Appendix 3: Documentation of Expenditure Functions - Wastewater

1 Wastewater

The wastewater infrastructure comprises the following elements:

- Simple pit latrine
- Improved latrine
- Pour flush latrine
- Septic tanks;
- Sewered interceptor tanks with or without treatment;
- Simplified sewerage with or without treatment;
- Small treatment plants;
- Conventional sewerage collection;
- Pumping stations; and
- Conventional wastewater treatment plants.

Below are described the investment and O&M expenditure functions of each type of infrastructure.

The investment expenditure function is actually a replacement value functions which is used to estimate three types of expenditure need the annual re-investment expenditure, the renovation need and the investment expenditure in case of service extensions requiring new infrastructure.

The cost is international price level, 2005. By international level means an average price level experienced or estimated to representative for an international cost level.

The investment expenditure function is actually a replacement value functions which is used to estimate three types of expenditure need: 1) the annual re-investment expenditure, 2) the renovation need and 3) the investment expenditure in case of service extensions requiring new infrastructure.

These expenditure functions are described in sections 1.1 to 1.5.

1.1 Simple Pit Latrines

The capital cost function for a simple unlined pit latrine:

Cost = 400 €/each unit;

O&M = 2 % of capital cost.

1.2 Improved Larine

The capital cost function for an improved latrine:

Cost = 800 €/each unit;

O&M = 2 % of capital cost/year

1.3 Pour Flush Latrine

The capital cost function for a pour flush latrine:

Cost = 1100 €/each unit;

O&M = 2.5 % of capital cost/year

1.4 Septic Tank

The capital cost function used for septic tank for a single household is:

Cost = -98 * log (PE) + 835[1] - €/PE

O&M = 8* PE + 100, €/year; where PE is here number of people[2]

1.5 Small Treatment Plants

There are three options as to small treatment plant technology:

- Reed bed treatment;
- Biological sand filters; or
- Stabilisation ponds.

1.5.1 Reed Bed Treatment Plants

Reed bed plants consist of a primary sedimentation tank (septic tank) followed a shallow soil filter planted with reed.

Expenditure functions, less than 2,000 p.e.
The replacement value function is:

[1] Connection to existing sewer pipes is assumed, i.e. excl. connection to house installations and discharge facilities.

[2] PE is the number of person equivalent calculated based on a total demand assuming e.g. a person is consuming 200 litres per day. In this rural context the one PE is assumed to be one person regardless the amount of water consumed as the BOD content is assumed to be the same.

Cost = 1521 * log(PE) + 6892, €/PE

O&M = 13.5 * PE + 6,750 - €/year

1.5.2 Biological Sand Filters

Expenditure functions, less than 2,000 PE
The replacement value function is shown below:

Cost = -777 * log(PE) + 3,872 - €/PE.

O&M = 13.5 * PE + 6,750 - €/year

1.5.3 Stabilisation Ponds

Expenditure functions, less than 2,000 PE.
The replacement value function is shown below assuming that the average temperature in ponds is 18°C[3].

Cost =-283 * log(PE.) + 1232 - €/PE

O&M = 13.5 * PE + 6,750 - €/year

1.5.4 Conventional Wastewater Collection

This component includes the works in relation to a single pipe wastewater collection system from the property lines to the wastewater treatment plant, i.e.

- Network collection system
- Service connections
- Main/trunk/interceptor sewers

The function for estimation of the total pipe length (L) is:

If population < 50,000 then L= Pop * (-0.00005833 * Pop + 4.92); where Pop is the population serviced.

Cost of pipe per meter: 0.004235*Dia^1.6811+152.8 - €/m, Diameter in mm.

Total capital cost = Unit price * length of pipe network.

O&M = 2 % of capital cost/year

[3] Stabilisation ponds are best suitable for hot climates.

1.5.5 Sewered Interceptor Tanks and Collection Pipes

One interceptor tank is used per household, and a unit cost per connection. For each of the house connection a default length of pipe to tank and to outfall from interceptor tank is used (can be changed by the user).

Capital cost of interceptor tank = 2000 $/each; and

Pipe cost = 0.0009*dia.^2+0.2884*dia., €/m, diameter in mm.

O&M for tanks are as for septic tanks.

O&M pipes= 1 % of capital cost/year ((default value, can be changed by user).

1.5.6 Simplified Sewerage

The simplified sewerage consists of small diameter collection network. The prices for pipes are the same as for interceptor pipes, and length of network is the same as defined under conventional wastewater collection network.

O&M = 1 % of capital cost/year (default value, can be changed by user).

1.5.7 Pumping Stations

Pumping stations for wastewater collection is only anticipated for conventional wastewater collection. The capital cost function for pumping station is:

Capital cost = 2*(16570*KW installed^0.559) - €/pump station; KW= total KW installed.

Power installed is calculated according to default values/user defined values for lift and efficiency of pump.

O&M = 3% of capital cost plus energy cost (default value, can be changed by user).

1.5.8 Wastewater Treatment

The expenditure functions are shown in Table 1.

New connections are estimated as the number of people assuming one P.E per person, while the effect of industries has to be assessed as part of the pre-model analysis.

Table 1 Investment expenditure functions for wastewater treatment plants, in €/PE in 1990 prices.

	Load in PE			
Technology	<400	400-2,000	2,000-100,000	>100,000
M	188.1	=10^(-0.2745*log(PE)+3.8605)/7.44	=10^(-0.2073*log(PE)+3.6385)/7.44	53.8
MB/ MBC	403.2	=10^(-0.4735*log(PE)+4.7093)/7.44	=10^(-0.2632*log(PE)+4.0149)/7.44	67.2

Source: Consultant's estimates.
Note: The new module on rural WSS in the Feasible model, the figures have been corrected to reflect the 2005 price level.

Operational Expenditure
The operational expenditure for wastewater treatment is estimated using a percentage of the investment expenditure. This covers all operational expenditure except electricity, which will be specified separately.

*Electricity consumptio*n (values are for efficiency of 40%):

Mechanical treatment: 15 kWh/year/PE
Mechanical/biological/chemical: 25 kWh/year/PE

*Other operational expenditur*e: 3% of the total investment expenditure for wastewater treatment default value can be changed by user).

1.6 Cost Element Shares

The weight factors for correction of investment expenditure and operation and maintenance cost to reflect the local price level are given in Table 2 and Table 3.

These weight factors are equal to the structure of the total investment expenditure and O&M costs at the international price level. E.g. for each type of wastewater infrastructure, the Table 2 shows how the total investment is distributed on various expenditure elements. The shares for each type sum to 100% (in each row).

Cost of land is not included in the cost functions.

Table 2 Weight factors for price correction of investment expenditure (cost item in % of total investment expenditure)

Sanitation Capital Cost Component	Land	Power	Fuel	Labour (Blue collar workers)	Professionals (White collar workers)	Consumables	Equipment	Buildings and construction materials	Other costs
Simple pit latrine	0	0	0	30	0	0	0	70	0
Improved latrine	0	0	0	20	0	0	0	80	0
Pour flush latrine	0	0	0	15	0	0	10	75	0
On site septic tank	0	0	1	20	0	0	10	69	0
Sewerage interceptor	0	0	1	20	3	0	30	46	0
Simplified sewerage	0	0	1	30	2	0	25	42	0
Convetional sewerage	0	0	1	20	10	0	30	39	0
Pumping station	0	0	1	25	10	0	30	34	0
Sandfiter	0	0	1	20	5	0	30	44	0
Reed bed filter	0	0	1	20	5	0	25	49	0
Stabilisation pond	0	0	1	20	5	0	20	54	0
M treatment	0	0	1	15	10	0	30	44	0
M&B teatment	0	0	1	15	10	0	30	44	0

Source: Consultant's estimates.

Table 3 Weight factors for price correction of O&M (cost item in % of total O&M cost)

Sanitation O&M Cost Component	Land	Power	Fuel	Labour (Blue collar workers)	Professionals (White collar workers)	Consumables	Equipment	Buildings and construction materials	Other costs
Simple pit latrine	0	0	0	40	0	0	0	60	0
Improved latrine	0	0	0	20	0	0	0	80	0
Pour flush latrine	0	0	0	30	0	0	10	60	0
On site septic tank	0	0	0	30	0	0	10	60	0
Sewerage interceptor	0	0	0	30	2	0	25	43	0
Simplified sewerage	0	0	0	38	2	0	20	40	0
Convetional sewerage	0	0	0	25	2	0	30	43	0
Pumping station	0	50	0	20	2	0	15	13	0
Sandfiter	0	0	0	30	0	20	10	40	0
Reed bed filter	0	0	0	30	0	0	30	40	0
Stabilisation pond	0	0	0	40	0	0	20	40	0
M treatment	0	10	0	30	5	0	25	30	0
M&B teatment	0	25	0	30	5	5	15	20	0

Source: Consultant's estimates.

Blue collar are workers, and white collar are other employees.