18.2 Sanitation Measures

18.2.1 Existing Plans for Wastewater Facilities

The Danish International Development Agency (DANIDA) has provided development assistance for water supply and sanitation to Quang Ninh province since the end of 1994. The first phase was for preparation of a Feasibility Study to define a priority investment project to upgrade the water supply, drainage and sanitation services in Ha Long city and Cam Pha. The Danish assistance to the project was in the form of a bilateral grant and was provided as project preparation support for the Quang Ninh component of the World Bank financed Water Supply and Sanitation Project (WSSP) in Vietnam.

Carl Bro International in cooperation with Water Quality Institute (Denmark), VIWASE (Vietnam Water Supply, Sanitation and Environmental Consulting Company) and the Community Health Research Unit (Vietnam) carried out the original Project Formulation/Feasibility Study during a seven month period from March 1995 to October 1995. A project proposal was formulated with the following main components:

- Rehabilitation of the existing water supply system to provide a reliable capacity of 60,000 m^3/day
- Rehabilitation of the sanitary drainage system in central parts of Hong Gai and Cam Pha. In Bai Chay it was proposed to rehabilitate and extend the sanitary drainage and construct an interceptor sewer and wastewater treatment plant
- Undertake a major institutional development program through human resource development. It was also proposed to merge the water supply and sanitary drainage activities into one organization
- Introduction of a simple tariff structure at a level which most residents were willing to pay
- Ensure community participation in the management and operation of the water supply and sanitary drainage services

Following the CBI Study, Kampsax International in association with Soil and Water Ltd. (Finland), Danish Waste, Danish Water Supply and Vietnamese consulting firms VIWASE and HADECON signed a contract with DANIDA in February 1997 for, firstly, detailed design and construction supervision of the water supply component and, secondly, completion of the feasibility study and detail design of the sanitation and drainage component.

Under the second part of their contract with DANIDA, Kampsax completed the Sanitation Feasibility Study and submitted a draft final report in April 1998. The World Bank requested some changes to this report and the final version was approved in February 1999. Detail design of the first phase was due to commence in 1999 and the construction program is expected to extent over a 4½ year period. The total cost of the first stage works is estimated to be about US$ 38 million, broken down by component and area below.

Estimated Costs of First Stage Sanitation Component of HWSSP

(Unit: US $x10^6)

Component	Bai Chay	Hong Gai	Cam Pha	Total
Sewerage and Sewage Treatment	3.1	1.2	1.2	5.5
Drainage	1.0	2.8	3.4	7.2
Solid Wastes Management	2.4	2.9	4.5	9.8
Technical Assistance	-	5.3	-	5.3
Sanitation Revolving Fund	-	0.5	0.5	1.0
Total Baseline Cost	6.5	12.7	9.6	28.8
Physical Contingencies	1.0	1.0	1.3	3.3
Price Contingencies	1.4	2.1	2.1	5.6
Total Project Costs	8.9	15.8	13.0	37.7

Source: Kampsax International, March 1999

The basis and objectives of the first stage works proposals may be summarized as follows:

- Rehabilitation of existing sanitary drainage channels and construction new channels to relieve flooding and provide public sanitation services in urban areas
- Construct interceptor sewers in Bai Chay to collect sewage from the storm water channels during dry weather. Overflow devices will allow storm water to pass directly to the sea
- Construct a wastes stabilization pond treatment plant for Bai Chay
- Initiate a system for systematic emptying of septic tanks and safe disposal of the septage
- Upgrade public latrines and improve sanitation in deprived areas

- Provide training and other inputs to strengthen the institutional capacity of the sanitation companies
- Conduct awareness campaigns and initiatives to encourage households in low density areas to install septic tanks

The first stage program sewerage and sewage treatment includes the following elements:

(1) Bai Chay Area

The project for the Bai Chay area includes rehabilitation of existing channels and construction of 9 km of new sanitary drainage channels. A sewage interception system comprising 3 km of gravity sewer and 6 km of pumping main with a total of 8 pumping stations (2 existing) will be constructed in two sections along the coast road to a wastewater treatment plant at Kenh Dong. The route of this interceptor sewer is indicated on Figure 18.2.1. The first section will stretch from the ferry to the post office from where the flow initially will be delivered to the Bai Chay wastewater treatment plant. However, it is intended in future that all the sewage from Vuon Dao will be pumped along the second section of main collector towards Cai Dam. Where feasible, the main collector will receive flow from overflow devices on the drainage channels and also by direct connections from properties along the main road. The works for Bai Chay are to be given the highest priority to encourage tourism in the area.

The Kenh Dong wastewater treatment plant is to be located in an expanse of brackish water which separates Gieng Day and Bai Chay and where there is sufficient area available to construct wastes stabilization ponds. The area required is 8.5 ha which includes a 50m wide buffer area. The treatment plant, which was designed to treat a flow of 3,500 m^3/day, comprised anaerobic, facultative and maturation ponds as well as a septage treatment facility to serve septic tanks in the Bai Chay area. However, an alternative design of the same capacity using the compact sequencing batch reactor process has been proposed and is presently under consideration.

(2) Hong Gai Area

The project's first stage proposals for Hong Gai with regard to sewerage and sewage treatment were modified during the approval process for the final report and no longer include a main collector sewer system or any wastewater treatment facilities, although a treatment facility at Deo Sen for septage is still included. The emphasis of the first stage works is to alleviate flooding and convey sewage by a combined drainage system to the coast where it will be discharged through outfalls which will be extended a short distance into the sea. The drainage works will comprise rehabilitation of 3 km of existing drainage channels and construction of 15 km new sanitary drainage channels and pipelines. The location of the combined drainage system is indicated on Figure 18.2.2.

The international funding includes a revolving fund of US$ 0.5 million for sanitation improvements in Hong Gai. It is expected that the fund will be used mainly for the provision of septic tanks.

(3) Cam Pha Area

Similarly to Hong Gai, the first stage works program for Cam Pha does not include a sewerage system or wastewater treatment. Flooding is considered to be the major immediate problem in Cam Pha and the emphasis of the works will be to improve the drainage system by extensive rehabilitation of existing sanitary drainage channels and construction of some new combined drainage channels. The location of the proposed combined drainage system is indicated on Figure 18.2.3. The drainage works in Cam Pha are scheduled to commence after those in Hong Gai.

A treatment facility for septage located on mud flats in an inlet between two rock outcrops some 4 km west of the town center is included in the first stage program. In the longer term, it is proposed that a wastes stabilization pond treatment system be provided on this site to serve Cam Pha.

The international funding is also to include a revolving fund of US$ 0.5 million for sanitation improvements in Cam Pha. It is expected that the fund will be used mainly for the provision of septic tanks and possibly also for double vault ventilated latrines.

18.2.2 Strategies for Development of Future Wastewater Management Plan

(1) Design Loads

1) Domestic wastewater flows

The Ha Long City Water Supply and Sanitation Project (HWSSP) has based water demands on overall per capita water consumption of 110 ℓ/c/day in the year 2003 and 150 ℓ/c/day in 2015. The planning horizon of this Study is 2010 and, for design purposes, wastewater flows have been calculated on the basis of a per capita contribution of 120 ℓ/c/day.

2) Per capita contributions

The proposed per capita contributions for determination of present and projected year 2010 pollution loads are shown below.

Per Capita Contributions

(Unit : g/day)

Pollutant	Present Day	2010
Biochemical Oxygen Demand (BOD_5)	50	54
Chemical Oxygen Demand (COD_{Mn})	22	24
Suspended Solids (SS)	38	40
Total Nitrogen (T-N)	9.0	9.1
Total Phosphorus (T-P)	1.0	1.0

The BOD contributions assumed are in line with the other studies carried out in Vietnam (particularly by CBI and Kampsax for HWSSP). These contributions apply to direct discharges to the sanitary drainage system. Pollutant loads in discharges through septic tanks are assumed to be reduced by the amounts shown below.

Reduction of Loads Through Septic Tanks

Pollutant	% Reduction of Load
Biochemical Oxygen Demand (BOD_5)	30
Chemical Oxygen Demand (COD_{Mn})	10
Suspended Solids (SS)	30
Total Nitrogen (T-N)	5
Total Phosphorus (T-P)	0

These reductions should be achieved in any septic tank that is operating correctly. They will not, however be achieved in septic tanks that cannot retain solids because they are in need of emptying.

3) Effluent discharge standards

As described in the previous chapter, two levels of treatment for domestic wastewater will have to be considered for alternative schemes to achieve the target conservation criteria. The discharge standards for the two treatment levels are as follows.

Domestic Wastewater Effluent Discharge Standards

Treatment Level	BOD_5, mg/ℓ	COD_{Mn}, mg/ℓ	SS, mg/ℓ	T-N, mg/ℓ	T-P, mg/ℓ
Level 1	25	35	35	-	-
Level 2	10	15	15	10	2

These standards are intended as limits that should be achieved at least 95% of the time and to achieve such standards it can be shown statistically that the average discharge concentrations must approach half these values. Average pollution loads from wastewater treatment plants have therefore been determined as follows.

Average Concentrations of Domestic Wastewater Effluent Discharges

Treatment Level	BOD_5, mg/ℓ	COD_{Mn}, mg/ℓ	SS, mg/ℓ	T-N, mg/ℓ	T-P, mg/ℓ
Level 1	15	21	21	-1	-1
Level 2	6	9	9	6	1.2

Note: Level 1 treatment is not designed to remove of Nitrogen and Phosphorus. However, secondary biological treatment processes will reduce T-N and T-P concentrations to 80% or less of the influent concentration.

It will also be necessary to limit coliforms in discharges near bathing beaches or other recreational areas. An effluent fecal coliform standard of 1,000 MPN/100 mℓ (on a 95 percentile basis) has been set and this can be achieved either by sterilization or through the provision of maturation ponds.

(2) On-Site Sanitation

The alternative on-site sanitation technologies have been reviewed in Chapter 4 and the recommended sanitation strategies for existing and infill development in different land use sectors are discussed below.

1) Tourism and commercial areas

Almost all properties in these areas already have flush toilets and the use of flush toilets in new construction should be universal. Septic tanks discharging to sewers or sanitary drains should be used in all cases in existing developed areas. Developers should be required to provide separate sewer systems in all major new developments.

The use of dry sanitation and soakaways for septic tank effluents is not considered appropriate in these areas and should be phased out as soon as this is feasible.

2) High density residential areas

The use of dry sanitation methods is not appropriate in high density urban development due to health risks, lack of space for adequate on-site facilities, and access difficulties for emptying pits or vaults. The use of pour flush toilets is recommended and, at least in the short term, a septic tank should be provided where feasible for each property. The space limitations have often been overcome by constructing septic tanks in the basements of houses and, providing there are adequate arrangements for access to empty the tank, this practice is considered acceptable. Separate sewerage systems will be required in high density areas in future but, where septic tanks have been installed for most properties, the provision of small bore systems would be feasible and could be financially attractive.

3) Low density residential and rural areas

The use of double vault pit latrines in these areas for properties without piped water supplies is acceptable but care needs to be taken not to contaminate groundwater supplies. In cases where there is a significant risk of contamination it is necessary to ensure that vaults are watertight and emptied regularly.

For houses with piped water supplies, pour flush toilets with septic tanks are recommended. Septic tank effluent should be discharged to soakaways where ground conditions allow and where this can be done without contaminating groundwater supplies. It may become necessary in certain areas to construct separate sewerage systems but again, where there are existing septic tanks, a low cost small bore system can be considered.

4) Tourist boats and boat residents

Tourist boats are generally large enough and generate enough revenue to make it feasible to install toilets on board and to either store or treat the wastewater. The most practical system for the majority of tourist boats will be to store the wastewater in a holding tank and provide a pump installation at the port to discharge it either to a public sewer or, initially, to a simple treatment facility. The larger tourist boats may be able to justify an onboard treatment system.

The situation with boat residents is different in that they generally do not have the space or resources to install sanitation facilities and holding tanks on their boats. It is recommended that an adequate number of public latrines are provided within easy access of the areas where the boats are moored and that an education program is conducted to persuade boat residents to use these facilities.

(3) Sewerage

The results of the Field Survey indicate that the largest sources of pollution to Ha Long bay arise from non-specific sources. A part of the non-specific pollution will result from domestic wastewater that is either flushed overland to the sea during rainfall or pollutes groundwater that enters the rivers and sea. In order to reduce the pollution loads from this source it is necessary to collect wastewater by a sewerage system and then to provide treatment to the required effluent standard.

It is recommended that conventional piped sewerage should be provided in all new development areas. The strategies for provision of sewerage facilities in areas of existing development will depend on both the timing of the works and the type of development. The various strategies proposed are discussed below.

1) Urgent measures

Although the long term objective should be to establish separate sewer systems, the most effective method of achieving immediate improvements will be to initially retain the existing combined sanitary drainage system as the collection system and to intercept wastewater flows for treatment. This is the strategy behind the program proposed by Kampsax for the first stage of HWSSP. The interceptor sewers, pumping stations and treatment plant to be provided in Bai Chay under this program will form the basis for the separate sewer systems that will be developed in the longer term. Consideration to the adoption of similar measures for Hong Gai is included in the Section dealing with phasing of work.

2) High density residential areas

Existing development in central high density areas will already have a significant number of septic tanks and there may be savings in adopting small bore sewer systems rather than conventional separate sewers.

In order to evaluate the comparative costs of these two systems, designs have been prepared and costed for the two systems to serve a typical sample area housing a population of 4,800. Details of cost estimates are given in Table 18.2.1.

The small bore system shows a clear saving over the conventional system in terms of construction cost (US$ 76/person compared to US$ 104/person). However, the small bore system will incur higher operating costs due to septic tank emptying and possible increased sewer maintenance costs, although these will be partly offset by lower treatment costs due to solids removal in the septic tanks. A net present value analysis for the two systems over a 20 year period has been carried out and the results are presented below.

Net Present Values of Small Bore and Conventional Sewer Systems

Description	Small Bore Sewer System		Conventional Sewer System	
	Rate	Amount (US$)	Rate	Amount (US$)
Initial capital investment		364,700		496,900
Annual maintenance and repair cost	2.0%	7,294	1.5%	7,454
Annual treatment cost	US$0.20/m³	22,776	US$0.30/m³	34,164
Annual tank emptying cost	US$25/tank	12,000	0	0
Net Present Value @ Discount Rate of	12%	602,302	12%	717,362
Net Present Value @ Discount Rate of	10%	651,466	10%	768,206
Net Present Value @ Discount Rate of	8%	711,781	8%	830,165

The small bore system shows savings over the conventional system in terms of net present value as well as construction cost and this system can be used to an advantage in areas of existing development where the majority of houses have septic tanks. However, it must be emphasized this system will only operate successfully if there is a strong sewerage authority to control connections to the system and the emptying of interceptor tanks. At the start of a scheme the sewerage authority should desludge and, if necessary, renovate the existing septic tanks. The authority should then arrange for the tanks to be desludged annually. The desludging costs should be recovered from householders as part of a general wastewater fee.

3) Low density and rural areas

These areas in general have a low priority for piped sewerage and it is recommended that systems should only be provided where necessary to protect ground water resources or to solve a particular public health problem. When piped sewerage is required, there will be significant savings through adopting small bore sewers.

(4) Wastewater Treatment

As discussed above, it is necessary to consider two different standards of treatment to suit the various scenarios. The two treatment and effluent standards may be defined as follows:

- Level 1 - basic secondary treatment to achieve an effluent standard of 25 mg BOD_5/ℓ and 35 mg SS/ℓ.
- Level 2 - with nitrification/denitrification and enhanced biological phosphorus removal to achieve an effluent standard of 10 mg BOD_5/ℓ, 15 mg SS/ℓ, 10 mg N/ℓ, and 2 mg P/ℓ.

The treatment processes that are considered suitable for use in the project area to achieve the Level 1 effluent standard are:

- Waste stabilization ponds with an anaerobic stage
- Conventional activated sludge
- Extended aeration (oxidation ditch)
- Biological filtration
- Sequencing batch reactors

The treatment processes that are considered suitable for use in the project area to achieve the Level 2 effluent standard are:

- Extended aeration (oxidation ditch)
- Sequencing batch reactor

1) Process descriptions for level 1 treatment

The main features of these systems are described below.

a) Waste stabilization ponds with anaerobic ponds

Stabilization ponds consist of a series of open, relatively shallow, flow-through lagoons which operate largely without mechanical treatment and with low maintenance requirements. The standard and reliability of treatment is high in adequately sized systems but the process is highly temperature dependent and relatively long detention times would be necessary to maintain performance during the colder winter months. Land requirements can be nearly halved by the use of anaerobic ponds before the facultative and maturation stages but the total land requirement is still large.

A small quantity of digested sludge is produced in the anaerobic ponds which can be removed as infrequently as once a year or less.

Operation and maintenance of waste stabilization ponds is simple and, although not advisable, it is one of the few treatment processes that will continue to operate for an appreciable period of time without adequate maintenance.

b) Conventional activated sludge

This process basically involves the aeration of settled sewage mixed with return activated sludge in an aeration tank, the air being introduced into the liquid by either surface aerators or by a diffused air system. The biomass generated in the aeration process is normally flocculent and settles out relatively easily in the secondary settlement tanks. The majority of this secondary, or 'activated', sludge is recycled to the aeration tank. Thus, the principal units required after preliminary treatment include primary settlement tanks, aeration tanks, secondary settlement tanks, and a return activated sludge pumping station.

The process produces a large quantity of unstable sludge that requires treatment before disposal. The most common method of sludge treatment for plants of the size required in Ha Long is digestion, either aerobic or anaerobic. Anaerobic digestion, which is commonly used for large plants, requires a considerable amount of mechanical equipment and adds to the cost and complexity of the overall treatment process. Against this, energy requirements are low, particularly if the methane produced during digestion is used as a source of energy. In contrast, aerobic digestion is simple in design and low in capital cost but has a high energy cost. Aerobic digestion is therefore favored where it is necessary to provide sludge treatment at smaller treatment plants serving a population up to about 50,000. Anaerobic digestion will be more economic for larger plants or for a sludge treatment center serving all the treatment plants in a region.

The activated sludge process is the most common aeration treatment system in use and is most commonly selected for large plants. However, the process requires skilled operation and has relatively poor resistance to shock loads. The system also requires a high proportion of electro-mechanical equipment and that results in relatively high construction and maintenance costs.

c) Extended aeration (oxidation ditch)

An extended aeration system normally comprises an oxidation ditch together with final clarifiers and pumps to recirculate sludge to the ditch or aeration tank. The retention period in the aeration stage is at least 18 hours compared to 4 – 8 hours in conventional activated sludge. The process is capable of producing a high quality nitrified effluent.

Extended aeration is a robust process with good resistance to shock loads and has the advantages of simple construction, no requirement for primary settlement, and moderate production of a stable sludge which does not require further treatment apart from dewatering. The process also requires less electro-mechanical equipment than conventional activated sludge and is therefore simpler and cheaper to operate and maintain. The disadvantages compared to conventional activated sludge are higher energy requirement and an increased land requirement.

Small oxidation ditches can be designed using lined earth embankments but, for larger works, a more land efficient solution is achieved by constructing the ditches with concrete bases, channel walls and central baffle walls.

d) Biological filtration

This comprises a permeable bed of media, of either graded natural stone or inert synthetic material such as plastic, through which sewage flows. The filter is generally some 2.0 m deep and normally circular in plan. Sewage is distributed evenly on the surface and effluent is collected through under drains in the base, which also allow circulation of air upward around the media. The units are normally preceded by primary settlement and followed by secondary (humus) to collect settleable organic solids washed out of the filters.

The oxidation process as the wastewater passes through the media results in a gradual build-up of slime (aerobic bacteria and biota) on the media surface. The organic fraction of the sewage is absorbed by the slime and degraded by the biota. The slime gradually sloughs off as the thickness builds up and settles in the humus tanks. The process produces a similar quantity of biological sludge to the activated sludge process and the sludge is also unstable and in need of further treatment. Thus, the prior comments on activated sludge regarding sludge digestion apply equally to biological filtration.

Percolating filters are able to withstand shock loads and provide a reliable means of treating wastewater with low energy requirement and relatively little maintenance or skilled operation (apart possibly for sludge treatment facilities). However, they require a relatively large land area and can be prone to odor and fly nuisance.

e) Sequencing batch reactor

The basic technology of a sequencing batch reactor (SBR) is the same as the conventional activated sludge process but all the steps of the process take place sequentially in one tank. The steps of a typical SBR process involve filling a tank with settled or unsettled sewage, aerating the sewage to convert the organic material to biomass, providing a quiescent period for settlement and finally discharge of the settled effluent. After discharge, an idle period is allowed in the batch process to provide flexibility and security as the incoming flow has to be switched to an empty tank while the other tanks are going through the aeration, clarification, and discharge procedures. A key element of the SBR process is that the majority of settled sludge is retained in the tank for the next cycle thus avoiding the need for return sludge pumps.

The quantity and characteristics of the surplus sludge produced depend to some extent upon the mode of operation. At the higher loading rates, a similar quantity of unstable sludge will be produced to that from the conventional activated sludge process. At the lower loading rates, the quantity of sludge will be similar to that from the extended aeration process and the sludge may also be stable.

Because of the dual function of the SBR tanks, civil construction costs and plant area are lower than for conventional activated sludge. There is also a lower requirement for mechanical equipment compared to conventional activated sludge but, against this, the process control system is normally automated and requires extensive use of motorized valves, timers, programmable logic controllers or computers, and other devices. The maintenance requirements for the process are therefore rather specialized. Operation of a system with automated control is relatively easy but skill is needed to adjust the system to cope with changes in loads or wastewater characteristics.

2) Process descriptions for level 2 treatment

The nutrient removal required to meet the Level 2 discharge standard inevitably makes the treatment process complex and relatively expensive. For large populations, nutrient removal can only be achieved at reasonable cost by biological methods. The methods that can be used are all variants of the activated sludge process and the variants that are economic and considered suitable for the project area are described below.

a) Oxidation ditch with side stream phosphorus removal

Nitrogen removal in oxidation ditches is readily achievable through the process illustrated in Figure 18.2.4. Nitrification, that is the oxidation of ammonia to nitrite and then to nitrate, takes place in the aerobic zone downstream of the surface aerator. Denitrification, that is the reduction of nitrate to nitrogen gas, oxygen and ammonia, takes place in the anoxic zone remote from the aerator. Incoming raw sewage is added at the start of the anoxic zone to provide the carbon source required for the reduction of the nitrate.

Phosphorus removal in an oxidation ditch system requires additional tanks either in the main stream process or in a side stream process. As will be explained later, the characteristics of the sewage in the EMP area are likely to be unfavorable for mainstream treatment and a chemically assisted side stream process is therefore preferred. The proposed system, which is a proprietary process known as PhoStripTM, is illustrated in Figure 18.2.5. A portion of the return activated sludge from the biological process is diverted to an anaerobic phosphorus stripping tank. The phosphorus released in the stripping tank passes out of the tank in the supernatant, and the phosphorus depleted activated sludge is returned to the oxidation ditch. The phosphorus-rich supernatant is treated with lime or another coagulant in a separate tank and discharged to a flocculation/clarification tank where the phosphorus can be removed from the system in the chemical precipitate.

The operation and maintenance requirements for a treatment plant with nutrient removal are inevitably more demanding than for an equivalent size Level 1 treatment plant. However, in this case the increased operation and maintenance requirements relate mainly to the phosphorus removal plant which is a side stream process and, if necessary, this could be taken out of commission for a period without affecting the main treatment process.

b) Sequencing batch reactors

Sequencing batch reactors can be operated to achieve any combination of BOD treatment, nitrogen reduction and phosphorus removal. Reduction of these constituents can, in theory, be accomplished with or without chemical addition by changing the operation of the reactor. In the arrangement shown in Figure 18.2.6, phosphorus release will take place in the anaerobic stir phase, with subsequent phosphorus uptake in the aerobic stir phase. Nitrification will also occur in the aerobic stir phase, with denitrification taking place in the following anoxic stir stage. In practice, additional aerobic, anaerobic and anoxic stages would also be introduced into the treatment cycle shown in Figure 18.2.6 to increase the efficiency of nitrogen and phosphorus removal. A carbon source, either external or endogenous respiration of biomass, is necessary in the anoxic stage to support denitrification. Depending on the characteristics of the raw sewage, a source of volatile fatty acids may have to be added to the reactor to ensure consistent phosphorus removal.

Operation and maintenance of an SBR with nutrient removal should not in theory be much more demanding than a conventional SBR with automatic control. However, operation would become far more complex, if, as is likely, it is necessary to add either primary settlement and digestion to produce the volatile fatty acids or chemical phosphorus treatment.

3) Cost comparisons for alternative treatment processes

a) Estimated capital costs

Outline designs for all of these treatment processes have been prepared and costed in order to evaluate which are the preferred methods for Level 1 and 2 treatment in the project area. The outline designs have been prepared for both Level 1 and Level 2 treatment plants to serve a nominal population equivalent of 20,000. The estimated capital costs, including land costs based on a rate of US$ 10/m^2, are summarized below.

Estimated Costs of Level 1 Process Alternatives

(Unit: US$ x 10^6)

Process	Construction Cost	Land Cost	Total Cost
Conventional activated sludge	2.03	0.03	2.06
Extended Aeration (Oxidation Ditch)	1.56	0.03	1.59
Biological Filtration	2.98	0.10	3.08
Sequencing Batch Reactor	1.63	0.02	1.65
Waste Stabilization Ponds	1.21	0.57	1.78

Estimated Costs of Level 2 Process Alternatives

(Unit: US$ x 10^6)

Process	Construction Cost	Land Cost	Total Cost
Extended Aeration (Oxidation Ditch)	2.10	0.04	2.14
Sequencing Batch Reactor	2.16	0.04	2.20

As would be expected, waste stabilization ponds have the lowest construction cost but their large land requirement means that they are not necessarily cheaper overall. At the land cost used for this analysis (US$ 10/m^2) the total investment cost for waste stabilization ponds is higher than that for oxidation ditches and sequencing batch reactors. It is, however, necessary to consider running costs as well as capital costs.

With regard to the higher Level 2 standard of treatment, an oxidation ditch appears to be marginally cheaper than a sequencing batch reactor but it is again necessary to consider running costs as well as capital costs.

b) Running costs

The running costs in terms of electricity costs, sludge conditioning (chemical) costs and general operation and maintenance costs have been determined for each process alternative and are summarized below.

Estimated Annual Running Costs for Level 1 Process Alternatives

(Unit: US$ x 10^6)

Process	Electricity Costs	Sludge Costs	O & M Costs	Total Running Cost
Conventional activated sludge	0.026	0.008	0.024	0.058
Extended Aeration (Oxidation Ditch)	0.025	0.009	0.021	0.055
Biological Filtration	0.016	0.006	0.032	0.054
Sequencing Batch Reactor	0.026	0.008	0.021	0.055
Waste Stabilization Ponds	0.007	0.004	0.016	0.027

Estimated Annual Running Costs for Level 2 Process Alternatives

(Unit: US$ x 10^6)

Process	Electricity Costs	Sludge Costs	O & M Costs	Total Running Cost
Extended Aeration (Oxidation Ditch)	0.030	0.010	0.027	0.067
Sequencing Batch Reactor	0.019	0.019	0.026	0.064

Due to the lack of mechanical equipment and minimal energy requirements, the running costs for waste stabilization ponds are significantly lower than the running costs of any other Level 1 treatment alternatives. However, as pointed out above, the overall costs of waste stabilization ponds depend very much on the cost of land and it is therefore necessary to carry out a net value analysis of the process alternatives to determine which are economically viable.

With regard to Level 2 treatment, the running costs of sequencing batch reactors are slightly lower than those of oxidation ditches.

c) Net present value analysis

The capital and running costs of all the process alternatives have been discounted over a 20 year period at discount rates of 8%, 10% and 12%. The results of these analyses for Level 1 and Level 2 treatment process alternatives are presented below.

Net Present Values of Level 1 Process Alternatives

(Unit: US$ x 10^6)

Process	Net Present Value		
	Discount Rate, 8%	Discount Rate, 10%	Discount Rate, 12%
Conventional activated sludge	2.417	2.308	2.215
Extended Aeration (Oxidation Ditch)	1.956	1.859	1.777
Biological Filtration	3.330	3.209	3.103
Sequencing Batch Reactor	2.019	1.921	1.837
Waste Stabilization Ponds	1.881	1.818	1.762

Net Present Values of Level 2 Process Alternatives

(Unit: US$ x 10^6)

Process	Net Present Value		
	Discount Rate, 8%	Discount Rate, 10%	Discount Rate, 12%
Extended Aeration (Oxidation Ditch)	2.579	2.456	2.352
Sequencing Batch Reactor	2.599	2.481	2.380

It can be seen that, for Level 1 treatment process alternatives, the discounted costs for wastes stabilization ponds are marginally less than those for oxidation ditches. Sequencing batch reactors are slightly more expensive than oxidation ditches, whilst conventional activated sludge and, in particular, biological filters are significantly more expensive and need not be considered further.

For Level 2 treatment, there is little or no difference between the overall costs of oxidation ditches and sequencing batch reactors. It should be noted, however, that Level 2 treatment is approximately 35% more than Level 1 treatment for an equivalent load.

4) Recommended processes for level 1 treatment

The advantages and disadvantages of the processes that are competitive are summarized in Table 18.2.2. Consideration of these advantages and disadvantages allows the following conclusions to be drawn:

- Waste stabilization ponds have some cost and operational benefits and should be adopted where sufficient suitable land is available. However, the availability of large areas of flat land in or near urban areas in the EMP area is very limited and major land reclamation is taking place to provide sites for future developments. It is therefore unlikely that sites for waste stabilization pond will be available.
- Oxidation ditches have a much smaller land requirement than waste stabilization ponds and also have some cost and operational advantages over sequencing batch reactors. They are therefore the preferred method of treatment for most locations.
- Where there is insufficient land available for oxidation ditches, sequencing batch reactors are a suitable compact treatment method.

5) Recommended processes for level 2 treatment

Although there is little or no difference in the costs of the two processes considered, oxidation ditches with side stream phosphorus removal are generally preferred to sequencing batch reactors because the process is more robust and requires less operational skill. This will be particularly true in the project area due to the characteristics of the wastewater. Since the majority of the incoming sewage will have passed through septic tanks it will be weak with a low BOD:P ratio. This is unfavorable for biological phosphorus removal and the addition of volatile fatty acids and/or chemicals will almost certainly be required to achieve the target phosphorus standard in a sequencing batch reactor. On the other hand, an oxidation ditch with the PhoStripTM process will be less influenced by the BOD:P ratio.

Sequencing batch reactors, with the addition of either primary settlement and digestion to produce the volatile fatty acids or chemical phosphorus treatment, may have to be used where the land available for treatment is very small and nutrient removal is necessary. However, either of these additions would increase both the complexity of the treatment process and the cost of treatment and this solution should only be adopted where absolutely necessary.

6) Strategy for locating wastewater treatment plants

It is normal practice in developed countries for wastewater treatment plant facilities for urban areas to be centralized and for flows from different natural catchment areas to be transferred to a limited number of plants for treatment. This practice has been common in recent years, with many small treatment plants being closed and flows transferred to larger central plants. The reasons for this have been mainly to reduce operating costs and to achieve compliance with more stringent discharge concentrations.

However, it can be argued that, for the coastal strip development and steep catchments common in the Ha Long Bay area, it may be cheaper to adopt a system using small treatment plants serving local areas and thereby largely avoid the costs of a main collection system. An outline analysis of the costs of centralized and local treatment schemes to serve the Hong Gai area has therefore been carried out. For this exercise, a scheme with one large central treatment plant has been compared with one using nine small treatment plants. All the treatment plants were designed for the extended aeration process using the same design criteria and costed using the same construction unit rates. The results of the analysis are illustrated in Figure 18.2.7.

The construction costs show little difference, with the centralized system being marginally cheaper. This is because the considerable savings on main collector costs in the local treatment scheme are more than balanced by the savings on the large centralized treatment plant due to economy of scale. As would be expected, there is a more noticeable difference in running costs in favor of the centralized treatment scheme. On the other hand, the possibility to phase investments more effectively in the local treatment scheme means that there is no significant difference in net present values.

Overall it is considered that, given the difficulties of finding treatment plant sites in the Ha Long area and the operational difficulties of running a large number of small plants, the centralized approach is still the most appropriate for the EMP area. This does not mean that a single plant for the Hong Gai area is the optimum answer but merely that a relatively small number of large treatment plants will be more appropriate in the long term than many small treatment plants. With regard to Hong Gai, there are strong reasons both from the point of view of topography and target conservation criteria for having a treatment plant to serve the south of Hong Gai in addition to one to serve the north.

18.2.3 Alternative Sewerage Schemes for Urban Areas

(1) West Ha Long City

The planned sewerage works under the first stage of HWSSP for the Bai Chay area have been described at the start of this Section and it is taken as a given condition for this Study that these works will be executed. While these measures will provide a solution in the short term for the Bai Chay area, it is also necessary to consider the longer term requirements of the whole of west Ha Long city and how the Bai Chay system may be integrated.

Under the Master Plan for Ha Long City for 1994-2000 (HLMP), the area to the west of the Cua Luc strait is to be a major focus of development with large tourism, commercial and residential developments in the Hung Thang area; a large industrial park in Cai Lan; and major industrial and residential development in the Hoanh Bo area. Wastewater discharges from this area are critical as they will either be to the enclosed Bai Chay bay or they can affect the tourist bathing beaches and the buffer zone of the World Heritage area.

With regard to domestic wastewater, two basic options have been considered. The area contains two natural catchments, the southern coastal area, and the inland areas that drain to Bai Chay bay. In the first option flows from the two catchments would be treated separately. Flows from the coastal area would be conveyed to a treatment plant at Don Dien, west of the World Heritage buffer area. This location for the treatment plant allows effluent to be discharged well away from the bathing beaches and buffer area and, in consequence, Level 1 treatment is adequate. In the long term it is assumed that the flows from the Bai Chay area would be transferred to this treatment plant rather than being treated at Kenh Dong. The location of Kenh Dong is regarded as unsuitable for development into a major treatment site as it is near the future bathing and resort areas and the site, which will be in a central development area, will be probably be more suited for other uses. However, the waste stabilization ponds that will be constructed under the first stage HWSSP program could continue to serve part of the Bai Chay area for many years. Flows from the inland catchment would be collected at a central treatment plant at Dong Dang from where the effluent would be discharged to Bai Chay bay. Level 2 treatment would be necessary at this plant to meet the target conservation criteria for Bai Chay bay. The locations of the treatment plants and the main collection systems are shown on Figure 18.2.8.

The second option, which is also indicated in Figure 18.2.8, would be to transfer the flow from the inland catchment to the coast for treatment at Don Dien. Although the route is fairly long, there is a pass in hills between the two catchments which allows the pumping head to be kept within the economic range. The advantage of this option is that treatment to Level 1 would be adequate for the combined flows from the two catchments.

The key parameters for the treatment plants required for the two options are summarized below and full details are included in Appendix 5. Land areas quoted include appropriate buffer areas.

Details of Domestic Wastewater Treatment Plants for West Ha Long City

Treatment Plant	Population Served (2010)	Process	Land Area Required (ha)
Option 1			
Don Dien	30,000	Oxidation Ditch	2.8
Dong Dang	90,200	Oxidation Ditch + Nutrient Removal	3.8
Option 2			4.1
Don Dien	120,000	Oxidation Ditch	

(2) Hong Gai Area

The population of the Hong Gai area is projected to increase to nearly 300,000 by 2010 and potentially it will be the source of the largest domestic wastewater flows in the EMP area. There are again two natural catchments, the northern area which drains to Bai Chay bay, and the coastal area which drains to Ha Long bay. The northern area has the majority of the population with a projected 2010 figure of some 200,000.

In theory it would be possible to consider similar options to those in the west Ha Long City area. However, sites for treatment plants are very limited in the southern part of Hong Gai so it is not feasible to find a site suitable in the long term for the combined population of the two catchments. Therefore, the only feasible option for Hong Gai is to have separate treatment plants for the northern and southern areas. The northern plant, which will be sited near the proposed HWSSP septage treatment plant at Deo Sen, will have to treat to Level 2 standard to meet the target conservation criteria for Bai Chay bay. The southern coast of the Hong Gai area is densely developed and it is difficult to find suitable sites for a treatment plant. In order to minimize collector costs it is desirable to locate the plant near the central area where the need for treatment is most urgent. Preliminary investigations indicate that it should be possible to reclaim land on the south side of an island in the Bach Dang area and locate a compact treatment plant on this site. Level 1 treatment will be adequate for this location.

The locations of the treatment plants and the main collector sewers are shown in Figure 18.2.9. The key parameters for the treatment plants required are summarized below and full details are included in Appendix 5. The land area quoted for Deo Sen includes an appropriate buffer areas but the area quoted for Bach Dang is the net area of the treatment facilities.

Details of Domestic Wastewater Treatment Plants for the Hong Gai Area

Treatment Plant	Population Served (2010)	Process	Land Area Required (ha)
Deo Sen	164,000	Oxidation Ditch + Nutrient Removal	6.4
Bach Dang	60,000	Sequencing Batch Reactor	0.6

Note: The population quoted for Deo Sen is for Alternative 3.2. Some alternatives require a larger population to be served.

(3) Cam Pha Area

Cam Pha is the second major urban area in the EMP area with a projected 2010 population of nearly 150,000. The development is all in the coastal strip draining to Bai Tu Long bay. This layout is suitable for a coastal collector system to a central treatment plant. The most suitable location for the treatment plant is at the proposed HWSSP septage treatment plant which is located at the western end of the town at the boarder of the Cam Thach and Quang Hanh districts.

The locations of the treatment plant and main sewer collection system are shown on Figure 18.2.9. The first stage of the treatment plant to be provided within the time frame of the EMP will have capacity to serve a population of 45,000. Treatment to Level 1 standard will be sufficient to meet the target conservation criteria in Bai Tu Long bay and the provision of an oxidation ditch is recommended. Full details of the treatment plant are included in Appendix 5. The estimated costs of the recommended program for Cam Pha are given below.

Estimated Costs for Cam Pha Sewerage Program

Component	Unit	Quantity	Rate (US$)	Amount (US$)
Main collectors sewers including pump stations	km	13.3	128,000	1,702,000
Interception structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater treatment plant	L.S.	1	2,327,000	2,327,000
			Baseline Cost for Cam Pha	5,663,000
			Add for engineering, supervision, contingencies, etc	1,532,000
			TOTAL COST FOR CAM PHA	7,195,000

18.2.4 Basis of Cost Estimation for Sewerage

(1) Collection Systems

Collection systems are considered in three sections: the main collection system, which includes pumping stations, local collection systems in existing development; and local collection systems in new development.

Rates for main collection systems have been developed on a unit length basis for each catchment area. The average sizes of collector sewers and pumping stations have been derived for each catchment based on the projected 2010 flows. The build up of the rates for each catchment is shown in Table 18.2.3.

Cost estimates for local collection systems are determined on a population served basis using the per capita rates shown in Table 18.2.1. Local collection in existing development is assumed to use the small bore system while conventional sewer systems are used for new development.

(2) Wastewater Treatment

The use of unit rates for estimation of treatment costs (either on a flow or load basis) is not suitable for comparative cost analyses since it ignores economy of scale, which can be a significant factor. The cost estimates for treatment plants have therefore been derived by costing preliminary designs for each treatment plant. Details of the designs and cost estimates are included in Appendix 5.

18.2.5 Priority Areas and Urgent Measures for Wastewater Management

The priority areas for wastewater management are the Bai Chay area because of its influence on tourism development, and the central areas of Hong Gai for public health reasons and because Hong Gai is the seat of the Provincial Government and the commercial center of Ha Long city. Cam Pha has a lower priority, principally because both water consumption and numbers of septic tanks are lower than in the other areas and the present domestic wastewater flows are therefore relatively small.

The first stage works of HWSSP for the Bai Chay area constitute a suitable urgent measures package to deal with the present wastewater problems and it is therefore unnecessary to consider any other urgent measures for this area in the EMP.

The situation in Hong Gai is different since sewage collection and treatment have now been omitted from HWSSP first stage program. It is therefore proposed that collection and treatment of sewage from the commercial center and densely populated central areas should be regarded as an urgent measure in the EMP. As described earlier, the approach should be to construct parts of the main collection system to intercept flows from the sanitary drainage channels and pipes that will be rehabilitated or provided in HWSSP first stage program. As outlined above, two treatment plants will be required, one at Deo Sen and the other near Bach Dang. It is recommended that the capacity provided at Deo Sen in the urgent measures should be 25% of the projected 2010 capacity. This equates to an initial population served of about 40,000. For the Bach Dang plant, 50% of the projected 2010 capacity should be provided and this would serve a population of about 30,000. The estimated cost of the urgent measures program is as follows.

Estimated Cost of Urgent Measures Program

(Unit: US$ x 10^6)

Component	Estimated Cost
1st Stage Works at Deo Sen	3.5
1st Stage Works at Bach Dang	2.2
Main Collector System	2.7
Interception Structures and local connections	1.4
TOTAL	9.8

The extent of the urgent measures main collection systems and the locations of the treatment plants are shown in Figure 18.2.10.

18.2.6 Recommendations for Domestic Wastewater Management

The recommendations for domestic wastewater management may be summarized as follows:

- The standard of treatment required for domestic wastewater discharges will be determined by the target conservation criteria for the receiving waters.

- Flush toilets should be provided in all tourism and commercial developments. They are also recommended for high density residential development.
- Dry sanitation methods and septic tanks draining to soakaways are generally suitable in low density and rural areas.
- Separate piped sewer systems should be provided in major new development.
- Small bore sewer systems will be suitable for existing development if properly managed and controlled.
- Oxidation ditches are generally recommended for Level 1 wastewater treatment. Sequencing batch reactors are suitable if a very limited land area is available.
- Oxidation ditches with side stream phosphorus removal are recommended for Level 2 treatment.
- Two options should be considered for the domestic wastewater plan for west Ha Long city, one with two treatment plants and the other with a single plant discharging at the west of the area.
- Separate treatment plants should be provided for the northern and southern areas of Hong Gai.
- A single treatment plant located to the west of the town should be provided to serve Cam Pha.
- The construction of parts of the main collection systems in northern and southern Hong Gai together with the first stages of the Deo Sen and Bach Dang treatment plants should form part of the urgent measures program of the EMP.

18.2.7 Existing Plans for Solid Wastes Facilities

The Feasibility Study for the Sanitation Component of HWSSP has proposed a first stage program for solid wastes collection and disposal. Detail design for this program has commenced recently. The overall targets for collection coverage in Ha Long city and Cam Pha in the first stage program are 65% and 50%, respectively. For Ha Long city the targets are 50% coverage in Bai Chay and 70% coverage in Hong Gai.

At present two systems for collection of household wastes are in use in Ha Long city and Cam Pha, namely, the door to door collection system and the collection point system. Kampsax International has evaluated two variations of the present collection point system, the wastes bin system and the fixed cart system, and they have recommended that they also be introduced in appropriate areas.

The first stage program includes the provision of vehicles and collection equipment to replace existing equipment and to provide capacity to meet the first stage targets.

With regard to disposal of solid wastes, Kampsax International reviewed a number of potential landfill sites proposed by the authorities in Ha Long city and Cam Pha and recommended in the Sanitation Feasibility Study that the following measures be included in the first stage works program.

i) Upgrading of the Deo Sen landfill for reception of wastes from Hong Gai until about 2010

ii) Construction a new sanitary landfill at Quang Hanh initially for wastes from Cam Pha but, in the long term to serve the whole urbanized area

iii) Construction of a new sanitary landfill at Ha Khau to serve Bai Chay for at least 10 years and possibly longer if the planned bridge across the Cua Luc straight is not constructed

The locations of the landfill sites are shown on Figure 18.2.11.

The landfill site for Bai Chay at Ha Khau has a total area of about 10 ha. The capacity to be provided in the first stage program is 140,000 m^3 compacted wastes, for which a disposal area of 3.2 ha will be required. An additional 1.0 ha will be required for leachate treatment but there will still be sufficient area for a second phase landfill if the wastes from Bai Chay cannot be taken to a joint landfill. A separate section of the landfill will be designed to accommodate dried sludge from the Kenh Dong wastewater treatment plant.

Under HWSSP, disposal of wastes from Hong Gai will continue at the existing Deo Sen site by upgrading it to a sanitary landfill and expanding the disposal area. The volume of the Deo Sen site is calculated to be 480,000 m^3, which should be adequate for about 10 years after the opening of the expanded filling areas. The total area of the landfill will be 5.4 ha which includes 0.6 ha for leachate treatment.

A separate section of the landfill will be designed to accommodate sludge from the Deo Sen septage treatment plant.

The proposed landfill site for Cam Pha is at Quang Hanh and the site has a total area of about 22 ha. The capacity to be provided in the first stage program is 340,000 m^3 compacted wastes, for which a disposal area of 5.2 ha will be required. An additional 1.1 ha will be required for leachate treatment but there will still be sufficient area for a second phase joint landfill development. A separate section of the landfill will be designed to accommodate dried sludge from the sludge treatment facility in Cam Pha. There is a large flat area on the site, previously occupied by a factory, that could be used for the storage and/or treatment of separated wastes fractions. It is suggested by Kampsax that the area could be used in the future for windrow composting of organic wastes and sludges.

The existing Vung Duc dump site will be closed and landscaped after two to three years when wastes disposal can start at the Quang Hanh site. An embankment will be constructed to prevent seawater washing out leachate and wastes particles. A three layer top cover system will be provided so that rain water cannot infiltrate the closed dump.

The estimated costs of the solid wastes component of the first stage program of the HWSSP are shown in Section 18.2.1.

18.2.8 Criteria for Development of Solid Wastes Management Plan

(1) Wastes Generation Criteria

Pilot studies carried out by Kampsax in 1997 indicated that total wastes generation from households was approximately 650 g/c/day in Hong Gai and Bai Chay, and 570 g/c/day in Cam Pha. The average density of the wastes was found to be 400 kg/m^3. These figures are in line with typical wastes generation rates in other low income countries and it is recommended that they are accepted as the basis for deriving wastes generation criteria. Kampsax also estimated that 15% of the total wastes generated was recycled before collection. Assuming a growth rate of wastes generation of 2% per annum, the household wastes collection potential rates will be as shown below.

Household Wastes Collection Potential

Area	Present		2010	
	Collection potential (g/c/day)	Collection potential (ℓ/c/day)	Collection potential (g/c/day)	Collection potential (ℓ/c/day)
Hong Gai and Bai Chay	550	1.38	710	1.78
Cam Pha	485	1.21	630	1.57

(2) Street Sweeping

Street sweeping takes place in areas with no collection system and in streets with many shops and markets. The environment companies advised Kampsax that the volume of street sweepings collected in Hong Gai, Bai Chay and Cam Pha were 33, 10 and 20 m^3/day respectively. These amounts are equivalent to 20% of the household wastes collection potential in Hong Gai and Bai Chay, and 13% of the potential in Cam Pha.

(3) Commercial, Market and Institutional Wastes

The volumes of these wastes collected by the environment companies in 1997 were 30, 12, and 18 m^3/day in Hong Gai, Bai Chay, and Cam Pha, respectively. These rates are equivalent to 18%, 25%, and 12% of the household wastes collection potential in Hong Gai, Bai Chay, and Cam Pha, respectively.

(4) Hospital Wastes

The volumes of these wastes collected by the environment companies in 1997 were 3.2 m^3/day in Hong Gai and 0.1 m^3/day in both Bai Chay and Cam Pha. These rates are equivalent to 2.0%, 0.2%, and 0.06% of the household wastes collection potential in Hong Gai, Bai Chay, and Cam Pha, respectively.

(5) Industrial Wastes

Any industrial wastes collected now by the environment companies is included in the figures given in section (3) above. Analysis of the questionnaire issued by this Study has confirmed that some industries transport their process wastes directly to landfills but with the exception of the coal industry, the quantities are small at present.

(6) Present and Projected Domestic Solid Wastes Quantities

The target areas for the domestic solid wastes management plan are the built up urban areas within the study area. The collection areas are indicated in Figure 18.2.10. The estimated present and 2010 populations in target area are given below.

Present and Projected Populations in Collection Areas

(Unit: person)

Area	Present	2010
Bai Chay including urban areas in Hoanh Bo	45,380	119,650
Hong Gai urban area	114,960	291,500
Cam Pha urban area	111,040	145,500
Total	271,380	558,660

The estimated quantities for domestic solid wastes collection potential in the Hong Gai, Bai Chay and Cam Pha areas are presented below for the present day and the projected 2010 situation. The solid wastes quantities have been calculated using the populations given above and the wastes generation criteria.

Present Solid Wastes Collection Potential Amounts

Solid Wastes Source	Hong Gai		Bai Chay		Cam Pha	
	ton/year	m^3/year	ton/year	m^3/year	ton/year	m^3/year
Household Wastes	29,792	74,480	11,760	29,401	25,534	63,834
Street Sweeping	5,958	14,896	2,352	5,880	3,319	8,298
Commercial, Market, etc.	5,363	13,406	2,940	7,350	3,064	7,660
Hospital Wastes	596	1,490	12	29	26	64
Total	41,709	104,272	17,064	42,660	31,943	79,856

Projected 2010 Solid Wastes Collection Potential Amounts

Solid Wastes Source	Hong Gai		Bai Chay		Cam Pha	
	ton/year	m^3/year	ton/year	m^3/year	ton/year	m^3/year
Household Wastes	75,542	188,856	31,007	77,518	33,458	83,644
Street Sweeping	15,108	37,771	6,201	15,504	4,350	10,874
Commercial, Market, etc.	13,598	33,994	7,752	19,380	4,015	10,037
Hospital Wastes	1,511	3,777	31	78	33	84
Total	105,759	264,398	44,992	112,479	41,856	104,639

18.2.9 Strategy for Solid Wastes Management

(1) Elements of a Wastes Management System

The activities associated with the management of municipal solid wastes can be grouped into six physical elements:

- Wastes generation
- Wastes handling, separation and storage at the source
- Collection
- Separation, processing and transformation
- Transfer and transport
- Disposal

A further element which is as important as any of the physical elements is education and enforcement.

(2) Wastes Generation

Wastes generation is the first element in solid wastes management but not one that is easily controlled. The creation of separate systems for handling and disposing of biomedical and other special wastes as well as facilities for treating septage will marginally reduce the quantity of municipal solid wastes. On the other hand, as the area becomes more industrialized and prosperous, per capita wastes generation will inevitably increase. The ways in which source generation may be limited include:

- Reduce unnecessary or excessive packaging
- Develop and use products with greater durability
- Substitute reusable products for disposable
- Use fewer resources (e.g. two sided copying).
- Increase recycled material content of products

(3) Wastes Handling, Separation and Storage at Source

Wastes handling and separation involves the management of wastes until they are placed in storage containers for collection. Handling also includes the movement of loaded containers to the point of collection. Separation is an important step in the handling and storage of solid wastes at source as this is the best place to separate wastes materials for reuse and recycling. Fortunately, as described previously, this is already widely practiced in the study area.

On-site storage is of primary importance because of public health concerns and aesthetic considerations. The types of storage for solid wastes can be divided into two categories: household storage and communal storage. Household storage units are generally designed for curbside collection services. This is a system that may be applicable to new development areas and some central areas but is unlikely to be suitable for the majority of existing residential development within the study area. Household storage units may be non-standard containers provided by the householder or standardized containers provided by the collection agency. The use of standardized containers provides considerable advantages in terms of public health and collection efficiency but they represent a large investment and can be subject to theft and misuse. The provision of standard household containers by the environment companies cannot be recommended in the short term but it may become realistic for some areas in the longer term.

Communal storage units are often portable and may include large steel drums, liftable metal containers and roll-on metal containers. In areas where motorized collection is not feasible, communal storage units may be cart mounted or small enough to be lifted on to a cart. Kampsax in the Sanitation Feasibility Study for HWSSP has proposed both of these systems. Larger portable units are appropriate for large buildings in city center areas as well as densely populated single family dwellings. An advantage of portable units which can be taken to the disposal site is that they allow the transport unit to be used efficiently as haulage time is not lost through collection activities. Typically the transport unit carries a number of containers and leaves an empty container to replace the full container. In this way the area should not be subject to blatant dumping because of inadequate equipment availability.

Location of storage containers is an important consideration, particularly for communal storage containers. They must be conveniently sited and near enough to the households served for it to be a realistic expectation that residents will carry their wastes to the container. On the other hand, they should not be located where they could be an obstruction, an eyesore, or a potential health hazard.

Household storage units, such as dustbins, require a different form of citizen participation in that the container should be placed at the curbside at a certain time of the day and should not be left on the curb for too long. More appropriate to Vietnam at the present time is the block (door to door) collection system in which residents bring out their refuse ready for discharge into the collection vehicle as it passes. A bell may be rung to alert the residents who emerge from their house carrying the wastes in non-standard containers, such as baskets. The system works well in areas where there are people in the houses at the collection times and where there is adequate access for the collection vehicle.

The recommendations for storage of wastes at source are summarized below.

Recommendations for Storage of Wastes at Source

Type of Development	Recommended Storage Method
High Density Residential Areas	- Household storage units for door to door collection (householder supplied – not standardized) - Large portable storage containers at collection points in areas with good access - Hand cart mounted containers at collection points for areas with difficult access
Low Density Residential and Rural Areas	- Portable storage containers at collection points in areas with good access - Hand cart mounted containers at collection points for areas with difficult access
Commercial Areas	- Large portable storage containers at collection points in areas with good access

(4) Wastes Collection

Collection includes the gathering and picking of solid wastes from various sources, haulage to the place where the vehicles are emptied, and unloading of the collection vehicles. Collection typically accounts for 50 - 70% of the total cost of urban wastes management and it is important to ensure that the methods employed are suitable and efficient. Planning of solid wastes collection systems involves evaluation of the various ways of using men and equipment to determine the most efficient arrangement. It is necessary to collect accurate data on performance and costs as well as on wastes quantities. Finding the best combination of methods and equipment requires a thorough understanding of local conditions, knowledge of collection activities, and the application of engineering economics.

There are many methods and vehicles used for collection of urban wastes ranging from hand pushed carts to large compaction type collection vehicles and collection vehicles for large containers. Open carts and trucks offer the advantages of versatility and low initial cost. Their disadvantages include load limitation, littering and odor problems. Littering and odor problems can be limited by providing a rigid or semi-rigid cover but this may restrict the versatility of the vehicle. Compactor trucks have much greater load capacity allowing longer collection routes but they are expensive to purchase and are less versatile than non-compaction vehicles. The choice of collection vehicles appropriate to the area being served is a fundamental decision that must be carefully evaluated.

Once equipment and labor requirements have been determined, collection routes must be planned to ensure efficient use of collectors and equipment. There is no universal set of rules that can be applied to all situations and route planning is largely a common sense process. Routes planned in an office need to be modified based on the operating experience of collectors, drivers, and supervisors.

The recommended methods for municipal solid wastes collection are summarized below.

Recommended Methods for Municipal Solid Wastes Collection

Type of Development	Recommended Collection Method
High Density Residential Areas	- Compactor trucks or hand carts for door to door collection - Collection and/or emptying of portable containers by trucks - Collection of wastes bins by hand cart for areas with difficult access
Low Density Residential and Rural Areas	- Collection and/or emptying of portable containers by trucks - Collection of wastes bins by hand cart for areas with difficult access
Commercial Areas	- Collection of portable containers or skips by trucks

(5) Separation, Processing and Transformation of Solid Wastes

These operations concern the recovery of separated materials, the separation and processing of solid wastes components, and the transformation processes used to alter the form of the wastes and to recover useful products.

The methods used in industrialized countries to recover source separated wastes materials include curbside collection and delivery by householders of separated materials to drop-off and buy-back centers. The source separation that is widely practiced in the study area is often done for direct financial gain and therefore curb collection and drop-off centers are not generally applicable. Buy-back centers would be appropriate but would probably only become established by either offering higher prices than the present private buyers or by buying materials that do not have an outlet at present.

In industrialized countries further separation and processing of wastes that have been source separated occurs at materials recovery facilities. This function is carried by the private sector in the study area and there is no need at present to introduce materials recovery facilities as part of the municipal solid wastes management system.

Chemical and biological transformation processes are used to reduce the volume and weight of wastes requiring disposal and to recover conversion products. The most commonly used chemical transformation process is combustion (incineration), which can be used to recover energy in the form of heat. Incineration may be applicable in the study area for disposal of clinical and hazardous wastes but it is not a realistic option for municipal solid wastes at this time.

The most commonly used biological transformation process is aerobic composting. This process is widely understood in Vietnam and is worthy of consideration for treating municipal solid wastes in the study area, possibly in conjunction with sewage sludge. However, it is first necessary to establish that there is a realistic market for the compost since there will be competition from animal manure compost which may well be cheaper and from organic fertilizers which are more convenient to use. Composting is an environmentally attractive way of disposing of wastes and obtaining benefit as a fertilizer/soil conditioner. However, it may well be necessary to provide a public subsidy and view it as an environmental improvement rather than a profit making enterprise.

(6) Transfer and Transport

Transfer and transport operations become a necessity when haul distance to available disposal sites increase and direct hauling is no longer economically feasible. Factors that may make transfer operations attractive include:

- disposal sites located more than 15 km far from collection routes
- the use of small capacity collection vehicles
- existence of low density residential service areas
- the use of a hauled container system with relatively small containers

The urban areas of Hong Gai, Bai Chay, and Cam Pha each have their own disposal sites at present and this situation is likely to continue for the next 10 years. Thus, there is no need to establish transfer stations in the study area within the time frame of the EMP. However, they will become necessary in the longer term if, as proposed by Kampsax, there is one landfill site to serve all the urban areas in the study area.

(7) Disposal of Solid Wastes

Even if wastes recovery and transformation are practiced, there are inevitably residues which have to be disposed of. There are only two basic options: disposal on land and disposal at the bottom of the sea. Marine disposal has generally fallen out of favor due to environmental concerns and it cannot be recommended near the sensitive waters of Ha Long bay. Thus, the only realistic option is disposal to sanitary landfills.

(8) Education and Enforcement

No matter how good a municipal solid wastes collection and disposal is, it will not be completely successful in improving the environment unless the public are persuaded to dispose of their rubbish in a responsible manner.

Public awareness can be improved through education programs in schools and in the community as well as through advertising campaigns in the press, on radio and on television.

However, experience elsewhere has shown that education on its own is not always sufficient and it is generally necessary to enforce anti-littering legislation through prosecution or fines.

18.2.10 Targets for Domestic Solid Wastes Collection and Disposal

The basis of the conservation criteria adopted for the EMP is that there should be no increase in pollution loads. For domestic solid wastes, the pollution load can be equated to the quantity of uncollected solid wastes. The present situation with regard to quantities of uncollected wastes is as follows.

Present Wastes Collection Situation

Parameter	Hong Gai	Bai Chay	Cam Pha	All Urban Areas
Solid wastes collection potential (ton/year)	41,709	17,064	31,943	90,716
Percentage coverage (%)	50	42	30	41
Amount collected (ton/year)	20,855	7,167	9,583	37,604
Amount uncollected (ton/year)	20,855	9,897	22,360	53,112

In order to maintain the same level of uncollected wastes in 2010 the following coverage rates would be required.

Wastes Collection Situation in 2010 to Meet Conservation Criteria

Parameter	Hong Gai	Bai Chay	Cam Pha	All Urban Areas
Solid wastes collection potential (ton/year)	105,759	44,992	41,856	192,607
Amount uncollected (ton/year)	20,855	9,897	22,360	53,112
Amount to be collected (ton/year)	84,904	35,095	19,496	139,495
Percentage coverage (%)	80	78	47	72

The collection coverage required to meet the conservation criteria conditions is relatively modest for a long term target; particularly for Cam Pha where the coverage is lower than the HWSSP first stage program target. The solid wastes problem is a highly visible one and it is desirable to set collection targets as high as realistically possible. Therefore, it is reasonable to increase the targets for 2010 somewhat. The recommended targets and required collection amounts are shown below and the areas to be served by collection services are indicated on Figure 18.2.11.

Recommended Solid Wastes Collection Targets for 2010

Parameter	Hong Gai	Bai Chay	Cam Pha	All Urban Areas
Solid wastes collection potential (ton/year)	105,759	44,992	41,856	192,607
Percentage coverage (%)	85	85	80	84
Amount to be collected (ton/year)	89,895	38,243	33,485	161,623
Amount uncollected (ton/year)	15,864	6,749	8,371	30,984

With regard to wastes disposal, the quantity of solid wastes that will have to be disposed between 2000 and 2010 to meet this target is estimated to be 950,300 ton which, assuming a compaction factor of two, is equivalent to a compacted volume of 1,188,000 m^3. The volume available in the sanitary landfills to be provided under the HWSSP first stage program is 960,000 m^3. Thus, by 2010 there will be a shortfall of 228,000 m^3, which is equivalent to approximately 182,000 tons of municipal solid wastes. It is projected that the landfills will be full in 2008 and thus it will be necessary to provide more landfill capacity by 2008 or to adopt a transformation method, such as incineration or composting, to reduce the quantities for disposal.

18.2.11 Required Projects to Meet 2010 Solid Wastes Collection Target

(1) Collection

The collection target can be met by the methods proposed for the first stage program of HWSSP, but some changes will be required to the percentage coverage for each method. The HWSSP program relies to a significant extent on collection point systems and, while these work well in high density development, they will be less effective in lower density areas where the householders will have to carry their wastes greater distances. It therefore is necessary to make greater use of door to door collection methods and this, in turn, will require greater use of mechanized compactor vehicles in order to cover the larger areas effectively. A considerable investment in additional vehicles and collection equipment will therefore be required.

The capacity of the solid wastes collection equipment that will be provided in the HWSSP first stage program is approximately 64,000 tons/year whereas the collection rate required in 2010 to meet the target is 162,000 tons/year. Based on the cost estimates in the HWSSP Feasibility Study, a rate of US$ 50/ton/year can be derived for equipment costs. Thus, the estimated base cost to increase the collection capacity by 98,000 tons/year is US$ 4,900,000.

(2) Domestic Solid Wastes Disposal

1) Options

a) Landfill

As described in Section 18.2.7, there is adequate land available at the Ha Khau and the Quang Hanh sites to provide additional landfill capacity. Kampsax International have proposed that Quang Hanh should, in the long term, become the disposal site for all the urban areas and, in line with this policy, it is recommended that any additional landfill capacity should be provided at this site. The shortfall in capacity to the end of 2010 is estimated to be 228,000 m^3 but, to provide a reasonable working life for the extension, the additional capacity provided should be a minimum of 450,000 m^3.

Based on the cost estimates in the HWSSP Feasibility Study, a rate of US$ 5.0/m^3 can be derived for providing increased landfill capacity. Thus, the base cost of extending landfill capacity by 450,000 m^3 is US$ 2,250,000.

b) Incineration

The incinerator capacity that would be required to avoid the need to provide additional landfill capacity is 200 tons/day assuming that the incinerator became operational at the beginning of 2005. Based on international prices, the construction cost of incineration with energy recovery is typically US$ 75,000/ton/day. Thus, the base construction cost of a 200 tons/day incinerator is US$ 15,000,000.

c) Composting

The organic content of municipal solid wastes in the EMP area is between 40 and 50%. To achieve the same reduction in the wastes for landfilling as the incinerator scheme, it would be necessary to phase the capacity of a composting plant as follows:

- 50 tons/day from 2001 to 2004
- 100 tons/day from 2005 to 2008
- 200 tons/day from 2009 to 2010.

Based on international prices, the construction cost of windrow composting plant with separation of the organic and inorganic material at site is typically US$ 20,000/ton/day. Thus, the overall base construction cost of a 200 tons/day windrow composting plant is US$ 4,000,000. This expenditure could be phased over the period 2001 to 2009 in three installments.

2) Recommendations for disposal

The only option in the proposed plan relates to the method of disposal or transformation of the solid wastes. The estimated costs of the options considered are as follows.

Estimated Costs of Disposal Options

(Unit: US$ × 10^6)

Disposal/Transformation Method	Estimated Base Construction Cost
Landfill	2.2
Incineration	15.0
Composting	4.0

Incineration would have a benefit through energy recovery but this would be partly offset by high operating costs. The construction cost of the incinerator is so much higher than the other options that it cannot be justified and incineration of municipal solid wastes is not therefore a feasible option in the EMP.

Composting is just under twice the cost of landfilling in terms of construction costs and therefore could be feasible if the value of the compost as a soil conditioner can be realized. However, the amount of agricultural land in the EMP area is limited (6%) and the use of compost for agriculture in the area is not common. It is doubtful whether a market exists for compost at an economic rate and so the additional investment required for a composting facilities cannot be recommended at present.

The recommended option is therefore extension of the landfill capacity.

(3) Hospital Clinical Wastes

Hospital clinical wastes is a hazardous wastes that should be collected and disposed of separately from municipal solid wastes. It is recommended that a suitable incinerator should be provided for all the hospital wastes generated in the EMP area. The estimated quantity of hospital clinical wastes in 2010 is 1,575 tons/year and an incinerator with a rating of 10 tons/day would be adequate to handle this quantity. Based on a construction cost of US$ 75,000/ton/day for a suitable incinerator, the base cost for the clinical wastes incinerator is US$ 750,000.

(4) Education and Public Awareness

As described in Section 18.2.9(8), it is recommended that an education program and advertising campaign be undertaken. An allowance of 5% of the overall construction costs has been included to cover the costs of this program.

18.2.12 Estimated Costs of the Recommended Program for Domestic Solid Wastes Facilities

The build up of the estimated costs of the domestic solid wastes management plan for both construction and running costs are shown in Table 18.2.4. The total construction cost is about US$ 10.0 million and the annual running cost in 2010 is about US$ 0.8 million.

The phased investment and running costs over the period 2000 to 2010 are shown in Table 18.2.5.

18.2.13 Recommendations for Domestic Solid Wastes Management

The principal recommendations for domestic solid wastes management may be summarized as follows:

- The target for 2010 should be to increase collection coverage to 85% in Ha Long city and 80% in Cam Pha.
- The sanitary landfill sites to be constructed under the first stage program of HWSSP will have adequate capacity for disposal of municipal solid wastes up to 2008.
- Additional landfill capacity should be provided at the Quang Hanh site for disposal of municipal solid wastes after 2008.
- Hospital clinical wastes should be handled separately and incinerated at a central facility for the EMP area.
- An education and advertising to campaign to improve public environmental awareness should be undertaken.
- The existing anti-littering by laws should be enforced.

18.2.14 Development of Industrial Wastewater Management

This Section considers management strategies and plans for industrial wastewater from factories. It does not consider discharges from coal mining and related activities. The strategies for managing wastewater related to coal mining are covered in Section 18.3.

There are few major factories in the EMP area at present and the pollution loads discharged are small. However, large industrial developments are planned and there is the potential for industrial wastewater from factories to become a significant source of pollution load in the EMP area. The management of industrial wastewater is therefore an important component of the EMP and this Section considers the measures that will be necessary to achieve the target conservation criteria set out in Chapter 17.

(1) Design Criteria

1) Industrial wastewater flows

The industrial wastewater flows used in this section for new industries are based on information presented in Chapter 14. Flows for existing industries and any expansion of those industries are based on the results of the field survey carried out for this Study in 1998.

2) Pollution loads discharged from factories

Pollution loads from existing industries have been based on the results of analyses carried out during the field survey. Pollution loads for new industries are based on the premise that it will be a prerequisite for all new industry to pretreat its wastewater to the Vietnamese Standard for industrial discharges to Class B receiving waters (see next Sub-Section).

Allowance has also been included for the wastewater loads from toilets and canteens. The BOD load from this source has been calculated on the basis of a contribution of 15 g/employee/day.

3) Effluent discharge standards

Vietnam Standard TCVN 5945 - 1995 specifies parameter limits and allowable concentrations of pollutants in industrial wastewater discharged into water bodies. The standard considers three classifications of water bodies: A, B, and C. Classification B includes waters used for navigation, bathing, aquatic breeding and cultivation and is therefore the classification applicable to Bai Chay bay and the coastal areas of the study area. Concentration limits for selected parameters for industrial wastewater discharges to class B waters are shown below.

Concentration Limits for Industrial Wastewater Discharges to Class B Waters

Parameter	Unit	Limitation value for discharge to Class B waters
Biochemical Oxygen Demand (BOD_5)	mg/ℓ	50
Chemical Oxygen Demand (COD_{Cr})	mg/ℓ	100
Suspended Solids (SS)	mg/ℓ	100
Total Nitrogen (T-N)	mg/ℓ	60
Total Phosphorus (T-P)	mg/ℓ	6
Coliform	MPN/100 mℓ	10,000

Source: TCVN 5945-1995

The Standard includes a more stringent effluent quality standard for discharges to Class A waters, which are waters used as a source of drinking water. This classification does not apply in a strict sense to Ha Long bay or Bai Chay bay. However, there are instances where a higher level of treatment than required for Class B waters could be necessary to meet the target conservation criteria. In such cases reference is made to the discharge standard for Class A waters. The allowable concentrations for this class for selected important parameters are shown below for reference.

Concentration Limits for Industrial Wastewater Discharges to Class A Waters

Parameter	Unit	Limitation value for discharge to Class A waters
Biochemical Oxygen Demand (BOD_5)	mg/ℓ	20
Chemical Oxygen Demand (COD_{Cr})	mg/ℓ	50
Suspended Solids (SS)	mg/ℓ	50
Total Nitrogen (T-N)	mg/ℓ	30
Total Phosphorus (T-P)	mg/ℓ	4
Coliform	MPN/100 mℓ	5,000

Source: TCVN 5945-1995

18.2.15 Strategy for Industrial Wastewater Management Plan

(1) General

From the point of view of industrial wastewater management, Ha Long city is fortunate in that there is little industry in existing developed areas and the planned industries are to be located in industrial parks. As described above, individual industries should be required to treat their wastewater to the effluent standard for discharges to Class B waters. In addition to this, the industrial parks should have the infrastructure to collect effluent discharges from the individual factories and, where necessary, either provide further treatment to the wastewater or deliver the combined factory effluents to a suitable discharge location.

Existing industries in mixed or residential development should preferably be relocated but, where this is not feasible, the industrial wastewater should be discharged to the domestic sewerage system after the necessary pretreatment.

(2) Wastewater Treatment

1) Pretreatment

The on-site pretreatment methods used by individual factories will depend on the types of industries and the characteristics of the wastewaters. The alternative technologies that can be used for treatment of industrial wastewater, either individually or as an integrated system, are indicated in Figure 18.2.12. With regard to secondary treatment, it should be noted that biological processes will be inhibited in the presence of heavy metals, pesticides, and other toxic compounds and therefore in-plant treatment may be necessary. In-plant treatment is also useful for treating low-volume streams rich in non-degradable materials, because it is easier and less costly to remove a specific pollutant from a small, concentrated stream than from a large, dilute one. The addition of nutrients to certain industrial wastewaters may also be needed for effective biological treatment.

As can be seen from Tables 4.3.2 and 4, the pollution loads from existing factories are small at present with only the breweries and possibly also the seafood processing factories discharging any significant quantity of organic pollution. The largest brewery and seafood processing factory are in Hong Gai within the area for which an urgent collection and treatment system has been proposed. Since the pollution loads from these factories are relatively small it is acceptable to connect the discharges directly to the collection system when it is commissioned. The factories in question are on congested sites and it would be difficult to provide biological treatment on-site. If absolutely necessary, compact anaerobic treatment, such as an upflow sludge blanket, could probably be provided on the sites. However, the justification for such pretreatment if the collection system is constructed is dubious.

2) Centralized industrial wastewater treatment

The collection of factory wastewater discharges in a common system has the advantage of balancing loads and diluting certain pollutants and inhibitory substances. Care has to be taken, however, to ensure that factory discharges are controlled so that reactions producing hazardous conditions do not take place.

Given adequate control of factory discharges, the combined wastewater flow should be treatable to the effluent standard for discharge to Class A waters by biological means. As for domestic wastewater treatment, oxidation ditches are the generally preferred method but the final choice will depend on land availability and the particular characteristics of the combined industrial wastewater to be treated.

It is also possible to treat combined industrial wastewater flows in combination with domestic wastewater. Again, given adequate control of factory discharges, it is possible to use the same treatment processes recommended for domestic wastewater treatment and to produce effluents to Level 1 or 2 standards as required.

3) Discharge locations and effluent standards

The effluent standard required for discharges to a particular receiving water will depend upon the target conservation criteria for that water. In general, the standards for industrial wastewater discharges to Class B waters will be adequate for discharges to Ha Long bay and Bai Tu Long bay. However, a higher level of treatment is likely to be necessary in order to meet the target conservation criteria for the enclosed Bai Chay bay.

18.2.16 Main Industrial Development Areas

The main industrial development areas and the projected 2010 industrial wastewater flows and loads are shown below.

Main Industrial Wastewater Flows and Loads

Area	Flow (m^3/day)	BOD_5 (kg/day)	T-N (kg/day)	T-P (kg/day)
Cai Lan Industrial Park	23,850	1,196	542	74
Hoanh Bo Industrial Park	27,550	1,382	627	86
Lang Bang (cement)	2,560	108	40	3
Quang Hanh (cement)	2,140	88	33	2
Cam Pha (cement)	2,140	88	33	2
Cua Ong (steel refinery)	2,400	168	163	18

The Cai Lan and Hoanh Bo Industrial Parks together the cement factories at Lang Bang are all within the Bai Chay bay catchment area (see Figures 18.2.13 and 14) and consideration of further treatment beyond the prerequisite pretreatment to Class B standard is necessary.

The Quang Hanh, Cam Pha and Cua Ong factories discharge to Bai Tu Long bay and wastewater treatment to the standard for discharge to Class B waters is adequate. Since pretreatment to this standard will be a prerequisite for these developments they are not considered further in the industrial wastewater management plans.

18.2.17 Options for Treatment and Discharge of Industrial Wastewater

In order to meet the target conservation criteria for Bai Chay bay it is necessary to reduce pollution loads below the level for discharges to Class B waters. The options for achieving this for the individual industrial areas are considered below.

(1) Cai Lan Industrial Park

Three options have been considered for reducing the pollution loads from this planned major industrial park. The options are shown on Figure 18.2.13.

- Option 1. The discharges from the individual factories would be collected and treated at a plant within the Industrial Park to effluent standard Class A prior to discharge to Bai Chay bay.
- Option 2. The discharges from the individual factories would be collected at a transfer pumping station in the Industrial Park and discharged to Ha Long bay

near Don Dien. No further treatment beyond the prerequisite treatment to Class B standard would be provided in this option.

- Option 3. The discharges from the individual factories would be collected at a transfer pumping station in the Industrial Park and delivered to the domestic wastewater treatment plant at Don Dien. The combined domestic and industrial wastewaters would then be treated to domestic Level 1 prior to discharge to Ha Long bay.

(2) Hoanh Bo Industrial Park

Four options have been considered for reducing the pollution loads from this industrial park, which is to be developed at a later date than the Cai Lan Industrial Park. The options are shown in Figure 18.2.14.

- Option 1. The discharges from the individual factories would be collected and treated at a plant within the Industrial Park to effluent standard Class A prior to discharge to Bai Chay bay.
- Option 2. The discharges from the individual factories would be collected at a transfer pumping station in the Industrial Park and discharged to Ha Long bay near Don Dien. No further treatment beyond the prerequisite treatment to Class B standard would be provided in this option.
- Option 3. The discharges from the individual factories would be collected and delivered to the domestic wastewater treatment plant at Dong Dang. The combined domestic and industrial wastewaters would then be treated to domestic Level 2 before discharge to Bai Chay bay.
- Option 4. The discharges from the individual factories would be collected at a transfer pumping station in the Industrial Park and delivered to the domestic wastewater treatment plant at Don Dien. The combined domestic and industrial wastewaters would then be treated to domestic Level 1 before discharge to Ha Long bay.

(3) Lang Bang

The factories in this area are remote from Ha Long bay and from the domestic sewerage systems. The only feasible way to reduce the pollution loads from these factories is provide further treatment in the area prior to discharge to Bai Chay bay. It is recommended that the wastewater discharges from the two main factories be treated at a central treatment plant to Class A standard prior to discharge to Bai Chay bay. The suggested arrangement is shown in Figure 18.2.13.

The treatment plant would have capacity for a flow of 2,560 m^3/day and would treat a BOD load of 108 kg/day. The estimated construction costs for the recommended project are shown below.

Estimated Cost of Lang Bang Industrial Wastewater Management

Component	Unit	Quantity	Rate (US$)	Amount (US$)
Collection System	km	2.9	146,000	423,000
Wastewater Treatment Plant	L. S.	1	738,000	738,000
Baseline Cost for Lan Bang				1,161,000
Add for engineering, supervision, contingencies, etc				314,000
TOTAL COST FOR LANG BANG				1,475,000

18.2.18 Basis of Cost Estimation Industrial Wastewater Management

(1) Collection Systems

Rates for main collection systems in industrial parks have been developed on a unit length basis for each park. The average sizes of collector sewers and pumping stations have been derived for each park based on the projected 2010 wastewater flows. The build up of the rates for each park is shown in Table 18.2.6.

(2) Wastewater Treatment

The use of unit rates for estimation of treatment costs (either on a flow or load basis) is not suitable for comparative cost analyses since it ignores economy of scale, which can be a significant factor. The cost estimates for treatment plants have therefore been derived by costing preliminary designs for each treatment plant. Details of the designs and cost estimates are included in Appendix 5.

18.2.19 Recommendations for Industrial Wastewater Management

The recommendations for industrial wastewater management may be summarized as follows:

- All new factories should pretreat their wastewater to the discharge standard for Class B waters.
- The standard of any further treatment required for industrial wastewater discharges will be determined by the target conservation criteria for the receiving waters.
- Industrial parks should have collection sewer systems so that the combined discharges can receive further treatment or be transferred to a suitable discharge location.
- Three options should be considered for the industrial wastewater plan for Cai Lan Industrial Park, and four for the Hoanh Bo Industrial Park.
- An industrial wastewater treatment plant should be provided at Lang Bang to treat the wastewater from the major industries to Class A standard prior to discharge to Bai Chay bay.

18.2.20 Development of Industrial Solid Wastes Management

This Section considers management strategies and plans for industrial solid wastes from factories. It does not consider wastes from coal mining and related activities. The strategies for managing solid wastes related to coal mining are covered in Section 18.3.

There are few major factories in the EMP area at present and the solid wastes quantities generated are small. However, large industrial developments are planned and there is the potential for solid wastes from factories to become a much greater problem unless measures are taken to limit generation and ensure that collection and disposal is carried out in a responsible manner.

(1) Design Criteria for Industrial Solid Wastes Management

1) Industrial solid wastes generation

Little information is available on the quantities of solid wastes generated by existing industry in the EMP area. A questionnaire survey by this Study in 1998 provided some information but not enough to allow precise design criteria to be developed. The largest non-mining related component of existing solid wastes generation is almost certainly building rubble and this is often dumped indiscriminately.

Wastes generation from new industry is difficult to forecast without knowledge of the exact types of industry to be established. However, the factories to be established in the various industrial parks are not expected to be of the type that generates large amounts of solid wastes. It is therefore considered that overall factory solid wastes generation can be taken as 25% of domestic solid wastes generation, or 0.17 kg/capita/day.

It should be noted that major planned installations such as power stations, cement factories and steel refineries must include satisfactory disposal arrangements for their residues in their development plans. The disposal of their residues is not therefore considered further in the general industrial solid wastes management plan.

2) Hazardous wastes generation

Hazardous wastes may be defined as all wastes that by their nature pose a threat to the environment and to human health. Hazardous wastes include toxic chemicals, biological wastes, flammable wastes, radioactive substances, and explosives. The handling and disposal of these wastes are normally controlled by legislation and there is an urgent need in the EMP area for regulation of these activities.

There are many substances that are potentially hazardous and whose inclusion in a wastes may require special measures to be adopted for the handling and disposal of the wastes. Table 18.2.7 lists potentially hazardous substances, the industries that they can be associated with, and the nature of the potential hazard. It must be emphasized that this list is a guide only and it does not follow that all the substances listed are necessarily hazardous or that the wastes from industries included in the list must necessarily be regarded as 'special'. Normally each case must be considered individually taking into account the quantity and concentration of potentially hazardous substances. A recommended assessment procedure is illustrated in Figure 18.2.15.

The Development Master Plan of Ha Long City for 1994-2000 includes fairly specific lists of the types of industries that should and should not be encouraged in future industrial development. If these guidelines are followed, the amounts of hazardous wastes generated by new industries should be relatively low and an allowance of 10% of the total industrial solid wastes generation would be adequate. It should be noted that hospital clinical wastes is hazardous and will probably be the largest single component of hazardous wastes generation. However, hospital clinical wastes has already been considered under the domestic solid wastes management plan and is not included in the allowance for industrial hazardous wastes.

(2) Projected Industrial Solid Wastes Quantities

Based the above design criteria, the projected 2010 industrial solid wastes generation will be as follows.

Projected Industrial Wastes Generation

2010 Urban Population	Generation Rate, kg/cap/day	Industrial Solid Generation, ton/yr	Hazardous Wastes Generation, ton/yr
556,650	0.17	34,500	3,450

18.2.21 Strategy for Solid Wastes Management Plan

(1) Industrial Wastes Generation

The ways in which source generation may be limited include:

- Reduction of wastage of raw materials
- Use of wastes from one industry as a raw material for another industry
- Efficient use of materials to minimize resource requirements
- Increase the recycled material content of products

(2) Collection of Industrial Solid Wastes

Collection includes the gathering and picking up of solid, haulage to the place where the vehicles are emptied, and unloading of the collection vehicles. It is recommended that industry be responsible for all aspects of collection. The method of collection should be the choice of industry and should include the use of its own transport, the use of private sector contractors, and the use of public sector collection services at a commercial rate.

(3) Separation, Processing, and Transformation of Solid Wastes

These operations concern the recovery of separated materials, the separation and processing of solid wastes components, and the transformation processes used to alter the form of the wastes and to recover useful products.

Certain industries may be able to use part or all of the separated or processed wastes products of other particular industries. Every effort should be made to encourage these practices by siting such 'compatible' industries together.

Chemical and biological transformation processes are used to reduce the volume and weight of wastes requiring disposal and to recover conversion products. The most commonly used chemical transformation process for solid wastes is incineration, which greatly reduces the volume of the wastes and can also be used to recover energy in the form of heat. In particular, incineration under closely controlled conditions can be used for the disposal of hazardous wastes. Modern cement kilns also have suitable characteristics for the safe incineration of certain hazardous wastes and the opportunity for mutually beneficial disposal of hazardous wastes in this manner in the EMP area should be investigated.

(4) Disposal of Solid Wastes Residues

Even if wastes recovery and transformation are practiced there are inevitably residues which have to be disposed of. There are only two basic options: disposal on land and disposal at the bottom of the sea. Marine disposal has generally fallen out of favor due to environmental concerns and it cannot be recommended near the sensitive waters of Ha Long bay. Thus, the only realistic option is disposal to land. In the case of industrial solid wastes this invariably means disposal to landfill. The guidelines for landfills are similar to those for municipal solid wastes, i.e.

- Low permeability engineered liners should be provided
- Where leachate can be generated, measures should be provided for its collection and treatment prior to discharge
- Wastes should be placed in layers 1-2 m deep and compacted
- Depending on the nature of the solid wastes, inert cover should be provided to the wastes preferably on a daily basis
- Litter and pests should be controlled
- When full the site should be covered and restored to be compatible with its surroundings

18.2.22 Required Projects to Meet Projected Industrial Solid Wastes Generation

(1) Collection

It is recommended that industry should be free to make its own choice as to the means of solid wastes collection but, whichever methods are adopted, significant investment in collection equipment will be necessary to handle the projected industrial wastes generation. This investment will essentially be funded by industry whether it purchases its own equipment, uses private sector contractors, or uses public sector services.

(2) Industrial Solid Wastes Disposal

There are two main options for the disposal or transformation of industrial solid wastes: landfill or incineration. Incineration will not be economically feasible for normal non-hazardous industrial solid wastes, particularly as compared to domestic solid waste, a lower proportion of industrial solid wastes is normally combustible. However, incineration of many hazardous wastes may be economically feasible and this is considered further below.

Disposal of industrial solid wastes to landfill must take place at authorized and controlled sites. Such sites could be those used for disposal of municipal solid wastes, privately operated sites, or sites owned by particular industries. In any event, industry will have to fund the cost of creating sufficient properly engineered landfill capacity.

The required landfill capacity to accept the projected solid wastes generation until the year 2010 is calculated to be 94,000 m^3. The calculation is based on the assumption that compacted industrial wastes will have a density of 1.2 tons/m^3. This is 50% more than the density assumed for compacted municipal solid wastes.

(3) Hazardous Wastes Disposal

The methods that can be adopted for disposal hazardous wastes vary depending on the nature of the wastes and can include incineration, special landfill facilities, and long term containment or storage. All of these methods will be applicable to a greater or lesser extent in the EMP area. Long term containment will be necessary for certain hazardous wastes that cannot be incinerated and burial in special landfill facilities will be economic for hazardous wastes that can be disposed of safely in this manner. However, there are certain wastes that are not suitable for burial in special landfill that can be incinerated in a suitable hazardous wastes incinerator. There has been considerable international concern over emissions from hazardous wastes incinerators and the disposal of clinker residues from incinerators. Many developed countries now have very stringent regulations for emission standards and clinker residues. Nevertheless, properly designed incinerators can still meet these requirements, although the costs have inevitably increased.

An incinerator capacity of 15 tons/day will be appropriate for the proportion of the projected 2010 hazardous wastes generation that is suitable for incineration.

18.2.23 Estimated Costs of the Recommended Program

The build up of the estimated costs of the industrial solid wastes management plan for both investment and running costs are shown in Table 18.2.8. The total investment cost is about US$ 3.1 million and the annual running cost in 2010 is about US$ 0.4 million.

The rates for collection equipment and collection running costs are taken as 50% of the corresponding rates for domestic solid wastes on the basis that fewer collections of relatively large amount will allow higher productivity per vehicle. The construction rate for additional landfill capacity is taken to be the same as for domestic solid wastes. The construction rate for the hazardous wastes incinerator is taken to be the same as for the clinical wastes incinerator but the operating costs for hazardous wastes incineration can be much higher and are taken to be, on average, twice those for clinical wastes.

The phased investment and running costs over the period 2000 to 2010 are shown in Table 18.2.9.

18.2.24 Recommendations for Industrial Solid Wastes Management

The principal recommendations for industrial solid wastes management may be summarized as follows:

- Investment is needed to collect and satisfactorily dispose of the projected 2010 industrial solid wastes and hazardous wastes quantities of 34,500 and 3,450 tons/year, respectively.
- Regulation of the handling and disposal of hazardous wastes in the EMP area is urgently required.
- Collection of the solid wastes may be carried out either by industry itself, or private contractors, or by the public sector at commercial rates.
- Minimization of industrial solid wastes generation, maximization of recycling and recovery, and co-siting of 'compatible' industries should all be encouraged.
- The recommended method for disposal of non-hazardous industrial solid wastes is landfill. Additional landfill capacity of 94,000 m^3 will be required for disposal of wastes up to 2010. The landfills could be publicly or privately operated but a system for control and licensing of private sites would be required.

- Various methods will be required for the disposal of hazardous wastes including long term containment, special landfills, and incineration. The construction of a 15 tons/day hazardous wastes incinerator is recommended.

18.3 Environmental Measures for Mining

18.3.1 Present and Future Mining Activities

(1) Production

Coal resources in Quang Ninh Province has been exploited since before the turn of the 20th Century, and the historical production is roughly estimated at 200 million tons (Pham et al., 1997). As of 1998, VINACOAL's production in Quang Ninh Province is about 10 million tons per year, and 8.4 million tons are produced in the EMP area (Cam Pha and Hong Gai area). Coal industries in Vietnam went through major restructuring in mid 1990's, and most mines in the EMP area have been consolidated under VINACOAL (Vietnam National Coal Corporation), which is a large State-Owned-Enterprise. The major mines in the EMP area include Coc Sau (1.5 million tons/year), Deo Nai (1.1 million tons/year), Cao Son (1.0 million tons/year), and Ha Tu (0.8 million tons/year). The estimated annual coal sales in Quang Ninh Province are in the order of 3 trillion VND or roughly 200 million USD, and it provides jobs for some 85,000 people in the province.

Table 18.3.1 summarizes the present and planned production to 2030. There is no officially approved long-term production plan, and the production is adjusted to the demand and the market condition on a yearly basis. According to an estimate by the Institute for Mining Science & Technology (IMSAT, 1999), the coal production in Cam Pha and Hong Gai area will further increase, and reach 12.5 million tons/year in 2005. Then, production will level off, and eventually decreases over a 30 to 40 year time span. The total production in the EMP area during 2000 and 2010 is estimated at 132 million m^3.

The coal market is very volatile. Some of the important international factors that are affecting the current coal industry in Vietnam include the decline of international coal price and the significant loss of market in countries like China and Bulgaria.

The domestic market appears to be relatively stable, and there are investment plans to construct thermal power plants in Lang Son, Thai Nguyen, Bac Giang, Da Nang, and Quang Ninh (in the EMP area). These plants are expected to use 5 million tons/year of coal in the future, or roughly 1/3 of the production. Because of these uncertain factors, the production plans will be subjected to further changes.

(2) Land Use in Mining Area

According to VINACOAL, the total mining area in Quang Ninh province where VINACOAL has mining permits is 45,840 ha (Table 18.3.2). The permit area in the EMP area is 27,550 ha of which 13,510 ha is in Hoanh Bo (classified under Uong Bi region), 6,970 ha in Hong Gai, and 7,070 ha in Cam Pha area (Figure 18.3.1).

Reported Permit Area

Area	Number of Mines	Area (ha)
Quang Ninh Total	45	45,840
EMP Area	33	27,550
Hoanh Bo	6	13,510
Hong Gai	12	6,970
Cam Pha	15	7,070

Source: VINACOAL, 1998

Table below shows the areas of production, dump site, and buffer area reported by IMSAT (IMSAT, 1999)

Reported Areas for Production, Dump Site and Buffer Area

(Unit: ha)

Region	Production	Dump Site	Buffer Area	Total
Hong Gai	1,537	750	167	2,454
Cam Pha	3,351	899	1,066	5,316
Total	4,888	1,649	1,233	7,770

Source: IMSAT, 1999

The reported mining area in the EMP area is 7,770 ha. The mining activity in the Hoanh Bo area is negligible. Thus, the data for Hoanh Bo area were not included in the analysis.

The pollution loads from non-specific sources are strongly related to the significantly disturbed area in the mines. Hence, it was of interest to identify such area, which is termed "denuded area" or "active mining area" in this Study. Figure 18.3.2 shows the locations of the denuded area in 1996 analyzed from the satellite images. It is evident that the mining activities in the EMP area are mainly concentrated in Hong Gai and Cam Pha areas. The estimated denuded area from the satellite image analysis is 5,418 ha in 1996. The analyses of the historical satellite image data showed that the denuded area increased 70% during 1989 - 1996. Dien Vong river basin experienced the largest increase in denuded area in the last 10 years.

Historical Change of Active Mining Area

Year	Active Mining Area (ha)
1989	3,256
1992	4,084
1996	5,418

Because detailed future mining plans were not available to the Study Team, the increase in active mining area in the future was estimated from the historical trend, the anticipated increase in production, the existing land use pattern, and other factors. Table 18.3.3 shows the anticipated increase in the active mining area. The active mining area is expected to increase further in the future. However, the rate of expansion will slow down for the following reasons:

- as the mining industry matures, the mining technology will shift from surface mining to deep-pit mining and underground mining
- large expansion of dumping site is costly

Assuming that no environmental measures are taken (without project case), the active mining area is expected to increase 40% by 2010: from 5,400 ha in 1996 to 7,570 ha in 2010. Currently, the active mining area occupies 38% of the permit area (Table 18.3.3). In the future, the share of the active mining area will increase to 54%. In terms of the spatial size, the large expansions are expected in Dien Vong basin (985 ha), Mong Duong basin (612 ha), and Ha Tu basin (232 ha). However, the rate of expansion in Mong Duong and Ha Tu basins will be smaller than the average because roughly 60% of the permit areas in these basins have already been intensively mined. On the other hand, Dien Vong basin is expected to experience an above-average rate of expansion.

18.3.2 Present and Future Environmental Problems

(1) Pollution from Point Sources

1) Overburden from coal mines

The table below shows the reported historical volume of the overburden wastes in Quang Ninh province.

Historical Release of Overburden

(Unit: × 10^3 m^3/year)

Period	Overburden
1961 - 1965	13,000
1966 - 1970	9,000
1971 - 1975	13,000
1976 - 1980	18,000
1981 - 1985	16,000
1986 - 1990	19,000
1991 - 1995	15,000
1996 - 1997	14,000

Source: IMSAT, 1999

Based on the available data, the stripping coefficient, i.e., the volume of overburden wastes generated per ton of coal, in Quang Ninh province is estimated as follows (Pham et al., 1997; IMSAT, 1999):

- Surface Mine: 4.6 m^3/ton raw coal
- Underground Mine: 2 m^3/ton raw coal

The amount of the overburden generated in the EMP area in 1997 was about 36 million m^3. The anticipated generation of the overburden is estimated in Table 18.3.1. The total overburden to be released in the EMP area during 2000 to 2010 is estimated at 437 million tons.

2) Mine wastewater

A large amount of water has to be pumped out of mines to keep the mines in operable condition. On average, the volume of the mine wastewater per ton of raw coal is (Pham et al., 1997; IMSAT, 1999):

- Surface Mine: 2 m^3/ton coal
- Underground Mine: 3 to 10 m^3/ton coal

The results of the interview survey with the local coal mining enterprises revealed that the amount of the mine wastewater generated in the EMP area in 1997 was 20 million m^3/year (see Chapter 11, Table 11.5.5). Between 2000 and 2010, an additional 317 million m^3 of mine wastewater is expected to be discharged.

Table 18.3.4 shows the reported water quality of mine wastewater. While the quality of mine wastewater varies significantly from mine to mine, low pH (pH 2 - 4) and relatively high concentration of SS are the general characteristics of mine wastewater. The total release of SS associated with mine wastewater is estimated at 0.10 million tons for the period of 2000-2010 (Table 18.3.1). To our knowledge, heavy metals in wastewater have not been the major environmental problems in the area although a long-term monitoring of water quality is needed.

3) Solid wastes from coal processing plant

There are two major coal processing plants in the EMP area, Cua Ong Coal Processing Plant and Nam Cau Trang Coal Processing Plant. The present processing levels are 3.0 million tons/year for Cua Ong plant, and 1.0 million tons/year for Nam Cau Trang plant. As much as 30 wt% of the raw coal becomes solid wastes during the coal processing. The estimated volumes of the solid wastes released from these plants are:

Solid Wastes from Coal Processing in 1997

(Unit: m^3/year)

Processing Plant	Solid Wastes
Nam Cau Trang Plant	350,000
Cua Ong Plant	470,000

Source: Nam Cau Trang Plant EIA Report, 1997; IMSAT, 1999

The historically produced solid wastes at the Cua Ong plant is 3.4 million m^3 (IMSAT, 1999). The wastes has been dumped to the Bai Tu Long bay from the Cam Pha/Cua Ong coast creating about 120 ha of a reclaimed dumping site along the coast. Assuming that the Cua Ong plant will operate at an average production rate of 4 million tons/year, the estimated solid wastes load during 2000-2010 will be in the order of 6.9 million m^3.

The Nam Cau Trang plant came to operation recently, and the solid wastes problem has been minor in the past. However, due to the relatively low grade of coal from

Nui Beo, Ha Tu, Tan Lap (surface mine) and Ha Lam mines, securing enough future dumping space is a major concern. Assuming that the plant will operate at the design capacity of 2 million tons/year, the estimated solid wastes load during 2000-2010 will be in the order of 7.7 million m^3.

4) Wastewater from coal processing plant

A large amount of water is used to wash coal at the coal processing plants. The reported volumes of the water used (excluding recycled water) at Nam Cau Trang and Cua Ong plants are as follows.

Water Use at Processing Plants

(Unit: m^3/day)

Processing Plant	Water Use in 1997
Nam Cau Trang Plant	2,100
Cua Ong Plant	3,000 - 4,000

Source: IMSAT, 1999

The wastewater, which is suspension of coal powder, is thickened at a primary sedimentation tank, and then directed to sedimentation ponds to recover coal powder. The volumes of the sedimentation ponds are given below.

Volume of Sedimentation Ponds at Processing Plants

(Unit: m^3)

Processing Plant	Volume of Sedimentation Pond
Nam Cau Trang Plant	80,000
Cua Ong Plant	117,840

Source: IMSAT, 1999

The collected coal powder, or coal mud, is dug up, and sold in the domestic market. According to the engineers from the plants, the supernatant in the sedimentation ponds is not discharged directly to the sea, but allowed to infiltrate through the bed of the ponds. Hence, there is no direct release of SS from the process itself. However, there are risks that the coal sludge overflows into the Bai Tu Long bay, especially in rainy condition. Also the water used to wash the floor of the processing plants and the runoff on rainy day are released to the sea directly. Assuming the event mean concentration of 1,000 mg SS/L and the runoff ratio of 0.8, the estimated pollution load from the processing plants including the dumping site is in the order of 2,200 tons SS/year presently. If 250 ha of dumping site is additionally created to accommodate solid wastes, the total SS load will increase to 4,400 tons SS/year by 2010.

(2) Pollution Loads from Non-Specific Sources

1) Pollution loads

The table below summarizes the unit pollution loads by different land types, which were calibrated against the available water quality data.

Unit Pollution Loads from Non-Specific Sources

(Unit: kg/ha/day)

Land Use	BOD	COD_{Mn}	SS	T-N	T-P
Forest, Grass and Scrub	0.14	0.20	2.0	0.10	0.04
Active Mine Area	0.16	0.26	30	0.32	0.06

From the unit pollution loads and the anticipated land use pattern in the mining area, the anticipated pollution loads were estimated as:

$$\text{Total Load} = \sum_i L_i A_i^{Permit}$$

where L_i : Unit Load for Land Use "i"

A_i^{Permit} : Area with Land Use "i"

Table 18.3.5 shows the estimated pollution loads from the coal mining area. The estimation method is identical to the one used to estimate pollution loads from each basin (see Chapter on Water Pollution Mechanism). However, the estimates given here are for the "permit area", and not for the entire basin. Table below summarizes the anticipated increases in pollution loads.

Estimated Pollution Loads from Coal Mining Area

(Unit: kg/day)

Items	1996	2010	increase
BOD	979	999	2%
COD	3,140	3,269	4%
SS	178,000	238,000	33%
T-N	2,589	3,063	18%
T-P	671	714	6%

Among the various pollutants, SS is most sensitive to the change in land use, and as much as 33% increase in SS load is anticipated. The loads of other pollutants will also increase, although the rates of increase will be smaller.

2) Erosion estimate

Erosion rate is determined by factors such as rainfall, runoff, soil erodibility, slope angle, slope length, vegetation cover, and level of erosion control measures. In this Study, the erosion rate was roughly estimated using the Universal Soil Loss Equation, USLE (see Morgan, 1995).

$$\text{Erosion Rate (ton/ha/year)} = R \times K \times LS \times V \times P$$

where R : Rainfall erosivity factor

K : Soil erodibility factor

LS : Slope length /steepness factor

V : vegetative coverage factor

P : erosion control practice factor

USLE was calibrated using available erosion data including the siltation rate on Cam Pha coast line, which is reportedly filled up at the rate of 25 m/year (IMSAT, 1999). The vegetative coverage factor was estimated from the satellite data (Figure 18.3.2). Figure 18.3.3 shows the estimated erosion rate in the permit area. It is evident that the vulnerability to erosion is highly correlated with the vegetation coverage factor. Table below shows the estimated erosion potential by basin. The estimated total erosion rate for the mining permit area in Cam Pha - Hong Gai area is about 2 million tons/year, and the erosion rate is about 145 tons/ha/year. In some areas, such as South Deo Nai dumping site, the erosion rate is as high as 700 tons/ha/year.

The erosion rate in 2010 was estimated from the estimated land use in the future (Table 18.3.5) and the erosion rate for each land use class for each basin.

Estimated Erosion Rate

No.	Basin Name	Permit Area (ha)	1996 (x10³ tons/year)	2010 (x10³ tons/year)
6	Dien Vong	6,750	505	769
7	Hong Gai North	1,275	69	111
8	Hong Gai South	125	6	8
9	Ha Tu	1,275	366	469
10	Cam Pha West	125	37	50
11	Cam Pha Central	525	175	212
12	Cam Pha East	214	66	66
13	Cua Ong	550	55	84
14	Mong Duong	3,250	766	1,005
	Total	14,089	2,045	2,774

No.: Catchment area number used in Chapter 5.

If no environmental measures were taken, the erosion would increase 36% to 2.8 million tons/year.

18.3.3 On-going and Planned Pollution Control Measures

(1) Regulatory and Institutional Aspect

1) Regulations

The coal mining operation in Quang Ninh Province is generally subject to the following laws and related regulations:

- Environmental Protection Law, 1994
- Mineral Law, 1996
- Forest Protection/Development Law, 1991
- Water Resources Law
- Land Law, 1993
- Decree No. 175/CP, Execution of the Law on Environmental Protection
- Decree No. 68/CP, Guidelines for the Implementation of Mineral Law
- Decree No. 26/CP, Guidelines for Administrative Violations of Environmental Protection Law
- Decision No. 2920/QD-MTg, Applying Vietnam Environmental Protection Standards
- Circular No. 2781 TT KCM of MOSTE, Guidelines for Environmental License

- Circular No. 291 TT/KCM of MOSTE, Guidelines on the Protection of Ha Long Bay Environment
- TCVN 5326-1991, Open Mining Technical and Operational Regulations
- TCVN 5945-1995, Industrial Wastewater Discharge Standard

As far as the overall regulatory frame is concerned, these laws and regulations appear to cover all essential aspects of environmental problems. However, because these laws and regulations are not necessarily specific, and because the QNPC does not have the strong authority to enforce environmental regulations to the State-Owned-Enterprises (SOEs), the environmental laws and regulations are not strictly enforced.

To facilitate the environmental compliance by mining enterprises, the UNDP Project VIE/95/003 (UNDP, 1998) recently drafted the following documents:

- Model Agreement between Quang Ninh People Committee and VINACOAL
- Special Environmental Protection Standards for the Open-Pit Coal Mining Industry in Quang Ninh Province
- Special Rules for Assessment, Compensation and Restoration of Damage to the Environment for the Coal Industry in Quang Ninh Province

To our knowledge, these documents from the UNDP Project were accepted by the central government in general terms, and VINACOAL is reviewing the details.

2) Environmental impact assessment

In 1997, 28 major coal mining enterprises in Quang Ninh Province submitted EIA reports in compliance with the Environmental Protection Law. The reports are being reviewed by MOSTE. This is significant progress from the past as essentially no formal EIA had been carried out before. The EIA reports cover the environmental impacts and plans for mitigating measures including financial analysis. However, because VINACOAL and mining enterprises do not have clear future production plans, the analyses of the future environmental problems are weak. In addition, the quality of the reports varies from one enterprise to another. Further coordination among mining industries is strongly recommended. Aside from the

EIA studies by mining enterprises, several environmental studies have been carried out by the national environmental experts.

3) Environmental fund

VINACOAL now sets aside a part of its production cost for environmental purposes, such as environmental measures and environmental compensation. The level of the allocation had long been debated among MOI, VINACOAL, and MOF since mid-1990's. To our knowledge, it is currently set at 1%, and some enterprises spend more than 1% of their production costs for environmental expenditures. There has been no official order to legally-bind VINACOAL to this environmental fund, and it is on voluntary basis for now. According to VINACOAL officials, the current environmental fund amounts to roughly 30 billion VND/year. Fifty percent of the fund is used by each enterprise, and the rest is pooled for high-priority environmental projects in the region. VINACOAL also contributes to the Provincial environmental projects through this fund.

(2) Technical Aspect

Coal mining enterprises have carried out a number of environmental projects in the past. Some of the major projects are listed in Table 18.3.6. Most of the environmental measures carried out in the past have not been well documented, and there have been no coordinated efforts to evaluate the environmental effectiveness of such measures. Because the information about the historical and existing environmental measures is scarce, it was difficult to analyze the overall extent of these efforts. However, it is easy to speculate the following:

- Environmental measures in the past have been limited, and not effective enough to control major environmental problems such as the sedimentation problems in rivers and irrigation systems, landslide in Cam Pha, saltwater intrusion, and siltation in Bai Tu Long bay.
- Most of the existing measures are oriented toward fixing the immediate problems by dredging, installing erosion control dykes, or compensating for the inflicted damages.

According to DOSTE, the environmental performance of the coal enterprises improved considerably after the restructuring and consolidation of the industries to VINACOAL in mid-1990's, and most mining enterprises now have plans for environmental projects. In addition, UNDP Project VIE/95/003 (UNDP, 1998) formulated "Pilot Project on Land Reclamation", "Pilot Project in Dust Prevention", and "Pilot Project on Wastewater Treatment". These pilot projects were designed to be financed through VINACOAL's environmental fund. UNDP project also developed "Environmental Monitoring Plan in Quang Ninh" (UNDP, 1998), in which a plan for environmental monitoring is briefly outlined. Recently, rehabilitation of coal processing plants has attracted the attention of Japanese investment, which aims at recycling coal sludge for commercial (power generation) purposes.

18.3.4 Environmental Targets for Coal Mining Industries

To set specific targets for each environmental program and project, the following requirements are proposed:

(1) Compliance with Environmental Regulations

1) Environmental laws and regulations

As it was reviewed in Section 18.3.3, the coal mining operation in Quang Ninh province is generally subject to a series of environmental laws, regulations, and guidelines. All coal enterprises should comply with these laws, regulations, and guidelines. In addition, a number of environmental regulations and guidelines are currently in consideration. They include the outputs from the UNDP VIE/95/003 Project (UNDP, 1998):

- Special Environmental Protection Standards for the Open-pit Coal Mining Industry in Quang Ninh
- Special Rules for Assessment, Compensation and Restoration of Damage to the Environment for the Coal Industry in Quang Ninh
- Technical Guidelines on Pollution Management on Open Cut Coal

Once these regulations and guidelines are officially adopted, they also have to be observed.

2) No mining areas proposed by QNPC

QNPC proposed to prohibit mining activities in the following areas.

Areas of No Mining Activities

No.	Name	Reasons
I*	Yen Tu Relics	historical and religious significance
II*	East Dong Trieu Lake	source of irrigation water
III*	North Dong Trieu Lake	source of irrigation water
IV	Yen Lap Lake	source of irrigation water
V	Dong Ho Lake	water supply source
VI	Cao Van Lake	water supply source
VII	Dien Vong Water Supply Plant	water supply source

Note: * Out side of the EMP area

Among these, Yen Lap Lake area, Dong Ho Lake area, Cao Van Lake area, and Dien Vong Water Supply Plant area are in the EMP area (see Figure 18.3.4). It is recommended that mining activities in these areas be prohibited.

3) Limitation of mining activities in environmentally sensitive area

Overburden dumping, deforestation, and other disturbances of environmentally sensitive areas shall be prohibited. Some examples of environmentally sensitive areas are:

- steep slopes
- 50 meters from rivers
- 500 meters from residential area
- 200 meters from coast line

(2) Basin-Specific Environmental Targets

1) Non-specific source pollution control/vegetation coverage

To ensure sustainable development of Ha Long bay and Bai Tu Long bay area, the environmental conservation criteria were set in Chapter 8 of this Supporting Report. The mining area is vast, and it is difficult to directly monitor environmental conditions, such as the pollution loads. For this reason, the target criterion was set in terms of "size of denuded area" rather than the pollution loads at specific locations. In some basins, rehabilitation is needed not only to control pollution, but also to prevent landslide, and other adverse impacts. Such considerations are also built into the targets. The table below summarizes the target sizes of denuded areas. The anticipated decreases in pollution loads are estimated in Table 18.3.5.

Target Size of Denuded Area in 2010

(Unit: ha)

No.	Basin Name	Present	Without Measure	With Measure
6	Dien Vong	1,709	2,694	1,720
7	Hong Gai North	195	333	200
8	Hong Gai South	3	5	5
9	Ha Tu	790	1,022	790
10	Cam Pha West	65	89	40
11	Cam Pha Central	376	458	36
12	Cam Pha East	213	213	53
13	Cua Ong	138	218	140
14	Mong Duong	1,876	2,488	1,890
	Total	5,420	7,520	4,874

Note: No mining is allowed in other basins.
No.: Catchment area number used in Chapter 5.

2) Revegetation

To meet the basin-specific environmental targets, the denuded areas have to be revegetated. In addition to the denuded area, vegetation in buffer area and area where existing vegetation is degraded may also have to be reinforced. Hence, the revegetation requirement shall be designed according to the following classification.

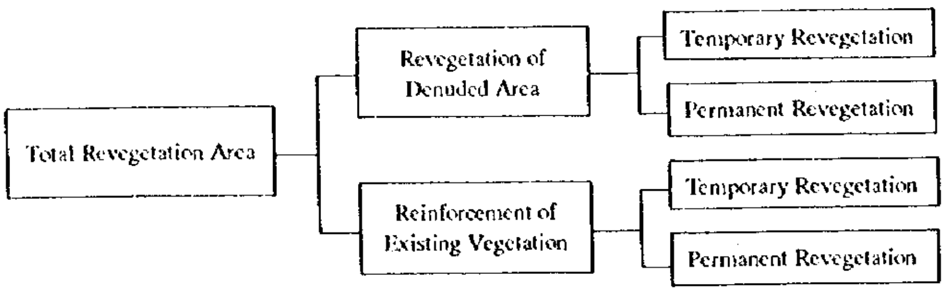

Figure 18.3.5 Classification of Revegetation Area

In total 3,900 ha of the area is revegetated, of which 2,736 ha is used to revegetate the denuded area, and remaining 1,164 ha is revegetated to reinforce existing vegetation as shown below.

Proposed Area for Revegetation

(Unit: ha)

No.	Basin Name	Total Revegetation Area	Revegetation of Denuded Area	Reinforcement of Existing Vegetation
6	Dien Vong	1,500	974	526
7	Hong Gai North	150	133	17
8	Hong Gai South	-	-	-
9	Ha Tu	400	232	168
10	Cam Pha West	50	49	1
11	Cam Pha Central	600	582	18
12	Cam Pha East			
13	Cua Ong	110	78	32
14	Mong Duong	1,000	598	402
-	Processing Plant	90	90	-
	Total	3,900	2,736	1,164

3) Point-source pollution control

For point sources, the compliance with the Discharge Standard, TCVN 5945-1995, by 2010 is the target.

(3) Rehabilitation Requirement

According to an estimate by VINACOAL, the coal production in the EMP area is expected to reach the peak in the next 5 to 10 years, and will start to diminish after 2010 (Table 18.3.1). Assuming that the production lasts 40 years from now, roughly 1/3 of the output will be produced by 2010. In principle, therefore, 1/3 of the cost for the mine land rehabilitation works, including the cost for operation/maintenance works, shall be generated by 2010, and be invested on rehabilitation works or set aside for future rehabilitation works. Obviously, there is an urgent need to develop a comprehensive rehabilitation plan, and implement it. To meet the basin-specific rehabilitation targets, it is suggested that any mine land developed from now on has to be rehabilitated as soon as practically possible. For the development of area that cannot be rehabilitated soon, the mining industry should rehabilitate other mine land larger than the area to be developed so that the area to be rehabilitated does not increase anymore.