Government of the Socialist Republic of Vietnam
Swiss Agency for Development and Cooperation

Nam Dinh Urban Development Project
Septage Management Study

Florian Klingel - November 1st, 2001

Nam Dinh Urban Development Project

10 Tran Dang Ninh
Nam Dinh City - Vietnam

Swiss Federal Institute for
Env. Science & Technology

P.O. Box 611
8600 Duebendorf -
Switzerland

TABLE OF CONTENTS

TABLES AND FIGURES

ACRONYMS AND GLOSSARY

$	US$, 1 US$ = 15,000 VND
AIT	Asian Institute of Technology Bangkok
Biosolids	The solids fraction of fecal sludge or of wastewater treatment plant sludge, which is biochemically stable and hygienically safe and, hence, can be used in agriculture as a soil conditioner and fertilizer.
Bucket sludge	Sludge from bucket latrines, collected by farmers or intermediaries.
CEETIA	Center for Environmental Engineering of Towns and Industrial Areas, Hanoi University of Civil Engineering
DOSTE	(Provincial) Department of Science, Technology and Environment
DTPW	(Municipal) Department of Transport and Public Works
EAWAG	Swiss Federal Institute for Environmental Science and Technology
Fecal Sludge	Sludge evacuated from all kind of on-site sanitation systems such as septic tanks, bucket latrines, pit latrines etc.
JICA	Japanese International Cooperation Agency
MSW	Municipal Solid Waste
NDUDP	Nam Dinh Urban Development Project
PUE	Pubic Utility Enterprise
SANDEC	Dept. of Water and Sanitation in Developing Countries
Septage	Settled solids, scum and liquid evacuated from septic tanks, usually by vacuum tankers.
TS	Total Solids (dissolved + suspended solids)
TVS	Total Volatile Solids (ignitable part of TS)
URENCO	Urban Environmental Company
UCMC	Urban Construction and Management Company
VND	Vietnamese dong, 15,000 VND = 1 US$

Title: Septage disposal in fishpond in Viet Tri - Vietnam. Photo: Agnès Montangero.

0 EXECUTIVE SUMMARY

In Nam Dinh City, pour-flush and WC toilets connected to some kind of septic tanks replace more and more traditional bucket latrines and other latrine types. Within the next 5 to 10 years, septic tanks will cover 80 to 90 % of the households. The management of septage, including its evacuation and collection, will become a very important issue in the near future.

Current septage management is characterized by indiscriminate dumping of septage in fishponds, on fields or on dumping sites, resulting in high risks for public health. Septic tanks are generally only emptied when they become blocked, and not at regular intervals. Emptying intervals which would be in accordance with the septic tank design, normally ranging from 2 to 5 years, would guarantee efficient solids retention in the tanks while longer intervals result in solids accumulation in the drainage system and hence increase risk of flooding.

The objectives for an improved septage management are to eliminate dumping of septage into the environment, to eliminate use of untreated septage in agriculture, and to reduce solids accumulation in the drainage system.

A concept for future septage management in Nam Dinh has been developed. This concept contains strategies regarding the increase of septage collection rate together with the shortening of septic tank emptying intervals, the treatment of all septage and the reuse of treated sludge in agriculture.

The recommended equipment for septage collection consists of classical vacuum tankers in combination with small hand-pushed vacuum tugs. These vacuum tugs allow accessing septic tanks located in very narrow lanes, which are today still emptied exclusively by hand. In this way, the public utility enterprise can extend its emptying service to all households.

Several issues must be discussed among decision-makers prior to the design of an effective septage collection system. Should septage management become a public task? Should frequent septic tanks emptying be compulsory? Should reduced monthly fees replace the high direct fees? How can the responsibilities of the public utility enterprises be better defined? The introduction of a systematic septic tank emptying and of monthly fees in selected wards is recommended. In this way the septage collection rate can be increased considerably and the experiences of the new system can be used in the political discussions and the institutional reform process. If this approach turns to be unfeasible, focus would then be made on intensive awareness campaigns in order to increase the willingness of the population to empty their septic tanks at regular intervals.

A septage treatment plant is proposed. The chosen technology is dewatering and biochemical stabilization of septage in constructed wetlands. This treatment plant will transform septage in a solids fraction with greatly reduced volume and very low pathogen content, and in a liquid fraction suitable for discharge after a minimal polishing treatment. Constructed wetlands have been chosen as the preferred option for Nam Dinh after a detailed evaluation of all available septage treatment technologies. Other feasible options for the kind of conditions prevailing in Nam Dinh include conventional drying beds and settling tanks followed by a pond. However, the latter tend to show lower performance and are less economic than constructed wetlands.

The solids produced from septage treatment constitute an excellent organic fertilizer. The commercialization of these biosolids is recommended, because it can generate revenues, save landfill space and supply Nam Dinh's agriculture with urgently needed soil-conditioner. Good marketing is very important for the successful commercialization. Close collaboration with agriculture services and cooperatives for trials with the new product and for commercialization is recommended.

1 INTRODUCTION

1.1 Background

Sanitation in Nam Dinh City is based on on-site sanitation systems. Traditional systems such as bucket latrines, pit latrines or double vault latrines are currently replaced in a high pace by the more convenient and hygienic pour-flush toilets connected to a septic tank. The construction of septic tanks is as well promoted by the Nam Dinh Urban Development Project (NDUDP) as part of the wastewater and drainage strategy, which favors the improvement of the existing sanitation and drainage system over the very costly switch to water borne sewer sanitation. So far the efforts of both the urban dwellers and of NDUDP have been concentrating exclusively on the construction of standardized septic tanks. The importance of periodical de-sludging to maintain the septic tank's function and a safe disposal or proper treatment of the sludge have been totally neglected. As a result, a relatively high coverage with new septic tanks is facing a very low collection capacity of the public services and septage is dumped indiscriminately in the urban environment.

The situation in Nam Dinh is very typical for urban areas in developing countries, where on-site sanitation predominate largely over sewerage, but where collection and proper disposal or treatment of sludge are insufficient. Despite of the widespread character of the problem, very little effort has been made so far to develop treatment technologies suitable for the conditions in developing countries. The Swiss Federal Institute of Environmental Science and Technology (EAWAG-SANDEC) is carrying out applied research to contribute to solutions closing this gap.

1.2 Study Objectives and Scope

The present study aims to propose a feasible concept how to complement the promotion of septic tanks by improvements of the collection and by the introduction of an adequate sludge treatment. The study is an important step towards the implementation of the NDUPD wastewater and drainage strategy. EAWAG-SANDEC executed the study as part of their mandate for R+D in fecal sludge management

The objective of the present septage management study is to provide:

- A thorough assessment of the situation in Nam Dinh relevant for septage management.
- A concept for septage collection and septage treatment.
- A detailed proposal for a septage treatment plant.

The Study does not encompass an assessment and evaluation of the overall sanitation strategy for the City.

1.3 Activities and Methods

The situation of septage management in Nam Dinh has been assessed in various site visits and interviews, sludge samples have been taken and analyzed and available documentation has been reviewed. In particular, following activities were carried out:

- Review of documentation concerning septage management, agriculture and general information.
- Various households have been visited and interviews with the inhabitants have been held to gather information about the use of toilet facilities, habits concerning septic tank emptying and the needs and perception of the people.
- Various meetings with both officials and workers of the public utility enterprises have been held and sites of activities have been visited. Current practice of septage man-

agement, technical issues and the perception of the municipality could be assessed in this way

- Interviews with provincial and municipal agriculture services, with officials from 7 of 10 agriculture cooperatives in Nam Dinh, and with numerous farmers have been held. The purpose of these visits and interviews was to analyze the human waste reuse situation and the market potential for treated fecal sludge.
- Data from sludge analysis were reviewed and new sludge samples have been collected and analyzed in the local DOSTE laboratory. However, no samples from vacuum tankers could be taken.
- The public utility enterprises in Hanoi, Haiphong and Viet Tri have been visited to get an impression of septage management elsewhere in Vietnam. Experts active in the cities of Hue, Dong Hoi and Thai Nguyen were visited for the same purpose.

A detailed reference list, minutes from meetings and interviews and data of analysis are given in the appendices.

The information obtained in the situation analysis has then been used to identify the main current problems, to establish objectives for future septage management, and to set clear criteria for evaluation of different treatment solutions.

Technical and institutional ways to improve septage collection have been discussed.

The core component of the study is the in-depth evaluation of various septage treatment technologies. After a first screening for excluding inappropriate technologies, only the potentially feasible technologies have been retained. Different designs of treatment plants have been worked out and have then been thoroughly evaluated relative to their performance, reliability of process and cost.

All obtained results and conclusions from option discussion and evaluation have finally been translated in a concrete proposal.

2 SITUATION ANALYSIS

2.1 General Situation

2.1.1 Geographic, Socio-Economic, Health and Climate Situation

Nam Dinh City is situated 120 km south of Hanoi in the greater area of the Red River Delta. Nam Dinh City with a population of 230,000 is the capital and only urban center of Nam Dinh Province with a population just below 2 million. The municipality of Nam Dinh consists of 15 (urban) wards and 7 (rural) communes.

Nam Dinh's economic development is somewhat behind of other Vietnamese cities, especially those included in the Northern Key Economic Area (axis Hanoi Haiphong). The economy of the province is still largely based on agriculture, whereas the city functions as local center for administration, industry, service and trade. Major industry includes textile and garment factories which had to face deep crisis in the past years. The overall growth of the population in Nam Dinh City with an estimated 1.25 % per year is very low, caused by falling birth rates and a steady migration flow towards the northern economic center, mainly Hanoi.

The most common diseases among Nam Dinh's population reported during 1996 were diarrhea, dysentery, typhoid and influenza. Worm (Ascaris) infections with 92% of school pupils affected constitute another health problem. Most of these diseases are related to poor personal hygiene and poor sanitation.

Tropical monsoons from August to October and a dry season from March to May characterize the climate in the Red River Delta. Average annual rainfall is 1800 mm, with peak days of 350 mm. Monthly rainfall averages range from 25 mm in January to 365 mm in August, temperature averages from 17°C in January to 29°C in July.

2.1.2 Public Services

Public services for water supply and sanitation in Nam Dinh City are provided by three companies: the Urban Construction and Management Company (UCMC) and the Urban Environmental Company (URENCO), which are subordinated to the Nam Dinh Municipal People's Committee, and the Water Supply Company (WSC) which is under the Provincial Department of Construction.

URENCO is responsible for the fecal sludge and solid waste collection and disposal.

UCMC is responsible for maintenance and cleaning of the drainage system, for parks and street lightening.

The WSC provides water supply for about 40 % of the urban population.

The merging of URENCO and UCMC as well as the transfer of WSC on municipal level are issues which keep being discussed within NDUDP and the municipality. However no changes are expected in near future (before 2005).

All PUE have generally weak capacity, including low staff skills, inadequate information systems and accounting procedures. Financial capacity is very limited as well, revenues are insufficient to meet the operational cost and capital investment in new equipment or facilities remains low.

2.1.3 Drainage, Sewerage and Solid Waste Management

Drainage and Sewerage

Nam Dinh is located in a very flat and low-lying area close to the Red River and next to the northern bank of the Dao River. Due to the flat topography the drainage system is characterized by close-to-zero gradients, which makes it very vulnerable to blocking caused by settled solids and dumped rubbish. This leads to frequent flooding of the city during rainy season.

No sewer system for the evacuation of domestic wastewater exists, and consequently no central sewage treatment facility. On-site sanitation is prevailing (see chapter 2.2). Nevertheless it is important to state that the drainage system, conceived for the rapid evacuation of storm waters, de-facto acts as a combined sewer system for both domestic wastewater, industrial wastewater and storm water. Industries mostly discharge wastewater directly into the drainage system. Domestic wastewater pretreated in septic tanks or greywater cannot infiltrate due to low soil permeability, and sooner or later ends up in the drainage system.

Many pour-flush toilets are directly connected to the next drain without pretreatment in a septic tank, sludge evacuated from septic tanks or latrines is often dumped into drains, or people defecate directly into drains. The direct consequence of this situation is increased solids accumulation in the drains, contributing to blocking and flooding. Through flooding the wastewater is widely distributed in the urban environment, causing negative effects on public health.

The sewer or drainage system is not a closed system but is connected at numerous points to the irrigation system and to fishponds. The dry weather flow, basically consisting of wastewater, ends up to a major proportion as irrigation water or in the fishponds. This bears the considerable advantage of the wastewater being naturally treated in ponds and the nutrients reused in agriculture and aquaculture. However the health risks through spreading the pathogen organisms and worse the industrial wastewater in the environment are high.

The sewers and drains are maintained and cleaned by UCMC. Currently the cleaning and dredging is realized manually, by means of shovels and pushcarts. The sewer sludge is disposed in the central park. Analyses of sewer sludge indicate a very high content of sand and silt and a low organic content (20% TVS). Sewer sludge often contains solid waste components.

New sewer cleaning equipment will be purchased under NDUDP, containing a high-pressure jetter, a vacuum tanker and mini-vacuum tugs. This equipment will be available around March 2002.

There is a French project for a centralized wastewater treatment project, but no detailed information is available to date.

Solid Waste

Roughly 60 % of the domestic solid waste is collected, equivalent to 80 t/d. URENCO operates pushcarts, tipper trucks and a hooklift truck with several containers for MSW collection. The waste is disposed on the new landfill, which was opened only recently (08/2001), after overcoming great protests of the neighbors by compensating them. The landfill (0.8 ha) is sealed with a clay layer (natural substrate) and a very basic plastic lining, and is equipped with a basic drainage system for leachate extraction. Two ponds (1000 m^2 and 1200 m^2) are foreseen for leachate treatment, but how the leachate treatment will be realized is not yet clear. Next to the landfill, land (20 ha) is available for extension of the landfill.

A composting plant is projected right next to the landfill. The project is funded by a French loan, design is completed, and the site clearance is under way. Construction is expected to finalize end of 2002. The treatment of the MSW will contain the following steps: primary manual and mechanical classification, 3 weeks composting with forced aeration, 3 weeks maturation without aeration, mechanical and magnetic classification, sieving, packing of compost. The produced compost is planned to be sold as fertilizer, the inert residue will be landfilled. The plant is designed for a total capacity of 250 t/d. Several requests have been made by NDUDP to influence design towards a co-treatment of MSW and septage, but the French side showed little interest, and the municipality delayed the decision unitl the hand-over of the plant in 2003. Both the landfill and the composting plant are or will be operated by URENCO.

2.1.4 Land Availability

All land in Vietnam is state property, only land use rights are transferable (leasehold system). Farmers usually have 15 years rights. Whenever land is required for public projects, lengthy negotiations need to be held to compensate the land user. The compensations paid are often considerable amounts. This makes the acquisition of land a time consuming, difficult and expensive process. Currently the Nam Dinh municipality possesses the land rights for some 20 ha, the site where the new land fill is already constructed and the composting plant is going to be constructed. Enough land is available for further extensions of the landfill and more surrounding land may be acquired when necessary. The municipality will eventually provide land on this site for septage treatment.

2.2 Toilet Facilities and Fecal Sludge Management

2.2.1 Toilet Facilities

Excreta disposal in Nam Dinh is based on on-site sanitation facilities in individual houses such as bucket latrines, pit latrines, double vault latrines, pour-flush or WC toilets connected to a septic tank, or on public facilities as public bucket toilets or toilets connected to a septic tank. Some septic tanks serve several households, mainly in apartment blocks.

Several surveys give information about the current distribution of sanitation facilities in Nam Dinh City and allow prognostic of the future developments:

- Table 1: Access to toilet facilities, 1997

toilet in housing unit	73%
shared toilet	10%
public toilet	14%
no toilet	3%

- Table 2: Type of toilet facility and way of excreta disposal, 1997

pour-flush or WC toilet connected to septic tank	50%
pour-flush or WC toilet connected to drainage system	10%
pour-flush or WC toilet disposing to open field/river/lake	3%
bucket latrines	21%
pit latrines	5%
double vault latrine	4%
open latrine or other	6%

- 1998, 66 % of the septic tanks were younger than 5 years.
- 1998 and 1999, roughly 900 septic tanks have been built using loans from the septic tank fund, more than 1650 until august 2001.
- 1998 and 1999, for each tank built with loan from septic tank fund, 5 tanks have been built without loan.

These results allow estimating the growth rate of coverage by septic tanks and the projection of future coverage. Except a limited number of septic tanks dating from the time of French colonialism, the construction of septic tanks has started only in the late eighties then rapidly increased within the last years. 1993, the total number of septic tanks was still under 10,000, 1997, the coverage was already 50 % with roughly 22,000 septic tanks, currently already 35,000 households have a septic tank, and in the year 2010, the coverage will reach 90 % with almost 50,000 septic tanks.

The basic concept of septic tanks is the retention of floatable and settable solids in the tank and their anaerobic digestion. Although the digestion is reasonably good, some sludge accumulates in the tank. To maintain the hydraulic conditions allowing proper retention of settling and floating solids, the sludge has to be removed before the tanks is one-third to half filled with sludge. With conventional design, the required emptying interval is from 2-5 years, depending on the sizing of the tank.

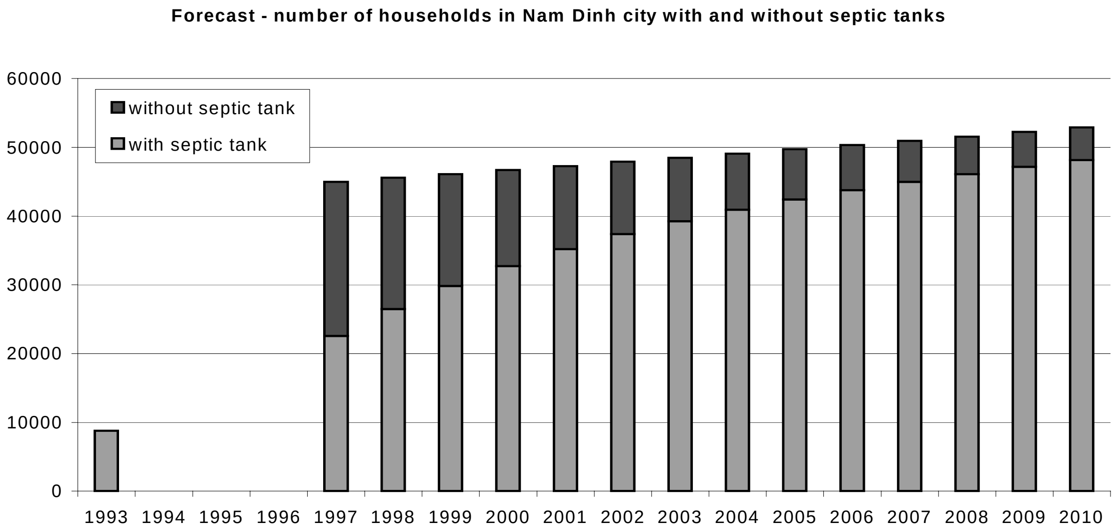


Figure 1: Forecast[1] of number of septic tanks in Nam Dinh City.

The septic tanks used in Nam Dinh comprise anything between a properly constructed two-chamber tank according to the Vietnamese standard, and a single small chamber with limited solids retention. No exact figures exist about the distribution of the different types of septic tanks. The tanks constructed with the NDUDP revolving fund have to fulfil the standard design, and apparently most of the new septic tanks constructed without loan from the fund are two-chamber tanks as well. The dimensions of new septic tanks are quite often deduced from availability of space and not designed according to the actual load depending on the number of users.

The Vietnamese Standard design foresees a volume of 200 to 250 L per person for septic tanks serving up to 10 persons.

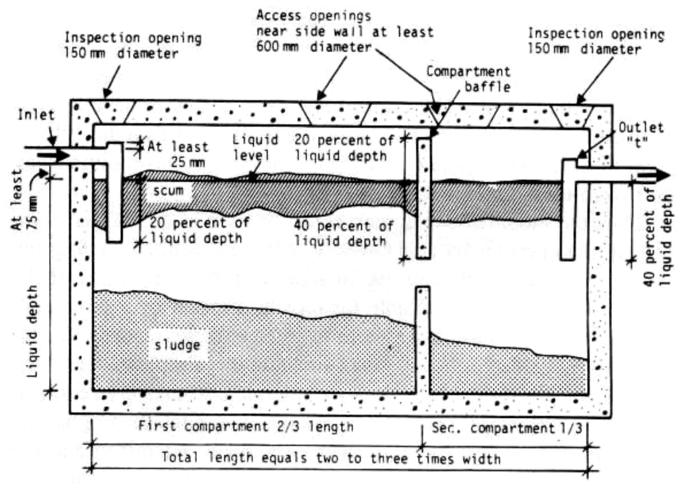


Figure 2: Two-chamber septic tank.

Bucket toilets were the second most important sanitation facilities in 1997. Together with other latrine types, these systems are increasingly replaced by pour-flush or WC toilets,

[1] Based on several NDUDP surveys, an assumed population growth rate of 1.25 % and the average household size of 4.75 cap.

mostly connected to a septic tank. More and more people can afford to build an own toilet in-house, the type chosen are the convenient and hygienic pour-flush toilet or WC. The promotion of septic tanks through the revolving fund of the Women's Union, initiated through NDUDP, certainly contributes to this development. However the increasing propagation of septic tanks is above all part of a generalized tendency observed all over Vietnam.

2.2.2 Sludge Collection

Septic tanks in Nam Dinh are in general only emptied when problems like blocking of the toilet or bad smell occur, which occurs when the tank is completely full with settled solids and scum. Sometimes tanks are emptied as well in periodical intervals, to prevent blocking. The owner mandates either URENCO or privates with the emptying of the septic tank. URENCO does the work by its single IFA vacuum tanker and charges 260,000 VND for the service. Only 150 septic tanks were emptied last year in that way. Unit cost for septic tank emptying and septage transport has been calculated as 40,000 VND/m^3. Private emptiers are workers of UCMC and URENCO doing this as second job out of working time, bucket collectors or others. They evacuate the sludge manually with shovels and buckets and charge between 100,000 and 500,000 VND. As no statistics exist, it is impossible to assess the number of septic tanks emptied in this way. Approximately one third of the houses are located in narrow lanes, out of the range of the vacuum tanker. Currently these houses are exclusively served by manual emptying, however even in the accessible areas, manual emptying is quite common.

The transport distances for septage in Nam Dinh are rather short. Even if all septage would be disposed in one central site outside the city, the maximal haulage distance would still be less than 10 km.

Bucket toilets and many public toilets are emptied in daily to weekly intervals by bucket collectors, usually by night or in the early morning hours. These collectors are either farmers or are intermediates who sell the sludge to farmers, who use it for fertilizing.

2.2.3 Disposal and Reuse

Septage is dumped in fishponds, on fields or wherever the driver of the vacuum tanker finds a location to dump it. Sometimes a small amount of money (10,000 VND per truck) can be obtained from a farmer or pond owner, but generally the money is not worth the effort necessary to find a person willing to take a load of septage. As a new landfill is available now, septage will eventually be disposed there as well in the near future.

Bucket sludge is very welcome by farmers practicing aquaculture as well as in agriculture. Farmers state that bucket sludge is becoming increasingly unavailable and more expensive, due to the replacement of bucket latrines by septic tanks, both in the urban and in the rural area.

The wastewater standard applicable for septage and effluents from treatment facilities is the *Industrial Wastewater Discharge Standard* (TCVN 5945-95). The standard specifies allowable concentrations for discharge into water bodies of class A (water used for drinking water), class B (water used for recreation or agriculture), or class C (permit needed). Following this regulation, it is against Vietnamese law to dump septage into the environment, in drainage and irrigation channels and in fishponds.

A new regulation for landfills is in preparation, which will not allow any more the disposal of sludge on landfill.

2.2.4 Potential for Reuse of Treated Fecal Sludge

The typical requirement for organic fertilizer in Nam Dinh's rice cultivation is 16 t/ha. Farmers generally only dispose of organic matter produced by the own family, such as pig manure, human waste from the family, vegetal matter. Only half of the total demand of organic fertilizer can be met in this way. The use of the available manure for vegetable cultivation is preferred over the use in rice cultivation. The latter often receives only very little organic manure and farmers try to compensate this by using more mineral fertilizer. Following the National Institute for Agronomic Science in Hanoi, the lack of organic fertilizer in rice cultivation is a limiting factor for rice production in the Red River Delta.

Currently, almost no trade with organic fertilizer exists. The only products traded are bucket sludge (1000 VND/kg wet sludge) and industrial organic fertilizer (1000 VND/kg dry fertilizer). The former is mainly used for aquaculture, whereas the latter is used for intensive cultures as bonsai, flowers or vegetable.

Compost from solid waste or treated fecal sludge is currently not on the market, but all farmers state that such a product would be very welcome if price and effectiveness were satisfying. Compost of high quality would mainly be used for vegetable, lower quality for rice cultivation. According to statements of farmers and representatives of agriculture services and cooperatives, compost of solid waste or treated fecal sludge has a high potential to be accepted by Nam Dinh Farmers. Following points are important for a successful commercialization:

- Farmers need trials with a new product to get convinced of its beneficial effects.
- The product must not contain glass or metal residues.
- Delivery to a local agent in sacked form is desired.
- The upper price-limit for a good quality product may be around 300-500 VND/kg.

2.2.5 Sludge Characteristics

Estimated Volume

The only type of sludge produced in future in considerable and increasing quantity will be sludge from septic tanks. The sludge from bucket latrines was a considerable amount still a few years ago (3000 bucket latrines in 1997), but the volume will be decreasing sharply with the increasing distribution of septic tanks. As the bucket sludge has a quite high market value, it is expected that privates continue to collect this type of sludge for agriculture. Sludge and night soil from other latrine types such as pit latrines or double vault latrines are of minor importance, as these facilities are distributed mainly in the suburban or rural area and the families usually directly use the sludge.

Reportedly, 150 septic tanks in individual houses and 20 septic tanks from office and apartment buildings have been emptied by URENCO in 2000. No statistics exist about the actual volume collected. It can be considered that the volume of sludge evacuated from a septic tank corresponds more or less to the volume of the septic tank, plus some cleansing and rinsing water. The size of a septic tank in individual houses ranges from 1 to 4 m^3, the size of a septic tank in office or apartment buildings from 10 to 100 m^3. The following estimations and assumptions will be used for the purpose of this study:

- One septic tank per 4.75 inhabitants
- Average volume of septage produced through emptying of a septic tank by vacuum tanker: 2.5 m3
- Emptying frequencies, which are in accordance with septic tank design (2-5 years intervals) will be observed

Most septic tanks are relatively new and have never been emptied so far. It is difficult to estimate exactly after how many years a septic tank is overloaded and blocked making emptying inevitable. 10 years might be a reasonable estimation. Certainly the septic tank has to be emptied earlier to maintain its function, the optimal frequency being 2-5 years depending on tank size and number of users.

Figure 3 shows the estimation of the future demand for septic tank emptying: The scenario with a 10 years frequency of emptying represents the situation when nothing is done for encouraging more frequent emptying, whereas the second scenario is the optimum scenario with all septic tanks emptied with a 5 years frequency.

Introducing 5 yearly emptying of all septic tanks will constitute a major challenge for the public services. Nevertheless, even if septic tanks are emptied only after blocking, the demand will increase sharply in near future.

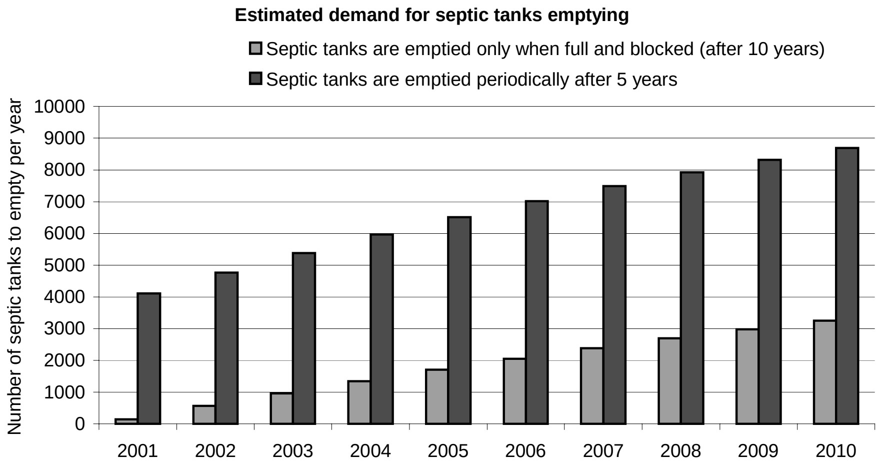


Figure 3: Estimation of future demand for septic tank emptying.

The estimations base on the figures of several surveys, but only one, the household survey 1997, was carried out following a scientific methodology. Nevertheless, the estimations are in good conformity with observation from other locations and the relative dimension of the figures is plausible.

Estimated Quality

Generally it is very difficult to establish representative characteristics of septage, as these characteristics vary considerably dependent on the properties of the septic tanks and the habit of its owners, the frequency and technique of emptying etc. Without a great number of samples, it is impossible to establish representative figures. This is also valid for the Nam Dinh situation, where only a few samples have been analyzed in the past and during this study. The data available is very inconsistent, and the low number of samples suggests that these figures should not be used for any kind of design or further estimations.

For this study, the values of septage from Bangkok, based on more than 150 samples from vacuum tanker have been adopted. Bangkok is a city of comparable climate and culture, and in its suburban parts of comparable living standard as Nam Dinh. Actually Bangkok is much bigger than Nam Dinh, but no comparable set of samples for city of minor size is available for SE-Asia.

Table 3: Characteristics of Bangkok Septage

Parameter	Range	Average
pH	6.7 – 8	7.5
TS [mg/L]	2,000 – 67,000	19,000
TVS [mg/L]	900 – 52,500	13,500
SS [mg/L]	1,000 – 44,000	15,000
BOD [mg/L]	600 – 5,500	2,800
TCOD [mg/L]	1,200 – 76,000	17,000
TKN [mg/L]	300 –5000	1,000
NH_4 [mg/L]	120 – 1,200	350

Based on 150 samples from vacuum tanker between 08/1997 and 11/2000 by AIT.

2.3 Stakeholders involved in Fecal Sludge Management

2.3.1 Urban Dwellers

When people decide about new type of toilet facility, comfort is the main criterion. Most Nam Dinh citizens move from using a shared toilet or a public toilet to a toilet within the house. The tendency to upgrade houses with more convenient and hygienic pour-flush toilets or WC these toilets, or to build new houses with a toilet, is very general. Most people know that for legal and practical reasons they need to combine a pour-flush toilet with a septic tank. Many but not all do so. There is no sufficient enforcement for the construction of septic tanks through the municipality.

Most people are somehow aware that they should empty a septic tank from time to time to prevent blocking. However many people do not know that a septic tank should be emptied in regular intervals to maintain its function for environmental reasons. Emptying a septic tank is expensive, equaling almost a month's income for poor people, and harassing with the bathroom floor to be broken and the work inside the house. That is why most avoid emptying as long as no problems occur, or they even try to postpone emptying by using "miracle" products available for this purpose.

The protests surrounding the opening of the new landfill have shown that people are quite aware of the negative impacts of a waste treatment or disposal site and that they are able to exercise considerable pressure on the authorities during negotiations for compensation. Sludge from septic tanks or bucket toilets is generally perceived as something terrible. It is therefore possible that a project for a septage treatment plant may face protests by neighbors, fearing impacts as odor emissions or fly proliferation.

Mircro Phot

Micro Phot is a well known and often used product in Vietnam, it is frequently advertised in TV and radio.

Micro Phot is said to free blocked toilets and make emptying of septic tanks superfluous.

Micro Phot contains microorganisms and fat/oil digesting enzymes. It might actually enhance the biological degradation of the fatty scum layer, responsible for blocked toilets.

However, it is absolutely impossible to make emptying of septic tanks superfluous. Digested sludge will still accumulate on the bottom of the septic tank.

2.3.2 Municipality and PUE

Currently, municipal officials are not aware that frequent emptying of septic tanks is in public interest. The prevailing opinion in the municipal departments as well as in URENCO is that the responsibility for emptying septic tanks is entirely on the owner's side. URENCO acts basically as provider of a commercial service. No efforts are made from municipal side to promote the service of URENCO, to increase awareness of the population towards more frequent emptying, or to increase mechanical emptying instead of the unhealthy manual emptying.

Financing of the PUE's activities, particularly of URENCO's, is a constant problem. URENCO has great difficulties every year to obtain the necessary budget for carrying out solid waste collection. URENCO soon will face a new huge challenge, both financially and operationally with the hand-over of the new composting plant. Providing additional financing for an increased septage collection capacity and eventual subsidizing of the collection fee will meet major difficulty.

2.3.3 Private Sector

The private sector is currently consisting of individuals only. Those are bucket collectors who earn money by selling sludge to farmers or they are workers emptying septic tanks against payment. Their actives are mainly influenced by market factors as price paid for sludge, price for emptying of septic tanks, availability of other better work opportunities, etc.

No private companies are currently involved in septage management, and no mechanical equipment other than the vacuum trucks of URENCO is used in Nam Dinh.

2.3.4 Farmers and Cooperatives

Use of human waste in agriculture is practiced for centuries in Vietnam, and is still fully accepted by both farmers and consumers. The traditional way to use human waste is to store it for one to two months on a pile next to the field, together with animal waste and vegetal matter. Farmers believe that fresh human waste cannot be applied directly on the field, mainly because damage to the plants is feared. Farmers know that use of fresh human waste is somehow dangerous for health, without actually being aware of the real nature of hygienic dangers.

Nam Dinh farmers are to some extent aware of the beneficial long-term effects of organic fertilizer and do not confuse the different nature of mineral and organic fertilizer. They know about the general lack of organic fertilizing. Farmers will accept a commercial organic fertilizer made from solid waste or fecal sludge, if they are convinced of the benefic effects and if it is not too expensive.

The choice of a fertilizer is almost exclusively influenced by agronomic and economic arguments. Environmental or hygienic reasons are less important.

Farmers are organized in agriculture cooperatives. Their main role is administrating the land use rights and providing services as irrigation, electricity, fertilizer supply etc. Thus, the cooperatives have considerable influence on practices of individual farmers, as they transmit instructions for fertilizer use and cultivation practice. The cooperatives are subordinated to the Municipal Agriculture Service and to the Provincial Agriculture Service. The Provincial Service's Fertilizer Division carries out trials with fertilizers and disseminates instructions of fertilizer use.

2.3.5 NDUDP

The wastewater and drainage strategy of NDUDP has the following main objective: "To build on the existing drainage and sanitation system and to optimize its function both financially and operationally." Further it is stated: "Sustained operation of the existing sewer system will require retention of solids in septic tanks; improved construction of the tanks, operation, cleaning, and treatment of sludge to form a product suitable for safe disposal."

So far the effort of NDUDP's activities in this sector has been concentrating the promotion of septic tanks only, without emphasizing on proper operation and emptying of the tanks. Some efforts have been made discussing co-treatment of septage and solid waste or septage treatment in constructed wetlands. The present study is the initiative for a more comprehensive approach of the problem.

There is the possibility that NDUDP might contribute to funding of investments for treatment plant, equipment and of initial operation costs.

2.4 Septage Management in other Vietnamese Cities

The comparison with other Northern Vietnamese cities shows that the situation is very similar all over. All cities show very low level of septage collection. In none of the cities, septage is successfully treated. None of the disposal practices is suitable for the projected volumes of septage.

In Hanoi and Viet Tri, co-composting with solid waste has been tried, however so far not in full-scale operation. The Haiphong example shows that with combined large and small equipment, a technical solution for reaching all households with vacuum tankers is available. The Viet Tri example shows that compost produced from solid waste has good potential for commercialization, which can be assumed for treated septage too.

Hanoi (pop. 4.5 Mio)

URENCO collects approximately 250 t/d of fecal sludge in a catchment area of 1.4 Mio inhabitants. This corresponds to 4500 t/year per 100,000 capita. Septage is currently dumped together with sewer sludge on a temporary dumping site (Yen So), or used in aquaculture.

At the Cau Dien solid waste composting plant, currently in renovation, a device for co-composting of septage will be installed. It is understood that this installation will consist of a sedimentation facility, the solid fraction then being mixed with solid waste for composting and the liquid fraction receiving further treatment. Reportedly up to 300 t/d will be treated in this facility, which will enter operation 2002.

A JICA concept recommends decentralized septage lagoons in the short to mid-term and co-treatment with sewage in the long-term.

Haiphong (pop. 400,000)

The Sewer and Drainage Company is responsible for septage collection. Collection is carried out with vacuum tankers and small vacuum tugs for areas difficult to access, used together with intermediate-storage-tanks mounted on a hook-lift truck. The mini-vacuum-tugs were developed by the company in collaboration with a local manufacturer. They have a capacity of 350 L and cost around 4000 $. The combination of large and small equipment has proven successful and almost 100% of the houses can be covered. The septage is disposed on the landfill, which is not perceived as satisfactory solution by the Finnish Water Supply and Sanitation Project. A future World Bank project will contain a component for septage treatment, drying bed were mentioned as possible treatment option.

Haiphong made mini-vacuum tug (350 L) for narrow lanes, used together with a intermediate-storage-tank placed in the next accessible road.

Irish made mini-vacuum-tug (500 L), has not been very successful as dimensions are still too large.

Figure 4: Equipment for septic tank emptying used in Haiphong.

Hue (pop. 250,000)

Approximately 6000 m^3/year of septage are collected by the 2 vacuum tankers of the PUE and by one of a private company. The costs for septage collection are estimated as 40,000 VND/m^3. The septage is disposed on the landfill, but the private company is not allowed to dump on the municipal landfill and has its own dumping sites. Landfilling is not seen as satisfactory. The SDC project has proposed settling tanks + co-composting as septage treatment. However municipal authorities favor co-treatment with sewage in a projected wastewater treatment plant, funded by the Belgians (the SDC project is phasing out and does not provide funding any more).

Viet Tri (pop. 130,000)

URENCO operates 2 vacuum tankers for septage collection. It was reported that 1,000 septic tanks are emptied per year. The collection fee is 400,000 VND per truck. The demand for septic tank emptying is increasing steadily, as most septic tanks have been build only after 1990. Septage is disposed in fishponds, the cooperatives pay up to 50,000 VND per truck. The solution is perceived to be satisfactory by the involved parties.

Solid waste is treated in a composting plant, which operates well since two and a half years. The entire quantity of compost is apparently sold to farmers for 20-550 VND/kg, depending on the quality. Out of 50t/d of municipal solid waste, 18-20 t/d of compost are produced. The composting plant possesses a vacuum truck for septage collection for co-treatment of septage with solid waste. However almost no septage is collected by this truck, and the co-composting is actually not existent. The projected septage to SW ratio was 1:20.

Thai Nguyen (pop. 220,000)

Approximately 150 septic tanks are emptied per year by the single vacuum tanker of URENCO, which operates since 1997. The emptying fee for one septic tank is 400,000 to 500,000 VND. Septage is mostly dumped on the solid waste dumping site and sometimes sold to farmers. End of this year a new sanitary landfill will be opened for solid waste disposal. Septage cannot be disposed on the new landfill, but so far no other solution was found.

Dong Hoi (pop. 100,000)

100-150 septic tanks are emptied per year in Dong Hoi, the fee is 300,000 VND per tank. The septage is used in a fertilizer factory.

2.5 Conclusion

Current Situation

Currently, the management of fecal sludge in Nam Dinh is very unsatisfactory:

- Septage is dumped into the environment (dumping sites, fishponds, fields, surface waters).
- Septic tanks are not maintained (de-sludged to maintain function).
- Septic tanks are emptied manually, septage is handled incautious and is dumped into the drainage system and the environment.
- Septage and bucket sludge is used untreated in agriculture and aquaculture.

The situation in Nam Dinh is typical for Vietnamese Cites. No city in northern Vietnam possesses a proper fecal sludge management.

Future Situation

It is expected that septage volume will increase considerably within a few years. While the today's situation is still somehow tolerable because of the little total volume of septage produced, this will soon change dramatically and great problems with the collection and the disposal of septage will occur.

Impacts

The handling of fecal sludge like it is currently practiced has two principal negative impacts. These will become much worse in future, with the expected increase of septage produced:

- *Risk for public health due to lacking treatment or safe disposal:* Sludge accumulated in septic tanks contains pathogen organisms like bacteria causing diarrhea, dysentery, cholera, typhoid, etc. and intestinal parasites. Whenever humans enter in direct contact with septage, these diseases can be transmitted. The risk of transmission of diseases consists when septage is handled without protection measures, when septage is spread in the environment or when septage is used in agriculture.

- *Solids accumulation in drainage system due to lacking maintenance of septic tanks:* If septic tanks are not emptied in regular intervals, they loose their main function, the retention of solids. Increased solid accumulation in the drainage system results and contributes to blockage of drains and flooding. The efforts for sewer cleaning have to be intensified.

Problems

Improved septage management requires increased emptying frequency of septic tanks, extended coverage of the service on all households, and eliminating untreated septage reaching the environment. The main problems to overcome are:

- The lacking awareness of municipality and population of the problem and the needs for improvement.
- The lack of financial and operational capacity of the PUE for improved septage collection.
- The lack of a treatment facility or a safe disposal site.

Some Possible Solutions

The following list is not exhaustive, but summaries potential solutions or measures that emerge from the situation analysis already. A complete discussion of solutions follows in the next chapter.

- Promotion of a correct septic tanks design and improvement of septic tank maintenance. The transition from traditional toilets to water toilets with septic tank has already progressed far. Soon septic tanks will be the dominant sanitation system as a matter of fact.
- Combined equipment of large and small vacuum tankers, as used in Haiphong, appears to be a good technical option to cover all households with an efficient and hygienic emptying service
- Reuse of treated septage in agriculture. There is a great demand for organic fertilizer in Nam Dinh agriculture. Available space for SW disposal is very limited. Recycling of septage in agriculture would require zero disposal space and contribute to better agriculture practices. This solution would be a perfectly sustainable.
- The haulage distances for septage in Nam Dinh are short. This makes one central septage treatment site more favorable compared to several decentralized sites.
- The site of the new landfill and the planned composting plant seems to be the ideal place for a first phase treatment plant. Land will be easily available on this site, whereas acquiring land on other sites will be time-consuming and expensive. The neighboring SW treatment and disposal facilities allow the consideration of many co-treatment options.
- Sludge from sewer and drainage system should not be treated together with fecal sludge, because its composition is very different. The high sand and silt content make sewer sludge suitable as material for filling of land. However, the sludge should be filled on sites inaccessible for the public.

3 SEPTAGE MANAGEMENT OPTIONS

3.1 Basis of Planning

3.1.1 Planning Horizon and Design Capacity

In industrialized countries it is common to design treatment facilities upon the demand of the next 10 to 20 years. However it is important to consider the relatively high uncertainty of projections for Nam Dinh. The data is based on very little statistical evidence, and all developments in Vietnam are much more dynamic and unpredictable as in industrialized countries. It is more prudent to design the first phase of the treatment plant for a rather short period. Periodical extensions of the treatment and the collection capacity should then follow, always adapted to the observed increase of demand and considering experience gained through operation of the first phase facilities. This approach is more pragmatic and adapted to the local conditions as the long-term planning of industrialized countries, and avoids major bad investment.

Two phases of planning are considered in this proposal:

2002 - 2003: Treatment capacity for 1000 septic tanks per year. This capacity corresponds to the already existing but more efficiently used collection capacity. The plant, which needs to provide treatment in this first planning phase, has to be built as soon as possible.

2004 - 2006: Extension of the collection and treatment capacity to 4000 septic tanks per year. The projected demand for the year 2006 is between 2000 and 7000 septic tanks per year. It is absolutely necessary to revise the proposed capacity before final design, using the experience gained with the first phase plant.

Predicted demand for septage collection and treatment:

Year	Septic tanks per year
2003	1,000 – 5,000*
2006	2,000 – 7,000*

*The demand depends on frequency of emptying (see Figure 3, page 6).

Chosen design capacity:

Year	Septic tanks /y	Sludge volume m^3/ y	TS t/y
2003	1,000	2,500	50
2006	4,000	10,000	200

3.1.2 Appropriateness of Measures and Technologies

The use of technologies and management concepts adapted to local conditions is extremely important for the successful implementation of proposed measures. Any expensive high-tech solution or organizational concepts directly transferred from different contexts implicate very high risk of failure. The proposed measures must be acceptable for Nam Dinh authorities and population and they must be compatible with the Vietnamese context. The municipality of Nam Dinh must be able, financially, technically and with its human resources, to operate the proposed system and also to extend it in order to satisfy future demands.

3.1.3 Principal Objectives

The principal objectives of improving septage management are the following:

- Improvement of public health.

  Elimination of dumping of septage into the environment and of unsafe use of untreated septage in agriculture.

- Improving the functioning of the drainage system.

  Enhancing solids retention in septic tank to reduce solids accumulation in the drainage system.

3.1.4 Specific Objectives

The following list of objectives specifies the above established overiding principles for the different components of septage management.

Collection

Until 2003:

- Increase collection rate to 1000 septic tanks per year.

Unitl 2006:

- Provide capacity to increase collection rate to 4000 septic tanks per year.

Long-term:

- 100 % of the households are reached by the service for emptying septic tanks.
- Shortening the emptying intervals to a maximum of 2 to 5 years depending on the size and number of users of a septic tanks.

Objectives for Septage Treatment

Until 2003:

- Providing treatment capacity for 1000 septic tanks per year until year 2003.
- Transforming septage into products suitable for safe disposal or reuse:
  a) Solid fractions with reduced volume and water content and with adequate hygienic quality.
  b) Liquid fraction with low content of pollutants and reduced level of pathogens.

Until 2006:

- Providing treatment capacity for 4000 septic tanks per year.

3.1.5 Criteria for Evaluation of Treatment Options

A detailed comparison and evaluation of various treatment technologies is the core component of this study. A clear list of criteria, defining in which way the established objectives have to be met, is essential for the systematic evaluation of the different technologies.

Performance

a) *Achievable consistency of solids*. The solids should be easy to handle and the volume be reduced as much as possible. The parameter, which best expresses this, is the achievable solids content. TS > 20-30 % should be achieved.

b) *Hygienic quality of solids*. The content of viable pathogens (worm-eggs) should be very low or zero to allow safe reuse in agriculture. The requirement for post-treatment to meet this criterion should be minimal.

c) *Quality of liquid effluent*. The content of pollutants should be as close as possible to the Vietnamese standard regulating discharge in surface waters. The requirement for polishing treatment should be minimal.

Simplicity and Reliability of Process

d) O+*M requirements*. The process should require as little input as possible to operate and to maintain it.

e) *Skills required for operation and supervision*. The skills required to operate the plant should be as basic as possible.

f) *Risk of failure*: The estimated risk of failure through identified weak points should be as low as possible.

Cost

g) Minimal Land requirement.

h) Minimal Investment costs

i) Minimal Operation and maintenance cost

3.2 Sanitation Options

The discussion of the sanitation strategy is beyond the scope of this report, as the attempt to improve septage management already bases on the proposed strategy to build on the existing sanitation system. Nevertheless a short overview and discussion of different options for a sanitation strategy is given to demonstrate the logic behind the chosen strategy.

On-site sanitation

The existing system is largely based on on-site facilities, such as different types of latrines and public toilets, as well as septic tanks. Pour-flush or WC toilets combined with septic tanks have become the option of choice in urban Nam Dinh, because they are perceived as the most modern and convenient to build in-house. The wastewater is subjected to preliminary treatment in the septic tank. This system is widely used also in industrialized countries. In the USA, e.g., 25% of the population are served by septic tanks.

In Nam Dinh, the soil conditions do not allow infiltration of septic tank effluents. The partially treated effluent ends up in the drainage system. Various improved designs of septic tanks providing improved effluent quality have been developed. These designs include three-chamber tanks, and add-on vaults with an up-flow anaerobic gravel filter or with baffles inducing suspended biomass growth, etc. These advanced systems are more failure-prone than conventional septic tank, particularly when adequate emptying intervals are not observed. The main focus of pre-treatment in septic tanks in Nam Dinh is the solids retention to relieve the drainage system, and to a lesser extent the improvement of effluent quality. The effluent usually ends up in fishponds or as irrigation water and the remaining organic components and nutrients are welcome for plant nutrition. The conventional two-chamber design is therefore considered satisfactory for Nam Dinh, and efforts should be concentrated on further promotion of this standard model and adequate design.

Septic tanks serving several households, so-called condominial septic tanks, can be an advantageous solution where several neighbors upgrade their toilets in the same time, or where new houses are being constructed in the same neighborhood. In rural and in peripheral areas, where space is available to build toilets outside the house, dry latrines, like the traditional double vault latrines, might still be a satisfactory solution. These latrines can be very hygienic if properly built and maintained.

Remaining problems with septic tank sanitation consist of the efforts to be spent for proper septage management and the health risks associated with the reuse of septic tank effluents in agriculture and aquaculture.

The great advantage of septic tank sanitation for the municipality is that the investment for septic tanks are exclusively made by the individuals and not by the municipality. However, the municipality bears responsibility for septage management.

Sewerage (separate system)

Sewerage is the collection of domestic wastewater in a conduit system constructed for this purpose. The diameter and the slope of the conduits and pipes must be designed for self-cleaning velocities, to avoid accumulation of solids. Due to the flat topography, the construction of such a system would be require numerous pumping stations and would, hence, be very expensive. The existing drainage system is designed for evacuation of large peak flows of storm water. If domestic wastewater, not pre-treated in septic tanks, would be collected in this system, considerable sedimentation in drains would occur.

Sewerage would eliminate the need for maintaining septic tanks and treating septage, but skills, cost and organizational measures required for operating and maintaining a complete sewer system are at least as high as for septage collection. Centralized or decentralized sewage treatment calls for proper solutions for sewage sludge disposal and, hence, is associated with similar challenges as the ones for septage disposal.

Separate collection and treatment of industrial wastewater would make much sense, because currently the mix of industrial and domestic wastewater in drains constitutes a major problem for the reuse of this water in agriculture and aquaculture.

Small-bore sewerage is a low-cost alternative to conventional sewerage. Small-bore sewers carry only the effluent from septic tanks or from so-called interceptor tanks, which are smaller than septic tanks and designed to trap coarse solids. Since the large solids have been removed in septic tanks, it is not necessary to provide self-cleaning velocities. The pipes can be as small as 75 mm in diameter, continuos downward gradient is not required and manholes can be spread at longer distance. The flat gradients obviate the need both for deep excavations and pumping, and in a flat area, this should allow considerable savings in cost. This system is theoretically very appropriate for Nam Dinh. However, small-bore sewerage extremely depends on regular and efficient emptying of the septic tanks. The small pipes are very susceptible to blocking by solids from not properly maintained septic tanks, and they are very difficult to clean. This system is not suitable for Nam Dinh, as long as regular desludging of septic tanks cannot be guaranteed.

Conclusion

It is evident that in the foreseeable future the described alternatives to septic tank sanitation are not feasible, neither technically nor financially. Sewerage systems might perhaps be introduced in future in selected neighborhoods. As a consequence there would be a patchwork of different sanitation systems adapted to the specific conditions of each city neighborhood. Improved septage management will thus be necessary, both in the near and far future.

3.3 Septage Collection Options

3.3.1 Long-term Options

Septage collection is more an institutional than a technical challenge. A number of institutional options exist, which can be combined in one or another way. Two opposite strategies have been elaborated to demonstrate the different possible scenarios.

Technical problems are limited to the choice of the appropriate equipment for emptying septic tanks. Below, a solution considered adequate and optimal for Nam Dinh is presented.

Technical Solution: Equipment for Septic Tank Emptying

Truck-mounted vacuum tanks of 3 to 6 m^3 capacity and small, hand-pushed vacuum tugs of 350 to 500 L will used for emptying septic tanks. In houses situated close to a road, the septic tank is emptied with the large truck and the septage can directly be hauled to the treatment site. If the house is situated in a narrow lane, a mini-vacuum-tug is used: an intermediate-storage-tank (3 to 6 m^3) is placed in the closest point accessible by truck, then the septic tank is emptied by a mini-vacuum-tug in several trips, the septage always being discharged into the storage tank. This storage tank is then transferred by hook-lift to another emptying site or to the treatment site. One unit of equipment, either large or small, can serve 2 to 3 septic tanks per day or approximately 500 per year. The demand for 2003 can be satisfied with 2 units only, however in 2006, 8 units will be needed to meet the projected demand.

Investment cost for collection of sludge from 500 septic tanks	
1 vacuum tanker	80,000 $
or	
1 mini-vacuum-tug and 1 inter-mediate-storage-tank	12,000 $
Operation cost for collection of sludge from 500 septic tanks	
1250m^3 septage x 40,000 VND /m^3	3300 $

New equipment of the described type is being purchased, however the current designation is for sewer cleaning only. The equipment is perfectly suitable for both sewer and septic tank cleaning. It would be very advantageous to use the equipment for both tasks in parallel, instead of operating two separate fleets with the same kind of equipment. The incorporation of both activities in one PUE is therefore recommendable.

If exclusively vacuum tankers and small vacuum tugs would collect septage, the unhygienic manual emptying could be eliminated.

Institutional Option A: Emptying Septic Tanks is the Owners Responsibility

This option keeps the current system and aims to improve it. The responsibility for emptying the septic tanks remains on the owner's side, they decide when they want to empty it. This requires a very high awareness of the population for the need to empty regularly the septic tanks and technical knowledge to determine the intervals of emptying. The service of emptying is provided by a PUE, which actively promotes its service. Ideally one single PUE (merged URENCO and UCMC) is responsible for sewer cleaning and septic tank emptying. A private company, under license of the responsible PUE can also provide the service of emptying septic tanks. The service is financed through directly paid fees, which are eventually subsidized by the municpality to render them more attractive. Disposal of septage collected by privates at the treatment plant has to be enforced.

The following measures have to be taken:

- Intensive and prolonged awareness raising campaigns
- Merging URENCO and UCMC or defining clear responsibilities.
- Increasing of collection capacity of the PUE and active promotion of the service

- Introduction of regulations concerning the emptying of septic tanks by the private sector, focus on worker protection and on elimination of indiscriminate septage disposal.
- Subsidizing of collection fees

Institutional Option B: Emptying Septic Tanks is a Public Task

This option implies a fundamental change of the existing system. The municipality decides that a proper septage management is in the interest of the public and has to become a public task. The PUE responsible for periodical emptying of all septic tanks has to be designed. The merging of URENCO and UCMC has to be considered as well. A detailed database is necessary to manage the periodical emptying. The PUE has to contact the household when it is time to empty the septic tank, carry out the emptying and register the action. The service is financed by a monthly fee, optimally included in a general "environmental betterment fee" collected together with other service fees, as for water supply and solid waste. A partially subsidizing out by the municipality can be considered, if the monthly fee is too high to be acceptable for the citizens. Broad awareness rising campaigns will help to increase acceptance and understanding of the population for the introduction of this service.

The following measures have to be taken:

- Introduction of a regulation defining periodic septic tank emptying as being in the public interest, making the emptying compulsory and transferring the responsibility for the emptying to the municipality.
- Merging URENCO and UCMC or defining clear responsibilities.
- Increasing of collection capacity of the PUE
- Creation of management capacity of the PUE, including a detailed database
- Introduction of a monthly fee for septic tank emptying
- Awareness raising campaigns for better acceptance of monthly fee and the compulsory septic tank emptying

Conclusion

Option A builds mainly on raising of public awareness. Conflicting decisions are not required, but it is unlikely that the objective of 5-yearly emptying of all septic tanks can be achieved. Option B is more promising to fulfil the objectives, but requires more delicate political decisions and institutional changes.

Decision in favor of one or the other option is not possible at the moment, as all political and institutional issues are influenced by many non-technical considerations, which are very difficult to take into account. Additionally, many institutional aspects of the septage management cannot be treated in an isolated way, as they interfere with other issues and processes. The introduction of a one-bill system for all environmental services, or the merging of PUE are examples for such interdependencies. The solution must rather be the result of a continuos political discussion.

Important questions to be answered by politicians and authorities include:

- Should local government become actively involved in the septage management issue?
- Which PUE should be responsible for management and execution of the service? Is it possible to merge URENCO and UCMC?
- Is it acceptable to include all fees for environmental services in one-bill, is it acceptable to include a fee for septage management?

- Are regulations required to ensure the installation of correctly designed septic tanks, to ensure proper maintenance, and to exclude unhealthy emptying practices and indiscriminate disposal of septage?
- How can the enforcement of relevant regulations be improved?

3.3.2 Short-term Options

The process of political and institutional discussions will necessarily take its time before resulting in concrete changes. It has been pointed out under 3.1.1 that a quick implementation of a small scale first phase project is necessary, later followed by the gradual increase of treatment and collection capacity, accompanied by institutional reforms. This first phase project includes as well an increased collection rate, hence short-term measures are required.

The existing collection capacity has to be used fully and effectively. The demand until the year 2003 can easily be met, if the one vacuum tanker of URENCO, and one of the two mini-vacuum-tugs which are currently being purchased for UCMC, is exclusively used for septage collection. In the short-term, the easiest way to share the equipment between the two companies and to minimize resulting organizational conflicts is a contract of collaboration between URENCO and UCMC. Eventually one unit of the mini-vacuum-tugs can be rented full time by URENCO.

Two options for short-term measures are possible, similar to the long-term options discussed in 3.3.1:

a) Intensive awareness campaigns covering the entire city to increase the willingness of the population to empty septic tanks. At the same time URENCO intensively promotes its service and reduces prices as far as possible. The awareness campaigns have to be planned in collaboration with URENCO and are financially supported by NDUDP and the municipality. After 2003, ongoing campaigns will gradually rise the demand for emptying and the average frequency of emptying.

b) One area is selected, covering 1-3 wards or up to 5000 households. In this area, the periodical emptying of septic tanks is introduced. URENCO creates a database and starts with systematic emptying of the septic tanks in this ward. Awareness campaigns complement the measures. Initially, the municipality (Department of Transport and Public Works, DTPW) finances the emptying, eventually in the form of a service contract with URENCO. Later on, monthly fees will be introduced and contribute to the financing. In the first phase, the other wards will continue to be served on request only, but after 2003, the coverage with the periodical service is extended step by step on other wards.

The option b) promises a very rapid increase of the collection capacity and constitutes the first step towards the more sustainable institutional reforms of the option B presented above.

3.4 Septage Treatment Options

3.4.1 Introduction

Much has been done to study low-cost wastewater treatment technologies adapted to conditions of developing countries. Those technologies have been widely used and proven successful in practice, various good design manuals are available. This is absolutely not the case for treatment of fecal sludge. The only techniques known so far are highly mechanized solutions derived from conventional sewage sludge treatment technology. No ready design guidelines exist for low cost technologies suitable in a context like Nam Dinh. It is therefore necessary to base design of the septage treatment plant on experiences from a few existing facilities in different developing countries. Figure 5 gives an overview of such potential low-cost treatment technologies.

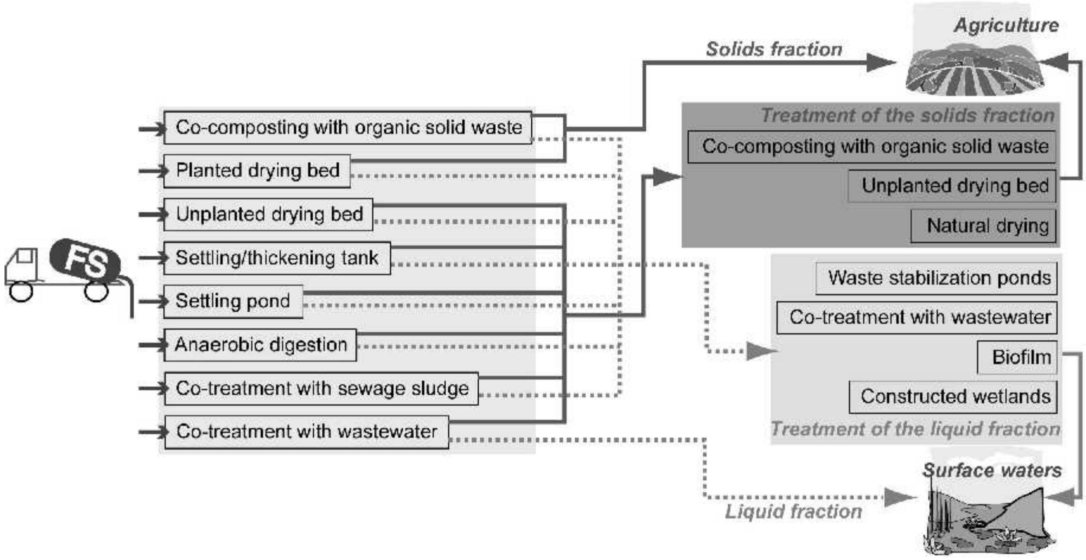


Figure 5: Treatment options - overview of potential technologies

A basic principle of fecal sludge treatment consists in separating solids and liquids through sedimentation and thickening in ponds or tanks or filtration and drying in drying beds. Resulting from this is a solid fraction of variable consistency, which may be designated as "biosolids", and a liquid fraction. The solids fraction may require a post treatment to meet the requirements for reuse in agriculture as soil-conditioner and fertilizer, or for disposal in a landfill. A polishing treatment may be necessary for the liquid fraction before safe discharge in surface waters.

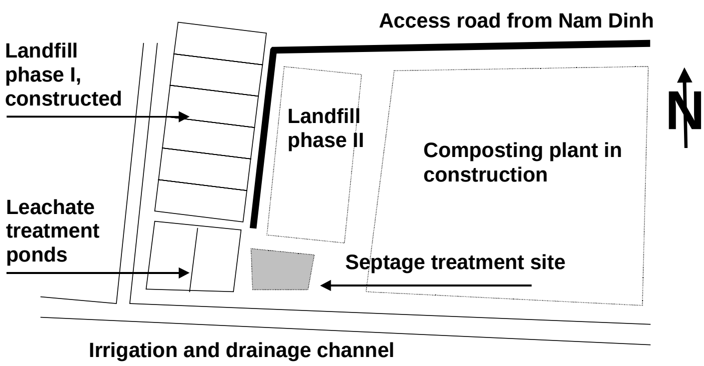


Figure 6: Location of septage treatment at Loc Hoa landfill site

The landfill site near Loc Hoa Commune has been identified as site for the septage treatment. The main reasons comprise the availability of land and the various co-treatment options on the same site, including co-composting of biosolids with solid waste, landfilling of biosolids, or co-treatment of the liquid fraction with landfill leachate. The receiving water body for any effluent produced on the site is a channel, functioning as irrigation and drainage channel.

All potential options have been considered and are discussed in detail in the following paragraphs. Several options can be excluded based on the lack of appropriateness for the conditions prevailing in Nam Dinh. The three most feasible options have been retained for a in-depth evaluation.

3.4.2 Unfeasible Treatment Options

Landfilling of Raw Septage

Disposal of raw septage on landfill is currently the most widespread way of septage disposal in Vietnam. It is simple and cheap. However this is only possible with the very low septage quantities currently collected. As soon as the septage volume increases in near future, disposal on landfills will not be feasible any more. Actually, the disposal of liquids on a landfill is completely opposite to the concept of a sanitary landfill, which is to seal the solid waste from the environment. Septage, consisting to 98 % of water, would infiltrate into the solid waste and dissolve high quantities of pollutants. Huge additional volumes of problematic leachate would be created, requiring high expenses for extraction and treatment. Already the relatively modest volume of septage projected for 2003 would almost triple the volume of leachate. This problem is reflected in a soon to be published new version of the Vietnamese standard for solid waste (TCVN 6696), which will prohibit the disposal of sludge on sanitary landfills.

Leachate generation through landfilling of raw septage

Septage is disposed in the active cell of the landfill (one cell: 1500 m^2)

Leachate volume (precipitation: 1800 mm/y, evaporation + runoff: 800 mm/y)	1500 m^3
Septage Volume 2003	2500 m^3
Septage volume 2006	10,000 m^3

➔Landfilling of septage in 2003 increases the quantity of leachate by factor 2 to 3!

The disposal of thickened sludge after pre-treatment is feasible, as the quantities of water introduced into the landfill are reduced. The question whether treated sludge should be reused in agriculture or rather be disposed on landfill is discussed in chapter 3.5.

Conventional Technologies

Conventional sewage and sewage sludge treatment processes and technologies, such as extended aeration, digesters, mechanically stirred sludge thickeners, centrifuges, belt presses, and vacuum filter presses, may theoretically also be used for the treatment of fecal sludge. However the high degree of mechanization, and hence, sophistication, require high expenses for operation and maintenance and high workers' skills. It would be difficult for Nam Dinh's PUE to satisfy these requirements. The high investment and operating costs for such technologies are only justified for large-scale plants in big cities with high costs for land.

Co-treatment with Sewage or Sewage Sludge

Where sewage treatment plants exist, co-treatment of fecal sludge in these facilities may be a suitable option if designed to take on the additional load from fecal sludges. No such plant exists in Nam Dinh. It is understood that the municipality is in discussion with a French agency on the subject of wastewater treatment, but no details are known so far. In any case, the introduction of a sewer system, condition for sewage treatment, is still in the far future (see 3.2).

Sewage sludge constitute generally a great disposal problem, because it concentrates all contaminants coming from industrial wastewater. Septage contains very little toxic substances, as it is of purely domestic origin. The separate treatment of septage would allow the safe reuse in agriculture with only minor contamination hazards caused by chemical contaminants, whereas the co-treatment with sewage would increase the volume of problematic sludge.

Anaerobic Digesters

Fecal sludge can be stabilized in anaerobic digesters. Dewatering characteristics of digested sludge are better than of fresh fecal sludge, and biogas (methane) could be produced during digestion. Generally, anaerobic digesters with biogas production require a rather sophisticated design with mechanical stirring and good solutions for the removal of solid sediments. The marketability of methane is a further problem to resolve.

The main reason for excluding this option for Nam Dinh, is that only septage will be treated. Septage is already partly digested and stabilized, the dewatering characteristics are good. No additional benefits are expected from digestion, the digested sludge would still require the same treatment as raw septage. Digestion would only make sense if the part of fresh sludge from public toilets was very high, but this is not the case in Nam Dinh. All fresh sludge is currently used in agriculture. Its production will further decrease with the ongoing construction of septic tanks.

Co-Composting of Raw Septage with Solid Waste

Currently a composting plant for solid waste treatment is under construction on a site adjacent to the landfill. Co-composting of septage with solid waste appears being an attractive option. Composting is a natural process allowing good hygienisation of sludge in a relatively short time. This is due to high temperatures of 50 to 70°C, which are reached during the thermophilic degradation process.

Several attempts have been made by NDUDP to discuss this issue with the French contractors and the municipality, but the inclusion of septage treatment in the design of the plant was not taken into consideration. Further decision on this subject will not be possible before the start of operation in 2003.

The optimal water content for the composting process is 50 to 60 %. If the water content is higher, the aerobic degradation process is hampered. As the organic fraction of typical MSW in Nam Dinh has already a water content close to 60 %, only very little quantities of raw septage can be added. Raw septage is not suitable for composting, but only thickened or dried septage with a water content close to 60 %. Co-composting of pretreated and thickened septage with solid waste might be a good solution, even for large sludge volumes. However this can only be considered once the composting plant is operating successfully.

Water content …

… of raw septage: 98%
… of organic solid waste: 60%
… ideal for composting: **50 - 60%**

Water content of organic solid waste and septage mixtures:

Year	SW	Septage	Water content
2001	32 t/d	1 t/d	61 %
2003	36 t/d	7 t/d	66 %
2006	40 t/d	28 t/d	76 %

A major uncertainty regarding the feasibility of co-composting is the question whether the composting plant itself will work successfully. This plant is not designed respecting the principles for appropriate technologies pointed out in 3.1.2, it is a large scale and highly technical project. It is not unlikely that URENCO will be unable to provide the necessary expenses for operating and maintaining the plant. Several similar composting plants in Vietnam never operated for exactly this reason.

3.4.3 Feasible Treatment Options

Three technologies are considered being potentially feasible for septage treatment in Nan Dinh: constructed wetlands, drying beds and settling tanks. For detailed comparison, approximate designs providing capacity for 1000 septic tank emptyings per year have been worked out. The design of constructed wetlands is based on experience gained from a pilot plant in AIT Bangkok. Experiences from an existing full-scale plant in Accra, Ghana, have been used for the settling tank/pond system. For the drying beds, standard design information for sewage sludge treatment and results of experiments for fecal sludge treatment in Ghana have been used.

Constructed Wetlands (CW)

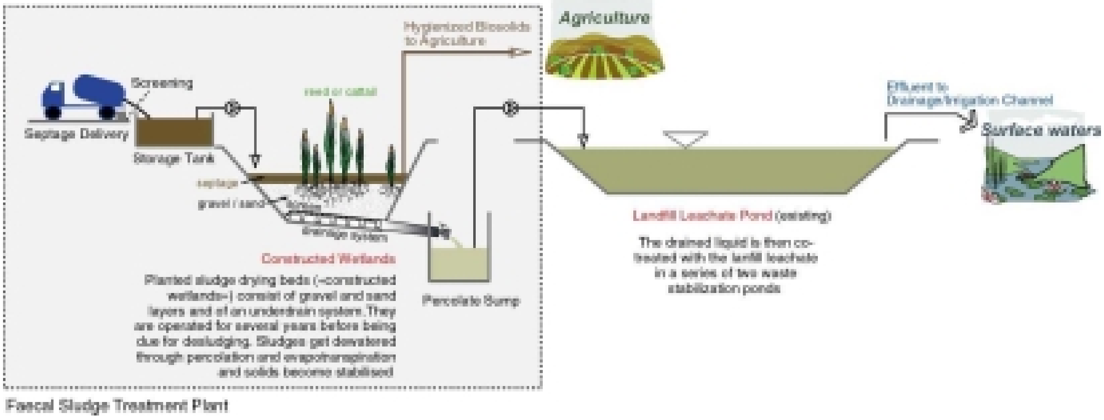


Figure 7: Constructed wetlands - functional sketch

A vertical-flow constructed wetland is a bed equipped with a drained gravel and sand filter and planted with marsh plants. The sludge is loaded on the bed and dewatered mainly by percolation in the filter, approximately one third of the water content is "lost" through evapotranspiration by the plants. The solid fraction remains on the bed. The plants develop an extensive root system, which maintains the permeability of the sludge layer. Hence, new sludge can be added continuously and the dewatered sludge layer has to be removed only once every few years. The long solids retention period favors further mineralisation and pathogen die-off. The dewatered sludge shows a greatly reduced volume and a water content of approximately 70 %. Its low pathogen content allows direct reuse in agriculture. The gravel-sludge-root medium has not only good physical filtering characteristics but also functions as a biological filter. The quality of the liquid fraction percolating through the filter will have improved considerably compared with raw septage, but might still require a polishing treatment (details see Polishing treatment of liquid fraction, page 30).

Plants suitable for constructed wetlands …

… develop extensive root systems.

… tolerate a wide range of humidity and a high salinity.

… are locally available.

Common Reeds *(Phragmites spp.)* have broad-spectrum qualities and are the plant most commonly used in CW.

Cattails *(Typha spp.)* are successfully used in the pilot septage treatment CW in AIT, they require regulation of the bed humidity.

Vetiver grass *(Vetiveria zizanioides*) is very resistant to a wide range of environmental conditions, it is commonly used for soil stabilization because of its extensive root system and has been successful in CW too.

Sedges and bulrushes are other common CW plants.

Two CW units would be required, providing a net treatment area of 200 m^2. The structure would consist of a stone-cement foundation with drainage channels and 50 cm of gravel and sand filter. The outside vertical wall of the unit would be constructed in bricks, 100 cm freeboard above the filter will provide space for sludge accumulation during several years. The filter would be planted with marsh plants. Experiments are currently conducted at AIT, Bangkok, to determine whether or not a mounting of vent pipes onto the under drain system would be required to avoid damage to the roots of the wetland plants.

The arriving septage would be loaded into a 20 m^3 concrete tank, equipped with a screening device and a pump. The screened septage would then be pumped onto the CW unit at a rate equivalent to the design loading rate expressed in TS/m^2.year with a low flow on the

CW unit. The receiving tank is required, because the septage is partly hauled in storage tanks loaded on a hook-lift truck. The direct discharge of several m^3 from these tanks in one single flush into the CW unit would damage the filter and the plants.

The percolate would be collected in a pump sump, and evacuated with a pump into the neighboring drainage channel or into the nearby leachate treatment ponds for further treatment.

Operation requirements of the plant are limited to pump operation and cleaning of the storage tanks and of the percolate collection vault. Care has to be taken to maintain a healthy plant growth, including plant harvest and control of the bed humidity. Humidity in the beds can be increased by periodical closure of the drainage outlet, by watering or by recirculation of percolate. Accumulated sludge has to be removed when it adds up to 80 cm, e.g. after 3 to 4 years. The removed sludge is easy to handle and can directly be used in agriculture.

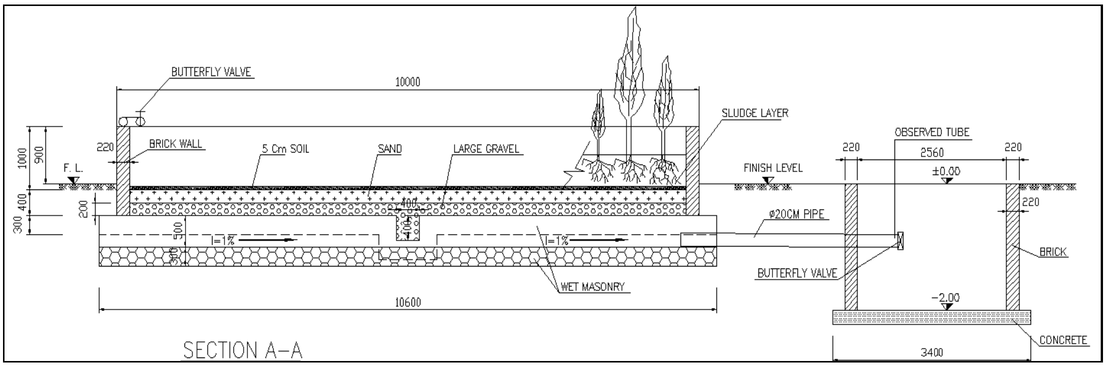


Figure 8: Section of constructed wetland unit and vault for percolate collection

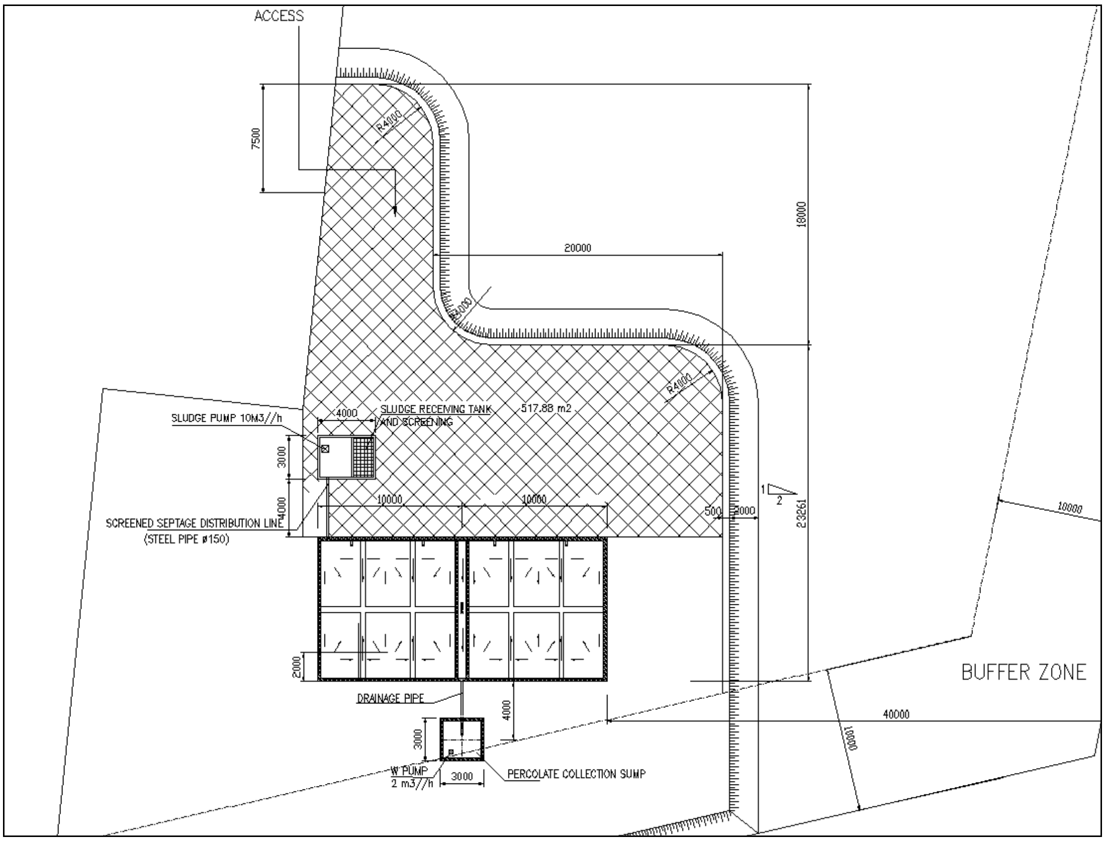


Figure 9: Situation of constructed wetland units, septage receiving tank and percolate collection vault

Drying beds

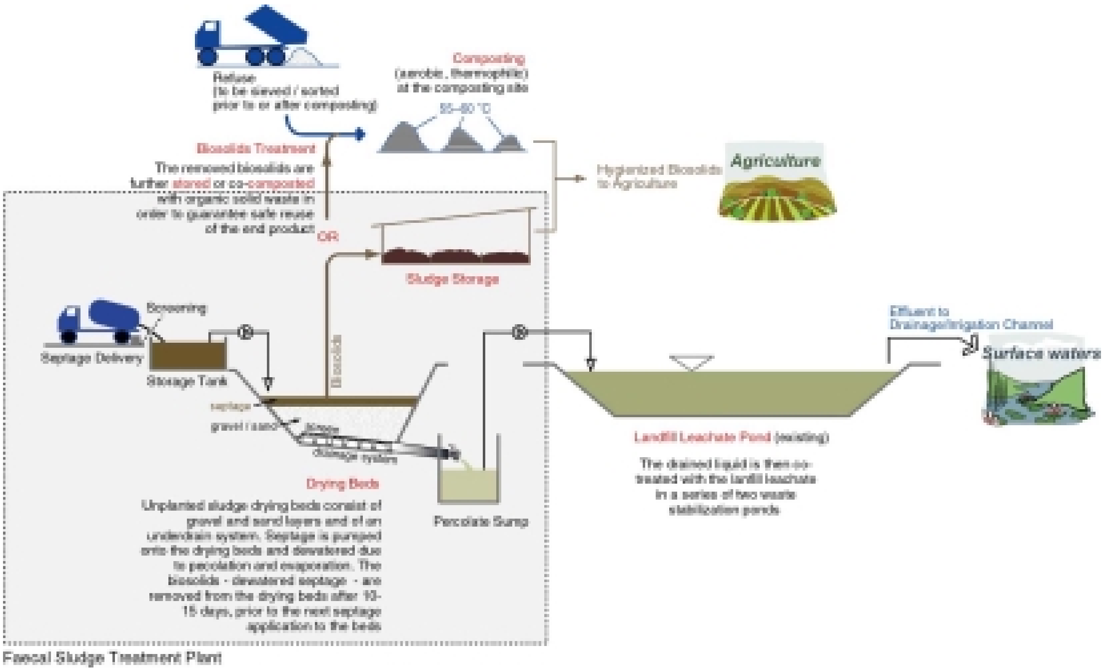


Figure 10: Drying beds - functional sketch

Drying beds are well known from sewage sludge treatment. They consist basically of a gravel-sand filter, equipped with a drainage system. The sludge is loaded on the bed, and the water is evacuated mainly by percolation through the filter and to a minor part by evaporation. The dewatered sludge has to be removed after 10 to 15 days, depending on the rate of dewatering. A new batch of sludge can then be loaded. It is not possible to continuously load sludge, because the accumulating sludge would form a compact and impermeable layer, making the percolation of the liquid impossible. Water contents of as low as 60 % can be obtained in the dried sludge. The consistency is suitable for disposal or reuse. However, the pathogen content is still too high for safe reuse and requires a post treatment, if reuse is desired. Some biomass growth might be possible in the gravel filter, enhancing its treatment property for the percolating liquid. The quality of the percolate will have improved considerably compared with raw septage, but might still require a polishing treatment before discharge (page 30).

The sludge drying bed for Nam Dinh would be composed of five units with a total of 250 m^2 effective area. The structure will be identical to the constructed wetlands. The only difference is that the required freeboard is less, 50 cm only, and they would, of course, not be planted. The devices for receiving the septage and for evacuating the percolate would be identical too.

Septage would be loaded in one unit, during two to three days, and to a maximal sludge height of 30 cm. Then sludge would be left to dry and other units would be loaded meanwhile. After 10 to 15 days, the dried sludge has to be removed. The duration of one operation cycle may vary, depending on the climate and on the actual loading. Especially heavy rains may cause prolonged drying time. Pumps would have to be operated as described for the constructed wetlands. Maintenance would be limited to periodical replacing of the upper sand layer, which is accidentally removed together with sludge.

The post-treatment, which is necessary if sludge is to be used in agriculture, does not require specific facilities. The dewatered sludge can simply be piled nearby the treatment plant or on the site of the composting plant. Plastic tarpaulins can be used for protection against heavy rain. The solids are safe for reuse in agriculture after approximately six months. Dewatered sludge can also directly be composted together with solid waste, once the composting plant works without problems and the produced compost is accepted by farmers.

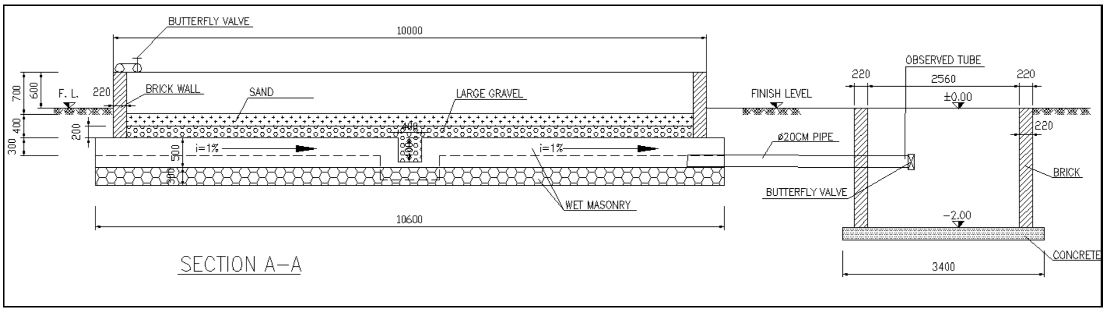


Figure 11: Section of drying bed unit and vault for percolate collection

See appendices for situation plans.

Settling/Thickening Tanks Followed by Ponds

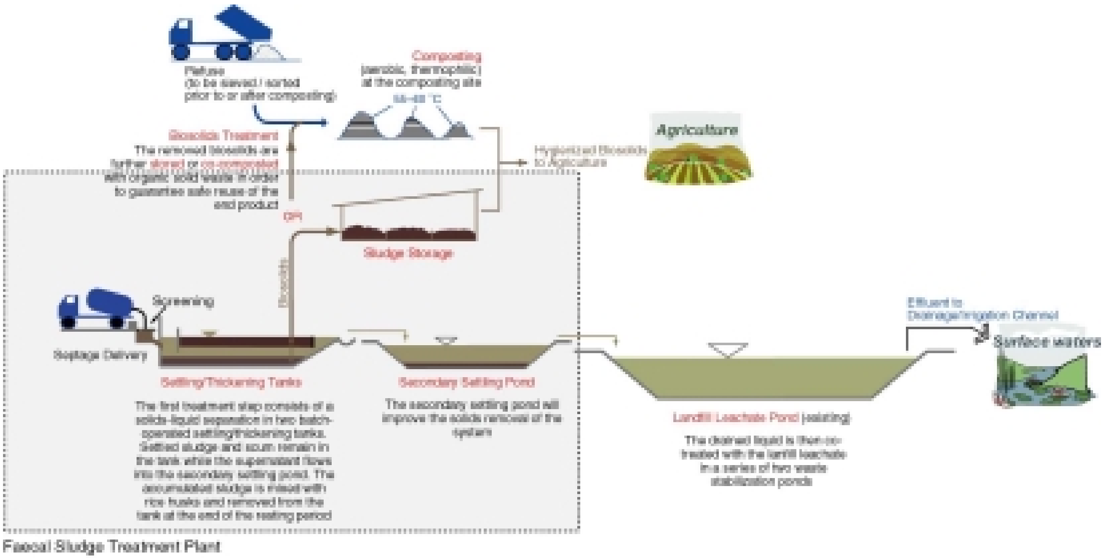


Figure 12: Settling/thickening tanks followed by ponds - functional sketch

Settling tanks and ponds retain septage long enough to allow sedimentation of solids. The solids accumulate and form a sludge layer on the bottom, which has to be removed periodically. Because the water content in the settled sludge is still too high (85%) for easy manipulation, a bulking agent like rice husks or straw or sawdust has to be added to allow removal.

A settling tank has a limited volume and the quickly accumulating sludge has to be removed frequently. Removal intervals between two weeks and two months are common in batch operated tanks. Settling ponds provide much more volume for sludge accumulation, the sludge is removed only once a year or less often. Settling tanks are much more land-use efficient than ponds. However, the effluent of settling tanks still contains a considerable amount of suspended solids, because the hydraulic characteristics are less favorable for solids sedimentation than in a pond.

A combination of two tanks followed by a pond would be the choice for Nam Dinh. The settling tanks, operated in parallel cycles, would retain the majority of the solids content, while minimizing land use. The pond would retain the remaining solids content. Additionally it would contribute to the removal of organic components (BOD), because it functions as anaerobic stabilization pond.

Two settling tanks with 40 m^2 each and one secondary settling pond with 120 m^2 would be designed for a maximum sludge accumulation of 50 cm, to allow easy manual removal. Septage would be directly discharged in the tanks. A screen would be installed at the discharge point. The tanks would be constructed in reinforced concrete, because heavy vehicles have to circulate very close to the tank. Baffle walls in the tank would be needed to minimize hydraulic short-circuiting, disturbance due to loading of septage, and to retain scum. The supernatant would be conducted into the pond by gravity flow, the pond outlet can also be realized with gravity flow.

The tanks would be loaded in 8-week cycles. After 4 weeks loading, vacuum tankers would evacuate the remaining liquid column into the parallel tank. Then, the parallel tank would be loaded during the following 4 weeks and the settled sludge in the first tank allowed drying partially. At the end of the cycle, the sludge would be mixed with an equal volume of rice husks to permit easy manual removal. The pond would require yearly desludging.

In future planning phases, when much higher septage quantities have to be treated, tanks with more depth and volume could be constructed. A ramp would allow access by front-loaders for mechanical de-sludging.

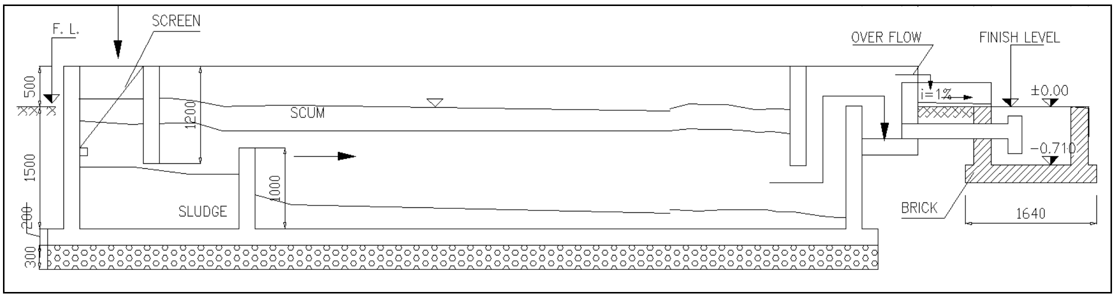


Figure 13: Section of settling tank

See appendices for situation plans.

Polishing treatment of liquid fraction

All options described above produce a liquid effluent, either percolate from CW and drying bed filters or supernatant from a settling pond. These might require further treatment. It is difficult to predict the effluent quality, as the characteristics for raw septage and the removal capacities of the three technologies are not precisely known. Figure 4 shows the estimated effluent quality. It appears that the effluents of all three options exceed the requirements of the Vietnamese Standard for discharge of wastewater into water bodies for agricultural use. Effluent treatment is therefore required.

Table 4: Selected treatment options - comparison of estimated effluent quality

Parameter	Unit	Raw septage	Percolate constructed wetland	Percolate drying beds	Effluent settling tanks, followed by secondary settling pond	Vietnamese standard for discharge into water for agric. use
Total solids	mg/L	20,000	3,000 (85%)*			
Suspended solids	mg/L	15,000	300 (98%)	750 (95%)	300 (98%)	100
COD	mg/L	15,000	300 (98%)	3000 (80%)		100
BOD	mg/L	3,000			760 (80%)	50
NH_4	mg/L	350	70 (80%)	175 (50%)		
Faecal coliforms	No/100mL	10^7	10^6	10^7	10^5	10^4**

*In brackets: removal efficiency, ** total coliforms

BOD load from leachate

Conc. = 10'000 mg BOD /L

Q (6 cell) = 9000 m^3/y = 25 m^3/d

➔250 kg BOD/d

BOD load from septage

Conc.= >750 mg BDO/L

Q (2003) = 7 m^3/d ,

Q (2006) = 28 m^3/d

➔5 kg BOD/d (2003), 20 kg BOD/d (2006)

An apparent solution is to treat the effluent from septage treatment in the ponds, which are already in place for treating landfill leachate. There are two ponds of 1,000 m^3 and 1,200 m^3, respectively. These ponds have not been properly designed, and actually it is very difficult to predict leachate quantity and quality. An approximate calculation has been made to verify the design of the ponds and the feasibility of co-treatment of septage treatment effluent and landfill leachate. The six cells of the landfill will be full by 2002 latest, and then will constantly produce leachate, although with gradually decreasing contaminant concentrations. The BOD contribution from leachate will be approximately 250 kg/d during the initial 1-2 years after the landfill has become full. The load from septage treatment will be 20 kg/d. The volumetric BOD load in a 1,200 m^3 pond is 200 g BOD/m^3, which means that the pond will function well as an anaerobic pond.

Hygienic quality of the effluent of the co-treatment ponds is likely to satisfy the discharge standard, given a total estimated retention time in the two ponds exceeding 40 days at $Q_{septage}$ (2006) = 28 m^3/d.

Co-treatment of leachate and septage treatment effluent is therefore feasible in the existing ponds. However, more than two ponds are required to diminish the high organic load of the leachate sufficiently to meet the Vietnamese standard.

The treatment of landfill leachate is a much greater challenge than the treatment of effluent from septage treatment. The organic load from leachate will be more than 10 times higher than from septage treatment. If adequate treatment for landfill leachate will be installed, the minor additional load from septage treatment will not be a problem. However it doesn't make sense to provide a good solution for septage only and to neglect at the same time the much bigger threat of environmental contamination by lacking leachate treatment.

3.4.4 Evaluation

a) Physical quality of solids

The solids should be easy to handle and the volume be reduced as much as possible. The parameters, which best express this, are the volume or mass and the achievable solids content. TS > 20-30 % should be achieved.

The reduction of sludge volume is highest in constructed wetlands due to the extensive storage period and, hence, compaction effects. The accumulated sludge is perfectly spadable and easy to remove manually.

Drying beds allow obtaining a relatively low water content, which makes sludge removal easy and volume reduction very good.

It is not possible to achieve a good volume reduction in settling tanks, as the attainable water content is still very high. To allow manual removal of the settled sludge, a bulking agent has to be added, which further increases the volume.

Table 5 shows the characteristic figures for each treatment option.

b) Hygienic quality of solids

The content of viable pathogens (worm-eggs) should be very low or zero to allow safe reuse in agriculture. The requirement for post-treatment to meet this criterion should be minimal.

The prolonged storage of sludge in the CW allows enough time for almost complete pathogen die-off, whereas the shorter cycles of the other treatments don't allow the necessary time. Investigations conducted at AIT showed that Ascaris worm-eggs[1] are sufficiently inactivated in constructed wetlands and consequently that the removed biosolids are safe for direct reuse. Sludge removed from drying beds or settling tanks requires a post-treatment before safe reuse.

Table 5: Selected treatment options - comparison of quantities and characteristics of produced biosolids

	Constructed wetlands	**Drying beds**	**Settling tanks and pond**
Dewatered sludge (biosolids) produced from 2500 t septage	75 t	110 t	300 - 450 t*
Water content	70 %	60 %	85 %
Content of viable helminth eggs	Very low	Considerable (very low after post-treatment)	Considerable (very low after post-treatment)

* Biosolids produced from settling tanks/pond include high quantities of rice husks.

c) Quality of liquid effluent

The content of pollutants should be as close as possible to the Vietnamese standard regulating discharge in surface waters. The requirement for polishing treatment should be minimal.

Figure 4 on page 30 shows the estimation for the different quality parameters. Obviously, the Vietnamese standard cannot be met by any of the three options. A polishing treatment will therefore be required in all three cases. The percolate from constructed wetlands is of best relative quality, however a polishing treatment is still required.

d) O+M requirements

The process should require as little input as possible to operate and to maintain it.

The main advantage of the constructed wetlands is that they can be loaded continuously without sludge removal. In drying bed operations, sludge has to be removed every 2 to 3 days. The settling tanks require less permanent activity, with its 4-weekly sludge removal, however the efforts are considerably higher, because of the wet consistency of settled sludge. Additional efforts are required for the supply of bulking agent, which is necessary to remove sludge from settling tanks.

Because of the flat topography of the treatment site, pumps are required for raw septage loading onto constructed wetlands and drying beds and for percolate evacuation. Flow within the settling tank/pond system can be by gravity.

Post treatment of dewatered sludge from drying beds and settling tanks requires additional handling. The sludge has to be transported to the nearby storage site and protected against rain.

The maintenance requirements for constructed wetlands are limited to periodical plant harvest and eventual control of bed humidity. In drying beds, the sand filter has to be restored form time to time as part of the sand is accidentally removed together with sludge. Pumps have to be maintained in both systems. The settling tanks do not require specific maintenance.

[1] Eggs of the intestinal worm Ascaris are the most persistent of all excreta-related pathogens. Hence, if Ascaris eggs are absent or at low concentrations, all other pathogens will have become inactivated, too.

e) Skills required for operation and supervision

The skills required to operate the plant should be as basic as possible.

Unskilled workers can conduct all daily works. A more skilled person is needed to supervise correct loading and punctual desludging. The skills needed for this supervision post can easily be acquired by training on-the-job. The required skills are equal for all three options.

f) Risk of failure

The estimated risk of failure through identified weak points should be as low as possible.

The weak point of the constructed wetland is that their function relies on plant growth. Plant health may be impaired by neglected plant care. If the development of the root system is insufficient, the filter conductivity might be lost.

The major risk of failure for drying beds could derive from is neglected maintenance. If the upper filter layer is not restored regularly, the drying bed looses its filtering properties, and solids are not retained any more. Another risk is related to the humid climate: heavy rains may cause prolonged drying periods, or hindering drying at all.

Settling tanks loose their function when they are not desludged in the designed intervals. The risk that this happens is considerable, as no sudden failure occurs when the designed interval is surpassed. The tank will loose the settling capacity but seemingly continues to function properly, similar to a septic tank. A strong responsibility of the supervisor is required to eliminate this risk. Another risk is related to the desludging itself. Due to the high water content, a bulking agent is needed to make removal possible. The procurement of this bulking agent may at times be difficult or impossible. This will then cause postponing of desludging, with the discussed effect.

If the post-treatment for sludge from drying beds or from settling tanks is not carried out correctly, health risks through reuse of incompletely hygienized sludge persist.

g) Land requirement

The land requirements for all three options are very similar. The plants with capacity for 2003 require between 200 m^2 (CW and settling tanks + pond) and 250 m^2 (drying beds) net treatment area. Roughly the same area will be added for access road and installations like receiving tank and pipes. The future land requirements will increase proportional to septage volume for constructed wetlands and drying beds. The settling tanks will be more land-use efficient, because with very big septage volumes, the tank could be realized in a deeper and more voluminous version.

h) Estimated investment costs

The estimation of the construction costs shows that the required investment is almost equal for the three plants.

Table 6: Selected treatment options - comparison of estimated investment costs

Item	Constructed wetlands	Drying beds	Settling tanks + pond
Constructed wetland units / Drying bed units / Settling tanks	3,500 $	4,300 $	5,400 $
Filling of low lying land	2,500 $	2,500 $	2,500 $
Access road	1,750 $	1,900 $	2,100 $
Septage receiving tank	750 $	750 $	
Vault for percolate collection	400 $	400 $	
Pumps	400 $	400 $	
Taxes and general expenses	1,400 $	1,600 $	1,600 $
Detailed design + construction supervision	7,500 $	7,500 $	7,500 $
Contingencies	5,000 $	5,000 $	5,000 $
Total	**23,200 $**	**24,350 $**	**24,100 $**

Settling tanks might be the cheapest technology, compared to constructed wetlands or drying beds, for treatment plants with much higher capacity like expected after the year 2010. The required surface and, hence, the construction cost of constructed wetland or drying bed units raises proportionally to the designed capacity. The settling tank could be constructed in a deeper and thus more voluminous version and the desludging cycles could be shortened. The construction cost would then raise less than proportionally to the designed capacity.

i) Operation and maintenance cost

Constructed wetlands are the cheapest option to operate, whereas the settling tanks followed by a pond are the most expensive one. High expenses for desluding of settling tanks, necessary because of the high water content of the sludge, make it more expensive to operate.

Table 7: Selected treatment options - comparison of yearly operation and maintenance costs

Item	Constructed wetlands	Drying beds	Settling tanks + pond
Septage loading and percolate evacuation	500 $	500 $	
Biosolids/sludge removal	300 $	400 $	2090 $
Procurement of rice husks			730 $
Maintenance	60 $	140 $	
Post treatment of biosolds		200 $	900 $
Management costs and taxes	540 $	770 $	2,480 $
Total (per year)	**1,400 $**	**2,010 $**	**6,180 $**

Conclusion

Table 8 contains the summary description of the three feasible treatment options and the summary of their evaluation.

The constructed wetland option offers the best and most cost-effective performance for septage treatment among the three evaluated options. The expected hygienic quality of the biosolids and the biochemical quality of the liquid effluent rate better for the CW than for the other options. Constructed wetlands offer complete biosolids treatment in one single treatment step, whereas the two other options require post-treatment of biosolids to achieve comparable results. The least satisfactory performance is observed for the settling tanks, with the still very high water content of the settled sludge.

All three treatment options use simple and reliable technologies. Nam Dinh’s PUE should be able to meet the requirements for operation and maintenance, and for workers’ skills too. All options contain some weaknesses, but the over-all risk of failure is rather limited if minimal operational care and maintenance are observed. All options can be considered as equally appropriate for the conditions prevailing in Nam Dinh.

Construction cost, including land requirements are very similar for all three options. However, estimations for operating costs show considerable differences: the most economic to operate are the constructed wetlands, the most expensive are the settling tanks.

The evaluation of the three options demonstrates that in all criteria, constructed wetlands are either equal or superior to drying beds or settling tanks. As a conclusion it can be stated, that constructed wetlands are the best treatment technology for the projected quantity and quality of septage and for the currently prevailing conditions in Nam Dinh.

In future, when conditions will change and septage collection rate will increase considerably, it might be possible that other technologies become more interesting. The revision of the treatment strategy after a number of years is recommended.

Table 8: Treatment options – summary description and evaluation

Septage Treatment Options – Description

	Constructed Wetlands	**Drying Beds**	**Settling tanks + pond**
Process description	• Dewatering through percolation and evapotranspiration • Mineralization and hygienisation of solids through prolonged storage • Filtration and bio-chemical stabilization of the liquid during percolation • Percolate polishing in landfill leachate ponds	• Dewatering through percolation and evaporation • Filtration and bio-chemical stabilization of the liquid during percolation • Post-treatment (storage or composting) of solids for hygienisation • Percolate polishing in landfill leachate ponds	• Primary settling in tanks • Secondary settling and anaerobic treatment in a pond • Post-treatment (storage or composting) of solids for hygienisation • Liquid polishing in landfill leachate ponds
Design values:	Loading rate: 250 kg TS / m^2 year	Loading rate: 200 kg TS / m^2 year	• Loading period: 28 days (tank), 1 year (pond) • Attainable SS content in settled sludge: 120 g/l • SS removal settling tank and pond: 80 % • Admissible sludge depth: 50 cm
Structure	• 2 CW units @ 100 m^2, 50 cm gravel and sand filter, drainage system, planted with marsh plants • Tank for septage receiving, pump for CW unit loading • Open vault for percolate collection, pump for percolate evacuation	• 5 DB units @ 50 m^2, 50 cm gravel and sand filter, drainage system • Tank for septage receiving, pump for DB unit loading • Open vault for percolate collection, pump for percolate evacuation	• 2 settling tanks @ 40 m^2, 150 cm deep, reinforced concrete structure, baffle walls, outlet • 1 settling pond, 120 m2 , 100 cm deep
Operation mode:	• Each unit: continuos loading for 4 years, then sludge removal ➔Sludge removal once every 2 years	• Each unit: loading for 2-3 days, drying for 10-15 days, sludge removal ➔Sludge removal every 2-3 days	• Each tank: 4 weeks loading, liquid evacuation, 4 weeks drying, sludge mixing with rice husk and removal • Pond: Sludge removal once per year

Septage Treatment Options – Evaluation

Criteria	**Constructed Wetlands**	**Drying Beds**	**Settling tanks + pond**
Performance			
a) Physical quality of solids	Sludge mass of initial m.: 3 % Water content: 70% (+) high volume reduction (+) low water content, solids easy to handle (spadable)	Sludge mass of initial m.: 4.5 % Water content: 60 % (+) low water content, solids easy to handle (spadable)	Sludge mass of initial m.: 14 % Water content: 85 % (-) water content too high, settled sludge neither pumpable nor spadable, bulking agent needed, resulting in volume increase
b) Hygienic quality of solids	(+) safe for reuse without post - treatment	(-) post-treatment required for safe reuse	(-) post-treatment required for safe reuse
c) Quality of liquid effluent	(-) Vietnamese discharge standard not met (+) Quality relatively close to standard, minimal polishing treatment required	(-) Vietnamese discharge standard not met	(-) Vietnamese discharge standard not met
Simplicity and Reliability of process			
d) O+M requirements	(+) Sludge removal only once every 2 years (every 4 years for each unit) (-) Pumping required for septage loading and percolate evacuation (-) Care for plant growth, periodical harvest and control of bed humidity	(-) Sludge removal 2-3 times a week (once every 10-15 days for each unit) (-) Pumping required for septage loading and percolate evacuation (-) Regular replenishment of sand	(+) No pumping required (+/-) Sludge removal from tanks every 4 weeks (-) Sludge removal difficult because of high water content, mixing with bulking agent (-) Regular supplying of bulking agent (rice husks) required
e) Skills required for operation and supervision	(+) Day to day operation: unskilled labor Supervision: technical degree	(+) Day to day operation: unskilled labor Supervision: technical degree	(+) Day to day operation: unskilled labor Supervision: technical degree
f) Risk of failure	(-) Problems with healthy plant growth, e.g. because of bad regulation of bed humidity, have neg. impact on filter permeability.	(-) Loss of filter property if sand is not replenished regularly (-) Increased drying time because of wet climate (-) If post-treatment is not properly executed, reuse is not safe	(-) Loss of settling capacity if the tanks are not desludged in the designed intervals (-) Sludge removal might be difficult and avalability of bulking agent might be limited, leading to prolonged desludging intervals (-) If post-treatment is not properly executed, reuse is not safe
Cost			
g) Land requirement	Net treatment area: 200 m^2	Net treatment area: 250 m^2 (-) highest land requirement	Net treatment area: 200 m^2 (+) more land-use efficient with higher septage load
h) Investment costs	23,200 $	24,350 $	24,100 $
i) Operation and maintenance	1,400 $/year	2,010 $/year	6,180 $/year

3.5 Disposal versus Reuse

The dewatered sludge produced from either constructed wetlands, drying beds or settling tanks is suitable for both reuse in agriculture and disposal on landfill.

Disposal on landfill is operationally simple, as the landfill is adjacent. The dewatered sludge can be landfilled directly after removal from the treatment plant. The landfill space required is minor in comparison to the space required for solid waste disposal.

Reuse in agriculture requires some additional effort for marketing and commercialization, but bears considerable advantages compared to direct disposal:

- Reuse generates revenues. The net revenues generated by selling treated sludge to farmers as fertilizer can contribute to partially cover treatment costs (see appendix 6.3.3).
- No landfill space is used.
- Nam Dinh's agriculture can be supplied with a high quality organic fertilizer. This advantage is not directly related to septage management, but is very important in a greater context. The agriculture of Nam Dinh is in great need for more organic fertilizer to maintain or restore the soil's humus layer. The traditional reuse of human waste is going to be cut off because bucket latrines are replaced by septic tanks. The use of treated septage would restore this reuse practice in a more hygienic way.
- In a long-term point of view, reuse of waste is always a preferable solution. Septage is a waste type very easy and safe to reuse, because it is usually not contaminated with toxic waste components, unlike sewage and solid waste.

Revenues from commercialization of biosolids from CW

Item	US$
Administration and marketing	-200
Packing and transport	-290
Revenues (75 t, 300 VND/kg)	1,500
Net revenues	**1,010**

Reuse of treated septage clearly should be preferred to disposal. However it is very important to spend sufficient efforts in good marketing of the product to guarantee a successful commercialization. The interviews with farmers and agricultural services indicate the necessary steps:

- Beneficial effects of biosolids application should be demonstrated by carrying out trials, best in collaboration with the fertilizer division of the provincial agriculture service. This institution usually carries out testing of fertilizer and transmits recommendations to the agriculture cooperatives.
- The cooperatives supply farmers with mineral fertilizer, and transmit recommendations for fertilizer use to the farmers. They could act as local agent and inform farmers about the quality of the product.
- The biosolids should be packed in 50 kg sacks and transported to local agents and cooperatives, because this is preferred by farmers.
- The biosolids should be made available throughout the year for vegetable cultivation, the demand for rice cultivation culminates in January/February and in June/July.
- A good idea is to introduce the product first in Nam Phong Cooperative. In this coop, more than 160 ha are used for vegetable, flower and bonsai cultivation. These cultures require high quantities of a high quality organic fertilizer. It will be easier to introduce the product in this cooperative than in a purely rice growing one. Once the product is accepted there, the introduction in other coops will be facilitated.

4 PROPOSAL

4.1 Septage Management Concept

This study proposes a concept and measures in order to cope with the coming challenges connected to septage management in Nam Dinh City.

The basic components of the concept for improved septage management are an increased rate of septage collection, the treatment of all collected septage in constructed wetlands and the reuse of treated sludge in agriculture.

The collection capacity has to be increased to meet the coming demand for septic tank emptying, because the number of septic tanks in Nam Dinh is increasing steadily. Additional efforts have to be spent on shortening the emptying intervals of septic tanks. This will improve solids retention in septic tanks and prevent increased solids accumulation in the drainage system. The translation into action of these suggestions requires substantial improvements of the management capacity in the concerned PUE.

The collected septage will be treated in constructed wetlands on the Loc Hoa landfill site. This treatment will separate the sludge in two fractions. The liquid fraction is safe for discharged into surface waters after having received additional treatment in ponds treating landfill leachate. The solids fraction shows greatly reduced volume in comparison to initial septage volume. The solids fraction can safely be reused in agriculture.

Reuse of the produced solids instead of disposal on the landfill is recommend, because it can generate revenues, it saves landfill space and it supplies Nam Dinh's agriculture with urgently needed soil-conditioner.

The following paragraphs contain the concrete proposed measures for the planning phases 2003 and 2006, and an outlook on measures to be taken after the initial phases.

4.2 Septage Collection

Until 2003

It is proposed to increase septage collection rate by introducing systematic emptying of septic tanks in selected wards:

- One new mini-vacuum-tug and one vacuum tanker is exclusively used for septic tank emptying. URENCO agrees with UCMC about the common use of the new sewer cleaning equipment.
- The municipality concludes a service contract with URENCO, mandating the latter with systematic emptying of all septic tanks in selected wards. Until 2003, the total collection rate is increased to 1000 septic tanks per year.
- The introduction of a monthly fee in the selected wards is discussed with ward representatives, URENCO and the municipality. The monthly fees should contribute as fast as possible to funding of the systematic emptying.
- A database is established, containing addresses of all households with a septic tank in the selected wards, and relevant data like tank size, age, last date of emptying and number of users. The database is created with support by wards and by NDUDP. The database serves as planning basis for septic tank emptying, and is updated and corrected continuously by URENCO.
- Awareness campaigns covering intensively the selected wards, but as well the entire city, raise acceptance of the population for the new compulsory emptying of septic tanks.

In parallel to these first measures, a political discussion has to be established. Following questions have to be answered:

- Should local government become actively involved in the septage management issue?
- Which PUE should be responsible for management and execution of the service? Should it be a merged URENCO and UCMC?
- Is it acceptable to introduce a common monthly fee for all environmental services, including septage management?
- Are regulations required to ensure installation of correctly designed septic tanks, to ensure proper maintenance, and to exclude unhealthy emptying practices and indiscriminate disposal of septage?
- How can the enforcement of relevant regulations be improved?

After 2006

After 2003, experiences with the new service of systematic emptying and with the introduction of monthly fees will be available. The political discussions will have progressed and it will appear more clearly which direction the organization of future septage collection will take.

If the proposed system with systematic emptying in selected wards has proven successful and is accepted by all stakeholders, it could be extended on other wards.

Septage management definitely would become a public task. Septic tank emptying would be defined as compulsory and a monthly fee would be charged. A responsible PUE would be designated, e.g. a merged URENCO and UCMC. The septic tank database would further be extended and updated by this PUE. New equipment would be purchased, comprising large vacuum tankers and mini-vacuum-tugs together with intermediate-storage-tanks for areas difficult to access. The collection rate should be increased up to 4000 septic tanks per year in 2006.

If, however, the necessary institutional changes turn out to be unacceptable for the population or for the authorities, a different way has to be taken. The focus would then be on intensive awareness campaigns to obtain a higher willingness of the population for emptying septic tanks. The PUE would be strengthened, both in its collection capacity and in its marketing capability. The emptying service would still be financed through directly paid fees, but the municipality, to render them more attractive, would eventually subsidize these.

4.3 Septage Treatment

Until 2003

A constructed wetland plant is proposed for the treatment of 2500 m^3 of septage per year, corresponding to 1,000 emptied septic tanks per year.

Following structures are designed:

- 2 CW units, providing an effective area of 200 m^2. The structure consists of a stone-cement foundation with drainage channels and 50 cm of gravel and sand filter. The outside vertical wall of the unit will be brickwork, 100 cm freeboard above the filter provide space for sludge accumulation. The filter is planted with reed plants or other suitable wetland species, which maintain the filter conductivity over a long period.
- 1 concrete tank, 20 m^3 for septage receiving, equipped with a screening device and a pump.
- 1 concrete vault for percolate collection, equipped with a pump for percolate evacuation.

The septage will be discharged from vacuum tankers or from storage tanks lifted by hook-lift trucks into the receiving tank. The screened septage will be distributed on the CW unit through perforated plastic pipes. The solids fraction remains on the bed and is further mineralized and consolidated. The liquid fraction percolates through the filter and is collected in the pump sump. The percolate is then evacuated into the nearby leachate treatment ponds where it is further treated before final discharge into the neighboring drainage channel. Accumulated solids have to be removed after 3 to 4 years.

One worker on part-time basis will carry out the daily operating tasks: pump operation, cleaning of receiving tank and percolate collection vault, and plant care. Sludge removal and plant harvest are exceptional tasks requiring several workers.

Detailed design calculations, drawings and cost estimations are given in the appendices.

Septage characteristics and treatment performance are intensively monitored to verify correct loading of the plant (250 kg TS/m^2.year) and to gain data for design of the extension phases. The minimum parameters to be measured are:

- Septage volume: easily measured by a scale in the receiving tanks. Every incoming septage load has to be registered.
- Solids content (TS). Samples have to be collected as often as possible from vacuum tankers or from the receiving tank. Analysis can be done by the local DOSTE laboratory.

NDUDP, EAWAG-SANDEC and AIT will provide assistance for final design, construction supervision and process monitoring.

Until 2006

The projected capacity for 2006 corresponds to 4000 septic tanks emptied per year or to 10,000 m^3 septage/year. Six additional constructed wetland units would be required, as well as one additional receiving tank and one or two percolate collection vaults. However it is absolutely necessary to revise the design based on new data gained through monitoring of the first phase plant.

After 2006

After 2006, the situation in Nam Dinh will have changed considerably. A revision of the proposed treatment concept is then necessary, and technologies rejected in this study have to be considered again.

Settling tanks followed by co-composting of thickened sludge with solid waste and pond treatment for the liquid fraction might be more cost-effective for large septage quantities than constructed wetlands. Necessary condition for this option, however, is that the composting plant is functioning well.

4.4 Commercialization of Biosolids

Intensive marketing efforts are necessary to achieve complete commercialization of the biosolids produced from septage treatment. The proposed steps are:

- Trials of efficiency of the fertilizer product are carried out in collaboration with the fertilizer division of the provincial agricultural service.
- The cooperatives are used for initial commercialization. The cooperatives could later act as local agent and inform farmers about the quality of the product.
- The produced biosolids are packed in 50 kg sacks and transported to local agents and cooperatives.

- The product is made available throughout the year (for vegetable cultivation), higher quantities are supplied in January/February and June/July (for rice cultivation).
- The product is introduced first in Nam Phong Cooperative. There, changes are best because this cooperative concentrates in cultures requiring a high quality organic fertilizer.

4.5 Funding of Septage Management

The following table resumes the cost estimations for septage management. The figures are calculated for 1000 emptied septic tanks per year. This corresponds to coverage of 5,000 households, considering a emptying interval of 5 years.

Table 9: Cost estimation for septage management

Cost estimation for collection and treatment of septage from 1000 emptied septic tanks per year (corresponding to 5000 households, if tanks are emptied every 5 years	
Investment for collection equipment – large	160,000 $
Investment for collection equipment – small	24,000 $
Investment for constructed wetland treatment plant	23,000 $
Operation and maintenance of collection equipment – large or small	7,000 $
Operation and maintenance of constructed wetland plant, diminished by revenues from bio-solids commercialization	500 $

Until the year 2003, no investment is required for collection equipment, as the existing equipment is sufficient to provide the projected capacity. The investment for septage treatment could possibly be funded by NDUDP.

For the coverage of the running costs, different possibilities exist:

- The service is free of charge for the individuals and is funded by either the municipality or NDUDP. 7,500 $ need to be covered per 5,000 households (1000 emptied septic tanks per year).
- The owners of the septic tanks directly pay the service. The fee covering operating costs would be approximately 115,000 VND.
- A monthly fee funds the service, the fee would then be approximately 2,000 VND per month.

This proposal recommends that the operating costs for septage management in the selected wards be first covered entirely by the municipality and by NDUDP. The monthly fee should then be introduced step by step and replace the central funding after a certain period. In the other wards, not yet covered by systematical emptying, the current system with directly paid fees would continue. In the next phase, after 2003, the same procedure will be repeated in other wards. In the long-term, monthly fees would then entirely finance the septage management.

However, the introduction of a monthly fee will probably meet considerable resistance in the population and it is not unlikely that the proposed optimum scenario will not entirely be feasible. It is realistic to expect that a considerable contribution of the municipality to funding of septage management will still be required in long-term.

The necessary extension of collection and treatment capacity to meet the demand after 2003 will require considerable investment for expensive collection equipment and for additional treatment capacity. It is not yet clear how this investment can be provided. If the municipality will not be able to provide the required means, it will be necessary to seek for funding through donor organizations.

5 REFERENCES

Berrut, S. (CTA in Donh Hio Urban Development Project). **(2001).** *Personal communication concerning septage management in Dong Hoi.*

Cairncross, S., Feachem, R., (1993). *Environmental Health Engineering in the Tropics, Wiley, Chchester.*

Heinss, U., Larmie, S. A.; Strauss, M., (1998). *Solids Separation and Pond Systems for the Treatment of Fecal Sludges in the Tropics, Lessons Learnt and Recommendations for Preliminary Design, EAWAG-SANDEC, Duebendorf, Switzerland.*

Hue UDP, (April 2001) *Septage Management Study.*

Hung B.T.,. Han T.N,. Dung N.V (1996). *Evolution de la riziculture de 1991 à 1995, Seminaire - Agriculture Familiale et Gestion des Ressources du Milieu dans le Bassin Du Fleuve Rouge, Institut National des Sciences Agronomiques du Vietnam, Hanoi.*

Koottatep T., Polprasert C., Nguyen Thi Kim Oanh, Surinkul N., Montangero A., Heinss U. and Strauss M. , (October 2001*) Sludges from On-site Sanitation Systems – Low-cost Treatment Alternatives, paper submitted to the IWA Conference, Kuala Lumpur, Malaysia.*

Koottatep Thammarat, *Nguyen Thi Kim Oanh; Polprasert, Chongrak; Preliminary Guidelines for Design and Operating of Constructed Wetlands Treating Septage, AIT Bangkok.*

Licogi, (September 1999)*. Report on Feasibility Study of Solid Waste Treatment Project in Nam Dinh City.*

Mara D., (1978). *Sewage Treatment in Hot Climates, Wiley, Chichester.*

Montangero, A. and Strauss, M., (September 2000). *Fecal Sludge Management –Strategic Aspects and Treatment Options. Proceedings, International Workshop on Biosolids Management and Utilization, Nanjing (P.R.China), and Forum on Biosolids Management and Utilization, Hongkong.*

NDUDP-I, (1997*). Interim Report – Wastewater Disposal,*

NDUDP-I, (1999). *Strategy Paper on Wastewater Disposal,*

NDUDP-I, (June 1997). *Final Inception Report.*

NDUDP-I, (November 1997*). Interim Report on Solid Waste Management.*

NDUDP-I, (October 1997*). Household Survey,.*

NDUDP-II, (April 2001*). Feasibility Study for Maintenance of Sewers and Procurement of Sewer Cleaning Equipment, Version 0.2b,*

NDUDP-II, (August 2001)*, Strategic Project Review.*

Nguyen Thi Kim Thai, (2001). *CEETIA, Personal Communication concerning septage management in Hanoi, Viet Tri and Thai Ngyuen and concerning legal issues.*

Puetpaiboon, U., *Septage Disposal Practices and Management Problems at Songklah Municiplaity, Thailand, Prince of Songklah University, Thailand.*

Strauss, Martin, (1998). *Treatment of Sludges from Non-Sewered Sanitation Systems, Seminario-Taller Saneamiento Basico y Sostenibilidad, Cali, Colombia.*

Summerfelt, S.T, et al., *Aquaculture Sludge: Removal and Stabilization within Created Wetlands, The Conservation Fund's Freshwater Institute, USA.*

Tran Hieu Nhue, Ngyuen Viet Anh, Nguyen Duc Thang, *Septage Collection and Disposal Practice in Vietnam, CEETIA, Hanoi.*

Truong, P., (2001). *Personal communication concerning use of Vetiver in constructed wetlands.*

Van Paassen, F. (2001). *Solid Waste Expert in Hue UDP, Personal communication concerning septage management in Hue City.*

Women's Union (1998). *Small Septic Tank Survey.*

Women's Union (1999). *Small Survey.*

Women's Union (2001). *Statistic about Septic Tank Fund,.*

World Bank (1994). *Red River Delta Master Plan, Background Report 1, 9, and 28.*

6 APPENDICES

6.1 General

6.1.1 Climatic Data

Climatic Data for Station Hanoi (presumed to be representative for Nam Dinh), source: Red River Delta Masterplan: (Binnie, SMEC, ACCM, Delft. Background report1, Sept. 94)

	jan	feb	mrz	apr	mai	jun	jul	aug	sep	okt	nov	dez	year
Monthly Average Rainfall (61-85) [mm]	18	26	44	90	189	240	288	318	265	131	43	23	1676
Monthly Average of Rainy Days (61-85)	8.4	11.3	15	13.3	14.2	14.7	15.7	16.7	13.7	9	5.5	6	144
Monthly Average Relative Humidity [%]	83	85	87	87	84	83	84	86	86	85	82	83	85
Monthly Average Temperature [°C]	16.4	17	20.2	23.7	27.3	28.8	28.9	28.2	27.2	14.6	21.4	18.2	23
Monthly Average Evaporation [mm]	71.4	59.7	56.9	65.2	98.6	97.8	101	84.1	84.4	95.6	89.8	85	989

6.1.2 Vietnamese Standard for Discharge of Industrial Wastewater

No. 5945 - 95

No.	Criteria	Symbol	Unit	Limits for effuent by waterbody category		
				A	B	C
1	Temperature		oC	40	40	45
2	pH			6 - 9	5.5 - 9	5 - 9.
3	Biological oxygen demand	BOD5(20oC)	mg/l	20	50	100
4	Chemical oxygen demand	COD	mg/l	50	100	400
5	Suspended solids	SS	mg/l	50	100	200
6	Arsene	As	mg/l	0.05	0.1	0.5
7	Cadmium	Cd	mg/l	0.01	0.002	0.5
8	Lead	Pb	mg/l	0.1	0.5	1
9	Overchlorine		mg/l	1	2	2
10	Chroml (VI)	Cr (VI)	mg/l	0.05	0.1	0.5
11	Chroml (III)	Cr (III)	mg/l	0.2	1	2
12	Mineral and oil grease		mg/l	undetected	1	5
13	Natural		mg/l	5	10	30
14	Copper	Cu	mg/l	0.2	1	5
15	Zinc	Zn	mg/l	1	2	5
16	Manganese	Mn	mg/l	0.2	1	5
17	Nickel	Ni	mg/l	0.2	1	2
18	Oganic phosphate	Porg	mg/l	0.2	0.5	1
19	Total phosphorous	Ptotal	mg/l	4	6	8
20	Iron	Fe	mg/l	1	5	10
21	Tetrachrorethylene		mg/l	0.02	0.1	0.1
22	Tin	Zn	mg/l	0.2	1	5
23	Mercury	Hg	mg/l	0.005	0.005	0.01
24	Nitrate	NO_3^-	mg/l	30	60	60
25	Trichlarethylene		mg/l	0.05	0.3	0.3
26	Ammonia	NH_4	mg/l	0.1	1	10
27	Flora	F-	mg/l	1	2	5
28	Phenol		mg/l	0.001	0.05	1
29	Sulfide		mg/l	0.2	0.5	1
30	Cyanide		mg/l	0.005	0.1	0.2
31	General radio-activity alpha		Bp/l	0.1	0.1	-
32	General radio-activity beta		Bp/l	1	1	-
33	Coliforms		MPN/100ml	5,000	10,000	

A Use of domestic water supply
B Use for communes and agricultural water supply etc.
C Discharge into main drainage

6.1.3 Projection of Number of Septic Tanks

Name of Ward	Number of households in ward (projection 97)	Housholds with septic tank (1997)		Septic tanks build with loan 04/1998 - 12/1999 (statistics of womens union)		Septic tanks build without loan 01/1998-12/1999 (small survey by womens union)		
		number	%	total number	yearly growth rate (ST buildt in 1 year / hh without ST)	number	number of hh questionned	yearly growth rate (ST buildt in 1 year / hh without ST)
Vi Hoang	2405	1603	66.7%					
Vi Xuyen	2493	2127	85.3%					
Ba Trieu	2242	1136	50.7%					
Phan Dinh Phung	2513	1076	42.8%					
Tran Te Xuong	3396	1400	41.2%	36	**1.1%**	60	394	**13.0%**
Nguyen Du	2355	1178	50.0%					
Ha Long	3153	531	16.8%					
Quang Trung	3072	1332	43.3%	74	**2.6%**	49	641	**6.7%**
Ngo Quyen	1903	1324	69.6%	88	**9.1%**	71	429	**27.2%**
Truong Thi	3001	1456	48.5%	82	**3.2%**	40	259	**15.0%**
Van Mieu	2974	876	29.5%	89	**2.5%**	77	433	**12.6%**
Tran Dang Ninh	2851	2011	70.5%	122	**8.7%**	31	239	**22.0%**
Nang Tinh	4438	1878	42.3%	154	**3.6%**	70	571	**10.6%**
Cua Bac	1912	1334	69.8%	72	**7.5%**	15	229	**10.8%**
Tran Hung Dao	2079	1256	60.4%	148	**10.8%**	36	286	**15.9%**
Loc Ha	1678	170	10.1%					
Nom Phong	2521	895	35.5%					
total/average	**25626**	**12866**	**50.2%**	**865**	**4.1%**	**449**	**3481**	**13.0%**
							total	**17.0%**

	households	new households (annual groth: 1.25%)	households with septic tank	households without septic tank	septic tanks constructed (annually 17 % of hh without ST and new hh)	coverage by septic tanks
1993			8743*			
1994						
1995	43882	549				
1996	44431	555				
1997	44986	562	22586	22400	3908	50%
1998	45548	569	26494	19054	3340	58%
1999	46118	576	29834	16284	2870	65%
2000	46694	584	32703	13991	2480	70%
2001	47278	591	35184	12094	2159	74%
2002	47869	598	37343	10526	1893	78%
2003	48467	606	39236	9231	1674	81%
2004	49073	613	40910	8163	1494	83%
2005	49686	621	42404	7282	1345	85%
2006	50307	629	43749	6558	1223	87%
2007	50936	637	44972	5964	1123	88%
2008	51573	645	46096	5477	1042	89%
2009	52218	653	47138	5080	976	90%
2010	52870	661	48113	4757	922	91%
2011	53531	669	49035	4496	879	92%
2012	54200	678	49914	4286	845	92%
2013	54878	686	50759	4119	818	92%
2014	55564	695	51577	3987	797	93%
2015	56258	703	52374	3885	781	93%

*septic tank survey 1998: 33% of septic tanks older than 5 years, 66% younger

6.1.4 Projection of Demand for Septic Tank Emptying

Calculation example: Demand for emptying septic tanks in year 2010 with 5 year frequency:

Number of septic tanks to be emptied in 2010 = Number of existing septic tanks in 2005 / 5

6.1.5 Sludge Analysis

Samples from septic tanks, analysis by CEETIA 06/2000

	suspended solids [mg/L]		water content [%]
m1	92,420		87.70
m2	57,.340		94.69

Samples from vacuum tanker, analysis by CEETIA 02/2001

	suspended solids [mg/L]	organic material [mg/L]	water content [%]
m1	1,143.2	906.1	81.62
m2	893.4	729.5	88.72
m3	672.5	505.2	62.72
m4	692.5	518.7	90.59
m5	736.4	496.3	90.47
m6	692.5	769.2	89.21
m7	951.3	472.5	92.37
m8	648.3	51.1	91.16
m9	1,624.4	882.7	83.53

Samples 07/2001, Analysis by DOSTE Nam Dinh

TS and TVS of Public Toilet Sludge and Sewer Sludge in Nam Dinh

	Samples taken during July 2001, using a shovel, all samples show the same semiliquid consitency	**TS [%]**	**TVS [%of TS]**
1a	Public toilets at Cua Truong Market, big septic tank, used to be emptied monthely but not any more since 2 years, sampling close to toilet slap	12.0%	54.2%
1b		12.6%	56.9%
2	Public toilets at ex-bus-station, less used, last emptying 2-3 years, sampling close to the exit of septic tank	5.9%	65.6%
3	Septic tank of general hospital, emptying every 2 years, last time 2 months ago	6.2%	61.6%
4	Public toilet, used by many people, never emptied by Urenco but frequently by bucket collectors	7.1%	56.1%
		7.9%	**60.0%**
5	Sewer, Phan Dinh Phung, middle	41.4%	31.0%
6	Sewer, Phan Dinh Phung at Hai Ba Trung	21.6%	28.5%
7	Sewer, Han Thuyen End	23.3%	34.5%
8	Sewer, Han Thuyen, Voi Phuc area	29.8%	18.4%
		29.0%	**28.1%**

Comments

- The two first series: The data is very inconsistent, because water contents show a similar dimension but suspended solids differ by factor 100. These parameters normally correlate better.
- The best sampling method is to take samples from vacuum tanker, as this is consistency in which the sludge will reach the treatment plant. Samples taken directly from septic tank usually are thicker, as they don't contain the liquid from the column above the sludge layer. Only the series 2 was taken in this way, however some doubts persist concerning the reliability of analysis (comment 1).

6.2 Minutes from Interviews and Meetings

6.2.1 Visit of Households

Several households have been visited 04/07/01and talks with members of women's union have been held, to get a image about people's habits with septic tank emptying.

- One household has build the septic tank 1 year ago, with loan of the septic tank fund. The Tank is 2,5 m3, 1m deep and located under the bathroom. Before the construction, they used the public toilets in the neighborhood. The Head of the household is aware that a direct connection to the sewer is bad. He thinks, based on the experience of others, that in 10 years he will have to empty his tank the first time to prevent blocking. He will hire some workers who do it by hand or by vacuum truck, his house is not far from a good road, so there will be no problem
- One household has a 10 year old septic tank (2,5 m3, 3 chambers) who has already been emptied 6 years and 2 years ago to prevent blocking. Bucket collectors carried out the emptying by hand, because the house is situated in a narrow lane. The tank was opened (tiles broken), the opening measured 20cm x 40 cm, the first chamber of the tank was partly emptied, the action took 1 hour. Cost: 100000 VND. Now they use a product, Micro Phot, which is poured every 6 months in the tank and which makes unnecessary the emptying. So they will not empty the tank any more until no problems occur. Apparently many people use this product.
- One household has replaced the bucket latrine in 1992 by a septic tank. They empty they tank every year to prevent blocking. Additionally they use Microphot but will continue to empty the tank. The emptying is done by Urencos vacuum truck, who empty regularly the nearby market toilets, so it is very convenient, the house is easy accessible. The fee is 300000 VND, which is not perceived as expensive.
- Usually the bucket toilets do not receive urine, urine is diverted directly into the drainage system or somewhere else. People from the rural communes empty in the early morning hours or by night the buckets and the public toilets.
- Microphot seems to be quite popular product to prevent septic tanks from blocking and which makes the emptying unnecessary: A package of 300g powder costs 17000 VND and gives the following advice:

" Microphot - Product of Sinh Hoa Company Limited. Oppose to the blocking of Septic tank.
If your toilet has badly smell or the water running slower than usual when flushing, that means the septic tank is blocking. With only one package of microphot for a capacity of toilet equivalent to 1.5m3 pouring into the toilet and after 3 to 4 days the above problem can be solved. If your toilet has no phenomenon as the above, and it works in normal condition it is only need one package of microphot for septic tank equivalent to 5m3 is enough. Microorganism sustainable timing in septic tank is from 5 to 6 months., A preventive pouring for every 3 to 6 months, your toilet will eternal not to empty the septic, due to the human waste and toilet paper have been disintegrate into water to dispel.
Contact address: No. 347 Tran Nhan Tong - Nam Dinh, Tel: 0350 - 848 629, Fax: 0350 - 849 159
Guarantee: 1 year, Technology production of Institution of Biology & Technology - Center of International, Technology natural scientific, Science Consultant: Associate professor, M.A. Ly Kim Bang"
The ingredients are reportedly: microorganisms, moulds and yeast who disintegrate the organic matter.

6.2.2 Interviews with Agriculture Services, Cooperatives and Farmers in Nam Dinh District

Objectives:

Get representative information about:

- Use of fertilizers in ND agriculture
- Acceptance of composted solid waste and treated FS by ND farmers, market potential

Interviews:

- Nam Dinh Province Agriculture And Rural Development Service, 27.06.01, Mr. Hoang Duy Khanh, Vice Director, Mr. Canh, Head of Planting Division
- Nam Dinh Municipal Agriculture Department, 28.06.01, Mr. Trung, Director, Mrs Yen (contact person to cooperatives)
- Nam Van Coop, 12.07.01, interview with chairman, field visit and talks to farmers
- Kenh Thuong Coop, 13.07.01, interview with chairman
- Vinh Mac Coop, 13.07.01, interview with chairman
- Mai Xa Coop, 17.07.01, interview with chairman
- 2nd of July Coop, 17.07.01, interview with chairman, field visit and talks to farmers
- Luong Xa Coop, 18.07.01, interview with chairman
- Nam Phong Coop, 18.07.01, interview with chairman

The information received through the different interview partners is quite consistent through all levels (municipal service – cooperative – individual farmer). It is thus admissible to consider the information as rather representative for the Nam Dinh district.

General Information

How many farmers in working age are member of this cooperative?, How many ha are cultivated in this cooperative?, How many ha are cultivated with rice?, Which other crops are cultivated?, Is fish raising practiced in the cooperative?

The main part of the cultivated area of all cooperatives is rice cultivation area. Some coops are pure rice producers, others produce the main part of the revenue with other activities as fish raising (Khen Thuong) or flower and bonsai production (Nam Phong). Vegetable cultivation and fish raising is widely practiced by individuals, in gardens and private ponds.

	farmers in working age (total population)	total cultivated area, ha	rice cultivation area, ha	
Nam Dinh Province	800000	200000	165000	
Nam Dinh District	10600 (27300)	2000		10 cooperatives, 7800 farming households
Nam Van Coop	1700 (4200)	357	287 (2x), 65 (1x)	5 ha vegetables, 1-10 ha fish ponds
Kenh Thuong Coop	900 (1900)	120	62	60 ha Fish ponds: main activity
Vinh Mac Coop	1520	148	140	8 ha vegetables
Mai Xa Coop	1300	174	174	30 ha private fish ponds
2nd of July Coop	730 (1260)	163	126	3 h vegetables
Luong Xa Coop	860 (1600)	129	115	rest: fish ponds
Nam Phong Coop	2700 (8180)	434	230	41 ha vegetables, 121 ha bonsai and flower, 44 ha ponds

What is the average income of a farmer household (d/year)?

1-3 Mio VND / year and capita (70-200$)

Is the equipment used by farmers rent or owned?

- Pumps, mechanical plugs, tractors and other equipment is provided by cooperatives, rent by private suppliers or owned by farmers and shared with others.
- Usual means of transport owned by farmers are bicycles.

Use of fertilizers

How much mineral fertilizer is used in this cooperative? At which time or period is the mineral fertilizer applied, and how?

- The usually recommended and applied quantities are:

During spring season:

Urea:	200 – 400 kg / ha	price: 2000-2500 VND/kg
Superphosphate:	400 – 700 kg / ha	price: 1000 VND/kg
Kali:	110 – 170 kg / ha	price: 2500 VND/kg

Average over the whole year:

Urea:	375 kg / ha
Superphosphate:	885 kg / ha
Kali:	205 kg / ha

- The quantities applied during the spring season (begin February) are higher than during summer season (begin June, 60-80% of spring season). During summer season there is more rain containing nutrients, the investment is reduced due to higher risk of damage by storms, and the lower fertilizer application causes slower growth of the crops which assures higher resistance against storm damage.
- The fertilizer is applied by hand, for example 50% N and 100% P at begin of cultivation, 50 % N and 50 K % 15 days later, 50% at flouring of rice, more N if problems.
- The farmers have enough money to buy mineral fertilizer, if not, the cooperatives provide fertilizer in advance of payment. The required fertilizer rate is usually applied.
- Generally the lack of organic fertilizer is compensated by mineral fertilizer, the farmers would reduce mineral fertilizer use if more organic fertilizer would be available.

How much organic fertilizer is used?

- 8 – 14 t/ha.year, average 9 t/ha.year
- Application limited by availability. Lack of organic is compensated by mineral fertilizer.

What types of organic fertilizers are used? What kind of human waste is used (from own household, from collected buckets)? What do farmers do with human waste before application? Why they do this?

- Pig manure, vegetal refuse, rice skin, human waste (little quantity, because limited availability)
- Wastewater is used for fertilization (Vinh Mac 50 ha, Kenh Thuong ca. 50 ha), the WW is applied 6-7 times per season, bad effects to crops and human health are observed and referred to toxic components in the wastewater.
- The different types of organic fertilizer are stored in a earth hole, phosphate is often added, and covered with straw or earth for ca. 2 months. This is usually called composting, but is actually storage of the continuously available waste until the punctual application twice a year.
- A commercial organic fertilizer (Song Gianh Product, content as shown on package: organic matter >12%, humic acids >2.5%, P2O5 > 3%, trace elements, enzymes, K2O, N; analyzed water content: 35,3%, price: 1000 VND/kg) is used for vegetable and flower/bonsai cultivation (Nam Phong, application for bonsai: 550 kg/ha).

Where do the farmers get the organic fertilizer? Do they buy part of it? How much they pay for it?

- Most organic fertilizer is from own farm, mainly pig manure and vegetal matter, sometimes bought, but rarely (Nam Van 20-30 VND/kg for "green fertilizer", see below). Farmers basically apply the quantity of organic fertilizer they have, so farmers who have many pigs apply more than those who don't have pigs.
- Human waste from bucket latrines is bought sometimes, but it becomes more and more rare because of replacement of bucket latrines by septic tanks (in Nam Dinh, but as well on villages). 600-1000 VND/kg are paid for bucket sludge, used for fish feeding mainly, but quantity is very little because of limited and decreasing availability.

At which time or period is the organic fertilizer applied, and how?

- Organic fertilizer for rice cultivation is always applied before seeding (spring: jan/feb, summer: june/july). The main part of the organic fertilizer is applied in spring, the leftover is applied in summer.
- For vegetable cultivation, the organic fertilizer is applied always before seeding, but as the growth-periods are short (1-3 months) and vary from vegetable to vegetable, the overall application-mode in vegetable cultivation can be considered as continuously.
- The organic fertilizer is brought to fields mainly by bicycle, or taken from the storage piles beside the fields, placed in piles on the filed and plugged under.

- The best organic fertilizer is used for vegetable or flower cultivation

Knowledge and Awareness

What do you think is compost? What do you think are the agronomic benefits of compost? What do you think are the problems connected to the direct use of fresh human waste as fertilizer?

- The traditional way of "composting" is to place a mix of vegetal matter, rice skin, straw, pig manure, human waste etc into a earth hole, to cover it by soil and grass, and to store it there for 1-3 months until application. The product is referred as compost or "green fertilizer". As reasons for this practice are mentioned: storage of org. waste until application date, increase of fertilizer volume by adding straw and other material, diminution of bad effects (damage to plants, bad smell, fly proliferation, pathogenic organisms).
- The farmers seem to know about the soil-conditioning effects of organic fertilizers and seem to be conscious of the long-term nature of the benefic effects.
- All say that fresh human waste (bucket sludge) is never applied directly because of damage to the plants due to heat production and bad effects to environment (smell, flies, human health).

Acceptance of compost and treated FS

The nature of compost from solid waste and from a fecal sludge treatment plant was explained. As an example of treated fecal sludge, a sample of dewatered sludge from AIT-Bangkok constructed wetlands was shown.

Would you use compost from a solid waste composting plant as fertilizer?Would you use treated human waste from a treatment plant as fertilizer?Why/why not?

- All interviewed agree that they would be interested in using a compost. There is need for more organic fertilizer.
- All say, if they would use it is depending on efficiency and cost. They always mention that they would need some trial before regularly use it.
- The sample from AIT dewatered septic sludge was always positively commented. One farmer said they would use this for vegetables.
- There might be problems with solid waste compost if it contains residues like glass or metal (farmers work barefoot in the fields!), plastic residues are less problematic.
- Compost from human waste is more interesting as from SW because of higher nutrient content.

What form or consistency should have a compost you would like to use as fertilizer? Would you transport the compost from Loe Hoa commune (new landfill and future composting plant site) to your fields?What is the maximum possible transport distance?

- Consistency of usual compost is ok.
- Best would be delivery in 50 kg sacks for easy transport by bicycles.
- Maximum distances of 5 km are mentioned. Less is better because most farmers transport fertilizer by bicycle.
- Most say that distribution by a local agency is desired, for example through the cooperatives.

Would you pay 500, 200, 100 VND/ kg for treated fecal sludge?

- It is very difficult to establish a good price, most say they would need trial to see the effects, to know the required application rate, and how much they can replace mineral fertilizer
- 100-300 VND/kg (of a compost similar to the AIT sample, wet weigh) is thought to be acceptable or cheap, 500 VND/kg seems to be rather expensive.

6.2.3 Meetings with URENCO

26/06/01 - Meeting with Mr. Dinh, Director of Urenco

A first meeting with Mr. Dinh, Director of Urenco, was held the 25 of June 2001 to complete information about septic tank emptying and sludge disposal. Coincidentally Mr. Nguyen Xuan Tuyen, Vice Director of Provincial Construction Department, joint the meeting and could give information about the planned wastewater treatment project.

Mr. Dinh:

- Data about current septic tank numbers can be obtained through the health care center.
- Today, one vacuum tanker is operated. The second one is broken down and not repaired, because there is not enough demand for two trucks.
- 150 septic tanks of 1-2 m3 each have been emptied last year, 20 tanks from offices with 10-100 m3. The total amount of sludge was 1000t.
- Reasons of the low demand is not awareness of the people and the high costs. Urenco reduced prices to 60% (by using a part of the NDUDP funds) but this didn't change a lot.
- The real cost for Urenco is 60000 VND per tank.
- Around 30% of the tanks are difficult to access by the vacuum tanker
- Septage is sold by the drivers for little money (5000 VND /m3) to farmers, disposed on the landfill or to ponds if no other disposal site is available.
- Workers from the drainage cleaning teams in UCMC are emptying septic tanks manually and dispose sludge into drainage system. They do this as second job, not as a part of UCMC services. The fee is much lower than the Urenco-fee. They serve a presumed 10 % of the households per year.
- 3000-4000 bucket latrines in the suburban areas, emptied by private collectors and sludge sold to farmers.
- Mr. Dinh thinks that the main problems for septic tank management is the lack of community awareness as well as the lack of awareness of municipal officials for the importance of the problem of septic tanks (with resulting low financing).
- The construction of the composting plant will probably be commenced in 3 months and completed end of next year.

- Mr. Tuyen (Nguyen Xuan Tuyen, Vice Director of Provincial Construction Department, Phone: 0913290715):

- Mr Tuyen is the chairmen of the pre-feasibility study for the projected wastewater treatment plant
- The project will be financed by the French
- Water from the sewer system, containing domestic and industrial wastewater will be treated, the effluent will be disposed into the River (presumed to mean Dao River).
- The current stage of the study is the identifying of potential sites. The treatment process is not yet defined.
- Urenco will operate the future treatment plant.

11/07/01 - Meeting with Mr. Binh, Driver of Urenco

A meeting was held with Mr. Binh to get information about fecal sludge collection practice, problems with septic tank emptying and to organize sampling.

Mr. Binh:

- The vacuum truck is not operational for the moment because it has to undergo annual maintenance (last maintenance was 4 years ago), maybe it will be operational next week.
- Usually 5-6 tank are emptied per month in this time of the year. Demand is higher end of the year, when people undertake construction works in their houses. Construction or renewing works are the main reason why people want their tank to be emptied. Approximately 80 individual septic tanks and 10 office or public tanks are emptied per year.
- Standard fee for a single emptying is 263000 VND. A contract for periodical emptying would cost 40000 VND per m3, or 160000 VND per truck, but nobody uses this option. Manual emptying is more expensive, but many prefer this, because manual emptying is more effective. Emptying by vacuum truck is less effective and requires periodical emptying.
- The septic tank is emptied by a opening in the bathroom (usually covered by tiles). The first chamber is emptied in a purging-pumping process, because the sludge there is very thick and difficult to pump. The capacity of the pump is quite low, and the emptying of this first chamber can take up to 2h (if the tube length is 20-30 m). The second chamber is usually very easy to empty, in a few minutes, without purging. The purging results in an increase of sludge volume (septic tank of 1-3 m3 gives a sludge volume of 4-5 m3 (?)).

- Sludge is usually sold to Mai Xa aquaculture cooperative or to farmers (10000 VND / 4m3). Only if Mr. Binh finds nobody willing to take the sludge, it is disposed on the landfill. The effort to find farmers willing to take the sludge is bigger then the money it brings. Transport distance would not be a big problem, for example the new landfill site would be ok, as often more than 15 km transport is necessary to bring sludge to the farmers.
- Most important technical problems with emptying by vacuum truck is the limited accessibility (max range 25-30m from large street) and the low pumping capacity (time consuming). Smaller trucks would improve the accessibility.
- Maximum capacity of the vacuum truck under ideal conditions is 2 septic tanks per day.

2nd Meeting Mr. Dinh, Urenco, 7/26/01, Visit of Loc Hoa Landfill/Composting Site 8/1/01

Purpose of the meeting: get information about the composting-plant project, discuss possible co-treatment of FS with SW, availability of land for FS-treatment at landfill/composting site, acceptance by neighbors

French composting plant:

- Design is carried out together by Berim, Paris and Licogi, Hanoi. Completion of design is expected to end of August 2001.
- The plant is expected to be operational begin of 2003
- In the process, no external water will be used, only water from solid waste (?). Nothing about treatment of wastewater from composting plant is known.
- The compost will be free of metal, glass and plastic residues, as it is mechanically classified.
- The future Business Department of Urenco will develop a marketing strategy for compost commercialization

Landfill, leachate treatment

- For treatment of leachate from landfill (already constructed: 6 cells 25 x 30 m), two ponds shall treat the leachate pumped from drainage of the cells. The planned treatment will be: first step treatment with EM additives (seems to be very popular in Vietnam for any kind of problem, is sprinkled over landfills, waste for composting etc, probably EM means effective microorganisms) in a 1200 m2 pond, second step biological treatment (with floating water hyacinths) in 1000 m2 pond. The ponds are already constructed, but not yet connected with tubes, inlets or outlets. No proper design documents are available. An environmental impact assessment exits for the landfill and the leachate treatment, but it's rubbish.
- One channel along all the cells is constructed to intercept leachate escaping the cells. How this channel will be actually used, if water is pumped or treated is not clear. There is no connection with other channels or ponds.
- Mr. Alcock, SW-Expert of NDUDP recommended re-circulation of leachate to enhance decomposing process and to reduce volume of leachate by evaporation.

Treatment process for FS

- Mr Dinh is in favor of a combined treatment of SW and FS (eg. co-composting of dewatered sludge). He says the French don't want to consider this option until the completion of the composting plant. This means Mr. Dinh will take any decision concerning co-treatment of FS and SW only after receiving the composting plant by the French (begin 2003)
- Mr. Dinh wants special attention to be paid for prevention of pollution of water and groundwater through FS treatment

Land for FS – treatment

- A small piece of land may be available for septage treatment. The location is between the already constructed leachate treatment ponds, the last cell of the future landfill phase II, the future composting plant, and the border of the site, formed by an irrigation / drainage channel, which constitutes the receiving waterbody for any discharge from the different installations.
- Size: max 900 m2, for first phase maybe half or less (Mr.Dinh).
- Attribution of land to septage treatment has to be decided by municipality, once proposal available.

Acceptance by neighbors

Mr Dinh and Mrs. Hahn (after assisting to a meeting between municipality and protesting villagers):

- Currently Urenco faces big problems with protest of villagers against the opening of the new landfill. All temporary landfills are full and the waste is piling up in Nam Dinh streets. Urenco needs urgently to open the new landfill to untreated SW.
- As main problems are mentioned: water pollution (mainly through the nearby old landfill site), odor and flies, pollution by open lorries transporting waste on the road passing the village.

- The protesting villagers are seeking for compensation measures (payments, piped water supply, other public investments…). Part of these compensations will probably given. If still necessary, the opening will be enforced, Mr. Dinh hopes the landfill will enter operation within a month.
- It is unlikely that the treatment of FS will cause big additional protests, considering the relatively small dimensions of the project. However some public consultation must be undertaken, because often FS is perceived as much worse (smell, pollution…) as SW.

Contact address of consultants in charge of design of composting plant

Berim, Paris, Tel. +33 1 41833636, Fax. +33 1 41710633 (-34)
Licogi,

6.2.4 Meeting at Licogi

A short meeting was held with Mr. Lap, Licogi on 7.8.01 in order to obtain the latest information about the design of the composting plant in ND.

Mr. Dang Van Lap, Chairman of design, Tel. 8549488, Fax 8542655, Mob. 0903218672, licogituvam@fpt.vn Licogi, Office Building G1, Than Xuan, Hanoi

- The design is almost completed. Completion is expected for end of August, design documents are then sent to Mr. Dinh.
- This composting plant is the first designed by Licogi. Apparently the support by the French partner, Berim, during design work was very limited.
- The design of the composting process is based on the solid waste characteristics mentioned in the feasibility study.
- The total capacity is 250 t/d
- A plan with the layout of the composting plant was handed out and explained:

The composting plant will contain the following treatment steps:

1. Delivery of solid waste, magnetic separator and manual classification
2. First composting phase with forced aeration, 3 weeks
3. Second composting phase without forced aeration, 3 weeks
4. Drum screen, second classification and final screening
5. Packaging of compost

- Storage for compost, capacity: 2000 t
- All wastewater produced during the different steps is collected and reused as process water. Additional water for the process is delivered by a well on the site. No piped water is used.

6.2.5 Visit of Haiphong Sanitation and Water Supply Project

The Haiphong Sanitation and Water Supply Project was visited at 6.08.01 in order to discuss experiences with different kind of equipment for cleaning of septic tanks and of septage management in Haiphong. The Haiphong project was already visited by NDUDP experts (Chris Eiben, Stefan Muerner, …) two times during 2000, with focus on sewer cleaning. This report should be seen as complement to the following reports:

[1] NDUDP2, Visit to Haiphong Water Supply and Drainage Project, 23.10.00
[2] NDUDP2, Report of Study Tour to Haiphong, Sewerage and Drainage Company, 27.9.00

Present were:

Mr. Esa Renko, Sanitation Adviser, HSAWSP
Mr. Willie Barreiero, Institutional Specialist, HSAWSP
Mr. Vu Trong Quang, Deputy Director of SADCo
Mr. Florian Klingel, NDUDP

The operation of all kind off equipment was demonstrated during the emptying of a large septic tank of an apartment block. Different matters were discussed during the demonstration and later on in the office.

Equipment for septic tank emptying

- Additional to the equipment described in [1], 4 new mini-vacuum-tugs, developed by Deputy Director Mr. Quang and assembled by the Haiphong based Company "Industrial and Agricultural Equipment" have been purchased. Together with the prototype, SADCo owns now 5 of those "Quang-tanks". This equipment is very small (width ca. 70 cm), and each house which is accessible by motorbike can be reached with this equipment. The capacity is 350 l, cost ca. 4000$.
- Large septic tanks and easy accessible septic tanks are emptied by the large vacuum trucks, but generally, this equipment is mainly used for sewer cleaning. Septic tanks in houses located in narrow lanes are emptied by the small equipment, together with a skid mounted sludge tank (5 m3). This intermediate-storage-tank is placed in the closest accessible point by the Iveco hooklift, the septic tank is emptied in several steps, when the 350 l tank is full, the tug is pushed over a short distance to the intermediate-storage-tank, which is later picked up by the hooklift. Each of the tugs is operated independently, together with one intermediate-storage-tank.
- The experiences with this equipment are good, especially the small vacuum tug seems to be a success. However the Irish manufactured mini-vacuum-tugs (description and photos in [1]) are not any more used frequently, because the capacity is too little in relation to the still quite big dimensions, the Quang-tank therefor usually used instead.
- The combination of large capacity vacuum trucks and of small vacuum tugs with intermediate-storage-tanks seems to be the optimal technical solution for septic tank emptying. Almost 100% of the households are in the range of this equipment, making unnecessary the manual emptying of septic tanks.
- 2 – 3 average household septic tanks per day can be emptied by each large or small equipment.

O+M of Equipment

- The equipment is maintained by a municipal unit, not by a private contractor, opposite to the statement in [2].
- There are no technical problems with O+M, the equipment is simple enough and the personal skilled enough to be able to maintain the equipment after having received some training.
- The big problem with O+M is serious budget problems of SADCo, often the equipment cannot be used because there is no petrol, or because repairing cannot be paid. The problem will become bigger in near future, when new equipment will be supplied through a World Bank project. Mr Quang says, they will probably not be able to operate all equipment.
- No exact figures about O+M costs are calculated, it is estimated that 100000 dong/m3 sludge cover operation, maintenance and salary costs.

Septage management

- The system of septage management is very similar to the Nam Dinh system: septic tanks are only emptied on request by owners, and for direct payment of the fee (100000 VND for a average septic tank emptied by small equipment). Septic tanks are usually only emptied when problems with blocking occur. In Haiphong, no special efforts have been made to increase frequency of emptying, except within the usual community awareness campaigns.
- Septage is disposed off in the landfill. Currently, no alternatives have been considered by HSAWSP, as a soon starting World bank project contains a package for septage treatment. No details about the design of the

treatment are known, but drying beds and co-composting with solid waste have been mentioned as chosen technology.

Financing of public services

- The HSAWSP may try in future to obtain a swift from direct fees for septic tank emptying to a regular fee, but at this moment, it is just an idea.
- It would be optimal to combine a regular fee for septic tanks with other service fees. Currently, a trial is under way with the water supply company adding 10% to the water bills for sewer cleaning. However the WSC fears to see decreasing its own collection efficiency with adding up other fees to its bill, and is thus opposed to further steps in this direction. It seems more feasible to combine the septic tank fee with the solid waste collection fee (collected by Urenco).
- Mr. Barreiro says that it is questionable if full cost recovery of public services is possible to achieve, as this concept is not fully compatible with the Vietnamese system.

6.3 Treatment Options

6.3.1 Design

The design for the different treatment options is based on the following assumptions (2002-2003 planning horizon):

Capacity: 5,000 households (1,000 households per year, frequency of emptying: 5 years)
2,500 m3 septage / year (2.5 m3 per septic tank)

Septage quality (quality of Bangkok septage septage; see Koottatep et al. 2001):

	mg/l
TS	20,000
SS	15,000
COD	15,000
BOD	3,000
NH4	350

Constructed Wetlands

Septage volume:	2,500 m^3/y
Solid content:	20 gTS/l
Optimal load on CW:	250 kg TS/m^2y (Koottatep et al.)
Effective CW area:	200 m^2

Biosolid production: 50% of TS remain in biosolids (Mass balance Sandec-AIT), septage in 20 gTS/L, biosolids out 300 g TS/L => 3%

Drying beds

Septage volume:	2,500 m^3/y
Solid content:	20 gTS/l
Optimal load on drying beds	200 kg TS/m^2y (Heinss 1998)
Effective drying bed area:	250 m^2

Biosolid production: 85% of TS remain in biosolids (Mass balance Sandec), septage in 20 gTS/L, bio-solids out 400 g TS/L => 4.25%

Settling tank + secondary settling pond

Primary settling tanks:

Septage volume:	2,500 m^3/y
Chosen loading period:	28 days
SS septage:	15 g/l
SS in settled sludge :	120 g/l (Heinss 1998)
Estimated removal:	80 %
Specific sludge accumulation:	0.1 m^3/m^3 of septage
Accumulated sludge volume:	20.4 m^3
Chosen max sludge depth:	0.5 m
Tank area:	40 m^2

Secondary settling pond:

Loading period:	12 months
SS inlet:	3 g/l
Specific sludge accumulation:	0.025 m^3/m^3 of septage

Accumulated sludge volume: 62.5 m^3
Chosen max sludge depth: 0.5 m
Pond area: 120 m^2

Biosolid production: 95% of SS remains in sludge (removal efficnecy: 80% +80%), septage in 15 gSS/L, settled sludge 120 g SS/L => 12%, adding bulcking agent, *1.5 =>18 %

BOD removal:

Inlet concentration:	3,000 mg/l
Removal in primary tank:	40%
Inlet secondary pond conc.:	1,800 mg/l
Volumetric loading rate	200 g BOD/m^3 d
Removal anaerobic pond:	60%
Outlet concentration:	760 mg/l

Co-treatment of liquid fraction with landfill leachate

Effluent from septage treatment:

BOD:	100-750 mg/l (dependent on septage treatment)
NH4:	200-700 mg/l (dependent on septage treatment)
Q	28 m^3/d (2006)

Typical leachate concentrations

BOD:	10000 mg/l
NH4-N	200 mg/l

Estimation of leachate flow for all 6 cells of existent landfill:

It can be considered that only percolation rainwater causes polluted leachate. The annual precipitation is not totally infiltrated into the landfill (run-off during heavy summer rain and evaporation, if leachate recirculation).

Precipitation:	1,800 mm
Estimated max infiltration:	1,000 mm
Landfill area:	8250 m^2
Q	8250 m^3/y = 22 m^3 / d

If constant pumping is applied (necessary to avoid migration of leachate outside the landfill), considerable infiltration from the groundwater can be expected. This water will dilute less of organic components as it dos not percolate through the entire waste column, and will thus contribute to a lesser extent to the BOD-load of leachate

Estimated gradient with constant pumping:	0.5m
Mean soil permeability:	1.56 * 10^{-7} m/s
Annual Infiltration:	2.46 m^3/m^2.y -> 20300 m^3/y

Anaerobic treatment in primary pond:

BOD leachate:	220 kg/d
BOD septage-liquid fraction:	20 kg/d
Anaerobic pond volume:	1200 m^3
Volumetric load:	200 g BODO/d

6.3.2 Estimation of Construction Cost

Cost summary - constructed wetlands

No	Expense	Total	Unit
	Expense bases on standard price unit		
	Expense on Materials	118,721,909	VND
	Additional to Material		VND
	Expense on Labor	6,427,820	VND
	Expense on Machinery	4,268,256	VND
I	**Direct expense**		VND
1	Expense on Materials	118,721,909	VND
2	Expense on Labor	9,384,617	VND
3	Expense on Machinery	4,567,034	VND
	Sum of Direct Expense	**132,673,560**	VND
II	**General Expense**	**6,287,693**	VND
III	**Income Tax**	**7,642,869**	VND
	Cost estimate before tax	**146,604,122**	VND
IV	**Value added tax**	**7,330,206**	VND
	Cost estimate after tax	**153,934,328**	VND
	Sludge pump 10m3/h DX80-26	3,500,000	VND
	Water pump 2m3/h	2,000,000	VND
	Total	**159,434,328**	VND

Cost summary - drying beds

No	Expense	Total	Unit
	Expense bases on standard price unit		
	Expense on Materials	131,954,555	VND
	Additional to Material		VND
	Expense on Labor	7,468,545	VND
	Expense on Machinery	4,390,038	VND
I	**Direct expense**		VND
1	Expense on Materials	131,954,555	VND
2	Expense on Labor	10,904,076	VND
3	Expense on Machinery	4,697,341	VND
	Sum of Direct Expense	**147,555,972**	VND
II	**General Expense**	**7,305,731**	VND
III	**Income Tax**	**8,517,394**	VND
	Cost estimate before tax	**163,379,097**	VND
IV	**Value added tax**	**8,168,955**	VND
	Cost estimate after tax	**171,548,052**	VND
	Sludge pump 10m3/h DX80-26	3,500,000	VND
	Water pump 2m3/h	2,000,000	VND
	Total	**177,048,052**	VND

Cost summary - settling tanks and pond

No	Expense	Total	Unit
	Expense bases on standard price unit		
	Expense on Materials	133,390,567	VND
	Additional to Material		VND
	Expense on Labor	7,478,921	VND
	Expense on Machinery	5,709,442	VND
I	**Direct expense**		VND
1	Expense on Materials	133,390,567	VND
2	Expense on Labor	10,919,225	VND
3	Expense on Machinery	6,109,103	VND
	Sum of Direct Expense	150,418,895	VND
II	**General Expense**	7,315,881	VND
III	**Income Tax**	8,675,413	VND
	Cost estimate before tax	166,410,188	VND
IV	**Value added tax**	8,320,509	VND
	Cost estimate after tax	**174,730,698**	VND

Construction cost estimation - constructed wetlands

Task	Unit	Amount	unit Price			Sum		
			Material	Labor	Machin-ery	Material	Labor	Machinery
Land filling (using sand) (2035.37*1-124)/100= 19.114 Excep sludge tank: -10*25*1/100= -2.500 -10*10*1*2/100= -2.000 -8*5*2.3*2/100= -1.840	100m3	12.774	2,720,600	19,456	220,756	34,752,944	248,531	2,819,937
Stone masonry, Cement mortar # 75 20.6*10.6*0.3= 65.508 0.3*0.3*2*(9.25*2+4.55*8)= 9.882	m3	75.390	197,231	28,406		14,869,245	2,141,528	
Brick masonry 6,5x10,5x22 wall 250 thick, cement mortar #75 10*1.4*0.25*4= 14.000 20*1.4*0.25*2= 14.000	m3	28.000	386,142	24,904	1,631	10,811,976	697,312	45,668
Plastering 2cm thick, cement mortar #75 Wall 10*1.4*2*4= 112.000 20*1.4*2*2= 112.000 Bottom screed 9.5*19.5= 185.250 0.3*2*2*(9.25*2+4.55*8)= 65.880	m2	475.130	7,176	1,874	136	3,409,533	890,394	64,618
Gravel 0.4*0.4*(9.5*4+9.25*2)= 9.040 9.5*19.5*0.4= 74.100	m3	83.140	112,000			9,311,680		
Steel pipe Dr.150mm	100m	0.250	11,685,010	1,146,837	60,324	2,921,252	286,709	15,081
butter fly vale Dr.150	c¸i	4.000	200,000	14,664		800,000	58,656	
Geotextile 9.5*19.5= 185.250	m2	185.250	10,000			1,852,500		
Access road foundation crushing stone 4x6 517.88*0.25= 129.470	m3	129.470	102,480	6,976	2,275	13,268,086	903,183	294,544
Road pavement 2x4 517.88*0.2/100= 1.036	100m3	1.036	10,680,000	59,528	671,016	11,064,480	61,671	695,173
Sum pit 2m3/h								
Cement concrete #100, crushing stone 4x6 3.4*3.4*0.1= 1.156	m3	1.156	255,882	20,481	12,041	295,800	23,676	13,919
Cement concrete #200, crushing stone 1x2 3.4*3.4*0.2= 2.312	m3	2.312	381,067	24,126	9,146	881,027	55,779	21,146
Rebar 2.312*200/1000= 0.462	Tone	0.462	4,041,572	147,377	99,351	1,867,206	68,088	45,900
Brick masonry 6,5x10,5x22, cement mortar #50 3*4*2*0.22= 5.280	m3	5.280	365,064	24,904	1,631	1,927,538	131,493	8,612
Plastering, Cement mortar #50 3*3= 9.000 3*4*2*2= 48.000	m2	57.000	5,666	1,874	136	322,962	106,818	7,752
Sludge tank 10m3								
Cement concrete #100, crushing stone 4x6 4.4*3.4*0.1= 1.496	m3	1.496	255,882	20,481	12,041	382,799	30,640	18,013
Cement concrete #200, Crushing stone 1x2 4.4*3.4*0.2= 2.992 (4+3)*2*2*0.15= 4.200	m3	7.192	381,067	24,126	9,146	2,740,634	173,514	65,778
Form work (4+3)*2*2*2/100= 0.560	100m2	0.560	1,866,390	375,836		1,045,178	210,468	
Rebar 7.192*200/1000= 1.438	Tone	1.438	4,041,572	147,377	99,351	5,811,781	211,928	142,867
Plastering , cement mortar #50 4*3= 12.000 (4+3)*2*2*2= 56.000	m2	68.000	5,666	1,874	136	385,288	127,432	9,248
						118,721,909	6,427,820	4,268,256

Construction cost estimation - drying beds

Task	Unit	Amount	unit Price			Sum		
			Material	Labor	Machinery	Material	Labor	Machinery
Land filling (use sand) (2035.37*1-124)/100= 19.114 (except sludge tank): -10*25*1/100= -2.500 -10*10*1*2/100= -2.000 -8*5*2.3*2/100= -1.840	100m3	12.774	2,720,600	19,456	220,756	34,752,944	248,531	2,819,937
Stone wet masonry foundation, Cement mortar #75 10.6*25.6*0.3= 81.408 0.3*0.3*2*(4.78*5*2+24.56)= 13.025	m3	94.433	197,231	28,406		18,625,115	2,682,464	
Brick masonry 6,5x10,5x22 wall 250 thick, Cement mortar # 75 25*1.4*0.25*2= 17.500 9.5*1.4*0.25*6= 19.950	m3	37.450	386,142	24,904	1,631	14,461,018	932,655	61,081
Screed, plastering 2cm thick, Cement mortar # 75 Plastering wall 20*1.4*2*2= 112.000 9.5*1.4*2*6= 159.600 Screed 25*10= 250.000	m2	521.600	7,176	1,874	136	3,743,002	977,478	70,938
Gravel 0.3*0.3*(4.78*4*2+24.56)= 5.652 9.5*24.5*0.4= 93.100	m3	98.752	112,000			11,060,224		
Steel pipe Dr. 150mm	100m	0.310	11,685,010	1,146,837	60,324	3,622,353	355,519	18,700
Butterfly vale Dr.150	Pcs	5.000	200,000	14,664		1,000,000	73,320	
Geotextile 9.5*24.5= 232.750	m2	232.750	10,000			2,327,500		
Access road foundation, crushing stone 4x6 568.27*0.25= 142.067	m3	142.067	102,480	6,976	2,275	14,559,026	991,059	323,202
Road pavement, crushing stone 2x4 568.27*0.2/100= 1.137	100m3	1.137	10,680,000	59,528	671,016	12,143,160	67,683	762,945
Sump pit 2m3/h								
Cement concrete# 100 for sum pit, Crushing stone 4x6 3.4*3.4*0.1= 1.156	m3	1.156	255,882	20,481	12,041	295,800	23,676	13,919
Cement concrete sum pit # 200, crushing stone1x2 3.4*3.4*0.2= 2.312	m3	2.312	381,067	24,126	9,146	881,027	55,779	21,146
Rebar for sum pit 2.312*200/1000= 0.462	Tone	0.462	4,041,572	147,377	99,351	1,867,206	68,088	45,900
Brick masonry 6,5x10,5x22, Brick wall cement mortar #50 3*4*2*0.22= 5.280	m3	5.280	365,064	24,904	1,631	1,927,538	131,493	8,612
Plastering Cement mortar #50 3*3= 9.000 3*4*2*2= 48.000	m2	57.000	5,666	1,874	136	322,962	106,818	7,752
Sludge tank 10m3								
Concrete #100, Crushing stone 4x6 4.4*3.4*0.1= 1.496	m3	1.496	255,882	20,481	12,041	382,799	30,640	18,013
Cement concrete #200, Crushing stone 1x2 4.4*3.4*0.2= 2.992 (4+3)*2*2*0.15= 4.200	m3	7.192	381,067	24,126	9,146	2,740,634	173,514	65,778
Form work (4+3)*2*2*2/100= 0.560	100m2	0.560	1,866,390	375,836		1,045,178	210,468	
Rebar 7.192*200/1000= 1.438	Tone	1.438	4,041,572	147,377	99,351	5,811,781	211,928	142,867
Plastering for sludge tank, Cement mortar #50 4*3= 12.000 (4+3)*2*2*2= 56.000	m2	68.000	5,666	1,874	136	385,288	127,432	9,248
						131,954,555	7,468,545	4,390,038

Construction cost estimation - settling tanks and pond

Task	Unit	Amount	Price unit			Sum		
			Material	Labor	Machinery	Material	Labor	Machinery
Land filling (using sand) (2035.37*1-124)/100= 19.114 Except sludge tank: -10*25*1/100= -2.500 -10*10*1*2/100= -2.000 -8*5*2.3*2/100= -1.840	100m3	12.774	2,720,600	19,456	220,756	34,752,944	248,531	2,819,937
Cement concrete #100, crushing stone 4x6 5.4*8.4*0.3*2= 27.216	m3	27.216	255,882	20,481	12,041	6,964,085	557,411	327,708
Cement concrete bottom #200, crushing stone 1x2 5.4*8.4*0.2*2= 18.144	m3	18.144	381,067	19,612	12,480	6,914,080	355,840	226,437
Cement concrete #200, crushing stone 1x2 (8*2+5*3)*2*0.2*2= 24.800	m3	24.800	450,926	46,177	15,888	11,182,965	1,145,190	394,022
Form work (8*2+5*3)*2*2/100*2= 2.480	100m2	2.480	1,866,390	375,836		4,628,647	932,073	
Rebar, diameter <=18mm (27.21+37.2)*200/1000*2= 6.441	Tone	6.441	4,041,572	147,377	99,351	26,031,765	949,255	639,920
Plastering 2cm thick, cement mortar #75 Wall (4+5)*2*2*2*2*2= 576.000 Bottom 4*5*2*2*2= 160.000	m2	736.000	7,176	1,874	136	5,281,536	1,379,264	100,096
Steel pipe Dr. 200	100m	0.200	11,685,010	1,146,837	60,324	2,337,002	229,367	12,065
Brick masonry 6,5x10,5x22, Trench, cement mortar #50 (0.5*2+2.44)*0.22*21.5= 16.271 2*0.72*0.22= 0.317	m3	16.588	354,885	21,662		5,886,832	359,329	
Trench plastering, cement mortar #75 (0.5*2+2)*21.5= 64.500 0.72*2*21.5= 30.960 0.5*2*2= 2.000	m2	97.460	5,113	1,808	136	498,313	176,208	13,255
Access road foundation, crushing stone 4x6 615.35*0.25= 153.838	m3	153.838	102,480	6,976	2,275	15,765,318	1,073,174	349,981
Road pavement, crushing stone 2x4 615.35*0.2/100= 1.231	100m3	1.231	10,680,000	59,528	671,016	13,147,080	73,279	826,021
						133,390,567	7,478,921	5,709,442

6.3.3 Operation and Maintenance Cost

Constructed Wetlands

			Unit cost		Sum		Sum US$
Item	Unit	Quantity	Labor	Machinery	Labor	Machinery	
Loading							
Cleaning of storage tank and screen, operating pump.	work day	50	20,000		1,000,000		67
Pumping 10m3/d of raw septage, pumping of 10m3/d of percolate	year	1		7,500,000		7,500,000	500
Sludge Removal							
Manual removal of biosolids, transport 500 m to storage/packing lot or to landfill	t	75	60,000		4,500,000		300
Maintainance							
Plant care (regulation of humidity etc)	work day	50	20,000		1,000,000		67
Harvest	100 m2	4	50,000		200,000		13
Pump maintainance	year	1		100,000		100,000	7
Sum					6,700,000	7,600,000	953
Management cost (labor*0.67)					4,489,000		299
Total expenses before tax					18,789,000		1,253
Income Tax (5.5%)					1,033,395		69
Total expenses+ Income tax (5.5%)					19,822,395		1,321
Value added tax (5%)					991,120		66
Total expenses after tax					**20,813,515**		**1,388**

Commercialisation of biosolids

Administration and marketing	work day	100	30,000		3,000,000		200
Packing	work day	25	20,000		500,000		33
Transport to agent	m3. 10 km	112		35,000		3,920,000	261
Sum					**3,500,000**	**3,920,000**	**495**
Revenue from biosoilds commercialisation	t	75	300,000		22,500,000		**1,500**

Drying beds

			Unit cost		Sum		Sum US$
Item	Unit	Quantity	Labor	Machinery/Material	Labor	Machinery	
Loading							
Cleaning of storage tank and screen, operating pump.	work day	50	20,000		1,000,000		67
Pumping 10m3/d of raw septage, pumping of 10m3/d of percolate	year	1		7,500,000		7,500,000	500
Sludge Removal							
Manual removal of biosolids, transport 500 m to storage/packing lot or to landfill	t	100	60,000		6,000,000		400
Maintainance							
Replenishment of sand	m3	50	20,000		1,000,000		67
Sand (twice a year, 10 cm)	m3	50		25,000		1,250,000	83
Pump maintainance	year	1		100,000		100,000	7
Post treatment (storage)							
Handling of biosolids	t	100	30,000		3,000,000		200
Sum					11,000,000	8,850,000	1,323
Management cost (labor*0.67)					7,370,000		491
Total expenses before tax					27,220,000		1,815
Income Tax (5.5%)					1,497,100		100
Total expenses+ Income tax (5.5%)					28,717,100		1,914
Value added tax (5%)					1,435,855		96
Total expenses after tax					**30,152,955**		**2,010**

Commercialisation of biosolids

Administration and marketing	work day	100	30,000		3,000,000		200
Packing	work day	25	20,000		500,000		33
Transport to agent	m3. 10 km	150		35,000		5,250,000	350
Sum					**3,500,000**	**5,250,000**	**583**
Revenue from biosoilds commercialisation	t	100	300,000		30,000,000		2,000

Settling tanks and pond

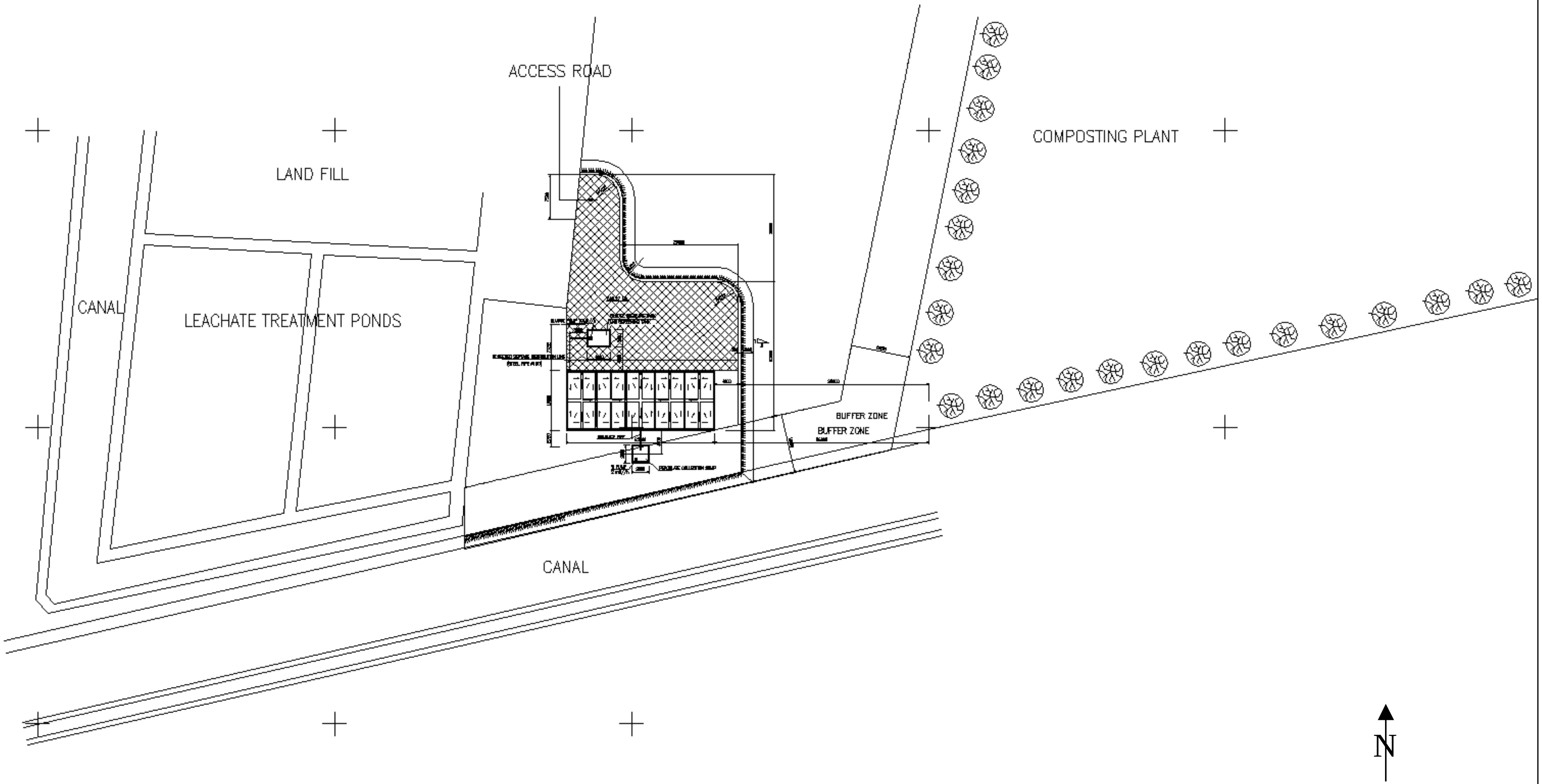
Item	Unit	Quantity	Unit cost Labor	Unit cost Machinery/ Material	Sum Labor	Sum Machinery	Sum US$
Sludge Removal							
Evacuation of liquid with vacuum tanker (20 m3, 12 times a year)	h	36		100,000	0	3,600,000	240
Mixing sludge with rice husks (12*2 + 1* 10)	work day	34	20,000		680,000	0	45
Manual removal of biosolids, transport 500 m to storage/packing lot or to landfill	t	450	60,000		27,000,000	0	1,800
Procurment of rice husks					0	0	0
Administration	work day	25	20,000		500,000	0	33
Transport	m3 10 km	300		35,000	0	10,500,000	700
Post treatment (storage)					0	0	0
Handling of biosolids	t	450	30,000		13500,000	0	900
Sum					41,680,000	14,100,000	3,719
Management cost (labor*0.67)					27,925,600		1,862
Total expenses before tax					83,705,600		5,580
Income Tax (5.5%)					4,603,808		307
Total expenses+ Income tax (5.5%)					88,309,408		5,887
Value added tax (5%)					4,415,470		294
Total expenses after tax					**92,724,878**		**6,182**

Commercialisation of biosolids

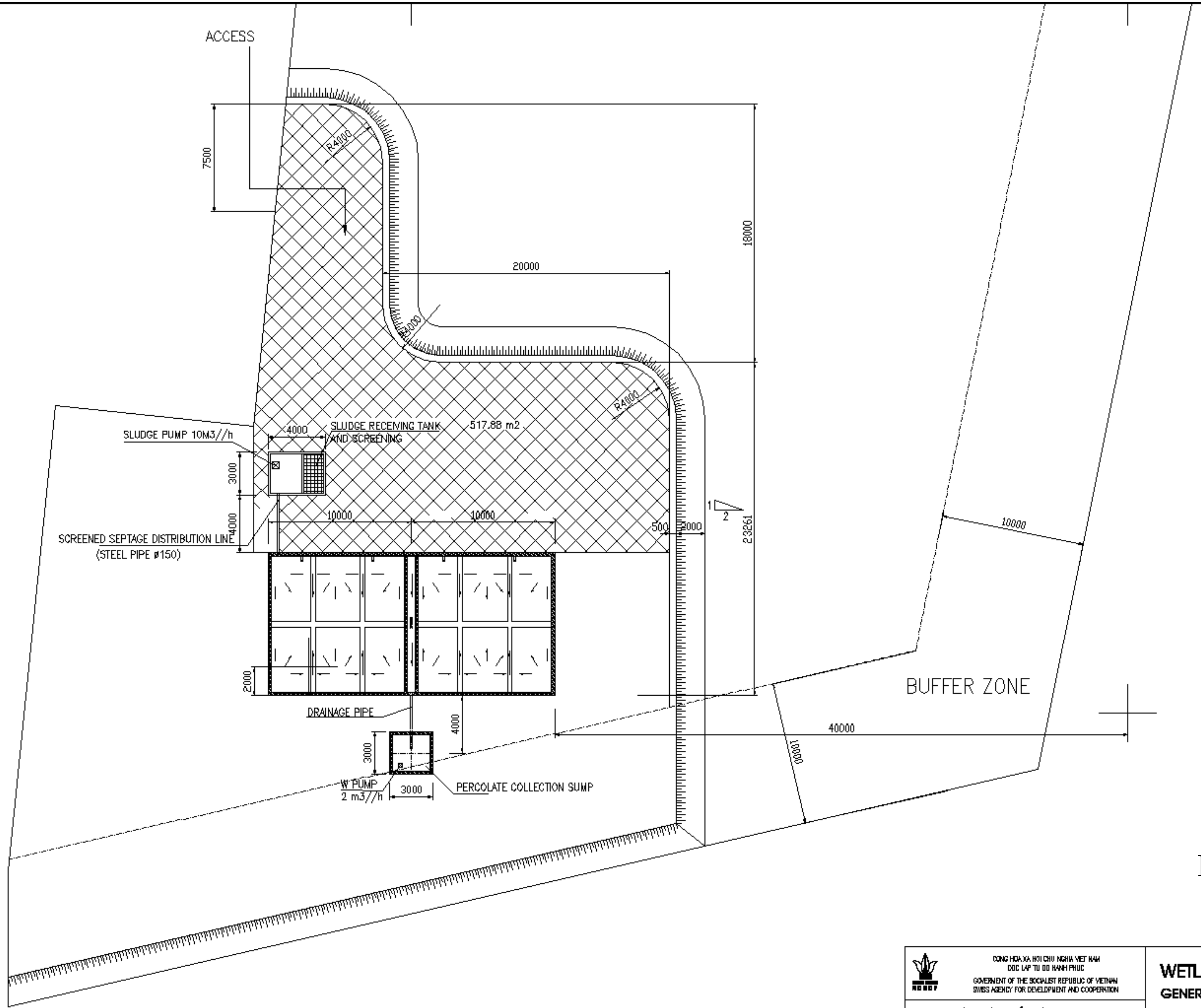
Administration and marketing	work day	100	30,000		3,000,000	0	200
Packing	work day	30	20,000		600,000	0	40
Transport to agent	m3. 10 km	675		35,000	0	23,625,000	1,575
Sum					**3,600,000**	**23,625,000**	**1,815**
Revenue from biosoilds commercialisation	t	300	300,000		90,000,000		6,000

6.3.4 Drawings

1. Situation plan 1:1000
2. Constructed wetlands - General plan 1: 400
3. Constructed wetlands - Plan 1:100
4. Constructed wetlands - Section 1:75
5. Constructed wetlands phase II development - General plan 1:400
6. Sludge receiving tanks and sum pit for constructed wetlands and drying beds - Plan and section 1:75
7. Drying beds - General plan 1:400
8. Drying beds - Plan 1:100
9. Drying beds - Section 1:75
10. Settling tank - General plan 1:400
11. Settling tank - Plan 1:100
12. Settling tank - Section 1:50



CONG HOA XA HOI CHU NGHIA VIET NAM DOC LAP TU DO HANH PHUC GOVERNMENT OF THE SOCIALIST REPUBLIC OF VIETNAM SWISS AGENCY FOR DEVELOPMENT AND COOPERATION	**DRYING BED** **GENERAL PLAN**
DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH NAM DINH URBAN DEVELOPMENT PROJECT	**DRAWING NO: FST-DRB4-4/ 3**
SCALE : (1/1000)	**REVISED** : 1 **DATE** : 19/ 10/ 2001



CONG HOA XA HOI CHU NGHIA VIET NAM
DOC LAP TU DO HANH PHUC
GOVERNMENT OF THE SOCIALIST REPUBLIC OF VIETNAM
SWISS AGENCY FOR DEVELOPMENT AND COOPERATION

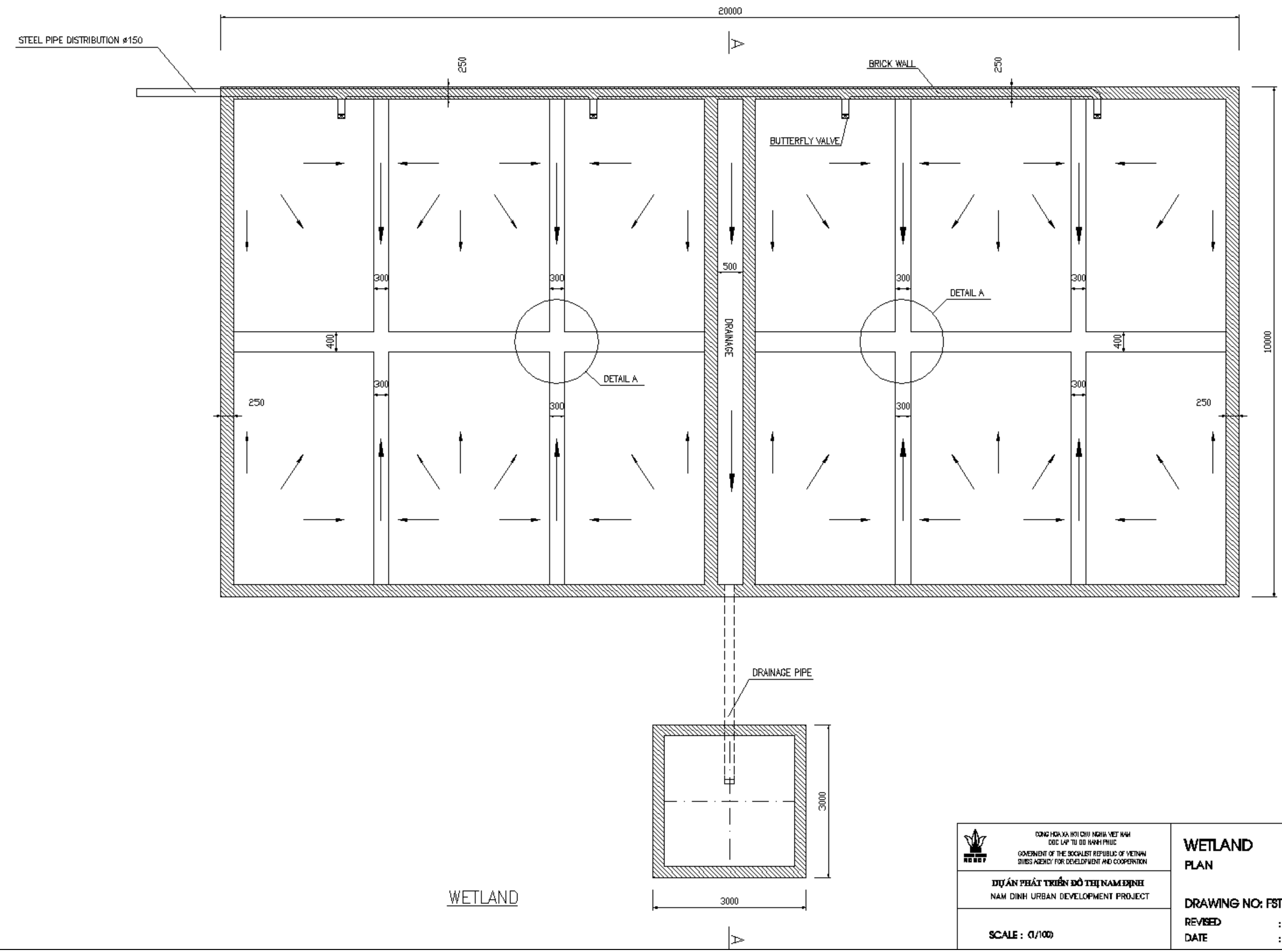
DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH
NAM DINH URBAN DEVELOPMENT PROJECT

SCALE : (1/400)

WETLAND
GENERAL PLAN

DRAWING NO: FST-WT3-5/ 3

REVISED	: 1
DATE	: 19/ 10/ 2001



WETLAND

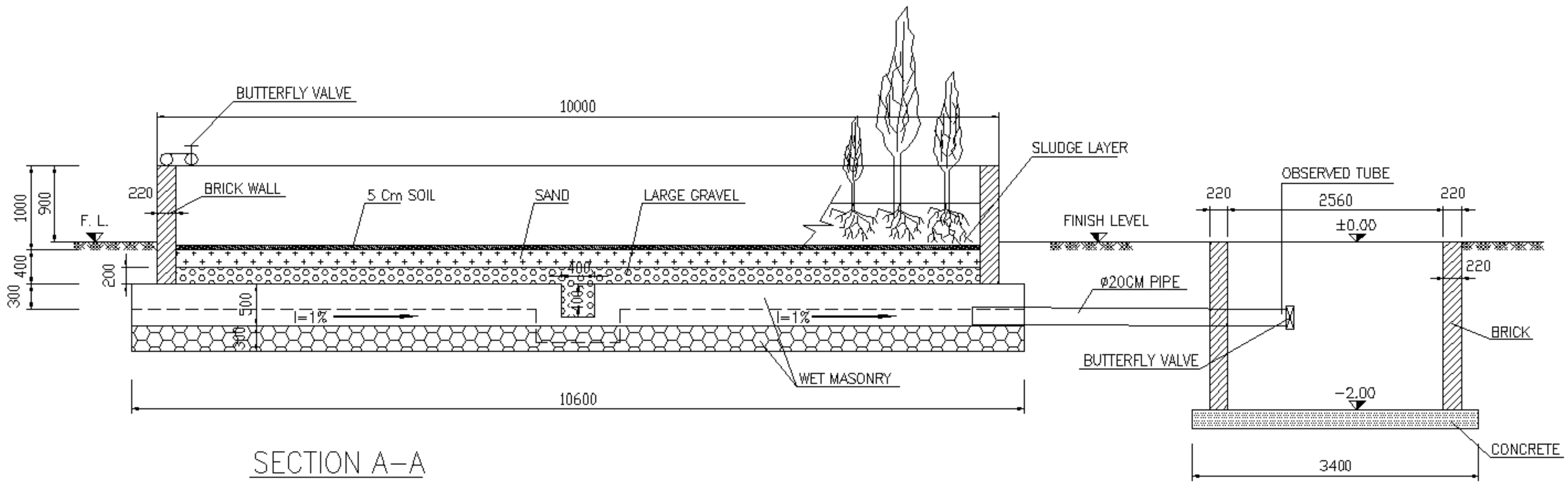
CONG HOA XA HOI CHU NGHIA VIET NAM
DOC LAP TU DO HANH PHUC
GOVERNMENT OF THE SOCIALIST REPUBLIC OF VIETNAM
SWISS AGENCY FOR DEVELOPMENT AND COOPERATION

DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH
NAM DINH URBAN DEVELOPMENT PROJECT

SCALE : (1/100)

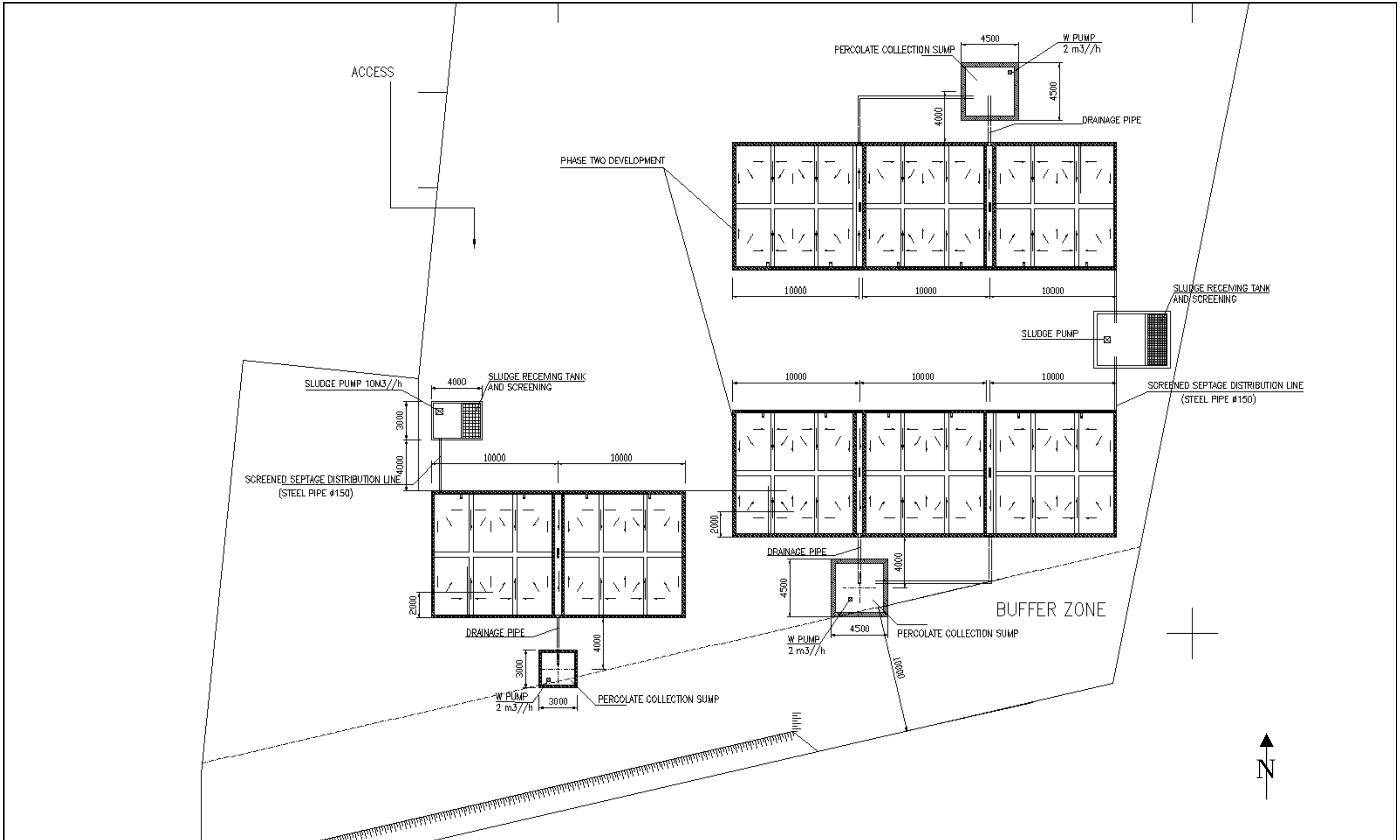
WETLAND
PLAN

DRAWING NO: FST-WT1-5/ 3
REVISED :
DATE : 30/ 09/ 2001



SECTION A–A

CONG HOA XA HOI CHU NGHIA VIET NAM DOC LAP TU DO HANH PHUC GOVERMENT OF THE SOCIALIST REPUBLIC OF VIETNAM SWISS AGENCY FOR DEVELOPMENT AND COOPERATION	**WETLAND** **SECTION**
DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH NAM DINH URBAN DEVELOPMENT PROJECT	**DRAWING NO: FST-WT2-5/ 3**
SCALE : (1/76)	**REVISED** : 1 **DATE** : 19/ 10/ 2001



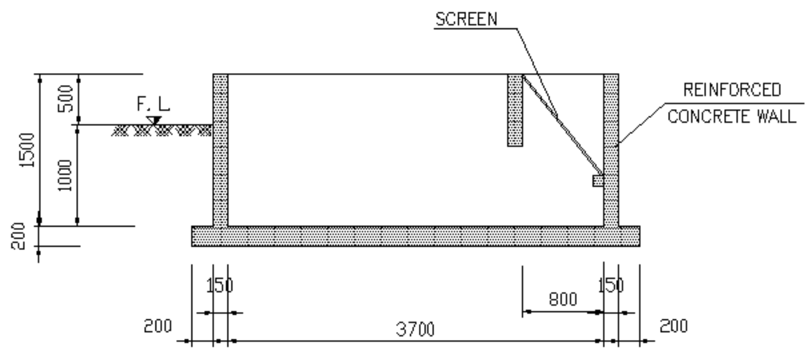
CONG HOA XA HOI CHU NGHIA VIET NAM
DOC LAP TU DO HANH PHUC
GOVERNMENT OF THE SOCIALIST REPUBLIC OF VIETNAM
SWISS AGENCY FOR DEVELOPMENT AND COOPERATION

DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH
NAM DINH URBAN DEVELOPMENT PROJECT

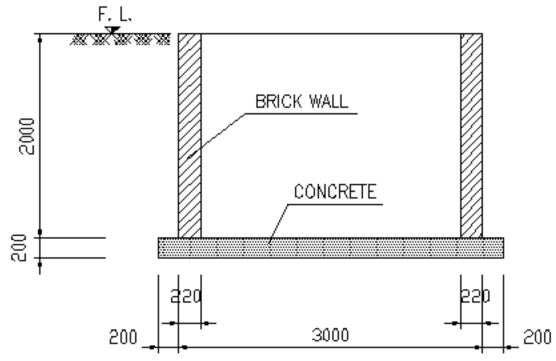
SCALE : (1/400)

WETLAND
DEVELPMENT OPTION PLAN

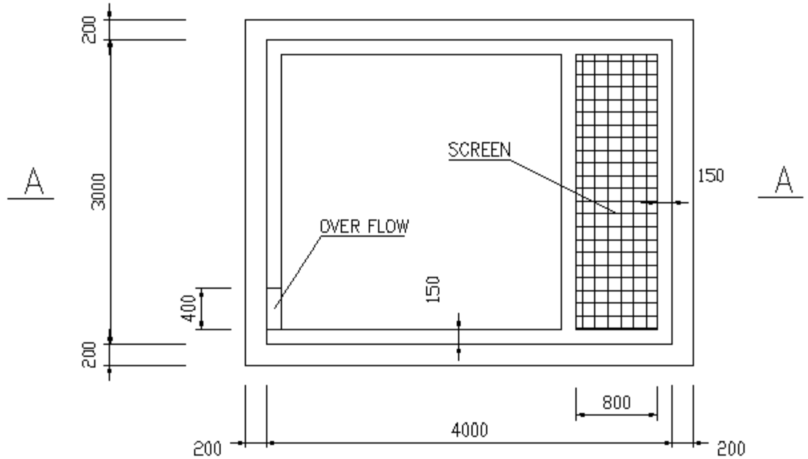
DRAWING NO: FST-WT5-5/ 3
REVISED : 1
DATE : 19/ 10/ 2001



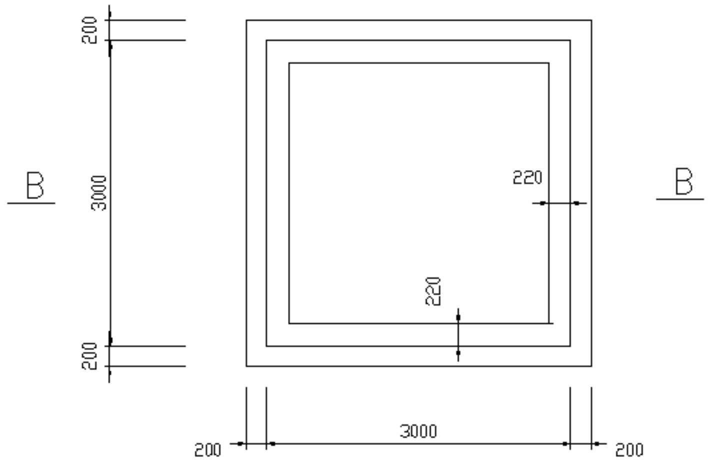
SECTION A–A



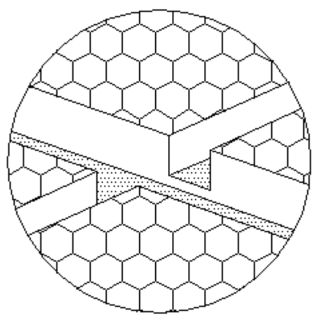
SECTION B–B

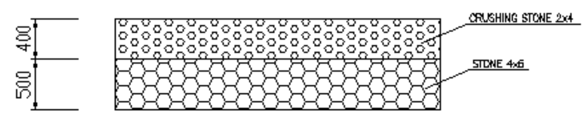


SLUDGE RECEIVING TANK AND SCREENING



PERCOLATE COLLECTION SUMP





PAVEMENT ROAD

DETAIL A

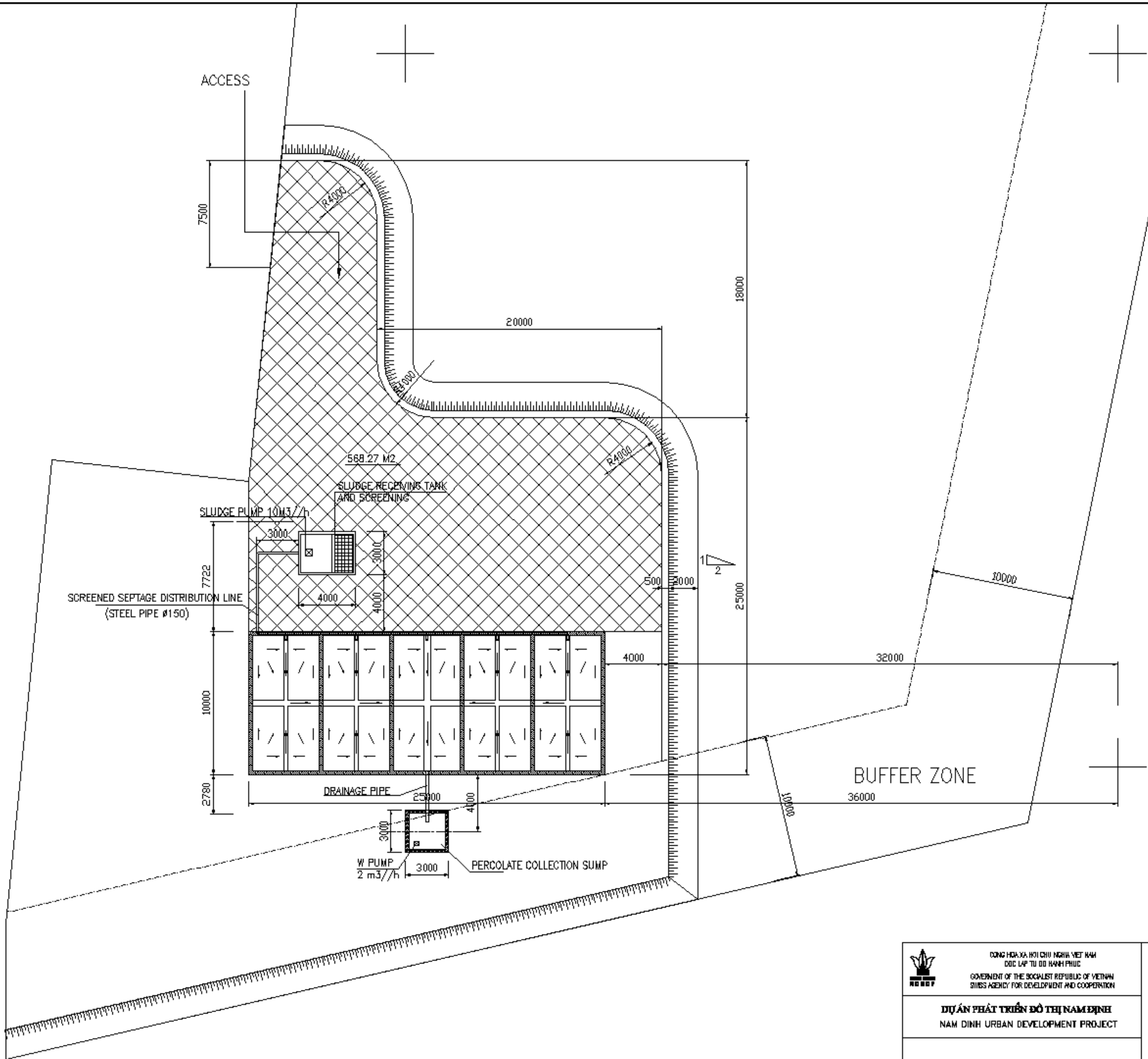
CONG HOA XA HOI CHU NGHIA VIET NAM
DOC LAP TU DO HANH PHUC
GOVERMENT OF THE SOCIALIST REPUBLIC OF VIETNAM
SWISS AGENCY FOR DEVELOPMENT AND COOPERATION

DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH
NAM DINH URBAN DEVELOPMENT PROJECT

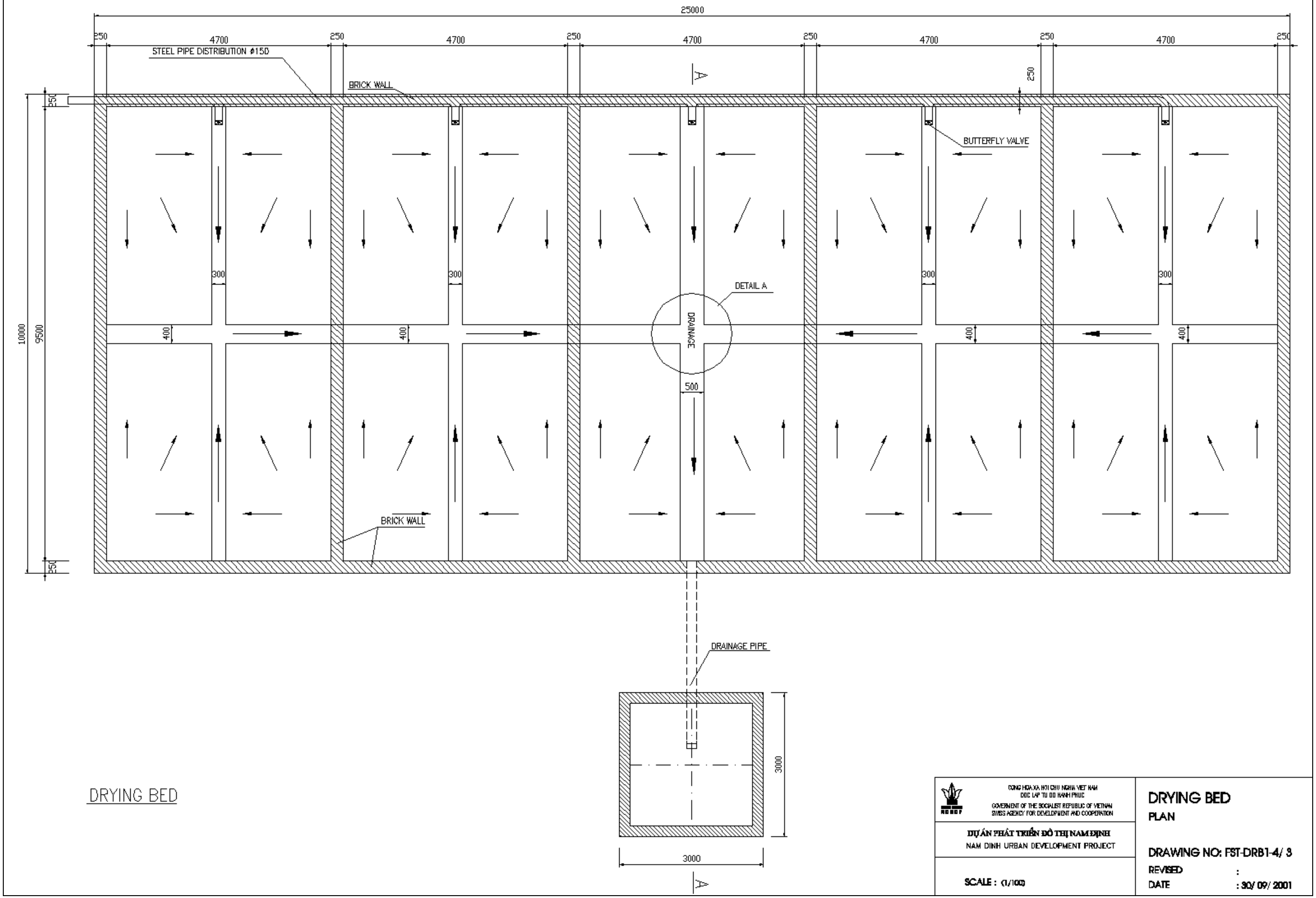
SCALE : (1/76)

SLUDGE TANK & SUM PIT
FOR WETLAND AND DRYING BED

SECTION AND PAVEMENT
DRAWING NO: FST-CM1-2/ 3
REVISED : 1
DATE : 19/ 10/ 2001



CONG HOA XA HOI CHU NGHIA VIET NAM DOC LAP TU DO HANH PHUC GOVERNMENT OF THE SOCIALIST REPUBLIC OF VIETNAM SWISS AGENCY FOR DEVELOPMENT AND COOPERATION	**DRYING BED** **GENERAL PLAN**
DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH NAM DINH URBAN DEVELOPMENT PROJECT	**DRAWING NO: FST-DRB3-4/ 3**
SCALE : (1/400)	**REVISED** : 1 **DATE** : 19/ 10/ 2001



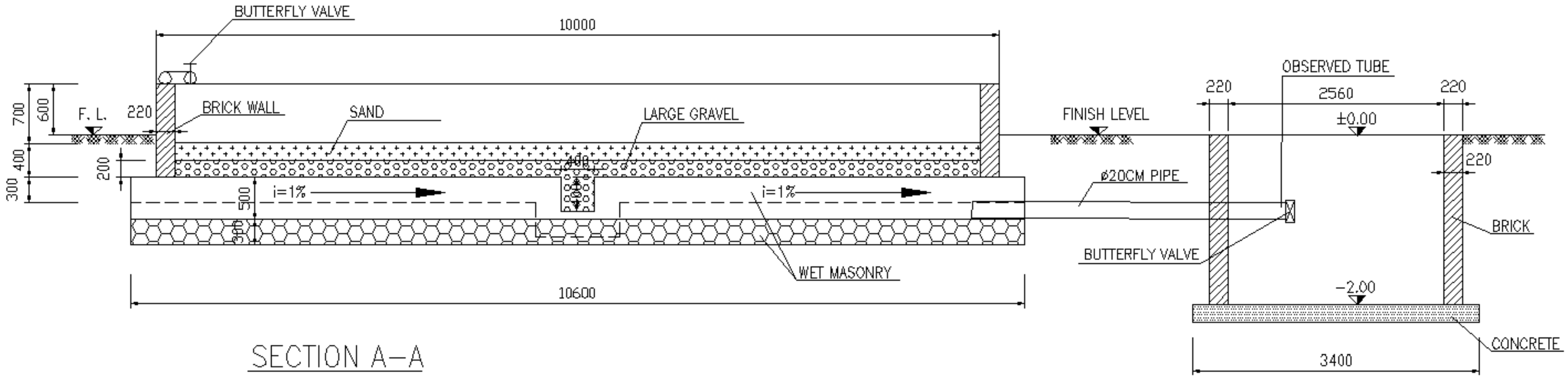
CONG HOA XA HOI CHU NGHIA VIET NAM
DOC LAP TU DO HANH PHUC
GOVERNMENT OF THE SOCIALIST REPUBLIC OF VIETNAM
SWISS AGENCY FOR DEVELOPMENT AND COOPERATION

DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH
NAM DINH URBAN DEVELOPMENT PROJECT

SCALE : (1/100)

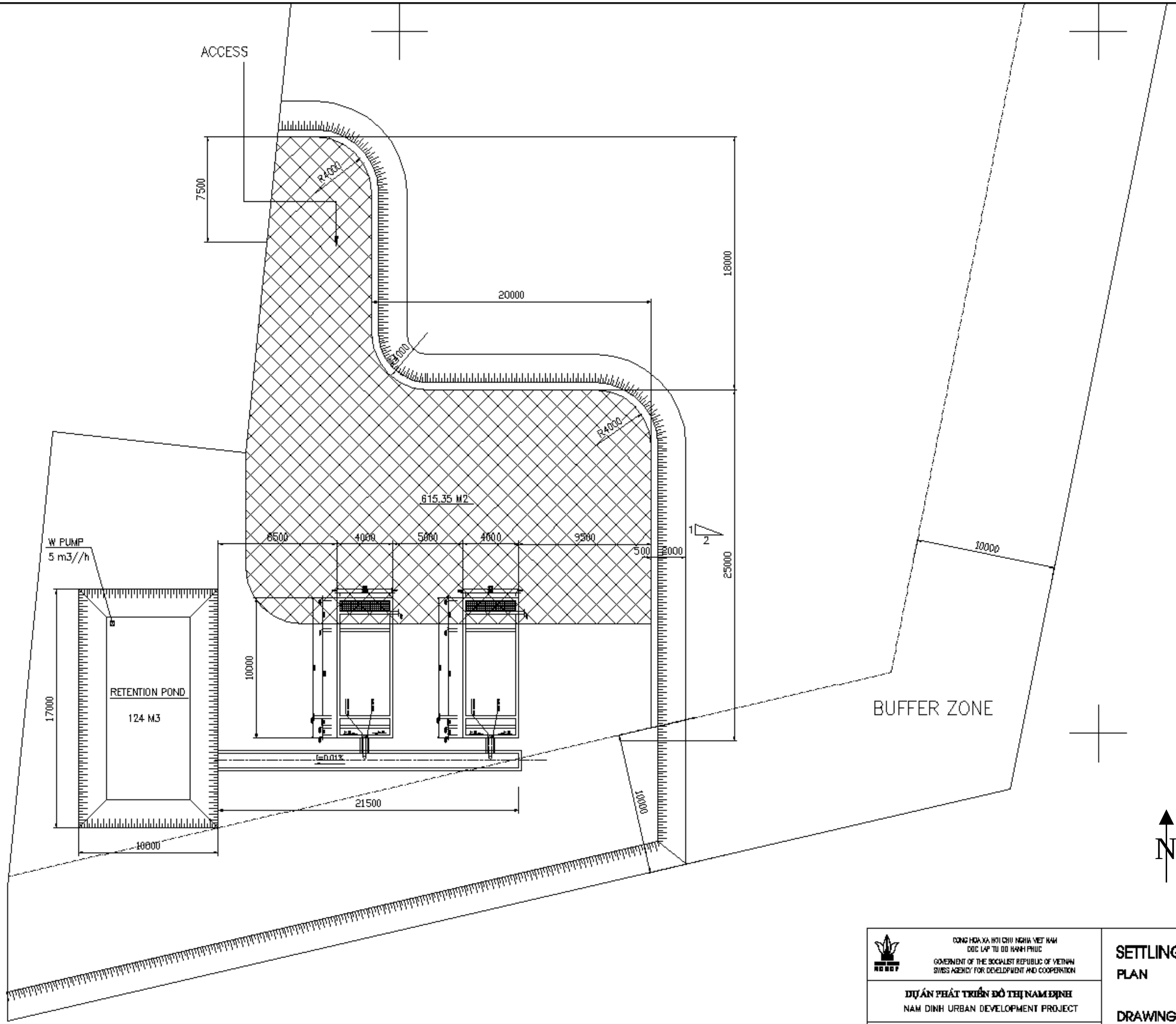
DRYING BED
PLAN

DRAWING NO: FST-DRB1-4/ 3
REVISED :
DATE : 30/ 09/ 2001



SECTION A–A

CONG HOA XA HOI CHU NGHIA VIET NAM DOC LAP TU DO HANH PHUC GOVERMENT OF THE SOCIALIST REPUBLIC OF VIETNAM SWISS AGENCY FOR DEVELOPMENT AND COOPERATION	**DRYING BED** **SECTION**
DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH NAM DINH URBAN DEVELOPMENT PROJECT	**DRAWING NO: FST-DRB2-4/ 3**
SCALE : (1/70)	**REVISED** : 1 **DATE** : 19/ 10/ 2001



CONG HOA XA HOI CHU NGHIA VIET NAM
DOC LAP TU DO HANH PHUC
GOVERNMENT OF THE SOCIALIST REPUBLIC OF VIETNAM
SWISS AGENCY FOR DEVELOPMENT AND COOPERATION

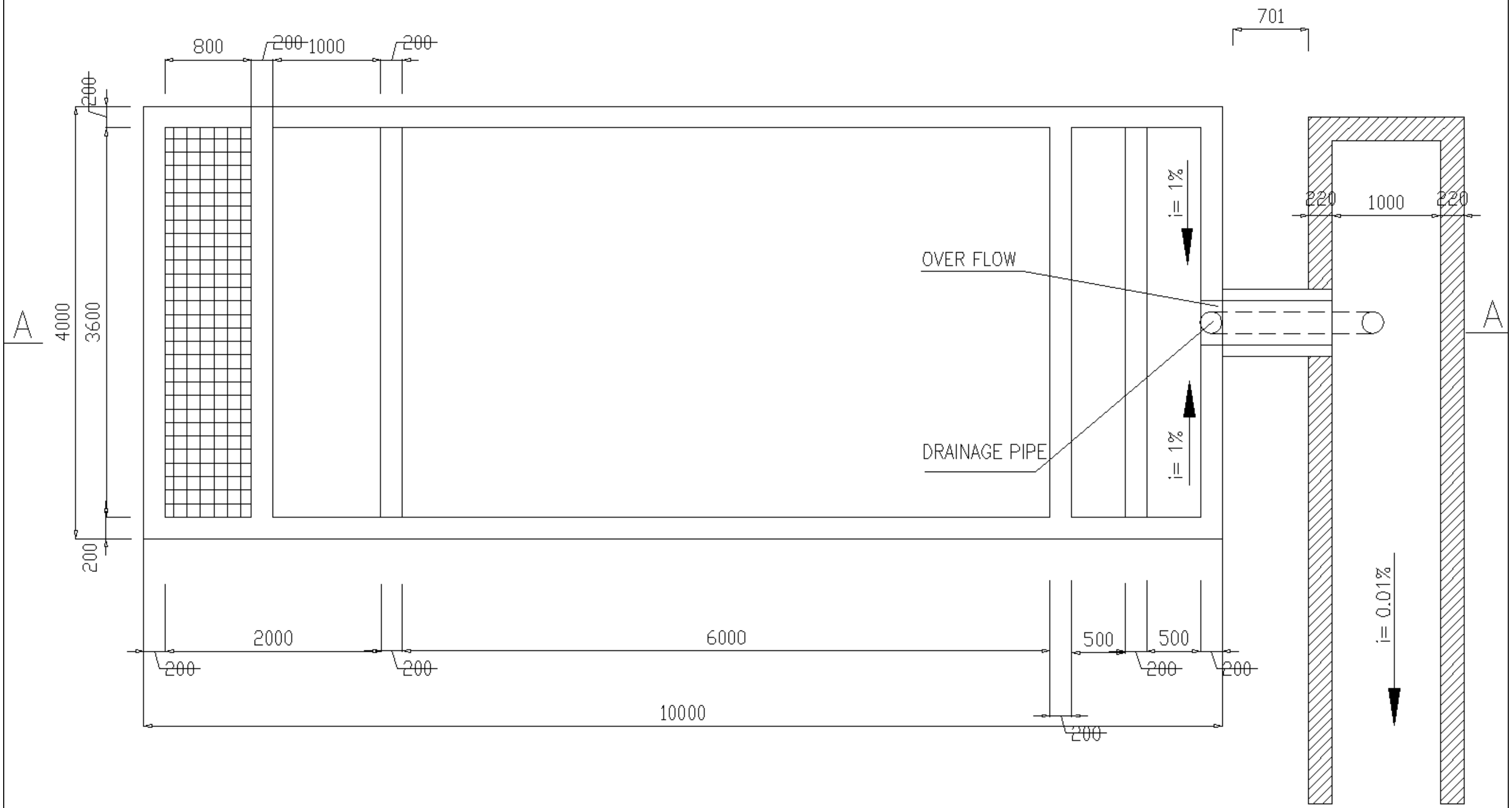
DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH
NAM DINH URBAN DEVELOPMENT PROJECT

SCALE : (1/400)

SETTLING TANK
PLAN

DRAWING NO: FST-ST3-4/ 3

REVISED : 1
DATE : 19/ 10/ 2001



SETTLING TANK

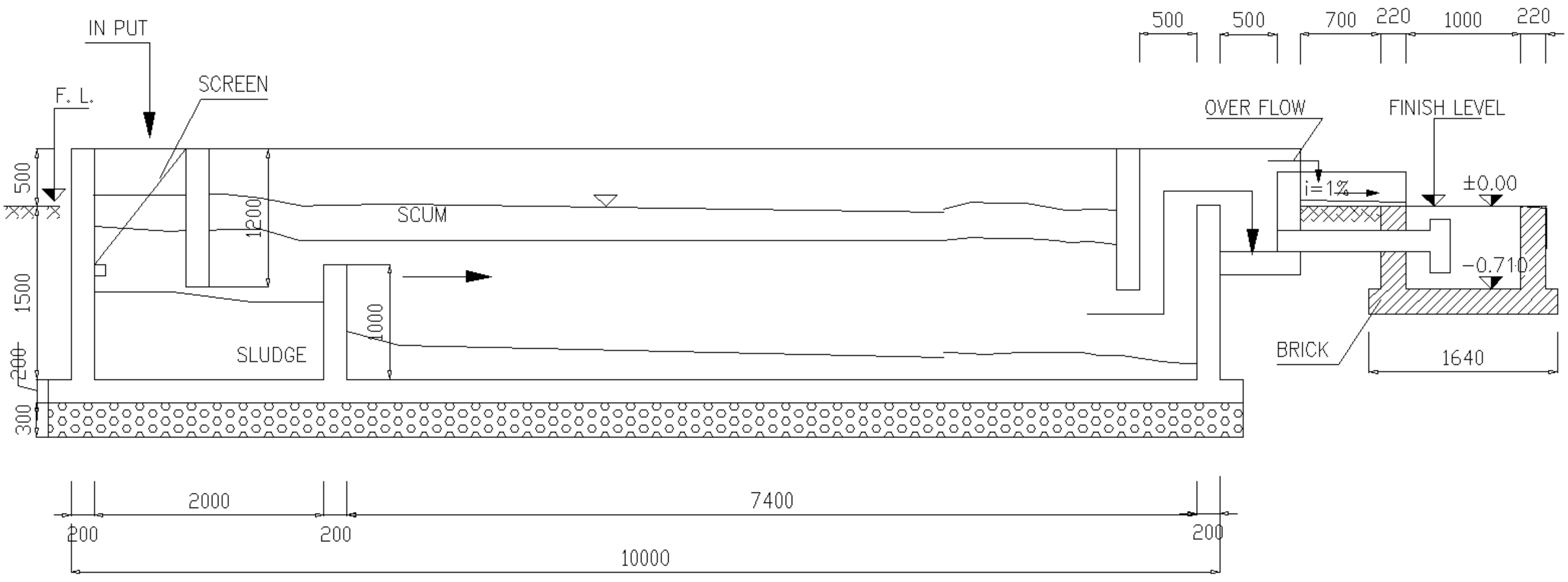
CONG HOA XA HOI CHU NGHIA VIET NAM
DOC LAP TU DO HANH PHUC
GOVERNMENT OF THE SOCIALIST REPUBLIC OF VIETNAM
SWISS AGENCY FOR DEVELOPMENT AND COOPERATION

DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH
NAM DINH URBAN DEVELOPMENT PROJECT

SCALE : (1/50)

SETTLINGTANK
PLAN

DRAWING NO: FST-ST1-5/ 3
REVISED : 1
DATE : 19/ 10/ 2001



SECTION A-A

CONG HOA XA HOI CHU NGHIA VIET NAM
DOC LAP TU DO HANH PHUC
GOVERNMENT OF THE SOCIALIST REPUBLIC OF VIETNAM
SWISS AGENCY FOR DEVELOPMENT AND COOPERATION

DỰ ÁN PHÁT TRIỂN ĐÔ THỊ NAM ĐỊNH
NAM DINH URBAN DEVELOPMENT PROJECT

SCALE : (1/50)

SETTLINGTANK
SECTION

DRAWING NO: FST-ST2-5/ 3
REVISED : 01
DATE : 09/ 10/ 2001