## 9.4 Institutional Arrangements

Proposed Autonomous Public Enterprise

The sewerage component of the ADB project includes the following tasks related to institutional development:
Review existing organizational structures and management systems
Evaluate adequacy, experience and qualifications of personnel
Evaluate department systems and procedures
Recommend appropriate organizational structures and functions
Recommend legal framework, systems and procedures to establish an Autonomous Entity

The ADB project has identified the following institutional options for managing the new sewerage facilities:
Create an Autonomous Public Enterprise established by sub-decree (Anukret) or,
Create an Autonomous Provincial Authority (Ratakor) established by order (Deka) or,
Create a Specialized Unit at the provincial level, operating under the Department of Public Works, established by proclamation (Prakas).

These options have been presented to concerned local, provincial and central government authorities but a final decision is still pending. MPWT is responsible for project management and implementation and has indicated that it would like to establish an Autonomous Public Enterprise named “The Siem Reap Sewage Collection and Treatment Autonomous Enterprise”.

However, in order to be truly autonomous the enterprise would have to be financially self-sustaining within a very short time. The project has proposed the implementation of user fees which would gradually be increased over time to achieve full cost recovery including depreciation of assets. However acceptance of such fees is likely to be a difficult issue in the beginning and much will depend on affordability and willingness of users to pay. It is therefore likely to take a several years before the cost recovery and full autonomy can be achieved.

Therefore in the shorter term it is recommended that a separate “Special Unit” be established within DPWT to focus on sewerage and drainage operating needs. In the longer term, when fees generate sufficient revenue to cover operating costs, the Unit can be split off into an autonomous enterprise.

It is also recommended that each sewerage and drainage project include technical assistance to support institutional reforms and develop proper maintenance practices. With time and help the special unit will eventually run along commercial lines and can later be converted into an autonomous enterprise with a strong client orientation and able to generate full cost recovery from revenues.

### 9.4.1 Option: Integrating Water Supply and Sewerage Services

The Royal Government of Cambodia has acquired a good model and learned important lessons from development of the autonomous Phnom Penh Water Supply Authority (PPWSA). The process of transforming this utility into a financially

self-sustaining enterprise has demonstrated conclusively that changes in institutional structures are possible and can improve performance and that separation of policy and regulatory functions from asset ownership and service provision can improve service provision.

The Phnom Penh experience is now being used to establish autonomous water authorities elsewhere in Cambodia by engaging PPWSA in the operation of systems in other towns in Cambodia including Siem Reap.

The construction of sewerage facilities in Siem Reap now provides an opportunity to pilot out this model in the sewerage sector. The operation and maintenance sewerage collection and treatment facilities are not too dissimilar to that of water supply and treatment. They both require many of the same technical and managerial skills as well as administrative support functions.

Integrating operations within one authority offers many advantages:
Reduces duplication of administrative and management functions
Simplifies customer service issues by providing one-window service.
Simplifies billing and collection of fees by providing customers with a single bill
It eliminates the need to transfer funds between different authorities and simplifies accounting

The main disadvantage is that the commercial viability of the water supply company might be affected since cost recovery of sewerage services is typically more difficult to achieve. Nevertheless this option has proven benefits and is quite a popular model in many cities worldwide.

### 9.4.2 Options for Public Private Partnerships

In public-private partnerships, the public and private sectors join forces to design, finance, build, manage or maintain infrastructure projects. Such partnerships can take many forms, depending upon the exact allocation of risks and responsibilities. These include:
*Service contracts.* The private sector provides a bundle of specific services to a public utility, but the public sector retains overall operational responsibility. Service contracts can in practice take many forms, but two of the most common ones are:
*Technical assistance.* The private operator supplies the public authority with human and technical resources for a fee. It provides technical know-how on all operational and financial aspects of project management remaining within the jurisdiction of the public authority.
*Management (O&M).* The private operator is in charge of daily operation and maintenance of the facilities. The private operator is paid for its services by the public authority according to specific and qualified performance criteria.
*Delegated management contracts.* In his type of contracts the public sector retains overall ownership of the assets, but delegates the responsibility for their operation to a private operator for a definite (often long) period of time. Two of most commonly seen models are:
*lease agreement.* The private operator manages the services for a period (often five to fifteen years) and is responsible for maintaining and renewing the facilities according the terms of the contract. In this capacity, it takes charge of all personnel and existing

assets but is not responsible for financing new facilities. The public authority remains responsible for all new investment and compliance to existing norms. The private operator invoices the end-users directly.
*Concession*. The public authorities fully entrust the private operator with management of the services and all necessary investment for a period of 20 years or more. The private operator invoices the end-users directly, the public authorities retaining strict control over service terms as well as all key decisions related to applicable rates and targets.
*Construction support*. In the most wide-ranging form of PPP contracts the private operator is involved in the design and construction phases of new infrastructure and carries at least some of the risks associated therewith. Some of the main forms of construction support have been:
Build Design Operate (BDO). The public authorities entrust the private operator for a fixed period of time with design, construction and operation of new facilities which remain the property of the public authorities. The private operator assumes the risks linked to design and management of the facility. It is paid a fee by the public authorities and commits to an overall cost for the facility's construction and operation.
BOT (Build Operate Transfer). The private operator designs, finances and builds infrastructure. While formal ownership of the assets is assigned to the government, the private sector operates the project long enough to service any debt incurred and to earn a suitable return.
BOO (Build Own Operate): In contrast to the BOT case, the private investor retains ownership and control of the project.

Table III.9.42 illustrates how the main forms of PPP differ in terms of the allocation of ownership, investment and operation between the private and public sector.

**Table III.9.42 Comparison of PPP Options**

| Option | Financing | Ownership | Operations | Knowledge transfer | | Duration (years) |
|---|---|---|---|---|---|---|
| | | | | Management | Technical | |
| Technical assistance | Public | Public | Public and some Private | No | Yes | 1-3 |
| Management Contract | Public | Public | Private | Yes | Yes | 3-7 |
| Lease agreement | Public | Public | Private | Yes | Yes | 7-15 |
| Concession | Private | Private/ Public | Private | Yes | Yes | 25-30 |
| BDO | Public | Public | Private | Yes | Yes | 20-30 |
| BOT | Private | Public | Private | Yes | Yes | 20-30 |
| BOO | Private | Private | Private | Yes | Yes | 20-30 |

The lack of experience on a national basis in the sewerage sector will be a serious constraint to the development of a strong operation and maintenance organization. Finding suitable management candidates with operational experience and hiring technical personnel with the required skills will be difficult if not impossible. Technical assistance and capacity building projects can develop the requisite skills but it will take substantial time and effort, as well as a committed donor.

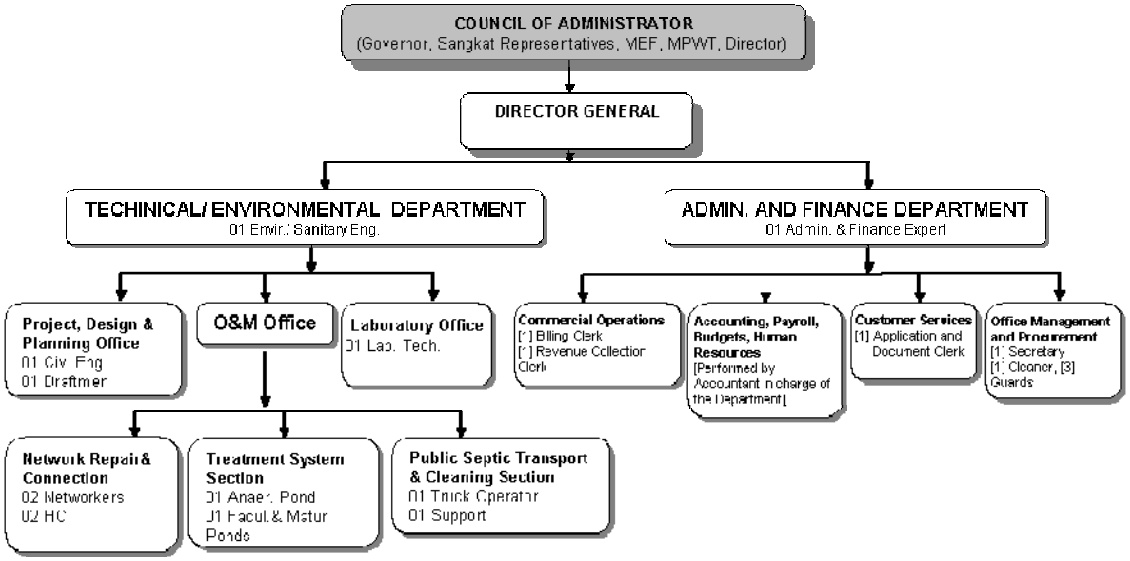
In the short term (first 5 years) it may be necessary and more expedient to enter into a management contract with a specialist contractor or engineering consultant for operation and maintenance of the new sewerage system. The contract would include training and capacity building of DPWT personnel who would eventually take over responsibility for the facilities at the end of the contract.

The option of a management contract is an option that should be considered by politicians and decision makers. Other forms of PPP requiring private sector financing are likely not viable since full cost recovery cannot be guaranteed and the risk of failure too high.

### 9.4.4 Organizational Structure for O&M

A substantial number of sewerage and drainage projects are to be implemented within the next 5 to 10 years. These projects will create a large inventory of new infrastructure that must be operated efficiently to achieve the intended environmental and health benefits. Furthermore the projects represent a significant investment and proper maintenance is essential in order to protect and prolong the life of these assets.

The ADB project is the first project to go ahead and it will set the precedent for future projects. A special unit within DPWT has been identified as the authority responsible for sewerage and drainage. The organizational structure and levels of staffing proposed by the ADB project for the special unit are shown below. The structure assumes that administrative functions related to accounting, payroll and budgets will be provided by the Department.




Source: ADB

**Figure III.9.15 Organizational Structure Proposed for ADB Project (SD-1)**

The number of personnel and the structure is for a relatively small service area defined by the project with relatively few facilities (1 interceptor sewer, 1 lagoon and 1 pumping station).

The structure and the number of personnel will need to be modified in order to deal with the larger number of facilities and larger service area defined under the master

plan. The timing of organizational developments is closely linked to the implementation of proposed projects as shown below:

**Table III.9.43 Timing of Organizational Development**

| Project ID. | Scope | Project Timing | Organizational requirements |
|---|---|---|---|
| SD-1 | Drainage<br>Interceptor sewer west district zone 1<br>Wastewater Treatment plant | 2005-2007 | Maintenance unit for cleaning open drains in West District<br><br>Collection system maintenance and treatment plant operations |
| SD-2 | Drainage improvements East district | 2006-2009 | Maintenance unit for cleaning open drains in West District |
| SD-3 | Separate sewage collection and storm water drainage system West district zone 1 | 2006-2010 | Augment capacity for collection system maintenance<br>Implement a separate maintenance unit for piped storm water collection system |
| SD-4 | Separate sewage collection system East district zone 1 | 2008-2012 | Additional personnel for collection system maintenance and treatment plant operations<br>Divide operations into two districts |
| SD-5 | Drainage improvements West district | 2000-2012 | Additional personnel for maintenance of open drains |
| SD-6, SD-7 | Septic sludge collection<br>Sludge treatment | 2012-2016 | Septage management unit |
| SD-8, SD-9 | Septic tank effluent collection | 2015-2019 | Additional personnel for collection system maintenance |

The proposed organizational structure for the special unit within DPWT is presented in Figure III.9.16

The drainage and sewerage unit will be divided into 5 branches on the basis of functional responsibility. Daily operations and maintenance activities will be carried out by the drainage branch, the sewerage branch and the septage branch. They will be supported by the Technical Services Branch and the Administration Branch.

Technical services branch will be responsible for the following activities:
Engineering related to planning, design and construction of septic tanks, drainage and sewerage
GIS based data management for septic tank registry, and sewer connections
Keeping accurate drawings of all sewer and drainage infrastructure and keeping them up to date
Maintenance management data including operating manuals, procedures, and equipment maintenance schedules
Laboratory for testing wastewater and septage influent and effluent, checking for compliance with environmental discharge standards

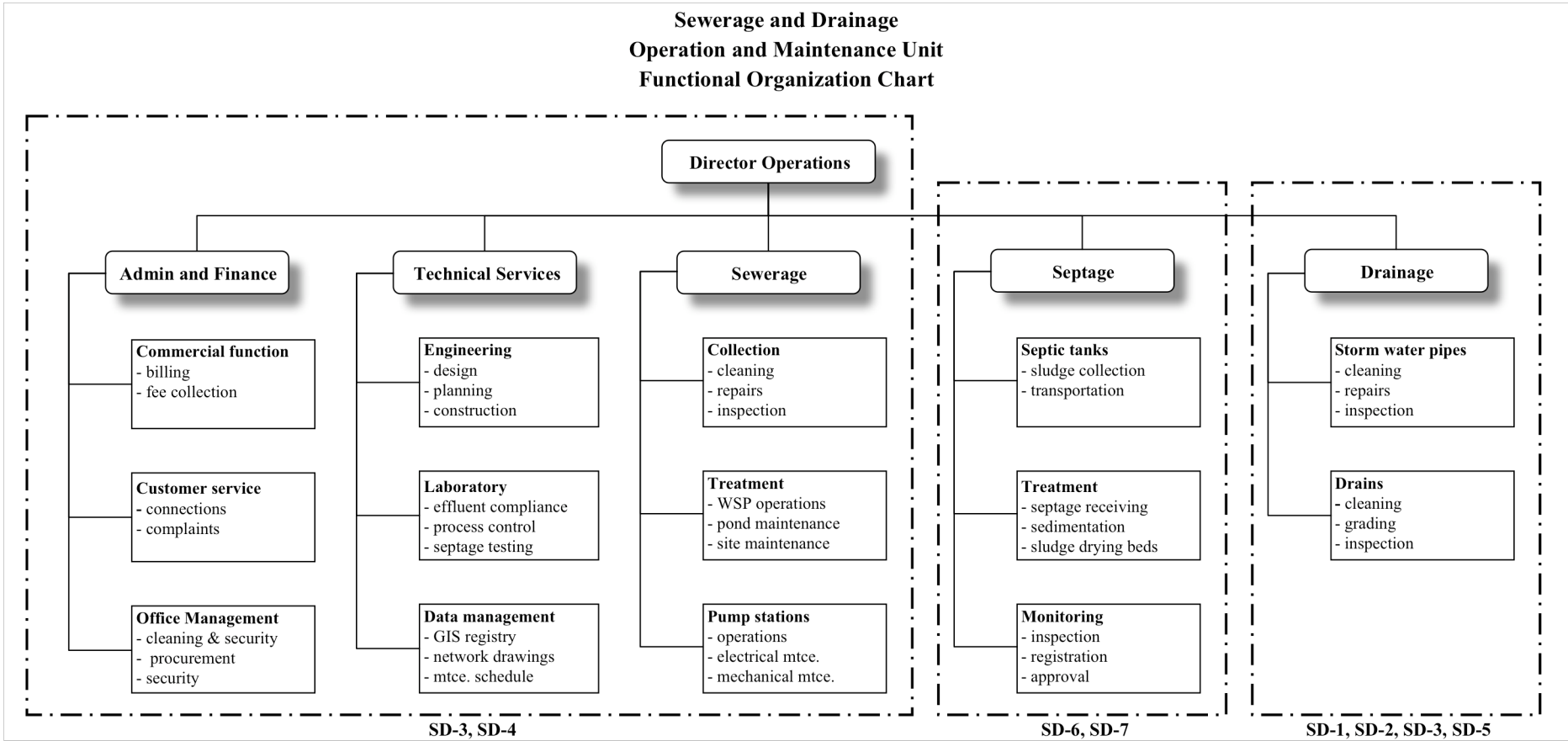



**Figure III.9.16 Organizational Chart for Operation and Maintenence of Sewerage & Drainage**

such as:
Billing and fee collection
Accounting and Budgeting
Preparing monthly management reports showing expenditures vs. budget
Customer services
Human resources, hiring and training

The personnel and equipment requirements for the operating and maintenance branches are discussed in the following sub-sections of the report.

### 9.4.4 Drainage Branch

The Drainage Branch will be responsible for all aspects of storm water drainage. This includes open drains as well as piped storm water collection networks. The drainage branch can be divided into two groups. One group would maintain the open drains while the other group would specialize in the inspection and cleaning of storm water collection pipes.

#### (1) Tasks

The maintenance tasks assigned to each group include:
Open drains
Removing garbage from open drains on a regular basis
Removing accumulated sand and silt from open drains on a regular basis
Maintaining rights-of-way along drains to prevent encroachment by illegal building activities and squatters.
Storm water pipes
regularly scheduled inspection and cleaning of sewer pipes
emergency cleaning to remove blockages
regular and emergency repairs to manholes and sewers
inspection and cleaning of street inlet grates

#### (2) Equipment and Personnel

Maintenance requirements for storm water collection pipes are similar to those of sewerage systems and similar equipment can be used and shared between sewerage and drainage branch. Systems in flood prone or tourist sensitive areas should be cleaned every year prior to the rainy season. The equipment and personnel requirements associated with each project are presented below. Staffing requirements are incremental.

**Table III.9.44 Maintenance Equipment for Drainage O&M**

| | SD-1 | SD-2 | SD-3 | SD-5 |
|---|---|---|---|---|
| Pressure Jetting machine | 1 | 0 | 2 | 0 |
| Vacuum tanker truck | 1 | 0 | 1 | 0 |
| Diesel engine and non clog sewage pump | 1 | 3 | 2 | 1 |
| Air Blower | 1 | 1 | 2 | 0 |
| Maintenance truck | 1 | 3 | 1 | 2 |
| Excavator | 0 | 3 | 1 | 2 |

**Table III.9.45 Personnel for Drainage O&M**

| **Management** | | SD-1 | SD-2 | SD-3 | SD-5 |
|---|---|---|---|---|---|
| Branch manager | | 1 | 0 | 0 | 0 |
| Assistant engineers | | 1 | 1 | 0 | 0 |
| Inspectors | | 2 | 4 | 1 | 1 |
| Admin assistant | | 1 | 1 | 1 | 1 |
| **Cleaning open drains** | | No. of Crews | | | |
| | | 1 | 3 | 0 | 2 |
| No. per crew | | Personnel requirement | | | |
| Supervisor | 1 | 1 | 3 | 0 | 2 |
| Machine Operators | 1 | 1 | 3 | 0 | 2 |
| Unskilled laborer | 4 | 4 | 12 | 0 | 8 |
| **Cleaning storm water pipes** | | Number of Crews | | | |
| | | 1 | 1 | 2 | 0 |
| No. per crew | | Personnel requirement | | | |
| Supervisor | 1 | 1 | 1 | 2 | 0 |
| Machine Operators | 1 | 1 | 1 | 2 | 0 |
| Unskilled laborer | 2 | 2 | 2 | 4 | 0 |
| **Repairs** | | Number of Crews | | | |
| | | 1 | 0 | 2 | 0 |
| No. per crew | | Personnel requirement | | | |
| Supervisor | 1 | 1 | 0 | 2 | 0 |
| Laborers | 2 | 2 | 0 | 4 | 0 |

### (3) Annual Costs

The following annual operating budget for drainage is based on a rough estimate of the repair, staff and energy requirements:

**Table III.9.46 Annual Costs for Drainage O&M**

| Project / components | Annual Operating Cost (US$) | | | |
|---|---|---|---|---|
| | Maintenance | Staff | Energy | Total |
| **Project: SD-1** | 30,000 | 7,300 | 1,700 | 39,000 |
| **Project: SD-2** | 25,000 | 9,900 | 3,300 | 38,200 |
| **Project: SD-3** | 75,000 | 7,200 | 2,700 | 84,900 |
| **Project: SD-5** | 25,000 | 4,500 | 2,200 | 31,700 |
| Total | 155,000 | 28,900 | 9,900 | 193,800 |

Maintenance is for construction materials for the repair and replacement of pipes and manholes. It also includes the costs of repairing vehicles and pumps.

Personnel costs are based on typical public works salaries. These salaries are quite low and will need to be increased in the future in order to attract and keep qualified

people. It is a well documented fact that poor salaries lead to apathy and poor performance thereby affecting the quality and effectiveness of maintenance services.

Energy costs are mainly related to fuel to operate jetting machines, tanker trucks and other heavy equipment used for cleaning drains and pipes.

### 9.4.5 Sewerage Branch

The sewerage branch will be responsible for all aspects of wastewater collection and disposal. The manager in charge of operations would be responsible for maintaining an efficient sewerage disposal system by ensuring that:
Treatment plant and pumping stations are operational
Sewers are inspected and cleaned on a regular basis
Blockages are cleared quickly in response to public complaints
Equipment is maintained regularly to prevent breakdowns and repairs are carried out promptly when breakdowns occur

The branch would be subdivided into 3 specialized groups: collection, pumping, and treatment.

#### (1) Wastewater Collection Group

##### 1) Tasks

The collection group consists mainly of technicians and a labor force responsible for inspection and maintenance of the separate wastewater collection system. The tasks assigned to the collection group include:
regularly scheduled inspection and cleaning of sewer pipes
emergency cleaning to remove blockages
regular and emergency repairs to manholes and sewers
inspection and installation of sewer connections

Typical problems with the system will include silt, sediment, garbage, rags, grease, building debris and rubbish and/or household rubbish.

Every year, about 5 to 10% of the network should be inspected by CCTV camera, and a systematic cleaning of about 20% of the network should be undertaken. The collection group along with support from technical services branch will be able to assess the problems, and formulate structured planned maintenance schedules to reduce the number of emergency incidents. Where the problem cannot be dealt with cost effectively by short term maintenance, then appropriate repair works or rehabilitation works will need to be programmed.

Cleaning and blockage clearance will involve a mixture of reactive and planned maintenance work:
Reactive maintenance will be needed to clear blockages which may cause localised flooding or restricted toilet use.
Where there are persistent problems it may become necessary to carry out sewer cleaning on a planned maintenance basis.

Repairs to sewers and manholes will be needed to maintain the structural integrity of

the sewerage systems, to reduce infiltration into the system and leakage from the system.

Old service connections should be checked at a rate of about 20 to 30% per year. New service connections should be installed as per requirements.

**2) Equipment and Personnel**

Smaller diameter sewers are usually cleaned using rods and tanker trucks with high-pressure jets. Larger sewers are usually cleaned using bucket machines and sometimes by hand using manual labor:
Small diameters (150 mm to 400 mm): Jetting machines
Larger diameters (400 mm - 1100 mm): Bucket cleaning equipment
Larger Diameters (Above 1100 mm): Manual de-silting

Most sewers in Siem Reap would be cleaned using jetting and vacuum suction equipment mounted on a truck chassis. This equipment would be similar to the equipment used for pumping out septic tanks. Water is stored in a tank (usually 5000 l capacity) mounted on the truck. This water is jetted in the sewer line using a high-pressure pump and a nozzle system. Fine jets with high velocity are generated. On the forward and the backward pass of the jet, the deposited silt is loosened and gets washed down and is collected in the downstream manhole. From this manhole, it is sucked out in a slurry form to a silt tank mounted on the chassis.

**Table III.9.47 Sewer Maintenance Equipment**

| | SD-3 | SD-8 | SD-4 | SD-9 |
|---|---|---|---|---|
| Pressure Jetting machine | 2 | 2 | 2 | 2 |
| Vacuum tanker truck | 1 | 1 | 1 | 1 |
| Diesel engine and non clog sewage pumps | 3 | 3 | 3 | 3 |
| Air Blower | 3 | 3 | 3 | 3 |
| Maintenance truck | 3 | 3 | 3 | 3 |
| Misc. maintenance equipment (rods, bucket machines) | 2 | 2 | 2 | 2 |

**Table III.9.48 Personnel for Sewer O&M**

| **Management** | | SD-3 | SD-7 | SD-4 | SD-8 |
|---|---|---|---|---|---|
| Branch manager | | 1 | 0 | 0 | 0 |
| Assistant engineers | | 1 | 0 | 1 | 0 |
| Inspectors | | 3 | 3 | 3 | 3 |
| Admin assistant | | 2 | 1 | 2 | 1 |
| **Routine Cleaning** | | No. of Crews | | | |
| | | 2 | 1 | 2 | 1 |
| No. per crew | | Personnel requirement | | | |
| Supervisor | 1 | 2 | 1 | 2 | 1 |
| Machine Operators | 2 | 4 | 2 | 4 | 2 |
| Unskilled laborer | 4 | 8 | 4 | 4 | 4 |

**Table III.9.48 Personnel for Sewer O&M (Cont'd)**

| | | SD-3 | SD-7 | SD-4 | SD-8 |
|---|---|---|---|---|---|
| **Emergency clearing** | | Number of Crews | | | |
| | | 1 | 1 | 1 | 1 |
| No. per crew | | Personnel requirement | | | |
| Supervisor | 1 | 1 | 1 | 1 | 1 |
| Machine Operators | 1 | 1 | 1 | 1 | 1 |
| Unskilled laborer | 2 | 2 | 2 | 2 | 2 |
| **Repairs** | | Number of Crews | | | |
| | | 2 | 2 | 2 | 2 |
| No. per crew | | Personnel requirement | | | |
| Supervisor | 1 | 2 | 2 | 2 | 2 |
| Laborers | 2 | 4 | 4 | 4 | 4 |

## (2) Pump Stations Group

### 1) Tasks

The pump stations group consists mainly of electro mechanical technicians and a small labor force. The primary objective of operating and maintaining a pump station is to keep the station in continuous operation in order to prevent sewage overflows to the environment and flooding in upstream reaches of the incoming sewers.

Maintenance tasks will consist of the following:
removal of screenings and grit from the inlet works;
removal of silt from the intake well
regular preventive maintenance mechanical and electrical equipment
emergency breakdown repairs to motors and pumps
monitoring pump operations and responding to abnormal conditions

### 2) Personnel Requirements

Recommended staffing levels are given below:

**Table III.9.49 Personnel for Pumping Station O&M**

| Post | SD-3 | SD-4 | SD-8 | SD-9 |
|---|---|---|---|---|
| Junior Engineer | 1 | 1 | 0 | 0 |
| Electrician | 1 | 1 | 1 | 0 |
| Mechanical technician | 2 | 2 | 1 | 0 |
| Pump Operators (three 8 hour shifts per day) | 3x3=9 | 4x3=12 | 2x3=6 | 0 |
| Laborer (two 8 hour shifts per day) | 3x2=6 | 3x2=6 | 2x2=4 | 0 |
| Grounds keeper | 2 | 2 | 0 | 0 |

### (3) Treatment Group

#### 1) Tasks

The maintenance requirements of ponds are very simple, but they must be carried out regularly. Otherwise, there will be serious odor, fly and mosquito nuisance. Maintenance requirements and responsibilities must therefore be clearly defined at the design stage so as to avoid problems later. Routine maintenance tasks are as follows:

removal of screenings and grit from the inlet works;

cutting the grass on the embankments and removing it so that it does not fall into the pond (this is necessary to prevent the formation of mosquito-breeding habitats

removal of floating scum and floating macrophytes from the surface of facultative and maturation ponds (this is required to maximize photosynthesis and surface re-aeration and prevent fly and mosquito breeding);

spraying the scum on anaerobic ponds (which should not be removed as it aids the treatment process), as necessary, with clean water or pond effluent, or a suitable biodegradable larvicide, to prevent fly breeding;

removal of any accumulated solids in the inlets and outlets;

repair of any damage to the embankments caused by rodents, rabbits or other animals; and

repair of any damage to external fences and gates.

Anaerobic ponds require desludging when they are one third full of sludge (by volume). For temperatures above $20^{o}$C ($\lambda v$ = 300 g/m3d) and a BOD contribution of 45 g/person day, desludging would be required annually ($n$ = 1.25 years).

#### 2) Equipment and Personnel

Sludge removal can be readily achieved by using a raft mounted sludge pump. These are commercially available or they can be assembled locally. The sludge is discharged into either the adjacent septage sedimentation tank or to vacuum tankers.

In order that the routine O&M tasks can be properly done, WSP installations must be adequately staffed. The level of staffing depends on the type of inlet works (for example, mechanically raked screens and proprietary grit removal units require an electromechanical technician, but manually raked screens and manually cleaned grit channels do not), whether there are on-site laboratory facilities, and how the grass is cut (manually or by mechanical mowers).

Recommended staffing levels are given below assuming manually raked screens and grit chambers.

**Table III.9.50 Personnel for Treatment Plant O&M**

| Designation | Staff Requirement For Waste stabilization Ponds | | | |
|---|---|---|---|---|
| | SD-3 | SD-4 | SD-8 | SD-9 |
| Senior Engineer - Project Manager | 1 | 1 | 0 | 0 |
| Assistant Engineer (mech./elect.) | 0 | 0 | 0 | 0 |
| Assistant Engineer (Civil) | 1 | 1 | 0 | 0 |
| Electro/mechanical tech. | 1 | 1 | 0 | 0 |
| Janitor | 2 | 2 | 0 | 0 |
| Lab tech | 1 | 1 | 0 | 0 |
| Lab Assistant | 1 | 1 | 0 | 0 |
| Operator | 2 | 2 | 0 | 0 |
| Front end loader driver | 0 | 0 | 0 | 0 |
| watchmen | 3 | 3 | 0 | 0 |
| Labor | 4 | 4 | 2 | 2 |
| TOTAL | 16 | 16 | 2 | 2 |

### (3) Annual O&M Costs

The following annual operating budget for wastewater collection and treatment is based on a rough estimate of the repair, staff and energy requirements:

**Table III.9.51 Annual Costs for Sewerage O&M**

| **2012 (Cost in US$)** | | | | |
|---|---|---|---|---|
| Project | Repairs | Staff | Energy | Total |
| **SD-3** | 144,600 | 24,700 | 16,200 | 185,500 |
| **SD-4** | 136,000 | 23,300 | 15,200 | 174,500 |
| Sub-Total | 280,600 | 48,000 | 31,400 | 360,000 |
| **2020 (Cost in US$)** | | | | |
| **SD-3** | 144,600 | 24,700 | 35,200 | 204,500 |
| **SD-4** | 136,000 | 23,300 | 37,700 | 197,000 |
| **SD-8** | 99,000 | 13,300 | 19,100 | 131,400 |
| **SD-9** | 49,700 | 6,600 | 18,600 | 74,900 |
| Total | 429,300 | 67,900 | 110,600 | 607,800 |

Maintenance is for construction materials for the repair and replacement of pipes and manholes. It also includes the costs of repairing vehicles, mechanical and electrical equipment including pumps. Annual maintenance and repair costs are estimated as a percentage of the investment cost as follows:

trunk and branch sewers : 1.0 %
other civil works : 1.5 %
mechanical and electrical equipment : 3.0 %
rising mains : 0.25%

Personnel costs are based on typical public works salaries. These salaries are quite low and will need to be increased in the future in order to attract and keep qualified people. It is a well documented fact that poor salaries lead to apathy and poor performance thereby affecting the quality and effectiveness of maintenance services.

Energy costs include two components:
fuel to operate jetting machines, tanker trucks and other heavy equipment used for cleaning drains and pipes
electrical energy to operate pumps

As expected the cost per m3 is relatively low because the waste stabilization ponds require little to no input of energy or chemicals. Most of the O&M costs are in maintaining the collection system.

**Table III.9.52 Unit Costs of Sewerage Collection and Treatment**

| | | 2012 | 2020 |
|---|---|---|---|
| Total O&M cost | $/day | 986 | 1,665 |
| Total treatment capacity | $m^3$/day | 4895 | 14777 |
| Unit cost | $/$m^3$ | 0.20 | 0.11 |

### 9.4.6 Septage Management Branch

The operation and maintenance aspect of septic tanks is critical to the sustainability and long life of that system. For privately owned on-site systems, this operation and maintenance responsibility has traditionally been left in the hands of the householder. However, householder neglect is often a significant contributor to the problem of poorly performing systems that contribute high pollutant loads to the environment. By adopting a managed maintenance programmed for on-site systems, such poor performance may be preventable, and the system life extended indefinitely.

**(1) Tasks**

In the short term, the only way to implement regular cleaning and proper disposal of septage is to make it a public task. Therefore a septage management branch is proposed. The branch would be responsible for overseeing all issues related to septic tanks including the following primary functions:
implementation of standards for septic tank installations
inspection of new construction
collection and transportation of sludge from septic tanks to the septage treatment facility
scheduling regular cleaning
collecting fees
operation of the septage treatment facility

The septage management unit would consist of three separate groups:
collection/transportation
septage treatment
monitoring

**1) Monitoring**

The monitoring unit would be responsible for approval of new construction, septic tank registration and septic tank inspection. The monitoring unit would develop a GIS based registry of septic tanks in order to keep a record of each installation and to schedule regular cleaning intervals. Establishing a database will require a baseline survey of septic tank installations throughout the proposed wastewater management area.

**2) Collection**

The collection/transportation group would be responsible for removing sludge from septic tanks on a regular cleaning cycle and transporting the sludge to the septage treatment facility. Septic tanks would typically be cleaned using conventional vacuum trucks with a tank capacity of 3 to 6 m3 however smaller trucks and some specialized portable tanks may be required to access narrow lanes. The vacuum trucks are the same equipment that would be required for sewer cleaning and could be used for both tasks in parallel. The collection group would be responsible for operating and maintaining the fleet of vacuum trucks.

**3) Treatment**

Treatment plant operations are simple from a technological point of view but will require a suitable labor force for moving dewatered and dried sludge. Operations will consist of removing dewatered sludge from sedimentation tanks at 8 week cycles, applying it to sludge drying beds and removing dried, stabilized sludge to stockpiles where farmers can come and collect it for use as fertilizer. Sludge drying beds and stockpiles will need to be protected from rain using simple shelters. Drying beds will need to have their sand filter replaced from time to time and pumps used for removing the liquid fraction will need to be maintained.

**(2) Equipment and Personnel**

Based on a total sludge volume of approximately 92m3/day it is estimated that a total of 10 trucks will be required for cleaning septic tanks on an average 3 year cycle: 4 to cover the East district and 6 to cover the west district. The trucks would operate 6 days a week and make an average of three round trips per day. Total operating costs include fuel for the trucks assuming an average of 90 km/day/truck (3 round trips at 30km), a fuel consumption of 8 km/liters and a fuel cost of $1 per liter. A front end loader is required at the septage treatment plant for unloading dewatered sludge from the sedimentation tank.

**Table III.9.53 Personnel Septage Management**

| Functional Unit | Technical | Administrative | Drivers | Unskilled labor | Total |
|---|---|---|---|---|---|
| 1)Monitoring unit | | | | | |
| Inspection | 5 | 1 | 0 | 0 | 6 |
| GIS Database | 3 | 1 | 0 | 0 | 4 |
| Fee collection | 1 | 4 | 0 | 0 | 5 |
| 2)Septage treatment | 2 | 1 | 2 | 8 | 13 |
| 3)Septage collection | 2 | 2 | 10 | 6 | 20 |
| Totals | 13 | 9 | 12 | 14 | 48 |

### (3) Annual Costs

The following annual operating budget for wastewater collection and treatment is based on a rough estimate of the repair, staff and energy requirements:

**Table III.9.54 Annual Costs for Septage Management**

| Project / components | Annual Operating Cost (US$) 2020 | | | |
|---|---|---|---|---|
| | Repairs | Staff | Energy | Total |
| **Project: SD-6** | 8,900 | 15,300 | 24,000 | 48,200 |
| **Project: SD-7** | 6,000 | 17,000 | 17,500 | 40,500 |
| Total | 14,900 | 32,300 | 41,500 | 88,700 |

Personnel costs are based on present salary rates (inclusive of benefits) paid to DPWT personnel. These salaries are low and would probably need to be revised in a commercial operation to improve job performance and productivity.

As expected the cost per m3 are relatively high because operation of transportation equipment is expensive. The management of septage also requires a substantial administration overhead. Most of the costs are in the collection of septage.

**Table III.9.55 Unit Costs of Septage Management** year 2020

| | | |
|---|---|---|
| Total O&M | $/day | 250 |
| Total sludge collected | $m^3$/day | 92 |
| Unit cost | $/$m^3$ | 2.71 |

## 9.4.7 Affordability and Willingness to Pay

Affordability and ability to pay are key parameters in assessing whether the proposed investment is affordable in view of the need to achieve financial autonomy for sustainable operation and maintenance of services.

Project beneficiaries include all residents and visitors to Siem Reap. The service industry (restaurants, bars, laundry shops, hotels and guesthouses) which depends to a large extent on tourism will also benefit from improved wastewater management.

**Table III.9.56 Project Beneficiaries**

| Wastewater management zone | | Project ID | 2012 | | 2020 | |
|---|---|---|---|---|---|---|
| | | | Population | No. of rooms | Population | No. of rooms |
| Zone 1 | W | SD-3 | 15,215 | 5,571 | 17,036 | 6,059 |
| | E | SD-4 | 16,296 | 2,369 | 18,682 | 2,754 |
| Zone 2 | W | SD-6, SD-8 | Implemented after 2012 | | 22,418 | 2,305 |
| | E | SD-7, SD-9 | | | 15,386 | 955 |
| Zone 3 | W | SD-6 | Implemented after 2012 | | 22,670 | 1,000 |
| | E | SD-7 | | | 16,002 | 134 |
| Total | | | 31,511 | 7,940 | 112,194 | 13,207 |

Affordability is measured by calculating the cost of per household and comparing to the average household income. A cost per room is also developed to show the potential for internal cross subsidy.

The annual costs of different projects are tabulated by WM as follows:

**Table III.9.57 Annual Operating Costs by Project (2020)**

(US$)

| | WM Zone | Project ID | O&M cost | Depreciation |
|---|---|---|---|---|
| Sewerage | Zone 1 | SD-3, SD-4 | 401,500 | 802,000 |
| Septic tank effluent disposal | Zone 2 | SD-8, SD-9 | 206,300 | 546,000 |
| Septage management | Zone 2, Zone 3 | SD-6, SD-7 | 88,700 | 79,000 |
| | | Total | 695,500 | 1,427,000 |

Based on the user pay principal the costs of providing services within each WM zone should be divided among the beneficiaries in that zone in proportion to how much wastewater they generate.

**Table III.9.58 Cost Allocation Ratios for Wastewater Collection and Treatment**

| | Wastewater m3/day | | | | Cost sharing ratio by zone | | |
|---|---|---|---|---|---|---|---|
| | Domestic | Tourism | Total | | Domestic | Tourism | Total |
| Zone 1 | 5483 | 4160 | 9643 | SD-3, SD-4 | 57% | 43% | 100% |
| Zone 2 | 5179 | 1546 | 6725 | SD-8, SD-9 | 77% | 23% | 100% |

**Table III.9.59 Cost Allocation Ratios for Septage Management**

| | Wastewater m3/day | | | | Cost sharing ratio by zone | | |
|---|---|---|---|---|---|---|---|
| | Domestic | Tourism | Total | | Domestic | Tourism | Total |
| Zone 2 | 5179 | 1546 | 6725 | SD-6, SD-7 | 36% | 11% | 47% |
| Zone 3 | 6876 | 626 | 7502 | SD-6, SD-7 | 48% | 4% | 53% |
| Total | 12055 | 2172 | 14227 | | 85% | 15% | 100% |

**Table III.9.60 Annual Operating Costs Allocated to Beneficiaries (2020)** **USD**

| | O&M costs | | | Depreciation costs | | |
|---|---|---|---|---|---|---|
| | Domestic | Tourism | Total | Domestic | Tourism | Total |
| Zone 1 | 228,292 | 173,208 | 401,500 | 456,016 | 345,984 | 802,000 |
| Zone 2 | 191,163 | 57,065 | 248,228 | 449,239 | 134,104 | 583,343 |
| Zone 3 | 42,869 | 3,903 | 46,772 | 38,181 | 3,476 | 41,657 |
| | | | 696,500 | | | 1,427,000 |

The average household income in the urban area is US$150 per month while the income for the low-income household is set at 50% of the average which corresponds to approximately US$75 per month. The average family size for both average-income and low-income households is 5.6 persons (data derived from JICA Study Team commune interview survey 2005). The monthly operating costs per household and per room are presented in Table III.9.61

**Table III.9.61Monthly Operating Costs per Household and per Hotel Room**
USD

| | O&M | | Depreciation | | Total | |
|---|---|---|---|---|---|---|
| | per household | per hotel room | per household | per hotel room | per household | per hotel room |
| Zone 1 | 2.98 | 1.64 | 5.96 | 3.27 | 8.94 | 4.91 |
| Zone 2 | 2.36 | 1.46 | 5.55 | 3.43 | 7.91 | 4.89 |
| Zone 3 | 0.52 | 0.29 | 0.46 | 0.26 | 0.98 | 0.54 |

The general rule of thumb for affordability is that water and sewerage charges should not exceed about 5% of the household income. The cost to average-income households appears to be affordable if depreciation is excluded. For sewerage in zone 1 it represents about 2% of the average monthly income. The cost to low-income households is not affordable even when depreciation is excluded. For sewerage in zone 1 it represents about 4% of the average monthly income.

The per-household cost of sewerage is higher than the present monthly solid waste disposal fees which vary from $1 to $1.8. It is noted that the majority of households are not paying the solid waste disposal fee and most of the operating revenue is covered by hotels. There is therefore a real concern that households will be unwilling or unable to pay for wastewater disposal.

A social survey (45 samples) was carried out by the study team. Results indicate that most respondents want sewerage services but are not willing to pay more than the solid waste fee. On average the willing-to-pay cost was $1.6 per month however it is actually lower (around $1.0 per month) if only the results from the proposed sewer served areas are considered (area 3,4 and 5 of the survey).

Compared to the household cost the monthly cost per hotel room appears to be less of a burden. Assuming a 40% occupancy rate, the cost per room per night would be approximately $0.14 excluding depreciation costs. Hotels obviously have the capacity to pay more since the cost can easily be transferred to the guests who are the real users.

An internal cross subsidy will likely be required with hotels and guesthouses paying a substantial portion of the costs. The cost per room per night would be approximately $0.65 assuming all of the depreciation costs are borne by hotels and a 40% occupancy rate. This is affordable for most visitors to Siem Reap.

### 9.4.8 Tariffs

A detailed tariff study is well beyond the scope of the present master planning study however some of the issues are highlighted here for future reference. A sewerage tariff study should be included future feasibility and detailed design studies to assess financial viability of each project. A tariff study would examine tariff policies, tariff structures and rates by consumer category.

Tariffs and fees should generate revenues sufficient to cover;
All expenses for maintenance and operation of the facilities
Non-cash items including depreciation and replacement costs.
Debt service requirements

The ultimate goal is to recover the full costs of operations including depreciation costs for future equipment replacement. As usual in most ODA financed projects the cost of debt servicing would be borne by the GOC.

The general public is not accustomed to paying for sewerage services. Tariffs should therefore be low in the beginning to be accepted. Tariffs can be increased gradually as consumers become oriented to paying for services until full cost recovery is achieved. This practice was followed by water supply authorities in Phnom Penh and has proven successful.

Tariffs and fees should be based on the user pay principle however the affordability analysis indicates that a substantial cross subsidy will be required from commercial to domestic consumers.

There are three wastewater management (WM) zones and each one will be served by a different system. It is therefore logical that each zone would have a different rate structure. For example consumers in WM zone 1 would pay centralized wastewater collection and treatment. Consumers in WM zone 3 would pay for the costs of collecting and treating septage. Consumers in WM zone 2 would also pay for septage disposal and later when the collection system is expanded they would pay the incremental costs associated with collecting and treating septic tank effluent.

Wastewater generation is generally considered to be a function of water usage and sewerage fees are quite often based on water consumption. There are two major concerns with billing for sewerage based on water consumption:
There is no requirement to connect to the water supply system and the water supply system does not cover the whole wastewater management area. Furthermore many hotels and residences have private wells to supplement public water supply. Therefore there is no way to establish a clear relationship between water consumption and wastewater generated.
Billing and revenue collection would require the timely transfer of meter reading data from the water supply company to the sewerage authority. There is concern that there

would be delays and coordination problems since responsibility lies with different ministries. One potential solution would be for the water supply company to collect revenue on behalf of the sewerage company providing customers with only one utility bill. There is concern that transfer of administrative costs and revenues would be difficult since responsibility lies within different ministries

Given the potential difficulties with a water based sewer surcharge it is recommended that sewerage tariffs be based on fixed fees. Fees would include:
A one time connection fee
A monthly fee that would vary for each type of consumer
A flat rate for cleaning septic tanks, collected as a lump sum at the time of cleaning once every three years or collected as a fixed monthly fee.

Consumers should be grouped into different categories to reflect to some extent the amount of wastewater produced. The monthly fee would be different for each type of consumer. For example large hotels would pay more than smaller hotels and hotels in general would pay more than domestic users. Commercial businesses such as restaurants would pay more than commercial shops which do not use as much water.

Domestic fees based on income level are not practical because it is difficult if not impossible to determine the difference in income between different domestic users it is therefore suggested that the flat rate fee for domestic users be based on the size of dwelling (gross $m^2$ of floor space).

In order to determine a tariff structure it will be necessary to develop a detailed database of all consumers and to classify them into categories. This has been carried out under the ADB project for the study area. The same approach will need to be repeated for other project areas.

Fixed fees proposed by the ADB for its project area are presented in Figure 15 (appendix). The fees assume a 70% collection efficiency. Initially (year 2007) the fees would cover all of the O&M costs plus 20% of the depreciation costs. The fees would be increased every year at the rate of 3.5% to cover rising O&M costs. The depreciation component is also increased in 20% increments until the year 2011 when fees would cover 100% of the depreciation cost.

## 9.5 Priority Project for Separate Sewers West Side Zone 1 (SD-3)

### 9.5.1 Project Background

Central urban core along the west side is the primary tourist accommodation and commercial center. At present there is no sewerage system and drainage is inadequate. Problems include:

- Frequent flooding in the central commercial and tourist accommodation area
- Inundation of streets and properties by combined storm water and sanitary sewage during heavy rainfall
- High levels of pathogenic contamination in Siem Reap River, drains and irrigation canals

Drainage from the central market and Old Market Area is directed to the Town Center Drain (TCD). The TCD, located on the west side of Shivata Road receives raw sewage, septic tank effluent, sullage wastewater and municipal solid waste resulting in gross contamination and reduced capacity for conveyance of storm water and wastewater flow. The resulting negative impacts include: reduced public safety and access, risk to public health as well as reduced aesthetic quality of the urban environment. These negative impacts significantly reduce the tourism amenity of the area.

The ADB project (SD-1) is proposing to rehabilitate the Town Center Drain to improve hydraulic capacity and reduce flooding. The project is already at the detailed design stage and focuses on resolving frequent flooding that occurs in the central commercial and tourist accommodation area. Details are presented in Figure 16 and 17.

The main focus of the ADB project is drainage but additional funding is also being considered and will likely be provided to build the initial infrastructure required for the stage-wise implementation of sewerage. The project includes the following components:

- Construction of combined interceptor sewer, pumping station and wastewater treatment plant
- Construction of interception chambers to divert wastewater from existing combined sewers in the central market and old market areas.
- Cleaning and rehabilitating the existing Town Center Drain including resettlement of squatters and removing illegal buildings on maintenance right-of-way.

The interceptor sewer would initially be used to convey combined stormwater and sewage from the central core (West Side) to the treatment facility. Stormwater flows exceeding the pipe's capacity would overflow to the Town Center Drain.

The ADB project does not include installation of new street sewers. Therefore the installation of separate sanitary and stormwater sewers is required as the next step. New storm sewers will reduce local flooding on streets and can be reorganized to relieve flows in the Town Center Drain. Separate sanitary sewers will eliminate combined sewer overflows and reduce the flows that must be pumped and treated during wet weather.

### 9.5.2 Project Outline

**(1) Purpose**

The purpose of the project is to provide a fully functional and separate system of sanitary and stormwater sewers in the central core of the city. The sanitary sewers will be connected to the interceptor outfall sewer provided under the ADB project. Wastewater flows will be conveyed to the waste stabilization ponds also provided under the ADB project. The reorganization of stormwater drains will divert flows from upper catchments thereby relieving the volume of stormwater discharged to the Town Center Drain.

**(2) Target Area**

The proposed target area is the central commercial and tourist accommodation area designated as Zone 1 on the West Side of Siem Reap River (Figure 18 appendix). The target area may be expanded slightly further west depending on results of surveys and analysis carried out during the feasibility study.

**(3) Prospective Beneficiaries**

Project benefits will include:

- Reduction in peak flows pumped to the wastewater treatment plant therefore energy savings and improved performance of the treatment process
- Improved operation of wastewater collection system and pump stations because less solid waste flushed into the system
- eliminates the overflow of raw sewage from the interceptor during significant rain events
- reduces wet weather flow in the Town Center Drain

Prospective beneficiaries include residents, hotels and other businesses in zone 1. Agricultural areas downstream of the Town Center Drain will also benefit because less sewage will be discharged to open drains. Agricultural areas south of Pou Bos will benefit because treated effluent can be used for crop irrigation.

| Population West District | 2004 | | 2012 | | 2020 | |
|---|---|---|---|---|---|---|
| | Domestic | Tourism | Domestic | Tourism | Domestic | Tourism |
| W1 | 14,080 | 4,087 | 15,215 | 10,101 | 17,036 | 11,837 |

**(4) Project Components**

1. Feasibility study and detailed design of sanitary sewerage infrastructure:

- branch sewers and house connections throughout zone 1, west.
- trunk collector sewers
- pump station north of NR6
- connection of trunk sewers to outfall sewer (interceptor provided by ADB)

2. Feasibility study and detailed design of stormwater drainage infrastructure:

- Old market stormwater relief sewer
- Shivata Rd storm sewer
- Samdach Tep Vong St storm relief sewer to TCD with provision for future extension to Western Drain.

3. Procurement of Sewer cleaning equipment such as jet machines and tanker trucks, pumps, rod and bucket machines.

4. Capacity building within DPWT for the sustainable operation and maintenance of sewers, pump stations and treatment plant.

5. Tariff study to determine policies, sewer connection charges and user fees.

### (5) Project Input

#### 1) Feasibility Study and Detailed Design

A detailed feasibility study will be required before proceeding to the detailed design stage. Feasibility study and detailed design should include the following components:

- Review of master plan proposals and coordination with ADB interceptor design
- Field surveys to establish a tributary area
- Topographic surveys to confirm ground elevations and invert levels of existing drains and storm sewers
- Selection of sewer alignments
- Profiles and invert levels
- Geotechnical surveys
- Hydrological analysis of drainage area
- Hydraulic calculations for sanitary and stormwater sewers, and canals.
- Design for house connections and separation of stormwater
- Civil engineering design drawings, tender documents
- Environmental assessment
- Site acquisition and resettlement plan

Preliminary estimate of input from foreign experts as follows:

- Hydrologist : 1 x 4 Months
- Stormwater drainage engineer : 1 x 18 Months
- Sewerage engineer : 1 x 18 months
- Civil engineer : 1 x 12 months
- Cost estimator : 1 x 3 months
- Specification/tender expert : 1 x 3 months
- CAD drawing and GIS support : 2 x 18 months
- Environmental expert : 1 x 3 months
- Topographic and geotechnical survey crews. : 2 x 4 months

Foreign experts would be supported by a team of locally engaged engineers for field surveys.

#### 2) Tariff Study

The project should include a tariff study to determine user charges and administrative requirements for billing and collection. The tariff study would include the following components:

- Determine tariff policy and rate structure for sewer connections and sewer use
- Develop a GIS database of all consumers in the tributary area (domestic, hotels, restaurants, businesses)
- Assess affordability and willingness to pay
- Investigate potential for internal cross subsidies from the tourism industry

- Determine administrative procedures for making sewer connections,
- Determine administrative procedures for billing and collection
- Identify human resources required for inspection, collection and billing

Preliminary estimate of input from foreign experts as follows:
- Financial/municipal tariff expert : 1 x 4 months
- Social expert (willingness/ability to pay) : 1 x 3 months
- Junior civil engineers, consumer survey : 4 x 3 months
- GIS support : 1 x 3 months

### 3) Capacity Building

Capacity building will be provided by a specialist consultant. Training will consist of:
- formal training courses during project implementation
- on-the-job training during the commissioning period, and
- technical assistance for a period of at least one year after the implementation of the project

Cost estimates include the following provisions:

| Training provided through technical assistance | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Course units | Days/unit | Trainer days | trainer cost/days | Total cost US$ |
| **Pre-construction training** | | | | | |
| Management Training | 8 | 10 | 80 | 750 | 60,000 |
| Technical Training | 8 | 15 | 120 | 750 | 90,000 |
| Maintenance Training | 6 | 20 | 120 | 750 | 90,000 |
| **Post operational training** | | | | | |
| Management Training | 10 | 10 | 100 | 750 | 75,000 |
| Technical Training | 12 | 15 | 180 | 750 | 135,000 |
| Maintenance Training | 12 | 20 | 240 | 750 | 180,000 |
| Exposure visits (national) | 3 | 10 | 30 | lump sum | 30,000 |
| **Total training** | | | | | 660,000 |

### 4) Services during Construction

The consultant will provide input at regular intervals during the construction to monitor progress and quality of work, and assist with commissioning and smooth transfer to DPWT.

## (6) Project Output

The project will provide the physical infrastructure for separate wastewater and stormwater collection in the central commercial and tourist accommodation area. It will help reduce the incidence of flooding and remove wastewater from stormwater drains.

The tariff study and capacity building will provide the operating authority with the tools and the knowledge it will need to properly operate and protect the significant

investment in infrastructure.

**(7) Environmental and Social Impacts**

The project's environmental impacts are considered beneficial.

The project will greatly improve the tourism amenity of the city by reducing the incidence of flooding.

The amount of raw sewage overflowing to the Town Center Drain will be reduced thereby improving the quality of stormwater that is conveyed to downstream agricultural areas. Improved drainage and sewerage will result in a cleaner urban environment with a reduction in disease vectors such as stagnant pools of wastewater.

The waste stabilization ponds will provide effluent that meets WHO guidelines for re-use in agriculture.

### 9.5.3 Institutional Arrangements and Implementation Schedule

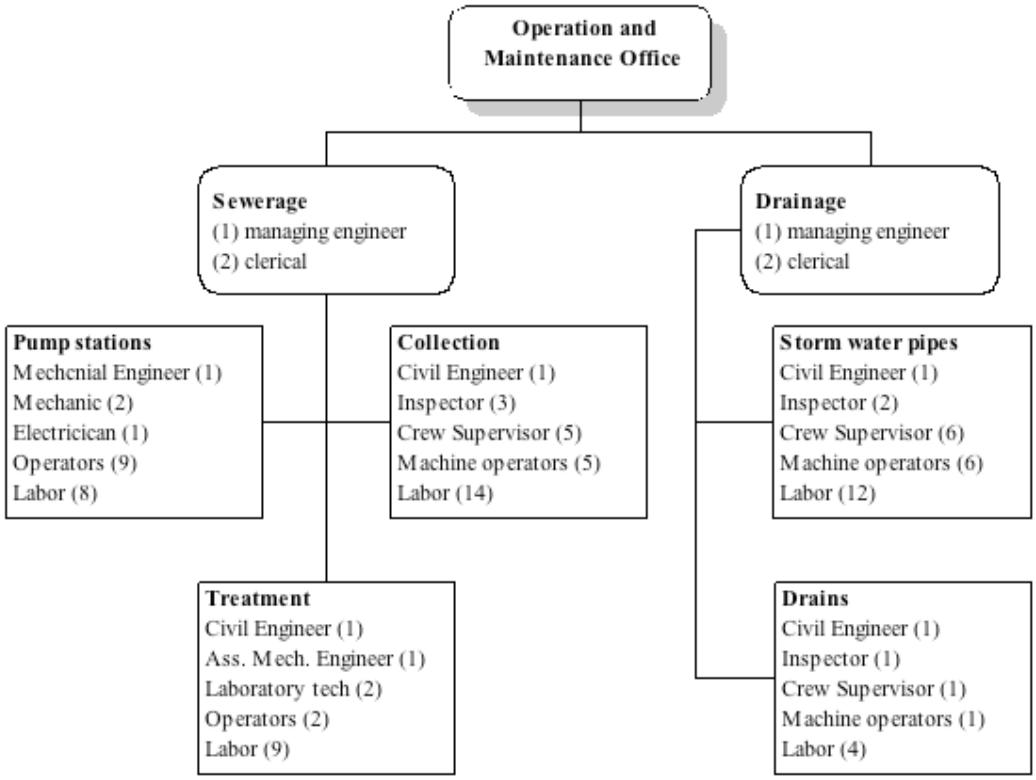
**(1) Institutional Arrangements**

The implementing agency is Ministry of Public Works and Transportation (MPWT). A project management unit (PMU) will be set up under MPWT for the project. The consultant team will report to the PMU.

The provincial Department of Public Works and Transportation (DPWT) will be responsible for managing operations and maintenance of the sewer system. A project implementation unit will be set up under DPWT to participate in feasibility studies, and detailed design. The PIU would also work closely with the consultants during the construction period.

**(2) Operation and Maintenance Organization**

The ADB project (SD-1) is the first project to go ahead and it will set the precedent for future projects. A special unit within DPWT has been identified as the authority responsible for sewerage and drainage. The organizational structure and levels of staffing proposed by the ADB project for the special unit will need to be modified in order to deal with the larger number of branch sewers and stormwater collection pipes provided by the priority project. The proposed organizational structure with staffing levels specific to project SD-3 is shown below




Administrative and technical services support for the management of operations is not shown here because it cannot be segregated on a project by project basis. It will be the responsibility of DPWT to provide for these support functions which are described in more detail in the master plan.

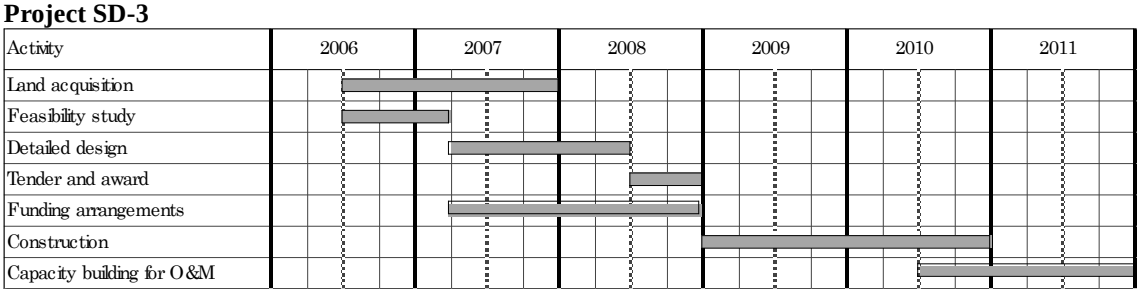
Maintenance equipment will be required for maintenance of drains, stormwater and sanitary sewer pipes. The following equipment should be procured under the project.

| Equipment | Sewerage | Drainage |
|---|---|---|
| Pressure Jetting machine | 2 | 3 |
| Vacuum tanker truck | 1 | 2 |
| Diesel engine and non clog sewage pumps | 3 | 2 |
| Air Blower | 3 | 3 |
| Maintenance truck | 3 | 2 |
| Misc. maintenance equipment (rods, bucket machines) | 2 | 2 |
| Excavator | 0 | 1 |

Maintenance requirements for storm water collection pipes are similar to those of sewerage systems and similar equipment can be used and shared between sewerage and drainage branch.

### (3) Implementation Schedule

**Project SD-3**




## 9.5.4 Financial Arrangements

### (1) Investment Costs

Preliminary project cost estimates are based on the following conditions and assumptions:

- Import duties are included in direct costs
- Physical contingency is 10% of total direct costs
- Costs are in US dollars at 2005 base price.
- Price escalation is10% of total direct costs
- Engineering services for feasibility study, detailed design and services during construction is 10% of direct cost including physical and price contingency
- Value added tax (VAT) is not included in the estimated cost
- Land acquisition includes compensation costs and is estimated using a unit price of $30/m2 in the urban area within the ring road, $10/m2 in the peri-urban area outside the ring road and $5/m2 in rural agricultural areas.

| **Direct Costs** | US$ ('000) |
|---|---|
| Stormwater drainage | 3,500 |
| Wastewater collection | 9,132 |
| Vehicles | 645 |
| Mtce. tools and equipment | 100 |
| Sub-total | 13,377 |
| Physical Contingency (10%) | 1,338 |
| Price escalation (10%) | 1,338 |
| **Total direct costs** | **16,053** |

| **Indirect Costs** | US$ ('000) |
|---|---|
| Engineering (10%) | 1,605 |
| Training/ technical assistance | 660 |
| **Total Project Cost** | 18,318 |
| Land acquisition by MEF/MPWT | 750 |

### (2) Operation and Maintenance Costs

Preliminary operation and maintenance costs are based on the following assumptions and conditions:

- Staffing levels are based on experience with similar projects in other developing countries
- Staffing costs are based on typical salaries paid in 2005 to DPWT staff
- Electrical energy costs are estimated on the basis of average flows and pumping heads required for 2012.
- Fuel costs are included in energy costs and these are based on number of vehicles in operation and average mileage.
- Annual repair and maintenance costs are taken as a percentage of the initial investment cost base on experience in other similar installations:
  - trunk and branch sewers : 1.0 %
  - other civil works : 1.5 %
  - mechanical and electrical equipment : 3.0 %
  - rising mains : 0.25%
- Mechanical equipment such as pumps is depreciated over a 15 year life
- Civil works such as sewers and manholes are depreciated over 30 year life.

| Project / components | Annual Operating Cost (US$) | | | |
|---|---|---|---|---|
| | Maintenance | Staff | Energy | Total |
| Stormwater drainage | 75,000 | 7,200 | 2,700 | 84,900 |
| Sanitary sewers | 90,000 | 13,260 | 4,000 | 107,260 |
| Wastewater pumping | 22,738 | 6,900 | 11,243 | 40,881 |
| Wastewater treatment | 34,763 | 4,500 | 1,000 | 40,263 |
| Total | 222,501 | 31,860 | 18,943 | 273,304 |

The O&M costs are incremental for the components provided under SD-3. These costs should be added to the costs of operating the interceptor sewer and treatment plant provided under SD-1 by ADB (estimated 39,000 per year)

Total annual depreciation costs related to the eventual replacement of the components provided under the project are estimated at $478,000.

JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

Project Long List

Sector: Sewerage and Drainage

| No | Project Title | Project Site | Project Outline | Present Activity | Project Components | Funding source | Estimated Cost ('000 US$) | Implementation Agency | Implementation Period | Necessary Further Action |
|---|---|---|---|---|---|---|---|---|---|---|
| SD-1 | Mekong Tourism Development Project Part A1: Siem Reap Wastewater Management | Siem Reap City Center West | Improvements to town center drain, construction of interceptor sewer, pump station and treatment plant | Detailed design study funded by ADB | Construction | ADB Loan No. 1969-CAM (SF) | 9,988 | Ministry of Public Works and Transportation (MPWT) and<br><br>Department of Public Works and Transportation (DPWT) | tender<br>construction | Sewer separation project SD-3 |
| SD-2 | Urban Development Project Siem Reap-Angkor | Siem Reap City East & APSARA zone | Rehabilitation and extension of urban infrastructure into the eastern growth area, including a network of open drains for combined storm water and sewage.<br><br>Capacity building to strengthen management and development of tourism programs | Feasibility study in progress | Priority road and drainage improvements | AFD Grant | 4,000 | APSARA, Siem Reap Province and District | FS / DD<br>construction<br>O&M capacity building | Funding for construction of identified priority projects and further studies |
| SD-3 | Siem Reap Sewerage Project Phase I | Siem Reap City Center West District (zone 1) | Install separate wastewater collection system in zone 1. Connect sanitary sewers to the interceptor sewer provided under project SD-1. Provide new storm water drainage pipes from central market and old market areas. Includes capacity building for O&M of sewerage facilities | Priority project identified by Integrated Master Plan for Sustainable Development | Feasibility Study, Detailed Design and Construction | Grant Aid or ODA loan | 18,326 | MPWT & DPWT | FS / DD<br>construction<br>O&M capacity building | Feasibility study |
| SD-4 | Siem Reap Sewerage Project Phase II | Siem Reap City Center East District (zone 1) | Provide a separate wastewater collection system for zone 1 and treatment plant located south-east side. Includes capacity building for O&M. | Priority project identified by Integrated Master Plan for Sustainable Development | Feasibility Study, Detailed Design and Construction | Grant Aid or ODA loan | 17,271 | MPWT & DPWT | FS / DD<br>construction<br>O&M capacity building | Feasibility study; possibly combined with SD-3 |
| SD-5 | Siem Reap Town Center Stormwater Relief Project | Siem Reap City West District | Storm water relief: provide new western drain to relieve flows in town center drain and improve drainage in extended urban growth areas, divert catchment areas to relieve flows in town center drain | Project identified by Integrated Master Plan for Sustainable Development | Feasibility Study, Detailed Design and Construction | Grant Aid or ODA loan | 10,935 | MPWT & DPWT | FS / DD<br>construction | Monitor impacts and benefits of SD-1 before proceeding with further improvements |

JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

Project Long List

Sector: Sewerage and Drainage

| No | Project Title | Project Site | Project Outline | Present Activity | Project Components | Funding source | Estimated Cost ('000 US$) | Implementation Agency | Implementation Period | Necessary Further Action |
|---|---|---|---|---|---|---|---|---|---|---|
| SD-6 | Siem Reap Septage Management Project Phase I | Siem Reap City West District | Provide septage collection vehicles and construct septage treatment facility at the wastewater treatment plant provided under SD-1. Includes technical assistance for developing a septage monitoring unit. | Project identified by Integrated Master Plan for Sustainable Development | Feasibility Study, Detailed Design and Construction | Grant Aid or ODA loan | 1,614 | MPWT & DPWT | FS / DD; Construction / Equip. procurement; Technical assistance | |
| SD-7 | Siem Reap Septage Management Project Phase II | Siem Reap City East District | Provide septage collection vehicles and construct septage treatment facility at the wastewater treatment plant provided under SD-4. Includes technical assistance for developing a septage monitoring unit. | Project identified by Integrated Master Plan for Sustainable Development | Feasibility Study, Detailed Design and Construction | Grant Aid or ODA loan | 1,027 | MPWT & DPWT | FS / DD; Construction / Equip. procure; Technical assistance | |
| SD-8 | Siem Reap Septic Tank Effluent Disposal (STED) Phase I | Siem Reap City West District Zone II | Install simplified pipe system for collecting and conveying septic tank effluent to trunk sewers installed under SD-3.<br><br>Expand existing pumping station and treatment capacity. | Project identified by Integrated Master Plan for Sustainable Development | Feasibility Study, Detailed Design and Construction | Grant Aid or ODA loan | 12,837 | MPWT & DPWT | FS / DD; construction | |
| SD-9 | Siem Reap Septic Tank Effluent Disposal (STED) Phase II | Siem Reap City East District Zone II | Install simplified pipe system for collecting and conveying septic tank effluent to trunk sewers installed under SD-4.<br><br>Expand existing pumping station and treatment capacity. | Project identified by Integrated Master Plan for Sustainable Development | Feasibility Study, Detailed Design and Construction | Grant Aid or ODA loan | 7,634 | MPWT & DPWT | FS / DD; construction | |

Implementation Period: 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

estimated cost excludes land acquisition

# Project Brief

## JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

**Sector: Sewerage and Drainage**

| No | Project Title | Beneficiaries and/or Target Group | Funding | Estimated Cost (USD) | **Project Priority** |
|---|---|---|---|---|---|
| **SD-1** | Mekong Tourism Development Project Part A1: Siem Reap Wastewater Management | Residents, hotels and commercial businesses along town center drain | ADB Loan No. 1969-CAM (SF) | 11,988 (thousand US$) | |

| Project Site | Implementation Agency | Department | Contact Person | Telephone | E-mail |
|---|---|---|---|---|---|
| Proposed sewerage zone 1, west district | MPWT | MPWT | Mr. Vong Pisith Deputy Director | 12833411 | |

Background:
- Frequent flooding in the central commercial and tourist accommodation area
- Inundation of streets and properties by combined storm water and sanitary wastewater during heavy rainfall

The ADB project will provide improved drainage. Additional funding is also being considered for construction of an interceptor sewer and wastewater stabilization pond. These trunk facilities would initially be used to relieve combined stormwater and sewage flows.

Project and Program Outline/Components:
1) Interceptor sewer, pump station, and wastewater treatment plant
2) clear and rehabilitate existing combined sewers
3) clear and rehabilitate town center drain

Project Purpose:
1) Reduce flooding along the town center drain
2) Reduce the amount of raw sewage that is discharged to open drains
3) Treat wastewater for agricultural re-use

Project Output:
1) Wastewater intercepted and conveyed to treatment during dry weather
2) Partial interception and treatment of stormwater mixed with sewage during wet weather (2 to 4 x dry weather flow)

Environmental and Social Impact:
1) Improves the surrounding environment by increases the amount of wastewater that receives treatment
2) Improves the quality of storm water that is conveyed to agricultural areas
3) Reduces the negative health impacts associated with sullage discharged to drains by reducing groundwater contamination and disease vectors

Related Projects:
1) SD-3 sewer separation in central core, west district

Implementation Schedule:

| | | |
|---|---|---|
| 1) Land acquisition | Jul-05 | Jul-06 |
| 2) Feasibility study and detailed design | Jul-05 | Dec-06 |
| 3 Funding arrangements | Feb-05 | Feb-06 |
| 4) Tender and award | Mar-06 | Sep-06 |
| 5) Construction | Oct-06 | Dec-07 |

Project Cost Breakdown: ('000 US$)

| | | |
|---|---|---|
| 1) Direct costs | | 9,080 |
| 2) Capacity building | | 0 |
| 3) Engineering | | 908 |
| | sub-total | 9,988 |
| 4) Land acquisition | | 2,000 |
| | | 11,988 |

# Project Brief

## JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

**Sector: Sewerage and Drainage**

| No | Project Title | Beneficiaries and/or Target Group | Assumed Fund | Estimated Cost (Eur) | **Project Priority** |
|---|---|---|---|---|---|
| **SD-2** | Urban Development Project<br>Siem Reap-Angkor | Residents, hotels and commercial businesses in east district | AFD grant | 4,800<br>(thousand Eur) | |

| Project Site | Implementation Agency | Department | Contact Person | Telephone | E-mail |
|---|---|---|---|---|---|
| East district zone 1, 2 and 3 | DPWT and APSARA | | | | |

**Background:**

The area east of Siem Reap River and along NR6 is being urbanized at a rapid pace and the formal construction of roads and drains should proceed as soon as possible while land and road allowances are still available. AFD has carried out a feasibility study and identified a number of priority projects for roads and drains. The feasibility study also identified the urgent need for additional studies related to Siem Reap River and city wide drainage.

**Project Purpose:**

1) Implement priority projects to improve storm water drainage and roads for growth areas East of Siem Reap River

**Project and Program Outline/Components:**

1) Design and construction of roads and drains identified as priority projects in feasibility study.
2) Drainage master plan for all of Siem Reap and Angkor town
3) Detailed hydraulic and hydrological studies of Siem Reap River including erosion and sediment control.

**Project Output:**

1) Storm water effectively removed from streets and conveyed via open drains to agricultural areas
2) Open drains coordinated with the construction of roads.
3) Master plan for drainage
4) Action plan for protection and management of Siem Reap River

**Environmental and Social Impact:**

1) reduce disease vectors by eliminating stagnant water
2) reduce the impact of urban stormwater on agricultural areas
3) facilitate organized development of urban growth

**Related Projects:**

SD-4: proposed "Siem Reap Sewerage Project Phase II"
Separate sanitary sewers and wastewater treatment plant

**Implementation Schedule:**

| | | |
|---|---|---|
| 1) Funding approval | Dec-05 | |
| 2) Detailed design for priority projects | Jan-06 | Dec-06 |
| 3) Tender and award | Dec-06 | Jun-07 |
| 4) Construction roads and drains | Jun-07 | Jun-09 |
| 5) Master plan for drainage | Jan-06 | Dec-07 |
| 6) Hydraulic study of Siem Reap River | Jan-06 | Dec-07 |
| 7) Capacity building | Jan-09 | Dec-09 |

**Project Cost Breakdown: ('000 eur)**

| | |
|---|---|
| 1) Master Plan | 450 |
| 2) Detailed Engineering | 300 |
| 3) Construction | 3,000 |
| 4) Capacity building | 250 |
| | 4,000 |
| x1.2(US$/Euro)= | 4,800 |

# Project Brief

## JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

**Sector: Sewerage and Drainage**

| No | Project Title | Beneficiaries and/or Target Group | Assumed Fund | Estimated Cost (USD) | **Project Priority** |
|---|---|---|---|---|---|
| **SD-3** | Siem Reap Sewerage Project - Phase I | Residents, hotels and commercial businesses in zone 1 west | International (Grant) | 19,076 (thousand US$) | |

| Project Site | Implementation Agency | Department | Contact Person | Telephone | E-mail |
|---|---|---|---|---|---|
| Proposed sewerage zone 1, west district | MPWT | | | | |

**Background:**

Present situation• Frequent flooding in the central commercial and tourist accommodation area
• Inundation of streets and properties by combined storm water and sanitary wastewater during heavy rainfall
• Effluent from septic tanks discharged directly to drains
• High levels of pathogenic contamination in Siem Reap River, drains and irrigation canals

ADB project is proposing to rehabilitate the Town Center Drain. Additional funding is also being considered for construction of an interceptor sewer and wastewater stabilization pond. These trunk facilities would initially be used to relieve combined stormwater and sewage flows and would later be converted to a fully separate sanitary sewage system.

**Project Purpose:**

1) To provide separate sewer systems for stomrwater and sewage.
2) To reduce teh amount of stormwater conveyed to the treatment plant
2) To reduce the amount of raw sewage that is discharged to open drains
3) Improve image of the commercial and tourist center by reducing flooding

**Project and Program Outline/Components:**

1) Separate sanitary sewers and house connections in zone 1
2) Connect separate sanitary sewers to interceptor sewer (project SD-1) and remove stormwater conections
3) Provide additional trunk sewer facilities and pumping stations to service zone 1
4) Additional storm water drainage pipes in old market and central market area with discharge to town center drain
5) Procure sewer cleaning equipment and capacity building for pumping station and sewer maintenance
6) Tariff study

**Project Output:**

1) Separate sanitary and storm water collection systems for the central commercial and tourist center of the city
2) Wastewater collected and conveyed to treatment
3) Storm water effectively removed from streets and conveyed via open drains to agricultural areas

**Environmental and Social Impact:**

1) Improves the surrounding environment by increases the amount of wastewater that receives treatment
2) Improves the quality of storm water that is conveyed to agricultural areas
3) Reduces the negative health impacts associated with sullage discharged to open drains
4) Treatment plant effluent can be used for agriculture

**Related Projects:**

(SD-1) ADB "Siem Reap Wastewater Management" project

**Implementation Schedule:**

| | | |
|---|---|---|
| 1) Land acquisition | Jun-06 | Dec-07 |
| 2) Feasibility study and detailed design | Jun-06 | Mar-07 |
| 3) Detailed design | Mar-07 | Jul-08 |
| 3 Funding arrangements | Jun-06 | Dec-08 |
| 4) Tender and award | Jul-08 | Dec-08 |
| 5) Construction | Jan-09 | Dec-10 |
| 6) O&M Capacity building | Jul-10 | Dec-11 |

**Project Cost Breakdown: ('000 US$)**

| | | |
|---|---|---|
| 1) Direct costs | | 16,060 |
| 2) Capacity building | | 660 |
| 3) Engineering | | 1,606 |
| | sub-total | 18,326 |
| 4) Land acquisition | | 750 |
| | | 19,076 |

# Project Brief

## JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

**Sector: Sewerage and Drainage**

| No | Project Title | Beneficiaries and/or Target Group | Assumed Fund | Estimated Cost (USD) | **Project Priority** |
|---|---|---|---|---|---|
| **SD-4** | Siem Reap Sewerage Project - Phase I | Residents, hotels and commercial businesses in zone 1 East | International (loan) | 19,521 (thousand US$) | |

| Project Site | Implementation Agency | Department | Contact Person | Telephone | E-mail |
|---|---|---|---|---|---|
| Proposed sewerage zone 1, west district | MPWT | | | | |

Background:
- Effluent from septic tanks discharged directly to drains
- High levels of pathogenic contamination in Siem Reap River, drains and irrigation canals
- Poorly drained streets and localized flooding

AFD project SD-2 will provide stormwater drainage via open drains. Separate sanitary sewers are required to prevent contamination of stormwater and groundwater.

Project Purpose:
1) Reduce the amount of raw sewage that is discharged to open drains
2) Treat wastewater for agricultural re-use

Project and Program Outline/Components:
1) Separate sanitary sewers and house connections in zone 1; conveying all wastewater to treatment.
2) Providing trunk sewers, pumping station and treatment plant to service zone 1
3) Procurement of sewer cleaning equipment and capacity building for pumping station and sewer maintenance

Project Output:
1) Separate sanitary and storm water collection systems for the commercial and tourist center of the city
2) Wastewater collected and conveyed to treatment

Environmental and Social Impact:
1) Increases amount of wastewater that receives treatment
2) Improves the quality of storm water that is conveyed to agricultural areas
3) Reduces the negative health impacts associated with sullage discharged to open drains
4) Treatment plant effluent can be used for agriculture

Related Projects:
SD-2: AFD "Urban Development Project
Siem Reap-Angkor", drainage component.

Implementation Schedule:

| | | |
|---|---|---|
| 1) Land acquisition | Jan-07 | Dec-08 |
| 2) Feasibility study and detailed design | Jan-08 | Jun-09 |
| 3 Funding arrangements | Jan-07 | Jun-09 |
| 4) Tender and award | Jul-09 | Dec-09 |
| 5) Construction | Jan-10 | Dec-11 |
| 6) O&M Capacity building | Jul-11 | Dec-12 |

Project Cost Breakdown: ('000 US$)

| | | |
|---|---|---|
| 1) Direct costs | | 15,360 |
| 2) Capacity building | | 375 |
| 3) Engineering | | 1,536 |
| | sub-total | 17,271 |
| 4) Land acquisition | | 2,250 |
| | | 19,521 |

# Project Brief

## JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

**Sector: Sewerage and Drainage**

| No | Project Title | Beneficiaries and/or Target Group | Assumed Fund | Estimated Cost (USD) | **Project Priority** |
|---|---|---|---|---|---|
| **SD-5** | Siem Reap Town Center Storm Water Relief Project | Residents, hotels and commercial businesses in west district south of NR6 | International (Grant and Loan) | 11,935 (thousand US$) | |

| Project Site | Implementation Agency | Department | Contact Person | Telephone | E-mail |
|---|---|---|---|---|---|
| West district zone 2 and 3 | MPWT | | | | |

**Background:**

The amount of stormwater discharged to the Town Center Drain will increase because continued development in the urban core will reduce the amount of pervious surfaces. The Town Center Drain has insufficient capacity for storm water runoff generated in up stream catchments therefore a diversion scheme will be required to relieve flows.

The area West of the Town Center Drain is growing rapidely but there is no organized drainage. Road an ddrainage infrastructure should be provided ahead of development in order to secure land and rights-of-way.

**Project Purpose:**

1) Reduce flooding in Town Center Drain
2) Improve storm water drainage for growth areas west of town center

**Project and Program Outline/Components:**

1) New open drains in western growth area
2) Reorganize stormwater drainage pipes in urban core
3) Storm relief drains from urban cor to new western drain

**Project Output:**

1) Storm water effectively removed from streets and conveyed via open drains to agricultural areas
2) Less storm water discharged into town center drain

**Environmental and Social Impact:**

1) reduce disease vectors by eliminating stagnant water
2) reduce the incidence of flooding along the town center drain

**Related Projects:**

SD-1: ADB "Siem Reap Wastewater Management" project
SD-3: Proposed "Siem Reap Sewerage Project" Phase I

**Implementation Schedule:**

| | | |
|---|---|---|
| 1) Land acquisition | Jan-09 | Jan-11 |
| 2) Feasibility study and detailed design | Jan-09 | Dec-10 |
| 3 Funding arrangements | Jan-09 | Jun-11 |
| 4) Tender and award | Dec-10 | Apr-11 |
| 5) Construction | Apr-11 | Dec-12 |

**Project Cost Breakdown: ('000 US$)**

| | | |
|---|---|---|
| 1) Direct costs | | 9,600 |
| 2) Capacity building | | 375 |
| 3) Engineering | | 960 |
| | sub-total | 10,935 |
| 4) Land acquisition | | 1,000 |
| | | 11,935 |

# Project Brief

## JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

**Sector: Sewerage and Drainage**

| No | Project Title | Beneficiaries and/or Target Group | Assumed Fund | Estimated Cost (USD) | **Project Priority** |
|---|---|---|---|---|---|
| **SD-6** | Siem Reap Septage Management Project Phase I | Residents, hotels and commercial businesses in West District. | International (Grant) | 1,614 (thousand US$) | |

| Project Site | Implementation Agency | Department | Contact Person | Telephone | E-mail |
|---|---|---|---|---|---|
| West district | MPWT | | | | |

Background:
Present situation
• Septic tanks not properly maintained discharging solids directly to drains
• Large increase in the number of septic tanks associated with growth of Hotel industry
• Raw untreated septic sludge used in agriculture and disposed to open drains and ponds leading to contamination of the environment an potential health problems

The wastewater management concept includes the use of septic tanks in zones 2 and 3 therefore septage collection and disposal must be improved. A septage treatment facility would be constructed at the wastewater treatment plant provided under project SD-1

Project Purpose:
1) Implement public collection service for regular cleaning of septic tanks
2) Provide treatment facility for disposal of septic sludge
3) Implement registry and monitoring of septic tank installations
4) Implement mandatory program and fees for regular cleaning of septic tanks

Project and Program Outline/Components:
1) Provide septage collection vehicles
2) Provide septage treatment facility at wastewater treatment plant
3) Provide technical assistance to implement monitoring unit
4) Develop standards and regulations for septic tank installation
5) Develop GIS based septic tank inventory
6) Develop fees for collection of septage
7) Develop administrative procedures for scheduling routine cleaning and collecting fees.

Project Output:
1) Standardization and control of septic tank installations
2) Regular inspection and cleaning of septic tanks
3) Treatment and re-use of septic sludge
4) Financially self-sustaining service through collection of fees

Environmental and Social Impact:
1) Properly maintained septic tanks can improve the environment
2) Reduces the amount of solids and sludge disposed to drains
3) Reduces the negative health impacts associated with disposal and reuse of untreated sludge
4) Septic sludge is treated and converted to hygienic fertilizer that can be used for agriculture

Related Projects:
SD-3: Siem Reap Sewerage Project - Phase I
Wastewater treatment plant: West District

Implementation Schedule:

| | | |
|---|---|---|
| 1) Feasibility study and detailed design | Jan-12 | Dec-12 |
| 2) Funding arrangements | Jan-12 | Dec-12 |
| 3) Tender and award | Jan-13 | Jun-13 |
| 4) Construction & procurement | Jul-13 | Jun-14 |
| 5) O&M Capacity building | Jan-14 | Dec-14 |

Project Cost Breakdown: ('000 US$)

| | | |
|---|---|---|
| 1) Direct costs | | 840 |
| 2) Capacity building | | 690 |
| 3) Engineering | | 84 |
| | sub-total | 1,614 |
| 4) Land acquisition | | 0 |
| | | 1,614 |

# Project Brief

## JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

**Sector: Sewerage and Drainage**

| No | Project Title | Beneficiaries and/or Target Group | Assumed Fund | Estimated Cost (USD) | **Project Priority** |
|---|---|---|---|---|---|
| **SD-7** | Siem Reap Septage Management Project Phase II | Residents, hotels and commercial businesses in West District. | International (Grant) | 1,027 (thousand US$) | |

| Project Site | Implementation Agency | Department | Contact Person | Telephone | E-mail |
|---|---|---|---|---|---|
| East district | MPWT | | | | |

Background:
Present Situation
• Septic tanks not properly maintained discharging solids directly to drains
• Large increase in the number of septic tanks associated with growth of Hotel industry
• Raw untreated septic sludge used in agriculture and disposed to open drains and ponds leading to contamination of the environment an potential health problems

The wastewater management concept includes the use of septic tanks in zones 2 and 3 therefore septage collection and disposal must be improved. A septage treatment facility would be constructed at the wastewater treatment plant provided under project SD-4

Project Purpose:
1) Implement public collection service for regular cleaning of septic tanks
2) Provide treatment facility for disposal of septic sludge
3) Implement registry and monitoring of septic tank installations
4) Implement mandatory program and fees for regular cleaning of septic tanks

Project and Program Outline/Components:
1) Provide septage collection vehicles
2) Provide septage treatment facility at wastewater treatment plant
3) Provide technical assistance to implement monitoring unit
4) Develop standards and regulations for septic tank installation
5) Develop GIS based septic tank inventory
6) Develop fees for collection of septage
7) Develop administrative procedures for scheduling routine cleaning and collecting fees.

Project Output:
1) Standardization and control of septic tank installations
2) Regular inspection and cleaning of septic tanks
3) Treatment and re-use of septic sludge
4) Financially self-sustaining service through collection of fees

Environmental and Social Impact:
1) Properly maintained septic tanks can improve the environment
2) Reduces the amount of solids and sludge disposed to drains
3) Reduces the negative health impacts associated with disposal and reuse of untreated sludge
4) Septic sludge is treated and converted to hygienic fertilizer that can be used for agriculture

Related Projects:
SD-4: Siem Reap Sewerage Project Phase II
Wastewater treatment plant: East District

Implementation Schedule:

| | | |
|---|---|---|
| 1) Feasibility study and detailed design | Jan-14 | Jan-15 |
| 2) Funding arrangements | Jan-14 | Jan-15 |
| 3) Tender and award | Jan-15 | Jun-15 |
| 4) Construction & procurement | Jul-15 | Jun-16 |
| 5) O&M Capacity building | Jan-16 | Dec-16 |

Project Cost Breakdown: ('000 US$)

| | | |
|---|---|---|
| 1) Direct costs | | 620 |
| 2) Capacity building | | 345 |
| 3) Engineering | | 62 |
| | sub-total | 1,027 |
| 4) Land acquisition | | 0 |
| | | 1,027 |

# Project Brief

## JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

**Sector: Sewerage and Drainage**

| No | Project Title | Beneficiaries and/or Target Group | Assumed Fund | Estimated Cost (USD) | **Project Priority** |
|---|---|---|---|---|---|
| **SD-8** | Siem Reap Septic Tank Effluent Disposal Project Phase I | Residents, hotels and commercial businesses | International (Grant and Loan) | 13,137 (thousand US$) | |

| Project Site | Implementation Agency | Department | Contact Person | Telephone | E-mail |
|---|---|---|---|---|---|
| West district zone 2 | MPWT | | | | |

Background:
- septic tank effluent is discharged to open drains and soak away pits
- this practice becomes unsustainable when population densities increase in the future
- septic tank effluent in densily populated areas should be collected and treated to prevent environmental degredation

Project Purpose:
1) Collect and treat liquid effluent from septic tanks

Project and Program Outline/Components:
1) Providing a simplified collection system in zone 2; conveying all septic tank effluent to treatment.
2) Providing additional trunk sewers and pumping stations
3) Increasing the capacity of the treatment plant provided under SD-3

Project Output:
1) Septic tank effluent in zone 2 is collected in pipes and conveyed to the wastewater treatment plant

Environmental and Social Impact:
1) Reduces the amount of fecal contamination discharged to surface drains and groundwater

Related Projects:
SD-3: Siem Reap Sewerage Project - phase I
Wastewater treatment plant: West District

Implementation Schedule:

| | | |
|---|---|---|
| 1) Feasibility study and detailed design | Jan-15 | Jun-16 |
| 2) Funding arrangements | Jan-15 | Jan-16 |
| 3) Tender and award | Jul-16 | Dec-16 |
| 4) Construction & procurement | Jan-17 | Dec-18 |

Project Cost Breakdown: ('000 US$)

| | | |
|---|---|---|
| 1) Direct costs | | 11,670 |
| 2) Capacity building | | 0 |
| 3) Engineering | | 1,167 |
| | sub-total | 12,837 |
| 4) Land acquisition | | 300 |
| | | 13,137 |

# Project Brief

## JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

**Sector: Sewerage and Drainage**

| No | Project Title | Beneficiaries and/or Target Group | Assumed Fund | Estimated Cost (USD) | **Project Priority** |
|---|---|---|---|---|---|
| **SD-9** | Siem Reap Septic Tank Effluent Disposal Project Phase I | Residents, hotels and commercial businesses | International (Grant) | 7,634 (thousand US$) | |

| Project Site | Implementation Agency | Department | Contact Person | Telephone | E-mail |
|---|---|---|---|---|---|
| East district zone 2 | MPWT | | | | |

Background:
- septic tank effluent is discharged to open drains and soak away pits
- this practice becomes unsustainable when population densities increase in the future
- septic tank effluent in densily populated areas should be collected and treated to prevent environmental degredation

Project Purpose:
1) Collect and treat liquid effluent from septic tanks

Project and Program Outline/Components:
1) Providing a simplified collection system in zone 2; conveying all septic tank effluent to treatment.
2) Providing additional trunk sewers and pumping stations
3) Increasing the capacity of the treatment plant provided under SD-4

Project Output:
1) Septic tank effluent in zone 2 is collected in pipes and conveyed to the wastewater treatment plant

Environmental and Social Impact:
1) Reduces the amount of fecal contamination discharged to surface drains and groundwater

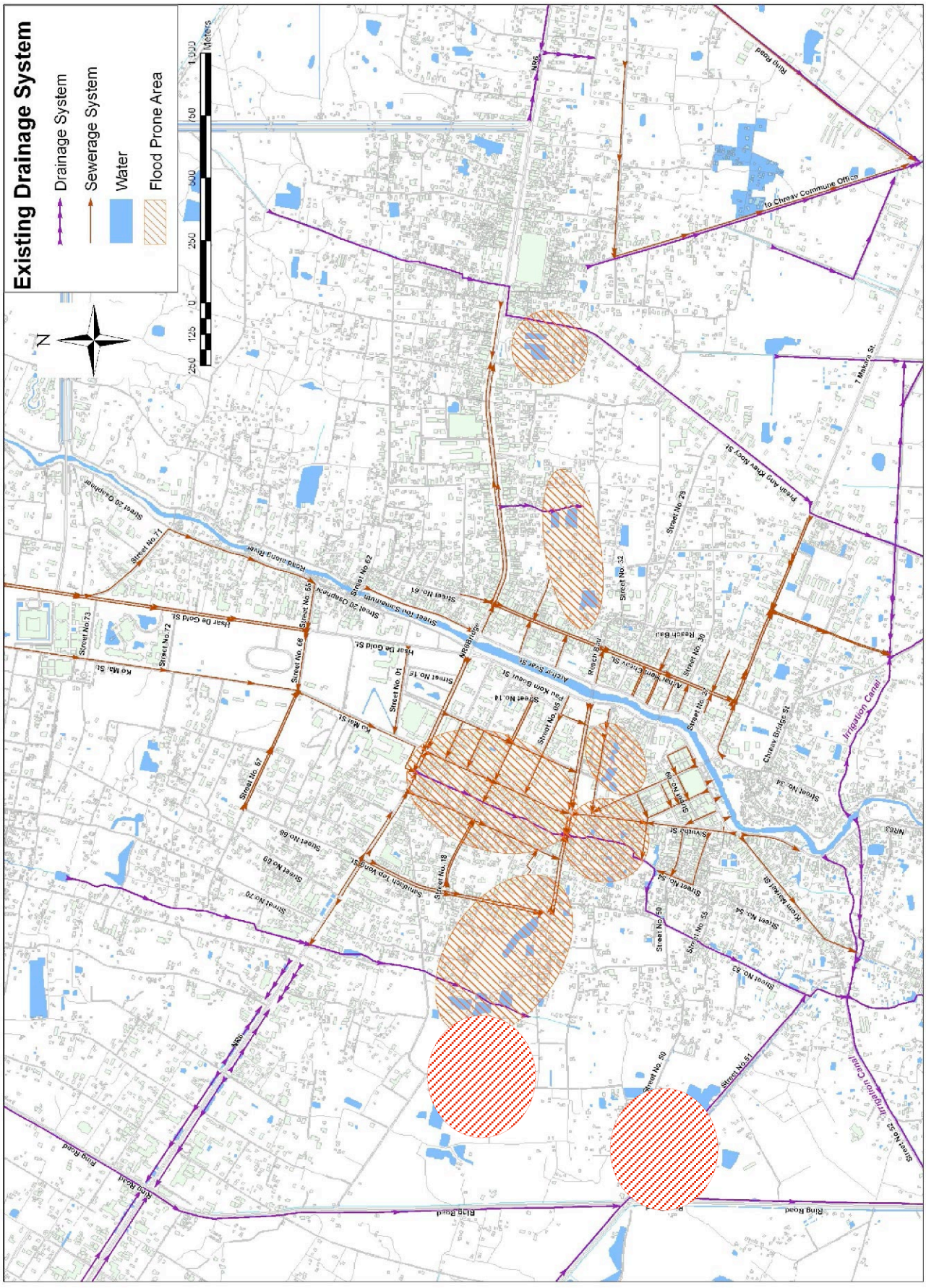
Related Projects:
SD-4: Siem Reap Sewerage Project - phase II
Wastewater Treatment Plant: East District

Implementation Schedule:

| | | |
|---|---|---|
| 1) Feasibility study and detailed design | Jul-16 | Nov-17 |
| 2) Funding arrangements | Jul-16 | Jul-17 |
| 3) Tender and award | Dec-17 | Jun-18 |
| 4) Construction & procurement | Jul-18 | Dec-19 |

Project Cost Breakdown: ('000 US$)

| | | |
|---|---|---|
| 1) Direct costs | | 6,940 |
| 2) Capacity building | | 0 |
| 3) Engineering | | 694 |
| | sub-total | 7,634 |
| 4) Land acquisition | | 0 |
| | | 7,634 |

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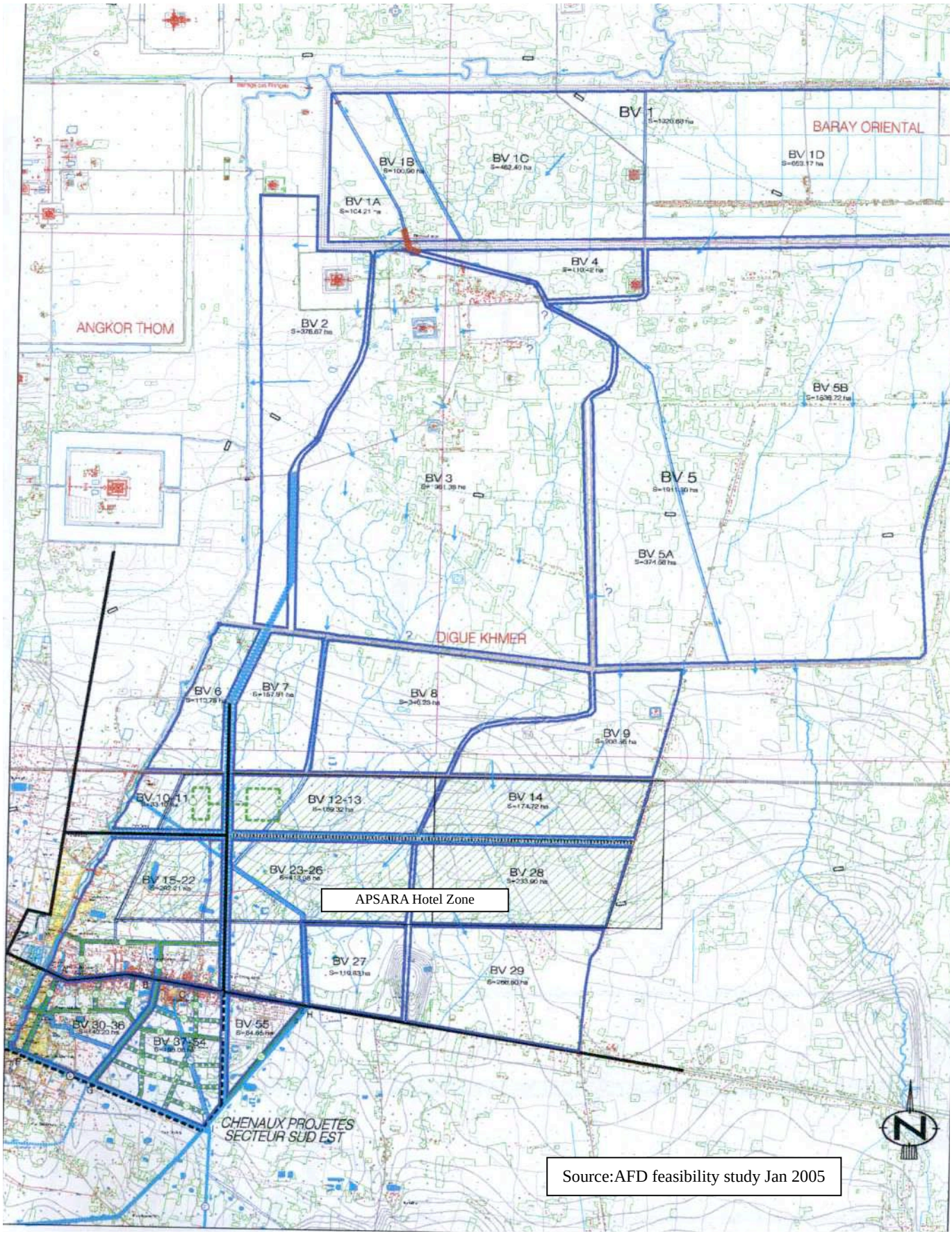
|---|---|
| **The Study on Integrated Master Plan for Sustainable Development of Siem Reap** | **Figure 1 Existing Sewers and Drains** |
| **Japan International Cooperation Agency** | |

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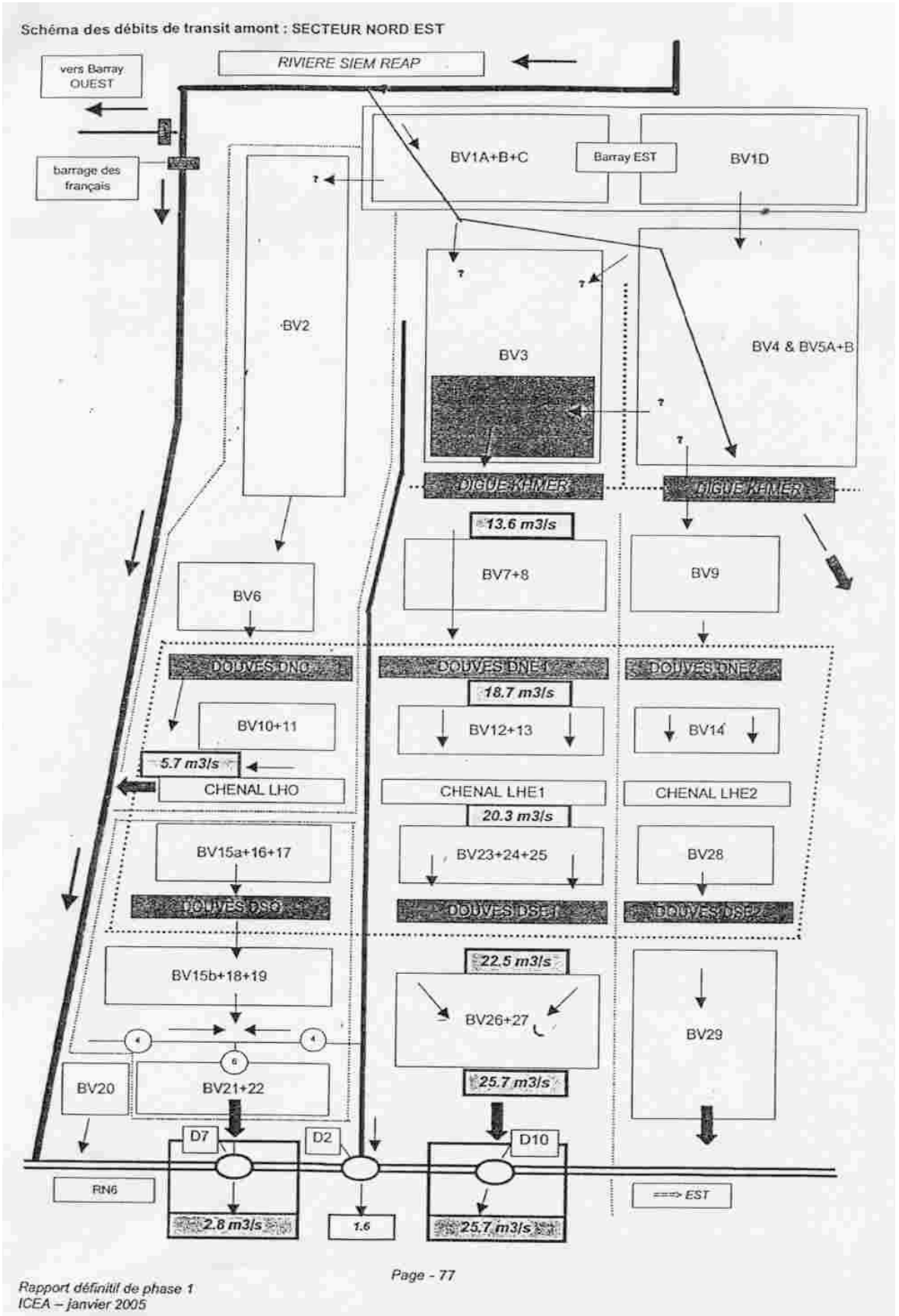
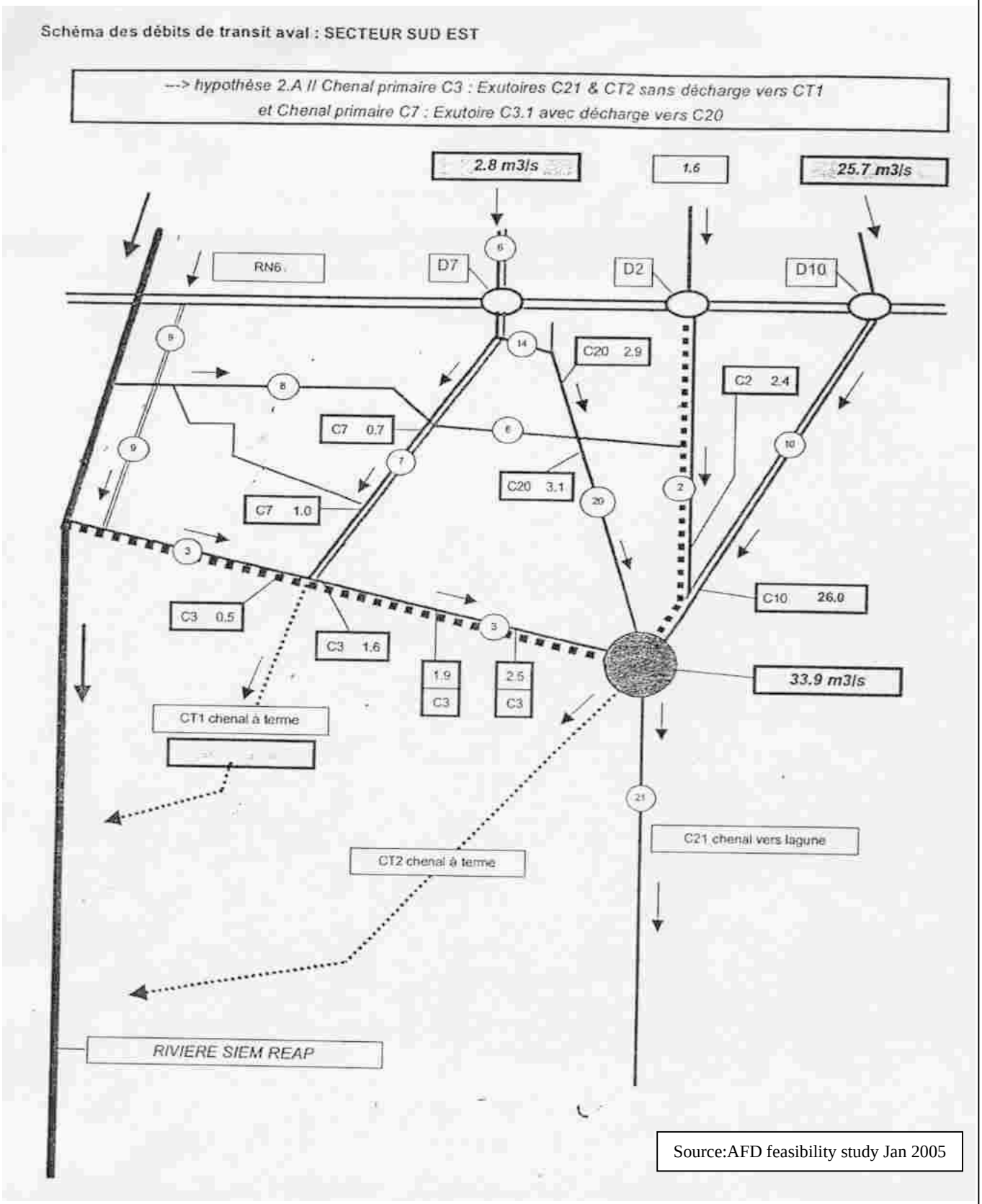
|---|---|
| **The study on Integrated Master Plan for Sustainable Development of Siem Reap** | **Figure 2 Catchments Areas - East Sector** |
| **Japan International Cooperation Agency** | |

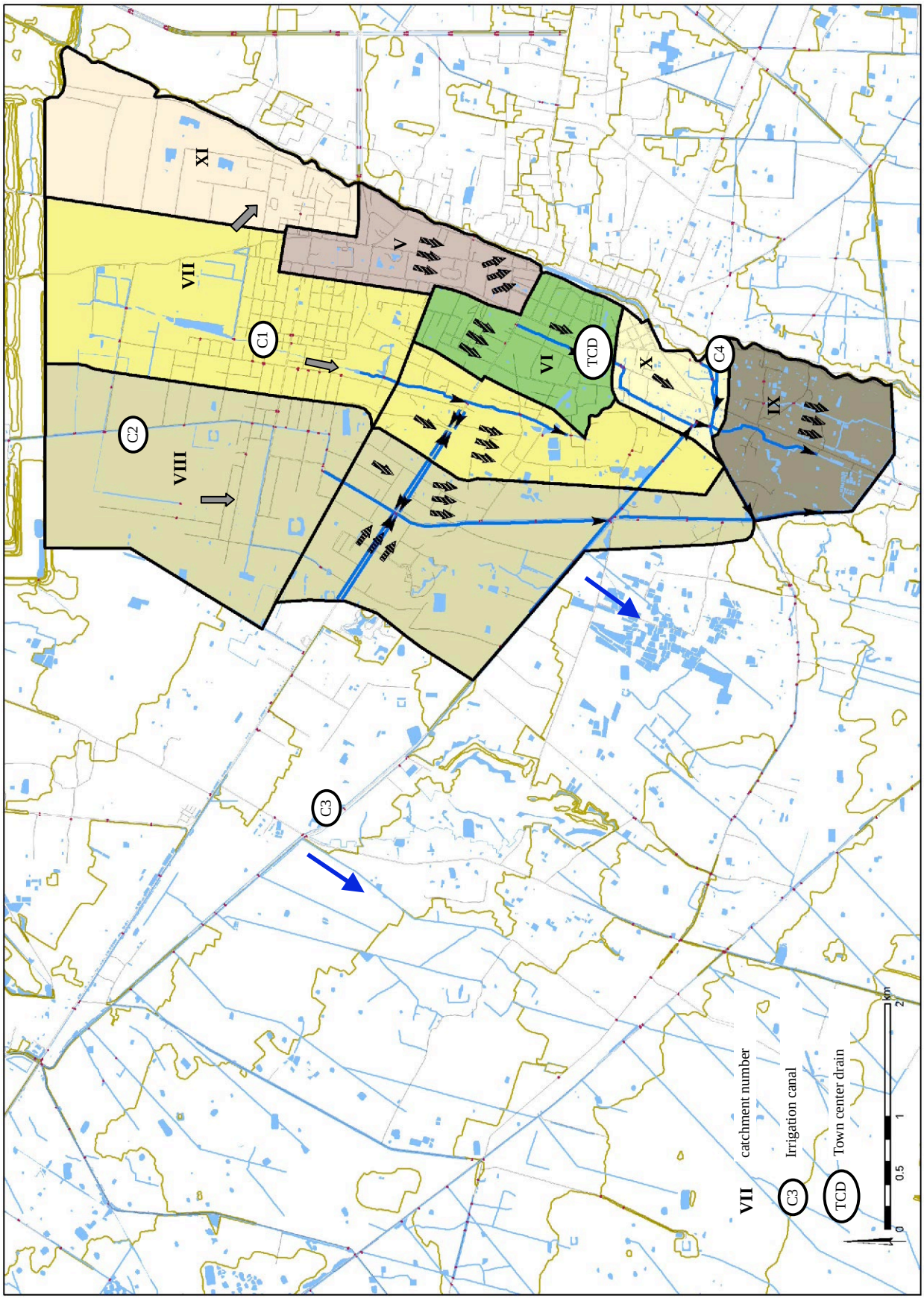



Source: AFD feasibility study Jan 2005

| | |
|---|---|
| **The study on Integrated Master Plan for Sustainable Development of Siem Reap** | **Figure 3 Stormwater Flow Schematic Northeast Sector** |
| **Japan International Cooperation Agency** | |




| | |
|---|---|
| **The study on Integrated Master Plan for Sustainable Development of Siem Reap** | **Figure 4 Stormwater Schematic Flow Diagram Southeast Sector** |
| **Japan International Cooperation Agency** | |




| | |
|---|---|
| **The study on Integrated Master Plan for Sustainable Development of Siem Reap** | **Figure 5 West Side: Catchment Areas and Main Drainage Features** |
| **Japan International Cooperation Agency** | |