. Air Temp. (°C)	37.0	38.0	35.7	34.9	37.0	35.9	35.1	34.8	36.8	35.5
4. Water Temp. (°C)	29.5	29.0	28.0	30.0	31.0	30.0	31.0	30.0	30.0	29.5
5. pH	7.8	7.4	7.6	7.6	7.5	7.4	7.6	7.9	7.1	8.5
6. Conductivity ($10^{-6}\Omega$/cm)	700	500	600	400	600	100	100	900	1,000	600
7. Dissolved Oxygen (mg/ℓ)	0.3	0.2	0.2	1.0	5.0	1.7	3.8	2.2	2.2	5.0
8. Suspended Solid (mg/ℓ)	23.0	187.0	56.0	22.0	25.0	65.0	65.0	4.0	2.0	2.0
9. BOD_5 (mg/ℓ) a	61.00	74.00	16.00	15.00	8.00	7.00	8.00	4.00	2.00	3.00
10. COD (mg/ℓ)	162.0	47.0	8.0	47.0	82.0	43.0	50.0	16.0	12.0	19.0
11. Fecal Coliform Bacteria (MPN/100 mℓ)	4.3E+06	4.3E+06	4.6E+06	4.6E+06	1.5E+05	2.4E+04	1.1E+04	3.6E+01	3.0E+01	9.2E+01

Note:

Station 1: Tonle Sap Upstream at Prek Phnou Confluence
Station 2: Prek Phnou
Station 3: Tonle Sap Downstream at Chak Tomuk
Station 4: Tonle Bassac
Station 5: Prek Thnot
Station 6: Phum Svay Pak
Station 7: Boeng Kak
Station 8: Boeng Salang
Station 9: Meanchey Drainage Channel
Station 10: Toul Sen West Drainage Channel
Station 11: Toul Sen East Drainage Channel
Station 12: Trabek Drainage Channel
Station 13: Boeng Trabek
Station 14: Outside Trabek Pumping Station
Station 15: Boeng Tompun
Station 16: Outside Tompun Pumping Station
Station 17: Phum Russey Drainage Channel Upstream from Dangkao Bridge
Station 18: Well 1 at Phum Dangkao Village
Station 19: Well 2 at Thnot Chrum Village
Station 20: Well 3 at Phum Chak Angre Kraom Village
a: upper column: upstream, lower column: downstream
b: not measured

Table G2-7 Results of Water Quality Analysis (November 4-5, 1998)

Parameter	Station									
	1	2	3	4	5	6	7	8	9	10
1. Depth (m)	NA*	1.3	NA*	NA*	NA*	1.1	3.1	1.1	0.6	0.6
2. Transparency (m)	0.4	0.4	0.3	0.3	0.1	0.3	0.7	0.1	0.1	0.1
3. Air Temp. (°C)	30.6	30.4	34.9	36.0	34.8	31.2	32.7	32.6	32.9	33.9
4. Water Temp. (°C)	30.0	29.0	30.0	39.0	29.0	28.0	31.0	28.0	29.0	30.0
5. pH	6.8	6.2	7.2	7.4	7.5	6.7	7.5	7.3	7.0	7.2
6. Conductivity ($10^{-6}\Omega$/cm)	100.0	100	100	100	100	300	700	800	300	800
7. Dissolved Oxygen (mg/ℓ)	3.9	4.9	4.0	3.7	6.2	0.2	4.4	0.3	0.4	0.2
8. Suspended Solid (mg/ℓ)	44.0	30.0	78.0	26.0	132.0	25.0	27.0	102.0	185.0	59.0
9. BOD_5 (mg/ℓ) a	7.00	6.00	7.00	7.00	9.00	11.00	18.00	46.00	19.00	73.00
10. COD (mg/ℓ)	19.0	27.0	23.0	16.0	27.0	27.0	105.0	120.0	74.0	159.0
11. Fecal Coliform Bacteria (MPN/100 mℓ)	2.2E+03	2.3E+04	4.3E+04	9.3E+03	4.6E+03	9.3E+03	4.3E+03	7.5E+03	2.3E+04	4.6E+05

Parameter	Station									
	11	12	13	14	15	16	17	18	19	20
1. Depth (m)	0.7	0.6	0.9	0.5	1.0	0.6	1.2	12.0	36.0	42.0
2. Transparency (m)	0.1	0.1	0.1	0.1	0.3	0.2	0.1	NA	NA	NA
3. Air Temp. (°C)	33.7	33.4	34.3	34.8	31.9	32.0	31.9	31.2	34.1	35.1
4. Water Temp. (°C)	30.0	30.0	29.0	32.0	30.0	30.0	29.5	30.0	30.0	30.0
5. pH	7.1	7.3	7.4	7.4	7.5	7.3	7.2	7.6	7.5	8.1
6. Conductivity ($10^{-6}\Omega$/cm)	1,100	1,200	700	800	500	400	100	1,100	1,000	600
7. Dissolved Oxygen (mg/ℓ)	0.4	0.2	0.2	0.3	6.8	3.2	4.6	1.7	2.4	6.8
8. Suspended Solid (mg/ℓ)	76.0	182.0	63.0	30.0	32.0	53.0	50.0	5.0	4.0	4.0
9. BOD_5 (mg/ℓ) a	71.00	76.00	30.00	20.00	10.00	13.00	8.00	5.00	4.00	4.00
10. COD (mg/ℓ)	175.0	124.0	62.0	31.0	74.0	85.0	47.0	14.0	12.0	16.0
11. Fecal Coliform Bacteria (MPN/100 mℓ)	2.4E+06	4.6E+03	1.1E+06	2.4E+05	1.5E+05	4.6E+04	3.4E+04	3.6E+01	3.0E+01	2.3E+02

Note:

Station 1: Tonle Sap Upstream at Prek Phnou Confluence
Station 2: Prek Phnou
Station 3: Tonle Sap Downstream at Chak Tomuk
Station 4: Tonle Bassac
Station 5: Prek Thnot
Station 6: Phum Svay Pak
Station 7: Boeng Kak
Station 8: Boeng Salang
Station 9: Meanchey Drainage Channel
Station 10: Toul Sen West Drainage Channel
Station 11: Toul Sen East Drainage Channel
Station 12: Trabek Drainage Channel
Station 13: Boeng Trabek
Station 14: Outside Trabek Pumping Station
Station 15: Boeng Tompun
Station 16: Outside Tompun Pumping Station
Station 17: Phum Russey Drainage Channel Upstream from Dangkao Bridge
Station 18: Well 1 at Phum Dangkao Village
Station 19: Well 2 at Thnot Chrum Village
Station 20: Well 3 at Phum Chak Angre Kraom Village

a: upper column: upstream, lower column: downstream

b: not measured

NA* Difficulty in measurement due to High flow conditions

Table G2-8 (1/3) Descriptive Summary of Water Quality Analysis Results

St. No.	Location	General Site Description	Water	Water Characteristic (dry season)		Water Characteristic (wet season)	
				April 1998	May 1998	October 1998	November 1998
1	Tonle Sap at confluence with Phnou river	River is about 400 m wide with housing, shops, industries.	For washing, cleaning aquacultural purposes. The river is also mean of transportation.	Water is clear SS of 4.0 mg/ℓ, transparency of 1.8 m, DO is high at 5.2 mg/ℓ. Pollution level is quite low with COD at 6.7 mg/ℓ. Fecal coliform at 2,493 MPN/100 mℓ.	Water is soft indicating by low conductivity (<100 $x10^{-6}\Omega$/cm). DO is high at 6.4 mg/ℓ due to the high flow and neutral pH at 7.4.	High flow water, SS 40 mg/L; Transparency at 0.5 m; DO is 3.6 mg/L; BOD 13 mg/L and COD 16mg/L	High flow water, SS 44 mg/L with transparency at 0.4 m, BOD and COD similar to Oct. wet season sampling
2	Prek Phnou at river mouth close to N.R. No.5	Steep bank with low flow. Garbage dumping can be found around the place. Housing and industries are located on both banks.	No water uses due to its polluted nature.	Water is relatively clear (SS of 2 mg/ℓ). Quite low in DO (1.0 mg/ℓ). The waterway is heavily infested with water hyacinth and highly contaminated with human waste (Fecal Coliform of 42,625 MPN/100 mℓ).	There are drastically increased of conductivity from 200 to 1,800x$10^{-6}\Omega$/cm detecting in April and May respectively. Other parameters, e.g., DO (0.8 mg/ℓ- and pH (7.6) are still at the same range as previous sampling period for dry season.	Water is relatively turbid (SS34 mg/L); transparency at 0.2 m; Low DO at 2.8 mg/L; Total coliform is very high at 460,000 MPN/100 ml	DO is 4.9 mg/L due to high flow with low BOD of 6 mg/L fecal coliform is high at 23,000 MPN/100ml
3	Tonle Sap at Chak Tomuk	River is about 500 m wide with housing, agricultural, business areas along both banks.	Washing, cleaning, and transportation.	Water is relatively clear (SS of 5.5 mg/ℓ). DO is 6.0 mg/ℓ with high flow. Aquatic weed (water hyacinth) can be found along the river.	DO is 6.8 mg/ℓ with low conductivity at 100x$10^{-6}\Omega$/cm and pH of 8.4 which are similar to previous dry season sampling results.	SS is 83 mg/L with transparency at 0.2 m; Do is 3.4 mg/L but Fecal coliform is very high at 1,100,000 MPN/ 100ml	Water flow is still high with SS 78 mg/L; DO is 4 mg/L, BOD 7 mg/L and Fecal Coliform 43,000 MPN/ 100ml
4	Tonle Bassac at Monivong Bridge	River is about 200 m wide. Housing, floating rafts can be found along the river. Garbage dumping can be found along the banks.	Washing, cleaning, and transportation.	High DO at 6.6 mg/ℓ. SS at 21 mg/ℓ. COD at 6.68 mg/ℓ with high Fecal Coliform at 57,167 MPN/100 mℓ.	DO is relatively high at 5.8 mg/ℓ with pH on the base side of 8.9 and conductivity of 100x$10^{-6}\Omega$/cm.	High flow water, DO is 3.2 mg/L; BOD at 8 mg/L and high Fecal Coliform at 75,000 MPN/ 100ml	Similar to October sampling period
5	Prek Thnot at river mouth near Tonle Bassac	The river is about 30 m wide with emergent and floating weeds. Housing, idle areas are scattered along river banks.	No water utilization other than transportation.	Water is very turbid (SS 458 mg/ℓ). DO is 3.8 mg/ℓ with high COD and Fecal Coliform 24.2 mg/ℓ and 86,000 MPN/100 mℓ.	The DO is similar to previous sampling to 3.7 mg/ℓ. Conductivity and pH are 600x$10^{-6}\Omega$/cm and 8.9 which are in similar range to April samples.	High DO at 5.6 mg/L; BOD 35 mg/l, SS 119 mg/l	BOD and COD are low at 9 and 27 mg/l respectively; DO is high at 6.2 mg/l; conductivity is low at 100 x 10^{-6} Ω/cm
6	Phum Svay Pak at N.R. No.5	This river receives water from Boeng Poung Peay which is the industrial area. Along both banks are congested household and agricultural areas.	No water utilization in dry season.	DO is 0.1 mg/ℓ with turbid brownish color (SS= 440 mg/ℓ). COD is 105.2 mg/ℓ and Conductivity at 1,000x$10^{-6}\Omega$/cm due to discharge from industrial area.	The algae bloom are detected at this site which obviously influences DO level to 6.4 mg/ℓ from 0.1 mg/ℓ (April).	Do is 2 mg/l, BOD 9 mg/l, COD 16 mg/l and fecal coliform high at 240,000 MPN/ 100ml	Water is turbid with transparency at 0.25 m; DO is low at 0.2 mg/l; BOD 11 mg/l and COD 27 mg/l
7	Boeng Kak Lake at guest house behind Mosque	Natural lake about 1.5 m deep surrounded by densed communities and shops.	Aquaculture and collect wastewater from nearby areas.	Water is greenish with SS of 12 mg/ℓ. DO is very high at 7.8 mg/ℓ due to photo-synthetic reaction. COD is high at 19.6 mg/ℓ with also high Fecal Coliform at 21,560 MPN/100mℓ.	DO is at 6.2 mg/ℓ, pH is 8.1 with conductivity at 900x$10^{-6}\Omega$/cm.	Water has green color with high DO at 7 mg/l; SS 107 mg/l, BOD 15 mg/l and COD 97 mg/L	Water has green color with transparency at 0.65 m; Conductivity is high at 700 x 10^{-6} Ω/cm; DO is still high at 4.4 mg/l

Table G2-8 (2/3) Descriptive Summary of Water Quality Analysis Results

St. No.	Location	General Site Description	Water	Water Characteristic (dry season) April 1998	Water Characteristic (dry season) May 1998	Water Characteristic (wet season) October 1998	Water Characteristic (wet season) November 1998
8	Boeng Salang Lake at Intersection with Street No. 336	This natural lake is about 0.5 m deep, surrounded by congested housing & shops and totally covered by water hyacinth.	No water usage.	The water is highly polluted with black color (SS 25 mg/ℓ) and strong H2S smell. DO is only 0.1 mg/ℓ and Fecal Coliform of 460,000 MPN/100 mℓ.	Deteriorated water is still obvious with DO of 0.2 mg/ℓ, strong H_2S smell and conductivity of 1,000x10^{-6}Ω/cm.	Fecal Coliform is very high at 240,000 MPN/ 100 ml. Black color with strong H_2S smell. Low DO at 0.2 mg/l	DO is low at 0.3 mg/l BOD is 46 mg/l. Fecal coliform is still high at 750,000 MPN/100 ml. Strong H_2S smell with black color
9	Meanchey drainage channel at Salang Pumping Station.	The channel is about 5 m wide fully covered with water hyacinth and surrounded by shops and housing.	No water utilization	Water is black (SS at 118 mg/ℓ) with very strong H_2S smell. DO is 0.1 mg/ℓ. COD is 61.6 mg/ℓ and very high Fecal Coliform of 221,600 MPN/100 mℓ.	Signed of polluted water is still obvious. Strong H_2S smell with DO of 0.1 mg/ℓ, conductivity of 1,400x10^{-6}Ω/cm, dark color and pH of 7.7.	Low DO at 0.2 mg/l; BOD is 25 mg/l; brown color with strong smell, very high fecal coliform (2,100,000 MPN/100ml)	Strong smell with black color; DO is 0.4 mg/l; BOD at 19 mg/l; fecal coliform 23,000 MPN/100ml
10	Toul Sen West drainage channel at the intersection with St. 310.	This drainage channel is about 2 m wide and is surrounded by housing and shops.	No water utilization	Water is black with strong H_2S smell. DO is only 0.1 mg/ℓ. Fecal coliform is 2,331,000 MPN/100 mℓ.	Similar quality of water is reported. DO is still very low at 0.2 mg/ℓ. Obvious pollutions are in the form of garbages and draining of wastewater into this channel.	Brown color with strong smell with extremely high fecal coliform (4,300,000 MPN/100ml); Do is low at 0.2 mg/l; BOD is 44 mg/l	BOD is high at 73mg/l, fecal coliform 460,000 MPN/100ml; DO is negligible at 0.2 mg/l; black color and strong smell
11	Toul Sen East drainage channel at intersection with St. 103	This drainage channel is about 2 m wide and surrounded by densed housing and shops.	No water utilization	Water is heavily polluted with DO of 0.1 mg/ℓ and black (SS of 36 mg/ℓ). COD is 39.8 mg/ℓ and Fecal Coliform at 2,840,000 MPN/100 mℓ.	This channel is highly polluted with indication from very low DO (0.2 mg/ℓ), strong H_2S smell, and high conductivity (800x10^{-6}Ω/cm).	Water is turbid brown, strong smell; transparency at 0.1 m, low DO at 0.3 mg/l; high BOD at 61 mg/l, COD 162 mg/l and fecal coliform 4,300,000 MPN/100ml	Black color, strong smell; DO is still low at 0.4 mg/l; BOD is 71 mg/l; Fecal coliform is extremely high at 2,400,000 MPN/100ml
12	Trabek drainage channel at intersection with St. 310	This drainage channel is about 2 m wide surrounded by dense housing and shops.	No water utilization	Water is heavily polluted with black color (SS 76 mg/ℓ) and strong H_2S smell. DO is only 0.1 mg/ℓ. Garbage dumping is all over the area. Fecal coliform is 462,308 MPN/100 mℓ.	Similar trend as previous sampling results can be found. DO is very low at 0.2 mg/ℓ. Water is black with strong H_2S odor. Conductivity is up from 700 (April) to 1,000x10^{-6}Ω/cm.	High BOD at 74 mg/l, low DO at 0.2 mg/l and high fecal coliform of 4,300,000 MPN/100 ml; turbid brown color and strong smell	BOD is high at 76 mg/l; DO is low at 0.2 mg/l; strong smell and black color; fecal coliform is high at 460,000 MPN/100 ml
13	Boeng Trabek Lake near pumping station	This swamp is surrounded by dense housing and hog raising can be found at some houses.	No water utilization. The lake is used for vegetable growing	Water is heavily polluted with strong H_2S smell. DO is only 0.1 mg/ℓ. COD is quite high at 30.34 mg/ℓ and Fecal Coliform of 232,131 MPN/100 mℓ.	This swamp is highly polluted with wastewater from nearby communities and garbages. DO is 0.2 mg/ℓ, conductivity of 800x10^{-6}Ω/cm and Fecal Coliform of 2,633,333 MPN/100 mℓ.	Water color is black; strong H_2S smell, low DO at 0.2 mg/l; fecal coliform is high at 4,600,000 MPN/100ml	Black color with strong H_2S smell; low DO at 0.2 mg/l; fecal coliform is still high at 1,100,000 MPN/100 ml
14	Outside Trabek Pumping Station	The area receives wastewater from Trabek Pumping station.	Waterbody is covered by vegetable harvesting.	Water is heavily polluted with very strong smell of H_2S. DO is at 0.1 mg/ℓ. COD is very high at 26.65 mg/ℓ and Fecal Coliform at 384,000 MPN/100 mℓ.	Analysis of water sample from this station shows similar results as April's sample. DO is very low at 0.1 mg/ℓ with H_2S smell and dark in color (SS of 27.0 mg/ℓ) and Fecal Coliform at 2,323,388 MPN/100 mℓ.	Black color, strong smell, transparency at 0.2 m; SS of 22mg/l; fecal coliform is still high at 4,600,000 MPN/100 ml	DO is low at 0.3 mg/l; BOD is 20 mg/l, Fecal coliform iis 240,000 MPN/100 ml; black color and strong smell; transparency only 0.1 m

Table G2-8 (3/3) Descriptive Summary of Water Quality Analysis Results

St. No.	Location	General Site Description	Water	Water Characteristic (dry season)		Water Characteristic (wet season)	
				April 1998	May 1998	October 1998	November 1998
15	Boeng Tompun Lake 50 m north of Tompun pumping st.	Loosely surrounded by housing and agricultural area.	Waterbody is used mainly for wastewater collection and vegetable growing.	Water is highly polluted with highly contamination from human waste (DO = 0.0 mg/ℓ, SS =5.5 mg/ℓ and Fecal Coliform of 570,000 MPN/100 mℓ.)	Water quality is very poor with DO of 0.2 mg/ℓ, dark in color, very high Fecal Coliform of 40,080,000 MPN/100 mℓ.	Water has relatively green color with a lot of algae/ weeds. DO is high at 5 mg/L. Fecal coliform is 150,000 MPN/100ml	Green color, turbid with transparency at 0.25 m; high DO at 6.8 mg/L; fecal coliform is 150,000 MPN/100 ml
16	Boeng Tmai Lake South of Tompun pumping station on the other side of the road.	This low lying area receives water from Boeng Tompun Lake via pumping station.	Water is utilized for morning glory harvesting and cattle.	Water is highly polluted with DO of 0.1 mg/ℓ with very strong H_2S smell and Fecal Coliform of 530,000 MPN/100 mℓ.	Similar trend can still be observed. Storng H_2S odour, DO is very low at 0.2 mg/ℓ, Fecal Coliform of 1,844,444 MPN/100 mℓ and conductivity at $1,100 \times 10^{-6}$ Ω'cm.	Turbid brown color, transparency at 0.1 m; low DO at 1.7 mg/L; BOD 7 mg/L	DO is high at 3.2 mg/L (pump operating); BOD is 13 mg/L; transparency at 0.15 m
17	Phum Russey drainage canal 100 m upstream from Dangkao Bridge	The channel is about 80 m wide. Both banks are about 5 m high with scattered housing and rice mill.	The channel is covered by water hyacinth. The water is utilized for cattle only.	Water is quite turbid with SS at 270 mg/ℓ. DO is at 1.0 mg/ℓ. Fecal Coliform is 32,500 MPN/100 mℓ.	Sign of pollution is obvious. DO is at 1.2 mg/ℓ .ith high turbidity (SS of 360.0 mg/ℓ). Water is drained into the channel from surrounding community. Fecal Coliform is 3,636 MPN/100 mℓ.	High flow water; DO 3.8 mg/l; BOD 8 mg/l; fecal coliform 11,000 MPN/100ml	High flow water; high DO at 4.6 mg/l; Low BOD at 8 mg/l; fecal coliform is still high at 34,000 MPN/100 ml
18	Groundwater well #1 at Phum Dangkao Village	This well is about 12 m deep with cement castled and covered with wood plank.	Washing, cleaning, plant watering Normally boiled before drinking.	The water is clear (SS 0.79 mg/ℓ, and relatively clean with Fecal Coliform at 352 MPN/100 mℓ.	Water is soft and clear with conductivity at 800 mg/ℓ, SS at 0.0 mg/ℓ, Fecal Coliform of 82 MPN/100 mℓ.	Water is clear, SS 4 mg/l, fecal coliform low at 36 MPN/100 ml; conductivity at 900×10^{-6} Ω'cm	Water is still clear (SS 5 mg/l) and clean (Fecal coliform 36 MPN/100 ml); cooductivity is also high at 1000×10^{-6} Ω'cm
19	Groundwater well #2 at Thnot Chrum Village	This well is about 36 m deep with cement casted.	Water is used for all domestic purposes (10 households).	Water is clean with no detection of Fecal coliform and low SS of 1.0 mg/ℓ.	This is the new sampling station because pump for previous well is out of ordor. It is approximately 20 m from the April station. Many households use the well water for domestic use and boil before drinking. Water is clear and clean with SS of 0.0 mg/ℓ, cooductivity of 900×10^{-5} Ω /cm and Fecal Coliform of 1 MPN/100 mℓ.	Water is very clean (SS 2 mg/l) and clean (Fecal coliform 30 MPN/100 ml); high conductivity at 1000×10^{-6} Ω'cm	Water is still very clear (SS 4 mg/l) and clean (Fecal coliform 30 MPN/100 ml), high conductivity at 1000×10^{-6} Ω'cm
20	Groundwater well #3 at Phum Chak Angre Kraom	This well is about 42 m deep with cement casted.	Water is utilized for all domestic purposes (cooking, cleaning, washing and drinking).	Water is relatively clean (Fecal coliform 178 MPN/100 mℓ), SS = 0 mg/ℓ with relatively high conductivity at 600×10^{-6} Ω'cm.	Water is clear with SS of 0.0 mg/ℓ and soft (cooductivity at 700×10^{-6} Ω'cm). The Fecal Coliform of 11 MPN/100 mℓ is reported.	Water is clean and clear; conductivity is 600×10^{-6} Ω'cm	Water is clear (SS 4mg/l), coliform count 230 MPN/ 100 ml; conductivity 600×10^{-6} Ω'cm

Table G2-9 (1/2) Results of Benthic Material Analysis (May 20-21, 1998)

Parameter		Station									
		1 (N)	2 (N)	3 (N)	4 (N)	5 (N)	6 (N)	7 (L)	8 (L)	9 (C)	10 (C)
1. Color		Brown (Pale)	Brown	Brown	Brown	Brown	Brown (Pale)	Brown	Brown	Brown (Pale)	Brown
2. Texture		Clay + Sand	Sand + Clay	Sand + Clay	Sand + Clay	Sand + Clay	Sand + Silt	Sand + Silt	Sand + Silt	Sand + Clay	Sand + Silt
3. Cd	(ppm)	2.2	1.7	1.5	2.2	2.3	2.7	3.1	1.9	1.8	1.6
4. Total Cyanide	(mg/kg)	0.79	0.95	0.74	0.24	1.24	2.00	1.18	0.39	0.16	0.68
5. Organic Phosphorus	(mg/kg)	226	16.0	29.0	54.0	115.0	355.0	48.0	108.0	ND[1]	285.0
6. Pb	(ppm)	37.5	30.2	31.2	25.2	32.7	59.4	142.3	53.9	93.2	99.9
7. Cr^{+6}	(ppm)	21.4	5.2	8.4	7.3	19.5	11.0	8.9	4.9	9.0	7.3
8. As	(ppm)	5.9	3.6	3.7	3.1	3.2	2.4	5.9	2.1	2.3	3.1
9. Total Hg	(ppb)	143.0	118.7	91.50	27.65	49.50	35.9	36.7	94.9	48.95	292.4
10. Alkyl Hg	(mg/kg)	1.22	2.88	1.15	0.24	0.40	0.07	ND[3]	0.32	0.11	0.14
11. PCB	(mg/kg)	ND[2]	ND	ND	ND	ND	ND	ND	ND	ND	ND

Note: Station 1 : Sap River Upstream at Phnou River Confluence
Station 2 : Phnou River
Station 3 : Sap River Downstream at Chak Tomuk
Station 4 : Bassac River
Station 5 : Thnot River
Station 6 : Phum Svay Pak
Station 7 : Kak Lake
Station 8 : Salaug Lake
Station 9 : Meanchey Drainage Channel
Station 10: Toul Sen West Drainage Channel

ND[1]: Non detectable, Detection limit = 1.0 mg/kg
ND[2]: Non detectable, Detection limit = 0.1 mg/kg
ND[3]: Non detectable, Detection limit = 0.02 mg/kg
ND[4]: Non detectable, Detection limit = 0.005 mg/kg
N: Natural Waterway
L: Lake/Swamp
C: Drainage Channel
W: Well

Table G2-9 (2/2) Results of Benthic Material Analysis (May 20-21, 1998)

Parameter		Station									
		11 (C)	12 (C)	13 (L)	14 (L)	15 (L)	16 (L)	17 (C)	18 (W)	19 (W)	20 (W)
1. Color		Brown	Brown	Brown	Brown	Brown	Brown (Pale)	Brown (Pale)	Brown (Pale)	Brown	Brown (Pale)
2. Texture		Sand + Silt	Sand + Silt	Sand + Silt	Sand + Silt	Sand + Silt	Sand + Silt	Sand	Sand	Sand + Silt	Sand
3. Cd	(ppm)	2.6	1.1	1.2	0.8	1.5	0.8	1.2	0.1	2.1	0.8
4. Total Cyanide	(mg/kg)	0.54	0.33	0.48	0.27	0.96	0.58	0.50	0.05	ND[4]	0.85
5. Organic Phosphorus	(mg/kg)	90.0	153.0	144.0	95.0	348.0	153.0	145.0	443.0	16.0	237.0
6. Pb	(ppm)	194.2	56.8	195.3	75.0	54.7	21.4	37.0	23.8	46.5	10.6
7. Cr^{+6}	(ppm)	11.2	15.1	13.8	16.4	22.5	19.0	11.0	9.0	19.7	7.3
8. As	(ppm)	4.3	1.1	2.1	1.5	4.6	1.5	3.6	1.5	2.3	5.2
9. Total Hg	(ppm)	63.25	121.5	81.9	178.65	36.55	44.15	21.3	75.25	21.75	66.9
10. Alkyl Hg	(mg/kg)	0.28	2.44	0.30	0.13	0.38	0.16	0.68	0.31	0.35	0.58
11. PCB	(mg/kg)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Note: Station 11 : Toul Sen East Drainage Channel
Station 12 : Trabek Drainage Channel
Station 13 : Trabek Lake
Station 14 : Outside Trabek Pumping Station
Station 15 : Tompun Lake
Station 16 : Outside Tompun Pumping Station
Station 17 : Phum Russey Drainage Channel Upstream from Dangkao Bridge
Station 18 : Well 1 at Phum Dangkao Village
Station 19 : Well 2 at Thnot Chrum Village
Station 20 : Well 3 at Phum Chak Angre Kraom Village

ND[1]: Non detectable, Detection limit = 1.0 mg/kg
ND[2]: Non detectable, Detection limit = 0.1 mg/kg
ND[3]: Non detectable, Detection limit = 0.02 mg/kg
ND[4]: Non detectable, Detection limit = 0.005 mg/kg
N: Natural Waterway
L: Lake/Swamp
C: Drainage Channel
W: Well

Table G2-10 Average Contaminant's Concentrations in Benthic Material

Parameter		Natural Waterways	Lake / Swamp	Drainage Channels	Wells	Average
1. Cd	(ppm)	2.10	1.55	1.66	1.00	1.58
2. Total CN	(mg/kg)	0.99	0.64	0.44	0.45	0.63
3. Org. Phosphorus	(mg/kg)	132.50	149.30	168.25	232.00	170.51
4. Pb	(ppm)	36.03	90.43	96.22	26.96	62.41
5. Cr^{+6}	(ppm)	12.13	14.25	10.72	12.00	12.27
6. As	(ppm)	3.65	2.95	2.88	3.00	3.12
7. Total Hg	(ppb)	77.71	78.81	109.48	54.63	80.16
8. Alkyl Hg	(mg/kg)	0.99	0.26	0.73	0.41	0.59
9. PCB	(mg/kg)	ND	ND	ND	ND	ND

Selected Environmental Multimedia Goals and/or Quality Standards for Solid

Contaminants by Class	Concentration, mg/kg dry material		Concentration, mg/L
	Solid Waste DMEG[#A]	Soil AMEG[#B]	Water Quality (Drinking)[C]
Poly-chloride benzenes	0.001	0.0002	ND
Cyanide	3.6	-	ND
Phosphorous	200	-	ND (organic P)
Alkyl Mercury	0.6	0.002	ND
Total Mercury	0.4[D] (0.002 mg/L)	-	0.005
Arsenic	2[D] (0.05 mg/L)	-	0.05
Cadmium	0.3	0.08	0.01
Chromium	44	10	0.05
Lead	0.76	-	0.1

Notes:

ND: Not Detectable

#: Source: Canter L.W., 1996, Environmental Impact Assessment, McGraw Hill, Second Edition

A: Discharge Multimedia Discharge Goals (DMEGs) prposed for use in USA. DMEGs represent approximate concentration maxima in source emissions to receiving water, atmosphere, or soil (through solid waste) which should be tolerable for short term exposure values based on acute human health effects and short term reversible effects on natural biological communities.

B: Ambient Level Multimedia Discharge Goals (AMEG) are appropriate levels of contaminants in water, air or soil below which unacceptable negative effects on human populations or in natural biological communities should not occur, even with continuous exposure

C: Source: Environmental Agency of Japan, 1990, Quality of the Environment, 1990

D: Estimated herein from the liquid emission values given in brackets using a simple leachate model whose assumptions are given below. These are the same used in deriving all DMEGs and AMEGs.

The MEGs for terrestrial environments (expressed in milligrams per kilogram) are based on a simple leachate model for solid waste (in this case DMEGs) and for contaminated soil (here, AMEGs are used). They are equal to the liquid emission MEGs (expressed in micrograms per liter) for the chemical of concern, multiplied by a factor of 0.2. This model assumes that all contaminants in 1 kg of soil or solid waste would be leached by 2L of water. The major human exposure route to contaminants from soil or solid waste is assumed to be consumption of contaminated drinking water. Similarly, the major exposure route for aquatic life is through leaching of contaminated soil or solid waste by surface waters. It is further assumed that the concentrated leachate entering a body of water (groundwater or surface water) will be diluted almost instantaneously by an arbitrary factor of 100. While this model is simplistic and in most situations very conservative (e g. it considers almost no retention or attenuation of contaminants before reaching surface water).

Table G2-11 Results of Leaching Test for Benthic Material

Parameter	Unit	Station*				EEC Surface Water Standard	Japan's Standard	
		1	2	3	4		Disposal to Dumping Site	Disposal to the Sea
Org.Phosphate	mg/ℓ	0.01	0.01	ND	0.01	0.03 (US.EPA)	1.0	ND
Cyanide (CN)	mg/ℓ	ND	ND	ND	ND	0.05	1.0	ND
Chromium(Cr)	mg/ℓ	ND	ND	0.020	ND	0.05	-	0.2
Cadmium (Cd)	mg/ℓ	0.005	ND	ND	0.004	0.005	0.3	0.01
Lead (Pb)	mg/ℓ	ND	ND	ND	0.0049	0.05	0.3	0.01
Arsenic (As)	mg/ℓ	0.0037	0.0012	0.0020	0.0018	0.05	0.3	0.01
Mercury (Hg)	mg/ℓ	ND	ND	0.0009	0.0006	0.001	0.005	0.0005

Note* Station 1 : Mean Chey Channel
Station 2 : Inside Tompun Pumping Station
Station 3 : Outside Tompun Pumping Station
Station 4 : Inside Trabek Pumping Station
ND = < 0.0001 mg/ℓ

Table G2-12 Comparsion of Heavy Metal concentration in Polluted and Non-Polluted Estuaries (Solway Firth)

Unit: mg/l

Parameter	Solway Firth	Firth of Clyde	Severn Estuary	Clyde Estuary (Glasgow) Silt	Average near-shore sediment
Mn	360	1,118	1,820	1,600	850
Ni	38	50	36	69	55
Co	16	34	7	60	13
Cr^{+6}	35	64	71	624	100
V	-	-	86	-	130
Pb	37	86	119	528	20
Zn	63	165	280	1,680	95
Sn	7	19	101	85	-
Ag	<0.2	<0.2	-	-	-
Cd	<0.1	3	-	7	-
Ga	15	-	17	-	-
Mo	<2	0	-	3	-
Cu	10	37	38	225	48

Table G2-13 Housing Indicators by Geographic Area (1993-94)

Indicators	Nation	Phnom Penh	Other Urban	Rural
% of Households in Single Detached Housing Unit *	n.a	54.1	88.5	97.6
% of Households in One Room Units	n.a	61.0	68.1	84.8
% of Households with Roof of Housing Unit				
Made from Thatch	n.a	15.8	46.5	61.7
Made from Tiles	n.a	84.2	53.5	38.3
% of Households with Outer walls of Housing Unit				
Made from Bamboo / Thatch	n.a	15.7	43.2	75.0
Made from Concrete/ Brick / Stone	n.a	84.3	56.8	25.0
% of Households with Floor walls of Housing Unit				
Made from Earth / Clay		60.4	33.9	9.6
Made from Wood / Bamboo		39.6	66.1	90.4
% of Households with				
Piped Water	2.5	29.7	5.8	0.0
Tubed / Piped Well	3.3	3.9	7.6	2.9
Dug Well	58.1	12.2	44.6	62.6
Spring , river, stream , rain	28.7	10.6	27.2	30.3
Bought	7.4	43.6	14.8	4.2
% of Households without Toilet Facilities	80.0	22.0	53.3	88.3
% of Households Using Firewood as Main Fuel for	92.1	54.2	88.6	95.3
Cooking				
% of Households using Electricity for Lighting	9.5	67.5	30.3	3.0
% of Households who have				
Radio	27.5	38.7	31.4	25.9
Television	11.4	5.7	21.6	7.2
Car / motorcycle		50.9	30.8	10.7
% of Monthly Households expenditure on				
Rent	7.8	19.0	15.7	3.5
House Maintenace and Light Repair	0.2	0.4	0.6	0.2
Water, Light, and Fuel	4.3	4.5	3.9	4.3
Total Housing related Expenditures	12.4	23.9	20.2	8.0

Source:
Socio-Economic Survey of Cambodia (All Rounds 1993 / 1994) as reported in Cambodia Urban Development Strategy Study, ADB, 1996

Table G2-14 Urban Socio-Demographic Indicators by Geographic Location (1993-94)

Indicators	Nation	Phnom Penh	Other Urban	Rural
Average Household Size	5.6	5.9	5.9	5.5
% of Female Headed Household	21.2	25.8	23.4	20.4
% of One-Person Member Household	1.1	1.9	1.0	1.0
Proportion of Female Population to Total Pop.	52.2	50.9	52.1	52.5
Proportion 0-14 years old	43.7	39.5	44.0	43.9
Proportion 15-64 years old	52.2	57.4	52.6	51.9
Proportion 65 and over	4.1	3.1	3.4	4.2
Adult Literacy Rate (15 yrs & over)				
Both Gender	65.2	82.0	72.7	63.5
Male	79.7	91.8	84.4	78.6
Female	53.4	63.3	63.2	51.0
% with No Grade Completed Among Pop'n 15 yrs & Over				
Both Gender	27.3	14.6	22.2	28.7
Male	15.0	6.5	12.1	15.8
Female	37.5	22.0	30.1	39.0
% with Degree Holder Among Pop'n 25 yrs & Over				
Both Gender	0.2	1.4	0.3	0.1
Male	0.4	2.4	0.3	0.1
Female	0.1	0.5	0.2	
Labor Force Participation Rate	56.6	46.5	51.7	58.4
Employment Rate	97.5	93.9	95.5	98.0
Unemployment Rate	2.5	6.1	4.5	2.0
Women Labor Force Participation Rate	55.4	39.9	46.8	58.0
Women Employment Rate	97.3	94.1	94.5	97.8
Women Unemployment Rate	2.7	5.9	5.5	2.2
% Self-Employed	59.9	54.4	57.6	60.8
% Workers W / O Pay in Own Family Operated				
Farm / Business				
Both Gender	29.3	5.8	19.7	31.7
Male	14.2	2.4	9.3	15.4
Female	43.2	10.1	30.7	46.2
% of workers working for government	7.2	29.0	17.1	4.7

Source:
Socio-Economic Survey of Cambodia (All Rounds 1993 / 1994) as reported in " Cambodia Urban Development Strategy Study, ADB, 1996 "