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Guide for Wastewater Management in Rural Villages in China

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Guide for Wastewater Management in Rural Villages in China

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Background

China has a rural population of about 727 million (2007 data) which comprises 55% of its total population. The Chinese rural population is scattered over 20,000 townships and 18,000 'xiang' (township-level village clusters) which, in turn, consist of 720,000 administrative villages or 3.2 million natural villages.

Despite the economic development that China has achieved in its rural areas since its economic reforms, the Chinese countryside is lagging far behind its urban counterpart. Basic infrastructure is significantly underdeveloped, with particularly poor sanitation conditions. Many villages have limited or inadequate sanitary facilities to protect public health and the environment. In most villages there is no modern sanitary facilities including dry or water based sanitary facilities. Zhoa (2009) estimated that only 3% of rural villages effectively treat their wastewater (grey or black water). Most villages, which have wastewater collection and treatment systems, have low levels of connections, and rarely succeed in the sustainable operation and maintenance once the facilities are transferred to the villages.

The World Bank (the Bank) had focused on urban environmental projects in China over the last two to three decades. In accordance with the central government's development goals and regional sector development strategy, and the World Bank Country Partnership Strategy, the Bank has financed, and continues to finance projects in small towns and villages, particularly, to improve rural water supply and wastewater management. Rural wastewater management is fundamentally different from urban sewerage system management in terms of policies, regulations, standards, financing, designs, operation and maintenance (O&M), and beneficiary community involvement and participation.

Many improperly planned, designed and executed projects, with low community participation or support and a lack of O&M, or inappropriate technologies, have led to a disproportionate level of failed rural wastewater projects in China. Only around 10% of projects constructed in the past are adequately maintained.

There is an urgent need to provide practical guidelines for Chinese decision makers and officials to better understand the key issues and constraints related to rural wastewater management and to identify feasible solutions and tools to improve the performance and sustainability of these projects.

To address these needs, the World Bank has developed this *Guide for Wastewater Management in Rural villages in China*. The *Guide* is intended to be a useful resource for Chinese policy makers and practitioners. It includes a review of historical and current policies and practices related to wastewater management in rural China. The *Guide* outlines a framework and strategies for establishing municipal and village level wastewater management programs. The *Guide* is intended to assist local jurisdictions improve planning of rural

wastewater management, practitioners to develop appropriate solutions for rural situations [public services] in rural areas and in line with the Peoples Republic of China's (PRC's) New Socialist Countryside Initiative.

Rationale for Rural Wastewater Management

Limited water resources and ensuring access to clean water confront rural China with critical environmental challenges. Over the past several decades, the Chinese government has made significant strides to improve water supply in rural areas; however, over 300 million rural Chinese residents still do not have access to safe drinking water and proper sanitation (UNDP, 2007). Rural water issues range from problems of shortage or scarcity to severe contamination and related public health problems. Four major water related issues in the rural areas include: (i) regional and temporal shortage of water resources, (ii) contaminated water resources and increased threat of diseases related to water sanitation and hygiene, (iii) inefficient water resources management, and (iv) lack of appropriate and sustainable waste management technologies.

Environmental degradation and pollution exacerbate poverty in China's countryside, while also threatening the health of vulnerable rural populations, particularly children. Diarrhea is still a leading cause of child death in rural areas. The OECD (2007) estimates that in rural areas, over 30,000 children die each year from diarrhea associated with polluted water. In rural China, less than 30 percent of the population has access to adequate sanitation, compared to 70 percent of the population in the urban areas. In rural areas, sewage is commonly dumped into the fields or small streams creating public health threats to the local residents.

Implementing sustainable and appropriate sanitation and wastewater management practices in rural China is a priority to address the environmental and public health issues in rural areas. Adopting simple, low-cost decentralized and small centralized wastewater management schemes is fundamental to effectively manage and in some instances reuse wastewater for the benefit of rural populations.

China is a large and physically and culturally diverse country. Adopting sustainable, long-term sanitation and wastewater management programs will not occur at the national level, but will depend on the ability of many municipal, county and village governments to formulate cohesive and realistic wastewater management programs. The key role of the municipal and county governments is to provide technical and financial assistance and regulatory oversight to rural villages. In turn rural villages should be made responsible for implementing and maintaining effective wastewater management projects to protect the environment and public health. Ultimately, improved sanitation in rural villages will provide economic benefits to the communities in the form of improved health, better living and working conditions, and overall improvement to the welfare and economy of the village.

Overview of Rural Wastewater Management

A comprehensive rural wastewater management program (WMP) is a multi-tiered approach including institutional, educational, technical, and financial commitments at all sectors of village, county, municipal, provincial and central governments. The institutional aspects of a program require the establishment of clear policies, regulations, and governance to facilitate the planning, implementation, operation, supervision and evaluation of projects. Continued education and training at the municipal, county, and village levels are important to building institutional and technical capacity. Appropriate sanitation technology should be selected that is low cost and can be easily and reliably operated and maintained by rural villages. Project financing will likely use different sources of funds, including public funds, non-governmental loans, public subsidies to assist low-income villagers, and cost sharing opportunities for both monetary and non-monetary expenses. Issues of importance in considering wastewater management systems can be divided into technical issues, institutional issues and financial issues:

Technical Issues:

- **Decentralized versus Centralized Approaches.** Any wastewater management program in rural China needs to consider the costs and benefits of decentralized and centralized solutions. In a low-density setting, a decentralized system may be more suitable, while in high-density settings, a centralized system will be the most effective.

- **Changes in Level of Water Supply.** Increases in water supply create a corresponding need for to manage greater volumes of wastewater

- **Physical factors**. The climate, geography, hydrogeology, soil type, and other environmental factors can affect the sanitation solutions that might be the most feasible and cost effective in a given location.

- **Technological Factors.** Complex technologies can be difficult as well as costly for villages to operate and maintain, or to obtain spare parts and consumable materials, such as filters or chemicals.

Financial Issues:

- **Organization and Finance.** Investment and operation and maintenance costs must be kept low. Great care must be taken to ensure that generated income can match expenses throughout the lifetime of the system. Thus, low-cost technologies may often represent more sustainable options. Promising innovative solutions include simple, less mechanized biological wastewater treatment options, such as simple fixed film trickling filters or constructed wetlands, which may integrate well with local agriculture. Some of these solutions can provide benefits to the community.

- **Balancing Private Investment and Subsidies.** In China, rural households have often been expected to finance their own sanitation improvements. As a result, citizens' individual responsibility is well-developed and development efforts match needs closely. On the other hand, this has meant that many poorer families have not been able to afford approved sanitation devices. Thus, recently more funding has become available, but directing this funding adequately remains a great challenge.

Institutional Issues:

- **Policies, Standards, Regulations and Guidelines.** Policies, regulations and guidelines need to be clear. Particular importance needs to be given to clearly outline the responsibilities of different parties to minimize potential for conflict.

- **Participatory Approach in Community Development.** Recent wastewater management programs in China, including the World Bank's Ningbo Wastewater Management Program have included significant a participatory component. Thus, local communities get an important voice in their own development. This ensures high levels of participation and close matching of the community's needs, and empowers the local communities.

- **Project Monitoring, Tracking and Evaluation.** A major cause of previous failures has been a lack of oversight and inadequate operation and maintenance of facilities. A project tracking system implemented by the municipal and county wastewater management offices should be an essential part of the WMP.

- **Long-term Planning for Future Needs.** The planning period established for many infrastructure projects is commonly based on a 20 to 30 year life cycle. A longer lifetime trajectory (30 to 50 years) is suggested to anticipate future changes.

- **Training and Capacity Building.** For the long-term success of wastewater management programs, it is essential that the required skills are available locally to ensure effective maintenance, operation and supervision. Sufficient funds need to be allocated to training to ensure establishment of the necessary skills. Institutional training and capacity building are also key to support villages and supply a skilled work force.

- **Lessons Learned.** Future projects need to take into account what lessons can be learned from past experience.

Purpose and Objectives of the Guide

The purpose of the Guide is to provide a comprehensive resource for local municipal, county, and village level jurisdictions (hereafter collectively referred to as local jurisdictions) so that they may develop successful and sustainable wastewater management programs (WMPs). The

Guide is designed to improve local public services and governance reflected in the Peoples Republic of China's New Socialist Countryside initiative.

The overall objective of the Guide is to identify key issues and to present effective strategies and approaches to implement sustainable wastewater management programs at the local jurisdictions in order to improve rural sanitation in China. A key objective of the guide is to present institutional, programmatic and technical guidelines that can be adopted by local jurisdictions, forming the basis for consistent, affordable, practical, and effective sanitation project planning, design, implementation, and operations.

CHAPTER 1 - INTRODUCTION

1.1. Background

China has a rural population of about 727 million (2007 data) which comprises 55% of its total population. The Chinese rural population is scattered over 20,000 townships and 18,000 'xiang' (township-level village clusters) which, in turn, consist of 720,000 administrative villages or 3.2 million natural villages.

Despite the economic development that China has achieved in its rural areas since its economic reform, the Chinese countryside is lagging far behind its urban counterpart. Basic infrastructure is significantly underdeveloped, with particularly poor sanitation conditions. According to the WHO/UNICEF in 2008 access to improved sanitation in urban areas was estimated to be 58% and 52% in rural areas of China. Many villages have no sewage collection, treatment, or disposal facilities. Zhoa (2009) estimated that only 3% of rural villages effectively treat their gray and black water. Most villages, which have built wastewater collection and treatment systems, have low levels of connections, and rarely succeed in the sustainable operation and maintenance once the facilities are transferred to the villages.

The World Bank has focused on Chinese urban environmental projects over the last decade. Recently, in accordance with the Bank Country Partnership Strategy and regional sector strategy, and the Chinese government's development goals, the Bank has been and continues to finance projects in China aimed at improving rural water supply and wastewater management. Rural wastewater management is fundamentally different from urban sewerage system management in terms of policies, regulations, standards, financing, designs, operation and maintenance (O&M), and community participation.

Many improperly planned, designed and executed projects, with low community participation or support and a lack of O&M, or which use inappropriate technologies, have led to a disproportionate level of failed rural wastewater projects in China. Only around 10% of projects constructed in the past are adequately maintained.

There is an urgent need to provide practical guidelines for Chinese decision makers and officials to better understand the key issues and constraints related to rural wastewater management and to identify feasible solutions and tools to improve the success and performance of these projects.

To address these needs, the World Bank has developed this *Guide for Rural Wastewater Management in China*. The *Guide* is intended to be a useful resource for Chinese policy makers and practitioners. It includes a review of historical and current policies and practices related to wastewater management in rural China. The *Guide* outlines a framework and strategies for establishing municipal and village level wastewater management programs. The *Guide* is intended to assist local jurisdictions improve public services in rural areas and is in line with the Peoples Republic of China's (PRC's) New Socialist Countryside Initiative.

1.2. Rationale for Rural Wastewater Management

Limited water resources and ensuring access to clean water confront rural China with critical environmental challenges. Over the past several decades, the Chinese government has made significant strides to improve water supply in rural areas; however, over 300 million rural Chinese residents still do not have access to safe drinking water and proper sanitation (UNDP, 2007). Rural water issues range from problems of shortage or scarcity to severe contamination and related public health problems. Four major water related issues in the rural areas include: (i) regional and temporal shortage of water resources, (ii) contaminated water resources and increased threat of diseases related to inadequate water supply, sanitation and hygiene, (iii) inefficient water resources management, and (iv) lack of appropriate and sustainable waste management technologies.

Environmental degradation and pollution exacerbate poverty in China's countryside, while also threatening the health of vulnerable rural populations, particularly children. Diarrhea is still a leading cause of child death in rural areas. The OECD (2007) estimates that in rural areas, over 30,000 children die each year from diarrhea associated with inadequate water supplies, sanitation and hygiene. In rural China, less than 30 percent of the population has access to adequate sanitation, compared to 70 percent of the population in the urban areas. In rural areas, sewage is commonly dumped into the fields or small streams creating public health threats to the local residents.

Implementing sustainable and appropriate sanitation and wastewater management practices in rural China is a priority to address the environmental and public health issues in rural areas. Adopting simple, low-cost decentralized and small centralized wastewater management schemes is fundamental to effectively manage and in some instances reuse wastewater for the benefit of rural populations.

China is a large and physically and culturally diverse country. Adopting sustainable, long-term sanitation and wastewater management programs will not occur at the national level, but will depend on the ability of many municipal, county and village governments to formulate cohesive and realistic wastewater management programs. The key role of the municipal and county governments is to provide technical and financial assistance and regulatory oversight to rural villages. In turn rural villages should be made responsible for implementing and maintaining effective wastewater management projects to protect the environment and public health. Ultimately, improved sanitation in rural villages will provide economic benefits to the communities in the form of improved health, better living and working conditions, and overall improvement to the welfare and economy of the village.

1.3. Overview of Rural Wastewater Management

A comprehensive rural wastewater management program (WMP) is a multi-tiered approach including institutional, educational, technical, and financial commitments at all sectors of village, county, municipal, provincial and central governments. The

institutional aspects of a program require the establishment of clear policies, regulations, and governance to facilitate the planning, implementation, operation, supervision and evaluation of projects. Continued education and training at the municipal, county, and village levels are important to building institutional and technical capacity. Appropriate sanitation technology should be selected that is low cost and can be easily and reliably operated and maintained by rural villages. Project financing will likely use different sources of funds, including: public funds, non-governmental loans, public subsidies to assist low-income villagers, and cost sharing opportunities for both monetary and non-monetary expenses.

Initially, a WMP involves gathering information to understand the water source protection requirements, socio-cultural as well as physical conditions, needs and capacity of the village to select, finance, and operationally support a wastewater project. It will involve project planning, implementation, operation, maintenance and administration activities conducted at the village, county and municipal levels to maintain the project. Finally, the program and village projects will require municipal and county level oversight, monitoring, evaluation, tracking and regulation to assure environmental and public health goals are achieved or to identify and remedy problems that may arise.

Issues of importance in considering wastewater management systems can be divided into technical issues, institutional issues and financial issues:

Technical Issues:

- **Decentralized versus Centralized Approaches.** Any wastewater management program in rural China needs to consider the costs and benefits of decentralized and centralized solutions. In a low-density setting, a decentralized system may be more suitable, while in high-density settings, a centralized system will be the most effective.

- **Changes in Level of Water Supply.** Increases in water supply create a corresponding need for to manage greater volumes of wastewater

- **Physical factors**. The climate, geography, hydrogeology, soil type, and other environmental factors can affect the sanitation solutions that might be the most feasible and cost effective in a given location.

- **Technological Factors.** Complex technologies can be difficult as well as costly for villages to operate and maintain, or to obtain spare parts and consumable materials, such as filters or chemicals.

Financial Issues:

- **Organization and Finance.** Investment and operation and maintenance must be kept low. Great care must be taken to ensure that generated income can match expenses throughout the lifetime of the system. Thus, low-cost

technologies may often represent more sustainable options. Promising innovative solutions include simpler, less mechanized biological wastewater treatment options, such as simple fixed film trickling filters and constructed wetlands, which may integrate well with local agriculture. Some of these solutions can provide benefits to the community.

- **Balancing Private Investment and Subsidies.** In China, rural households have often been expected to finance their own sanitation improvements. As a result, citizens' individual responsibility is well-developed and development efforts match needs closely. On the other hand, this has meant that many poorer families have not been able to afford approved sanitation. Thus, recently more funding has become available, but directing this funding adequately remains a great challenge.

Institutional Issues:

- **Policies, Standards, Regulations and Guidelines.** Policies, regulations and guidelines need to be clear. Particular importance needs to be given to clearly outline the responsibilities of different parties to minimize potential for conflict.

- **Participatory Approach in Community Development.** Recent wastewater management programs in China, including the World Bank's Ningbo Wastewater Management Program have included significant a participatory component. Thus, local communities get an important voice in their own development. This ensures high levels of participation and close matching of the community's needs, and empowers the local communities.

- **Long-term Planning for Future Needs.** The planning period established for many infrastructure projects is commonly based on a 20 to 30 year life cycle. A longer lifetime trajectory (30 to 50 years) is suggested to anticipate future changes.

- **Training and Capacity Building.** For the long-term success of wastewater management programs, it is essential that the required skills are locally available, to ensure effective maintenance, operation and supervision. Sufficient funds need to be allocated to training to ensure establishment of the necessary skills. Institutional training and capacity building are also key to support villages and supply a skilled work force.

- **Project Monitoring, Tracking and Evaluation.** A major cause of previous failures has been a lack of oversight and inadequate operation and maintenance of facilities. A project tracking system implemented by the municipal and county wastewater management offices should be an essential part of the WMP.
- **Lessons Learned.** Future projects need to take into account what lessons can be learned from past experience.

1.4. Purpose and Objectives of the Guide

The purpose of the Guide is to provide a comprehensive resource for local municipal, county, and village level jurisdictions (hereafter collectively referred to as local jurisdictions) so that they may develop successful and sustainable wastewater management programs (WMPs). The Guide is designed to improve local public services and governance reflected in the Peoples Republic of China's New Socialist Countryside initiative.

The overall objective of the Guide is to identify key issues and to present effective strategies and approaches to implement sustainable wastewater management programs at the local jurisdictions in order to improve rural sanitation in China. A key objective of the guide is to present institutional, programmatic and technical guidelines that can be adopted by local jurisdictions, forming the basis for consistent, affordable, practical, and effective sanitation project planning, design, implementation, and operations.

Specific objectives of the Guide are:

1. To review and consider previous rural wastewater management endeavors and lessons learned as a basis for setting a new course and developing informed strategies to avoid the problems of the past.
2. To recommend an institutional and regulatory framework and supporting guidelines to implement the WMP.
3. To provide local level jurisdictions with the fundamental tools to understand and select appropriate sanitation solutions.
4. To identify the financial requirements and funding options available to sustain a long-term WMP.
5. To outline and present guidelines for the technical aspects of project planning, cost estimation, engineering design, and project procurement/implementation.
6. To present a framework for participatory approach strategies to increase community awareness, participation and support of the project.
7. To outline the broader administration, capacity building and training, operation, maintenance, monitoring and tracking activities fundamental to the long-term implementation of the WMP.
8. To introduce a series of modeling and data management tools that can be used by local jurisdictions to conduct feasibility studies and to track and assess projects during and after construction.

1.5. Guide Contents

In addition to the current Chapter (Introduction), the Guide contains twelve (12) chapters. The following provides a brief description of the information presented in each chapter.

Chapter 2. Background. Chapter 2 presents an overview of the history of rural sanitation and wastewater management in China. This chapter summarizes some of the key issues and constraints encountered in the implementation and management of sanitation projects in these rural areas.

Chapter 3. Overview of Wastewater Management Strategies for Rural Villages. Chapter 3 provides an overview of the different strategies or options that are available to improve sanitation and manage human wastes and domestic wastewater in rural villages. The information is provided to outline basic sanitation approaches that can be implemented at individual household or at centralized village level, and in between. The chapter outlines selection criteria that can be used to determine the most appropriate solution for various community settings.

Chapter 4. Institutional, Policy and Regulatory Framework for Rural Sanitation Development. Chapter 4 presents a proposed institutional frame work to develop and implement a local wastewater management program. The framework presented reflects the demonstration project currently underway in the Municipality of Ningbo, Zhejiang Province, China. This chapter also describes existing policies and regulations pertinent to sanitation and wastewater management in rural areas of China.

Chapter 5. Community Participation and Education Strategies. Chapter 5 presents the community participatory approach (PA) within the context of rural wastewater management and describes the basic principles of the PA from project planning through execution, operation, and maintenance. The chapter provides a framework for creating inclusive stakeholder groups/committees, forums/meetings for decision making, project planning and review and oversight. The chapter identifies education and training requisites, and related funding needs that are a critical part of the overall WMP.

Chapter 6. Technical Analysis and Design. Chapter 6 outlines the technical studies and information that are required to support the selection, planning, design and construction of rural wastewater management projects. It provides guidelines for completion of key studies, including community surveys to understand the village's preferences, cultural resource issues, willingness and ability to pay for improved sanitation, baseline engineering studies (geotechnical investigations and topographic surveys), feasibility studies, cost estimates, and engineering design plans and specifications. This information is provided to assist local project management offices (PMOs) develop consistent and comprehensive terms of references (TOR) for planning and engineering consulting services.

Chapter 7. Financing, Subsidies, and Cost Recovery. Chapter 7 describes the various costs for implementing the entire wastewater management program, including

programmatic costs to staff and operate a municipal and county level wastewater management program (WMP) and project costs to administer, construct, operate and maintain a project. A review of alternative project financing schemes and the type and level of subsidies is provided. A discussion on asset ownership and management is included. Guidelines on setting user tariffs are presented that considers villagers' willingness and ability to pay for services.

Chapter 8. Procurement and Implementation. Chapter 8 provides a review of alternative procurements methods that can be used to construct and execute rural wastewater projects. The chapter provides a discussion of the advantages and disadvantages of each method and criteria for selecting procurement options. The last part of the chapter outlines construction, administrative and supervision requirements and roles of the various entities involved in the project.

Chapter 9. System Administration, Operation, Maintenance and Monitoring. Chapter 9 presents guidelines for village level wastewater management committees on the administration and operational requirements of rural wastewater management systems. Administrative aspects presented include the establishment of village level ordinances and by-laws related to the connection and use of sewers, and procedures for suspension of services. The chapter outlines the operation and maintenance requirements, the responsibilities of the system operator and the guidelines for routine system monitoring and reporting. The last part of the chapter includes recommended operator training to build capacity in this sector and support the long-term maintenance of the new facilities.

Chapter 10. Regulatory Oversight. Chapter 10 has been prepared to assist municipal and county level rural wastewater management offices and Environmental Protection Branch offices supervise and track the status and performance of the village wastewater projects. The chapter outlines the data gathering requirements and procedures for conducting routine inspections and monitoring of rural wastewater projects. It presents information on data management systems that can be employed to track, evaluate and relay performance information to each community. The chapter provides guidelines for developing and implementing enforcement and administrative actions against villages that are not complying with pertinent national, provincial and local standards and/or regulations.

Chapter 11. Bibliography. Chapter 11 presents the bibliography of technical references for the entire guide.

CHAPTER 2 - BACKGROUND

This chapter presents an overview of rural wastewater management practices currently employed in rural villages in China. The chapter also outlines some of the key issues and strategies that should be considered by municipal and county level agencies that are undertaking rural wastewater management programs.

2.1. Historical Reuse of Human Wastes (Nightsoil)

Waste management and reuse is not a “new practice” in China. In China the reuse of human wastes (nightsoil) as a fertilizer has been a common practice for many centuries. The historical practice and reuse of human waste continues in different regions of China today. F.H. King (1911) reported that in 1908 the International Concession of the City of Shanghai sold night soil to Chinese contractors. At the payment of a considerable sum, contractors were allowed to collect night soil from residences and public places in Shanghai and transport it to the rural country side and sell it to surrounding farms as a fertilizer.

In many rural areas of China, nightsoil is still collected and stored in large water-tight ceramic tanks, slate trenches, or concrete pits where it is allowed to stabilize and later applied to fields as a fertilizer. In many households the storage pits are located in the animal stall area to mix with animal wastes, commonly pig wastes. The combined waste is typically applied to small-scale vegetable plots and other rain-fed household crops (Ellis &Wang, 1997). It should be noted that use of nightsoil as a fertilizer can pose a risk to human health if the nightsoil has not had the time to decompose or dry out. Fresh nightsoil often contains pathogens that cause illness.

Figure 2.1. Traditional nightsoil collection buckets

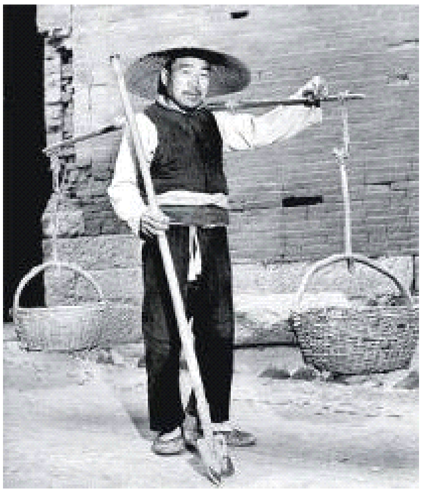

Figure 2.2. The collecting of 'night soil' in China
(The Independent, 2007)

Figure 2.3. Applying 'nightsoil' in a field in Chengdu, Sichuan, China
(Dunkbarnes, 2007)

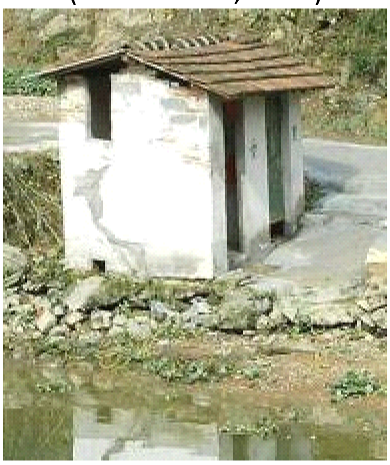

Figure 2.4. Early Community Latrine Project in Western China
(China Environmental Law, 2007)

2.2. Biogas Digestors

China is one of countries in the world to have used biogas technology early in its history. By the end of the nineteenth century, simple biogas digesters had appeared

in the coastal areas of southern China. Mr. Luo Guorui invented and built an eight cubic meter Guorui biogas tank in 1920, and established the Santou Guorui Biogas Lamp Company. In 1932, he moved the Company to Shanghai and changed his firm's name to Chinese Guorui Biogas Company with many branches along the Yangtze River and in the southern provinces. *Chinese Guorui Biogas Digester Practical Lecture Notes* was published in 1935, the first monograph on biogas in China and in the world. That was the first wave of biogas use in China. (Kangmin and Mae-Wan Ho, 2006)

The second wave of biogas use in China originated in Wuchang in 1958 in a campaign to exploit the multiple functions of biogas production, which simultaneously solved the problems of the disposal of manure and improvement of hygiene. (Kangmin and Mae-Wan Ho, 2006)

The third wave of biogas use occurred between the late 1970s and early 1980s when the Chinese government considered biogas production an effective and rational use of natural resources in rural areas. Biogas production not only provided energy, but also environmental protection and improvement of hygiene, and was an important aspect of modernization of agriculture. Over 6 million digesters have been set up in China, which became the biogas capitol of the world, attracting many from the developing countries to learn from it. The 'China dome' digester became the standard construction to the present day (Figure 2.4), especially for small-scale domestic use. (Kangmin and Mae-Wan Ho, 2006),

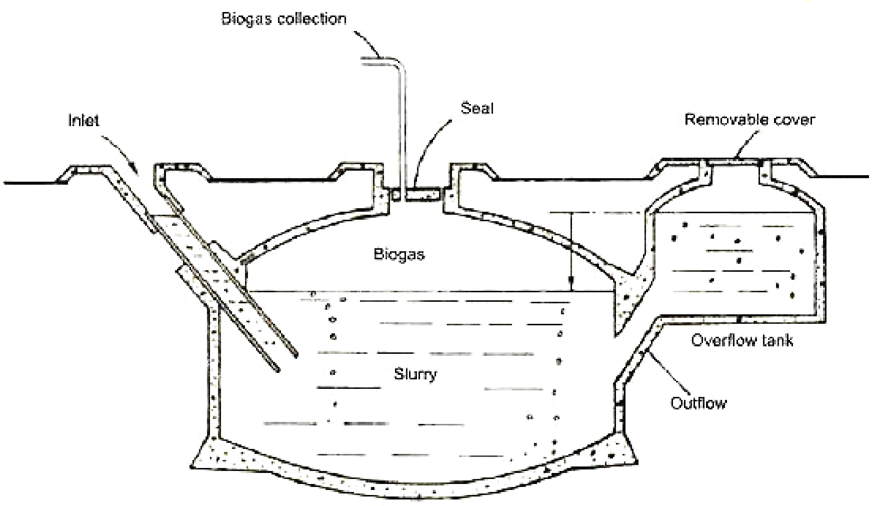

Figure 2.5. Traditional Chinese biogas dome digester

2.3. Recent Efforts and Issues

China's campaign to improve rural water supply and sanitation began in earnest in 1980. In response to the United Nations' Declaration of "International Drinking Water Supply and Sanitation Decade", the Government of China approved the

National Patriotic Health Campaign Committee (NPHCC) to act as the State Action Committee and to take lead in setting the central governments' target goals to improve rural water supply and sanitation works (CCDC, 2004). Since the adoption of these targets, rural water supply and sanitation have steadily improved. According to the World Health Organization (WHO), improved drinking water sources increased from less than 50 percent in the early 1980s to over 81 percent in 2006. Improved sanitation in rural communities increased from just over 20 percent in 1996 to over 59% in 2006.

In the early 1980s the Chinese Government developed technical guidelines for the construction of simple sanitary technologies for rural households. And the NPHCC (2002) reported that the most common sanitation technology employed in the rural areas, primarily at a household level, included three compartment septic tanks, dual compartment composting latrines, biogas latrines, and other latrine systems (including ventilated improved latrines, latrines with excrement and urine separation, and double pit latrines). Many on-site sanitation projects have been successful deployed in rural villages.

Throughout the past several decades, different parts of rural China have experienced different levels of "modernization" and the adoption of internal plumbing fixtures (sinks, showers, bathtubs, and flush toilets) in rural homes. These practices are most common in the coastal regions of rural China. The simple sanitation systems described above when originally installed were not likely designed for increased water use encountered in these villages. Many of the simple sanitation technologies employ bottomless septic tanks/cesspool systems that were too small and that can also experience failures during the rainy season when they become inundated by shallow groundwater, causing the surfacing of untreated sewage. Many are constructed under buildings and cannot be adequately maintained and clog up over time, resulting in overflows and spills. The continued discharge of untreated gray and black water poses severe water quality impacts and public health threats directly to downstream rural communities and to urban water supply sources located in rural areas.

Over the past decade, many village wastewater projects have been undertaken with marginal success. The success rate of sanitation projects in rural China is relatively low, and compared to other developing countries throughout world, the situation in China is not a unique experience. In the past, projects that have been undertaken by various governmental and non-governmental institutions have suffered from poor coordination, a lack of well-defined standards, inadequate oversight, low community participation, and limited or no monitoring or evaluation programs. As a result there is limited or no long-term operational data that allows for meaningful critique of projects.

Many projects have been completed that have had limited community participation. For example, in many small community projects that involve installing a sanitary sewer have resulted in a very low number (less than 15%) of households connecting

to the new projects. Projects are not being properly designed or maintained. Projects have been built in inappropriate locations, such as in flood plains that present risks of damage and pollution. There has been limited oversight and regulation of rural wastewater projects. There has not been a commitment from villages to recover costs and maintain projects. It is also worth noting that if wastewater that has been collected in sewers is not treated before disposal, the collected waste, concentrated in one place, can pose a greater threat to human health and the environment than uncollected waste.

Figure 2.6. Poorly Designed and Unmaintained Screen on a Rural Wastewater System – difficult system to maintain leading to sewage backup and mosquito breeding

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Figure 2.8. Over-engineered free surface water wetland system – costly design concept

Figure 2.9. Unbaffled Septic Tanks – poorly designed

Figure 2.10. Inaccessible Septic Design – difficult to maintain

Figure 2.11. Direct discharge to land or surface drainage – presents public health and water quality risks

CHAPTER 3 - OVERVIEW OF SANITATION STRATEGIES FOR RURAL VILLAGES

This chapter provides an overview of the different strategies that are available to improve sanitation and manage human wastes and domestic wastewater in rural villages. The information is provided to outline basic sanitation approaches that can be implemented at an individual household level, a cluster of households or neighborhood level, or on a larger scale in a centralized village level project that would include a sewage collection system, a central treatment system and central disposal and/or water reclamation systems.

This chapter does not provide detailed technical information about the engineering, design or cost of different sanitation technologies. This information can be found in other technical references listed at the end of the chapter.

The following information is presented to introduce municipal and county level planners, engineers, health workers, and community leaders to basic approaches that can be taken to improve sanitation conditions in villages. Guidelines are also presented that can be used to select an appropriate sanitation strategy for a village using site specific factors, including density of development, geology, soil, groundwater, and size of the village and corresponding wastewater flows.

3.1. Origin of Domestic Wastewater

Domestic wastewater is the water that has been used by a person or community, and which contains all the material added to the water during its use. Wastewater consists of black water and gray water. “Black water” is composed of human body wastes (feces and urine) either in a semi-dry form or diluted with the water used for flushing toilets. “Gray water”, or “sullage”, is the wastewater resulting from personal washing, laundry, food preparation, and the cleaning of cooking utensils but not containing human excreta.

The production of wastewater within a rural village is closely linked to water usage. In rural China, the volume of wastewater generated is typically 60 to 80% of the water usage. Typical water usage for a rural house with internal plumbing is shown in Table 3.1.

Table 3.1. Sources and Quantity of Domestic Wastewater

Source	Daily Per Capita Usage (in Liters)
Graywater (cooking and bathing water)	83
Urine	1.5
Feces	0.15
Toilet Flushing	3 to 9

3.2. Introduction to Village Sanitation Strategies

There are many different sanitation systems that are appropriate for rural villages in China; they can be divided into decentralized or centralized systems. Decentralized systems mean that the sanitation system is installed and managed on-site, generally at a household level.

Decentralized systems can also include systems where a group or cluster of houses together is connected to one small neighborhood system, which are sometimes called mixed systems.

Centralized wastewater management usually includes a community sewage collection system, a central wastewater treatment plant, and central disposal system. The following sections provide a more detailed description of the different sanitation systems commonly employed in rural China and other developing countries.

3.3. Decentralized Sanitation Systems

Decentralized sanitation systems include systems that are installed and managed at the household or neighborhood level. Figure 3.1 shows the conceptual layout of household (on-site) and neighborhood (cluster) decentralized sanitation systems.

3.3.1. On-site or Household Treatment and Disposal Systems

On-site treatment and disposal systems can be mainly divided in waterless and water-borne systems. Common waterless systems include pit latrines, ventilated improved latrines, and urine-diverting drying or composting latrines, also known as EcoSan latrines. Common water-based (or wastewater systems) include pour-flush latrines, double urn anaerobic digesters, urine diverting flush toilets, and septic tank and leachfield systems.

3.3.1.1. Waterless Sanitation Systems

Biogas Digestors. Since the 1970s, China has been promoting the use of underground, individual household scale, anaerobic digesters to process rural organic wastes including human waste. There are over 5 million households using anaerobic digesters in China. The digesters produce biogas that is used as an energy source by the households, and produce fertilizer that is used in agricultural production. Most reactors are built in conjunction with the construction of new pigsties and toilet facilities. The reactors are located directly under the floor of the pigsty and the drain from the pigsty as well as the toilet feed directly into the reactor. Construction time for a reactor is approximately one week, and the total cost including materials and labor is relatively low and estimated to be less than 1,000 RMB or $200.

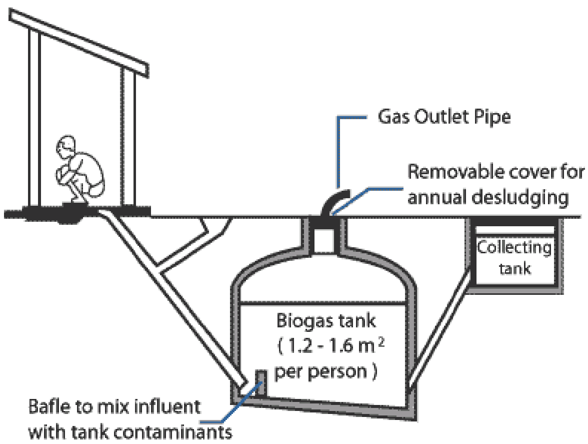


Figure 3.1 Simplified Biogas Digestor Layout (UNDP)

Pit Latrines. Waterless or dry latrine systems are designed to capture and manage human wastes and do not capture gray water from households.

Simple pit latrines: Waterless or dry simple pit latrines are typically very simple to design and build, and can usually be constructed using locally available materials and labor. These systems are managed by the household. Without proper construction and management, simple pit latrines can produce unpleasant odors and provide breeding grounds for flies and other vermin, and for this reason the general acceptance of these systems can be low.

A ventilated improved pit (VIP) latrine has a ventilation pipe installed on the side of the latrine, to vent gases and associated odors out of the latrine to reduce odors. In both the simple and VIP latrine systems the solids and urine enter a pit(s) and once it is full it is either covered with soil with a tree planted over the pit, or the solids are evacuated using a septage pumping truck and hauled offsite to an approved disposal location.

For VIP latrines there are additional conditions; the cabin should be dark, the vent pipe should be at least 100 cm in diameter, and extend at least 50cm above the level of the roof of the latrine. The cabin should be relatively dark so that flies will fly towards the light at the top end of the pipe rather than out through the cabin. Because air should flow into the defecation hole and out of the pipe, the defecation hole should not have a cover. It is important for the door – which should have a space for air to pass into the cabin – should face the prevailing wind because the pressure of the wind is more important than the effect of convection caused by heating in the pipe.

Simple pit and VIP latrines, among others, can also be constructed with “twin” or “double” pits, that is, with two pits. One of the pits is used until it is full, then the other is used while the excreta in the first pit decomposes for six months to two years. When the second pit is full, the first can be emptied of the decomposed matter, which will be odorless and inoffensive. Almost all of the pathogens die during decomposition, so the matter can be safely handled and used as fertilizer.

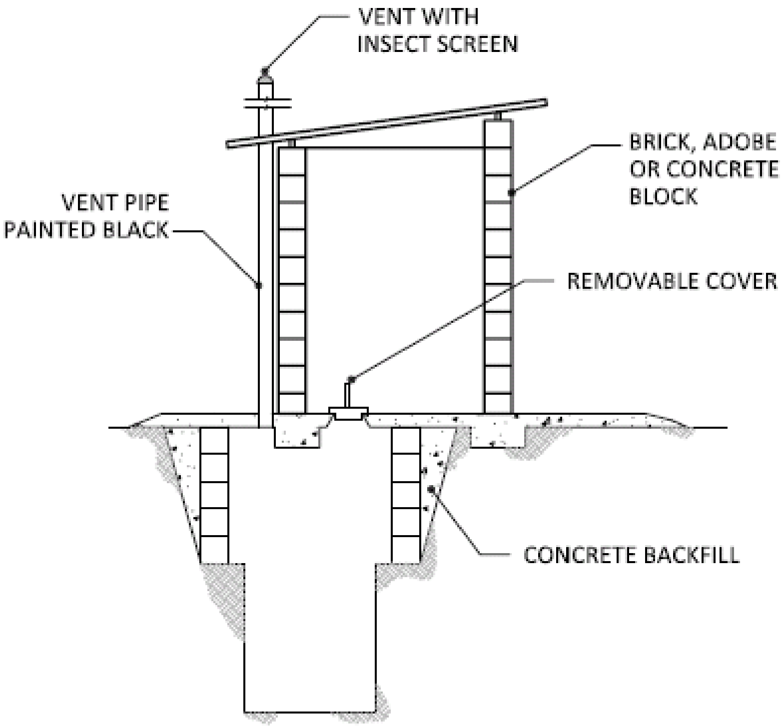


Figure 3.2. Ventilated Improved Pit (VIP) Latrine

Urine Diverting Dry Toilet. A urine diverting dry toilet (UDDT) (which is a type of Ecological Sanitation (EcoSan) system) has a specially made toilet that separates the urine and the feces. The UDDT toilet is built such that the urine is collected and drained from the front area of the toilet, while feces falls into a pit or an above-ground vault. The EcoSan dry toilet should include two pits or vaults, so that once one pit or vault is full, the second can be used while the contents in the full pit dry to a point where all or most of the pathogens have died; before the material is removed and used as a fertilizer. Commonly, a drying material, such as lime, ash or soil is added to the same pit as the feces to control odors. Urine is diverted to a separate urine holding tank and can be used as an organic fertilizer. Similar EcoSan latrines without separation of feces from urine and other liquids allow decomposition rather than drying of the excreta. It is important to note that the EcoSan system is not intuitive or immediately obvious to many users. Good education and demonstration projects are essential in achieving good acceptance with users (Tilley, E. et al, 2008). The EcoSan systems are relatively costly compared to other on-site systems, but they are an effective way to reuse treated waste by producing an organic fertilizer, and are well suited to low-density agricultural-based villages.

Figure 3.3. Urine Diverting Toilet

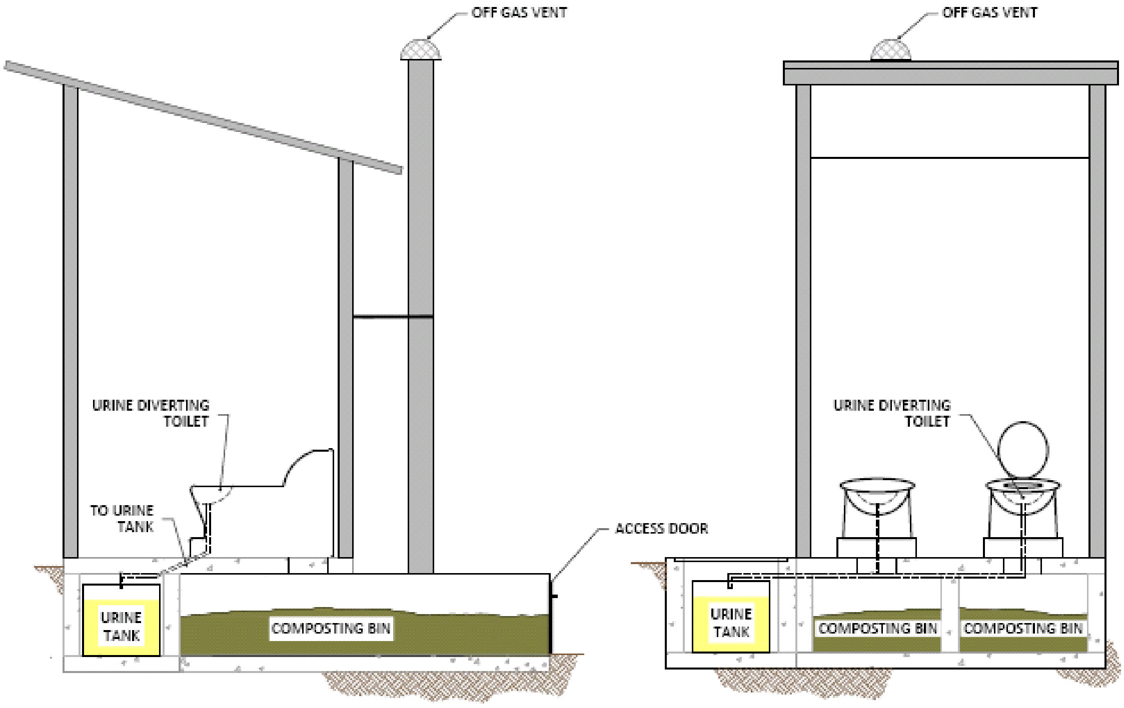


Figure 3.4. EcoSan Toilet

3.3.1.2**.** Water-Based Sanitary Systems

Common water-based sanitary systems include both pour-flush latrines or cistern-flush latrines, but pour-flush latrines generally use less water and are better suited to decentralized sanitation than cistern-flush latrines. The wastewater flows to double pits, dual urn anaerobic digesters, or septic tank and leachfield systems or to sewer systems. On-

site water-based systems use water to convey the waste (typically excreta) to a cesspit, an anaerobic digester to remove solids, or a septic tank, with the liquid fraction (effluent) flowing to a subsurface soil-based disposal system such as a leachfield, a small waste stabilization pond or constructed wetland, such as a vegetated gravel bed system to grow plants.

Pour Flush Latrine. A pour-flush latrine is similar to a cistern-flush toilet, with a water seal that prevents odors and flies from coming back up the pipe, except that the water is poured in by the user instead of coming from a cistern built into the toilet. The water seal prevents users from seeing or smelling the excreta of previous users, so pour-flush toilets are generally well accepted. Pour-flush latrines typically use less water than a conventional cistern-flush toilet. Wastewater from a pour-flush latrine is directed to a dual urn style anaerobic digester or to pits that retain the solids and typically have porous side walls (below 0.5 meters) and open bottoms to allow the liquid to infiltrate into the underlying soils as shown in Figure 3.5. Having a porous side wall area is important because the bottom of the pit often becomes matted and clogged. Because there are no mechanical parts, very little maintenance is required; only general housekeeping and cleaning of the toilet to prevent the buildup of organics and stains is necessary. This system does rely on a constant source of water and requires some education to be used correctly.

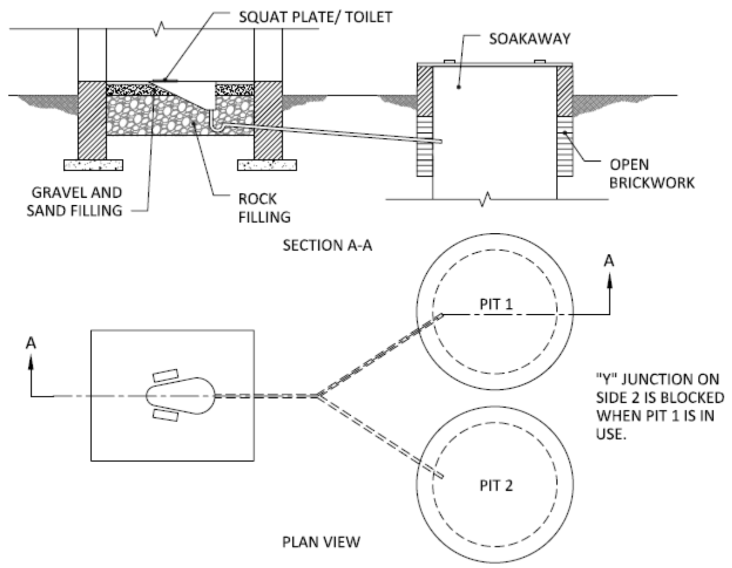


Figure 3.5. Twin-pit Pour Flush Latrine

Septic Tank and Leachfield Disposal System. A typical septic tank and leachfield system collects all of the wastewater from a household including both black and gray water discharges. The septic tank is usually baffled, with two or three compartments and is plumbed so that the water entering the tank does not re-suspend the solids that have accumulated in the tank. The volume of the septic tank should be sized to hold at least one to two days of the total daily wastewater flow from the household. Septic tanks can either be built on-site using concrete block or reinforced concrete or are commercially available in plastic or fiberglass construction in many parts of China. Liquid from the septic tank is usually discharged by gravity to a leachfield disposal system that consists of a series of shallow (less than 4 feet deep), gravel-filled trenches. A distribution box is installed between the septic tank and the leachfield trenches to make sure that the water is equally

distributed to each trench as shown in Figure 3.7. If site conditions do not permit the leachfields to be installed downhill from the septic tank then a small pump may be installed in the final chamber of the septic tank or in a small pump tank after the septic tank to pump the effluent to the leachfield system.

Figure 3.6. Conceptual Layout of Household and Neighborhood Decentralized Sanitation Systems

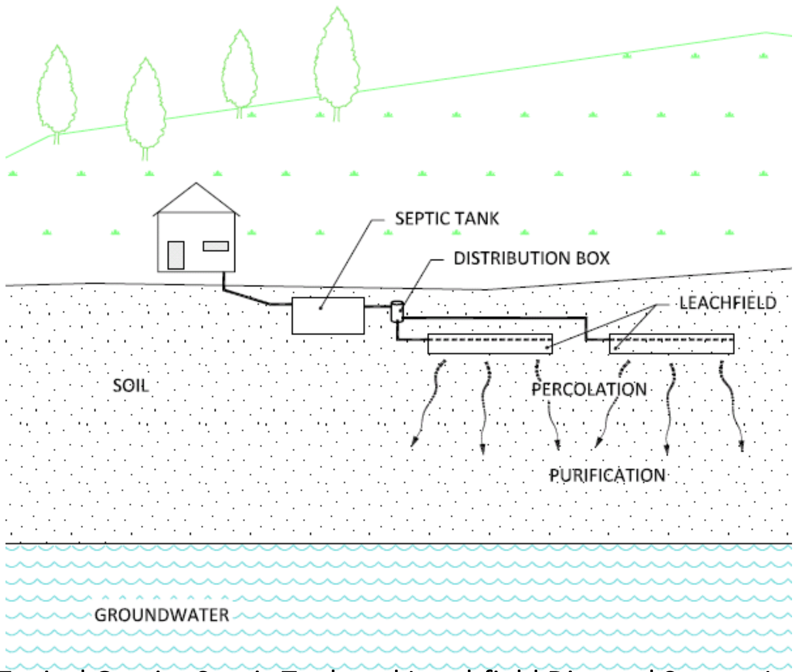


Figure 3.7. Typical On-site Septic Tank and Leachfield Disposal System Layout

3.3.1.3. Soil and Groundwater Conditions

Soil and groundwater conditions are important for all on-site sanitary systems. Soil stability is important for all dry and pour-flush latrines. In unstable soils, pits must be lined, often to their bases. Soil permeability is critical so that water will drain freely through unsaturated soils. The soils provide treatment of the wastes; however, installing infiltration systems in soils that are too permeable, such as in coarse sands and gravels, can allow the waste to percolate through the soils too fast to provide sufficient treatment. In impermeable soils, such as clays, these technologies are not feasible because infiltration is too slow.

In soil-based treatment/disposal systems such as pit latrines, leachfields and others, the soil around the installation treats the wastewater; the waterborne pathogens die off or are filtered out, and organic matter is also filtered out. Unsaturated soils provide more effective treatment than saturated soils. Therefore, where ever possible, the vertical separation between the bottom of a soil-based disposal system (such as a leachfield or a latrine pit) and bedrock or groundwater at its highest level (for example, during the rainy season) should generally be greater than 1 to 3 meters. In some cases, where rock or the water table is too close to the surface of ground, the latrine pit or vault can be constructed partially or wholly

above ground and, soil heaped or mounded around it or shallow leachfields or mound/fill type systems can be employed to provide the required separation. If it isn't possible to provide the needed vertical separation, additional care must be taken to locate the latrine pit, cesspit, leaching field or other sub-surface soil-based disposal system far from water sources or surface water bodies.

3.3.2. Neighborhood or Clustered Wastewater Management Systems

Many villages may be composed of different small but densely populated neighborhoods that are separated by agricultural fields or topographic features, such as hills, streams, rivers, highways or other physical features. In these particular situations, it may be more feasible to install small sanitation systems to serve each neighborhood or cluster of houses instead of installing a large, complex and expensive collection system.

A neighborhood system usually includes a small sewage collection system to collect the wastewater from each house. The collection system conveys the sewage to a large septic tank and the septic tank is connected to a large subsurface disposal field or constructed wetlands.

There can be alternative configurations of these systems depending on the layout of the neighborhood. For example, in areas with varying topography or shallow groundwater, a septic tank effluent pumping system (STEP) may be used, which involves installing individual septic tanks fitted with pumps at each house and the effluent from each house is pumped to a neighborhood leachfield disposal system or possibly to a small enhanced wastewater treatment and reclamation system, so that treated water can be reused for irrigation purposes. Section 3.5.1 describes alternative sewer systems that are appropriate for rural villages in China.

3.4. Community Laundry Graywater Systems

In most rural villages throughout China laundry is washed in streams and rivers (Figure 3.8). This practice degrades water quality and aquatic life in the water body. A relatively simple solution for many rural villages is to install small laundry washing stations. However, a key aspect of this approach is to make sure that the washing station is constructed with multiple wash basins to accommodate several users at a time. Laundry washing in most village settings is a very social activity and an important time for friends and community members to gather and discuss a wide array of topics.

Community laundry stations can be protected from the elements using roofs, and the roofs can be designed to capture rainwater to supplement water used in the basins. When choosing a design, it's important to consult the local users of the station to determine their needs to assure they accept and use the facility. Typical drawings of community laundry stations are shown in Figure 3.9.

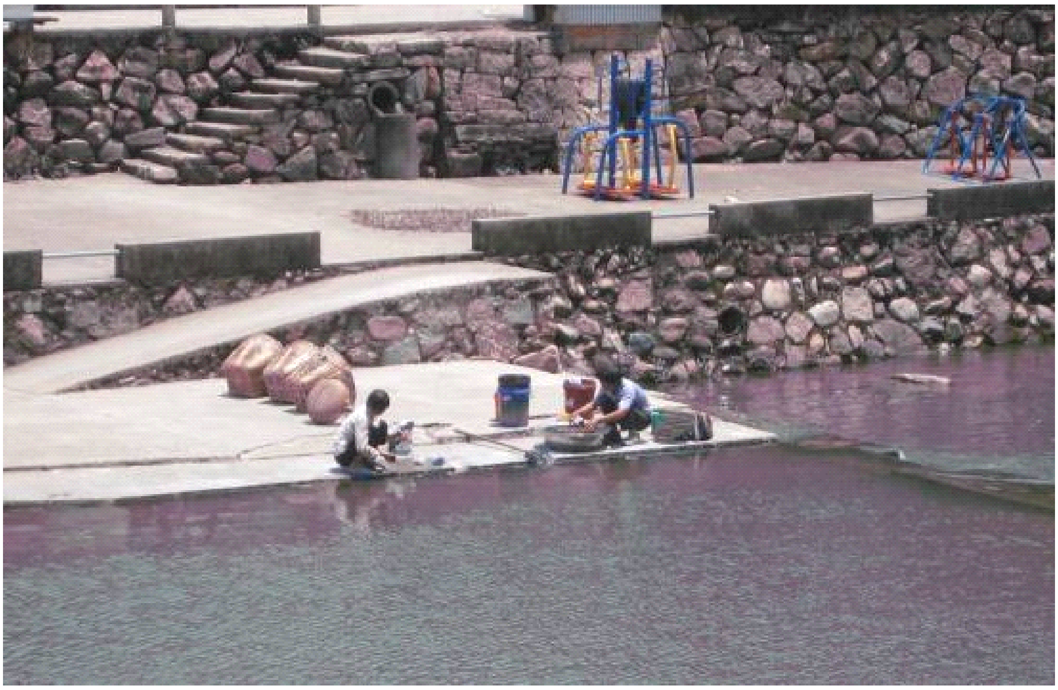


Figure 3.8. Women washing laundry on a small river in eastern China

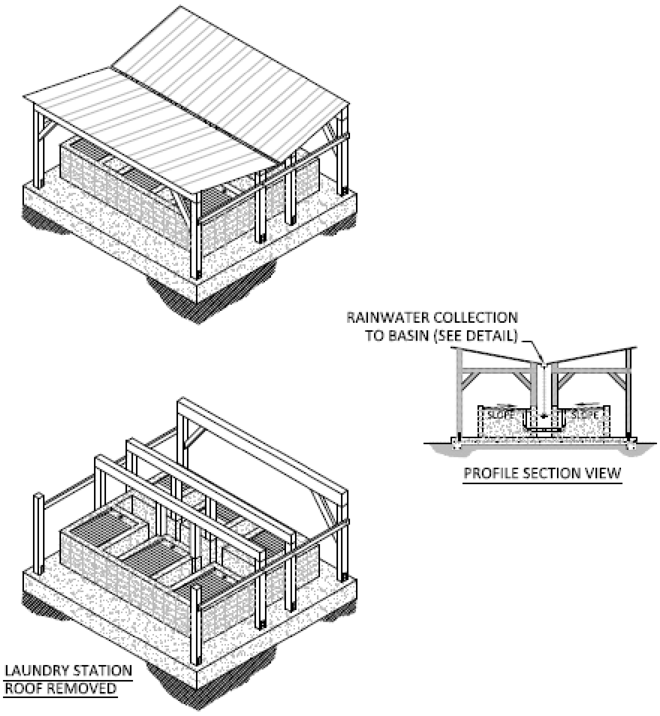


Figure 3.9. Community Laundry Washing Station

3.5. Centralized or Village Level Wastewater Management

Many rural villages in China have been constructed in high density land use patterns in order to preserve limited agricultural lands surrounding the villages. In these settings, where houses are supplied with running water (therefore producing more wastewater) and there is

not enough space for on-site sanitation, a centralized wastewater system may be more appropriate.

A centralized wastewater system generally consists of four parts: the collection or sanitary sewer network; a wastewater treatment system; a water reclamation/reuse system, and a disposal system. The water reclamation/reuse system may require some additional treatment, such as filtration and disinfection, so that the treated water can be reused to supplement irrigation supply in the village.

The following sections provide an overview of the various types of sanitary sewer, small community wastewater treatment, and alternative disposal and reuse schemes that are appropriate and in use in China.

3.5.1. Sewage Collection Alternatives

Unlike large municipal type sewers, sanitary sewers installed in rural villages will generally consist of small bore sewers, using small diameter plastic or concrete piped sewers. The layout, type and size of sewers will depend primarily on the topography of the village, underlying soil and groundwater conditions, and the density of homes served by the system.

Sanitary sewage collections systems are used to collect wastewater from rural homes resulting from human water use, including wastewater from toilets, sinks, showers, baths, kitchens and laundry. Many villages are small and the resulting wastewater flows will be low, and installing large diameter sewer pipes is not cost-effective or necessary to maintain adequate flow in the sewer pipe. Site conditions, such as very low gradient terrain, shallow bedrock and high ground water, may also require that sewers be installed at shallow depths or with minimum slopes to accommodate site conditions. In rural communities, sewer systems are generally laid at shallow depths with low flow conditions. The criteria for designing new sanitary sewer systems is based on providing sufficient velocity of flow in the sewer system to minimize deposition of solids in the sewer pipes and to maintain sufficient ventilation in the pipes. Small diameter pipes are recommended in these types of systems, because the number of connections and corresponding wastewater flows are relatively low.

It is important to note that these sanitary sewers are small piping systems, and are not designed to convey rainfall from roofs and other areas. Rainwater pipes and drains should not be connected to the sanitary sewer system.

Sewer systems will include cleanouts and manholes to provide points of access for cleaning and maintaining the sewers. Cleanouts are usually located in all lines between the house and sewer mainline connections. Manholes are installed at the intersection of sewers, major changes in directions, and/or at intervals of 150 to 200 meters in long, flat sections.

Under normal conditions in locations with no vehicle traffic, the minimum required cover over a sewer pipeline should be 0.60 meters. Under normal conditions in locations with vehicle traffic, the minimum required cover over a pipeline is normally 0.95 meters, including 0.80 meters cm of soil/sand and 0.15 meters of concrete. In areas of shallow

bedrock, special provisions may be made to allow for shallow trench depths; however, the depths should be sufficient to prevent freezing.

To prevent the cross contamination of sewers and water lines, there are rules to maintain adequate horizontal and vertical separation to domestic water lines. The minimum horizontal separation between the sanitary sewer line and domestic water line should be at least one meter. The minimum vertical separation between the sanitary sewer and domestic water lines should be 0.10 meters. Sanitary sewer lines and domestic water lines should not be buried in the same trench. Sanitary sewer and domestic waterline intersections should be perpendicular (90 degrees) to the extent practical.

Four types of small bore sewer systems that are recommended for rural village sanitary sewer systems, including:

- Small diameter gravity sewer system (SGSS);
- Small diameter gravity sewer with residential grit traps systems (SGSS-GTS);
- Small diameter gravity sewer with residential or community interceptor tank systems (SGSS-ITS); and
- Small diameter gravity sewer with residential or community septic tank effluent pump (STEP) tanks.

3.5.1.1. Small Gravity Sewer Systems (SGSS)

A small gravity sewer system (SGSS) is a piped network of gravity flow sanitary sewer pipes that are installed with a minimum slope of 0.75 % or 1 in 135 mts/mt. Small diameter pipes are recommended in these types of systems, based on the number of residential (service) connections, using the following criteria:

Number of Service Connections	Recommended Pipe Size
$\leq$ 25 connections	150 mm
$\leq$ 250 connections	200 mm
$\leq$ 1,500 connections	300 mm

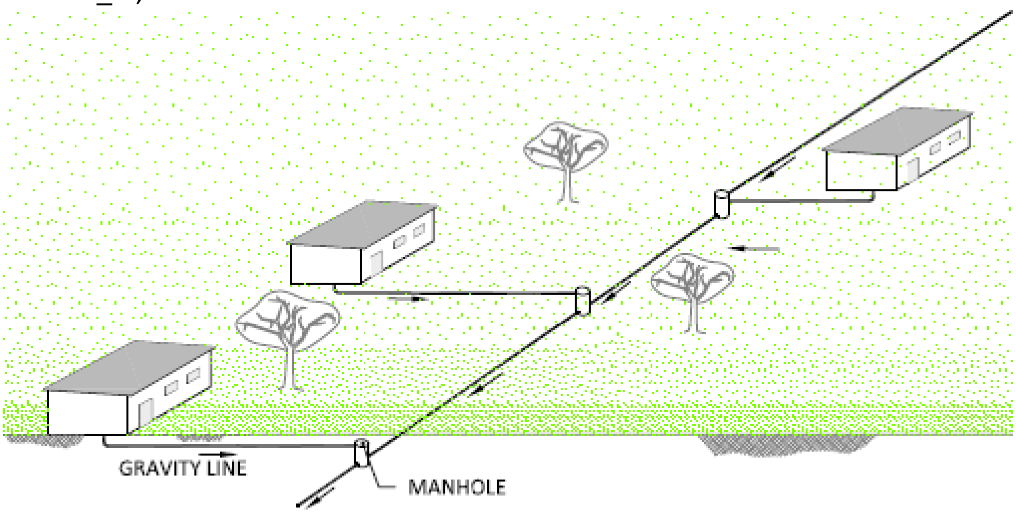


Figure 3.10. Small Gravity Sewer System

3.5.1.2. Small Gravity Sewer and Grit Trap Systems (SGS-GTS)

SGS-GTS are small gravity sewer systems that are installed when the slope of the pipes are less than 0.75% (1 in 135 mts/mts) and greater than 0.5% (1 in 200 mts/mts). In these situations small grit traps (Figure 3.11) are installed between the house and the main sewer lateral to prevent solids from entering and clogging the sewer lines.

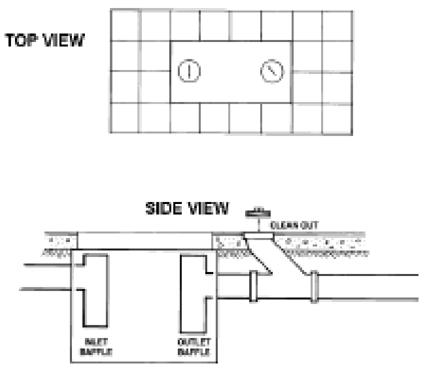


Figure 3.11. Typical Household Grit Tank

3.5.1.3. Small Gravity Sewer and Interceptor Tank System (SGS-ITS)

The SGS-ITS is used when the slope of the main lateral sewer systems is less than 0.5%. In this system, the interceptor tank is either installed at the individual household or to accommodate a neighborhood. The tanks are connected on the branch line upstream of the low gradient main sewer line. The purpose of the interceptor tank is to remove settleable solids before they enter the main low gradient sewer to prevent potential clogging of the sewer line.

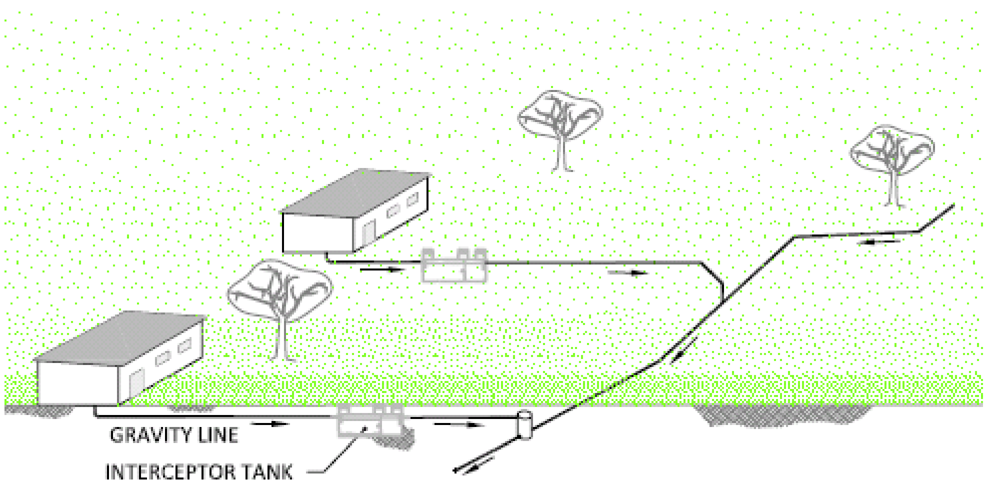


Figure 3.12. Small Gravity Sewer and Interceptor Tank System (SGS-ITS)

3.5.1.4. Small Gravity Sewer and Septic Tank Effluent Pump Systems (SGS-STEP)

The SGS-STEP system is used when there is insufficient slope or the topography will not permit the sewage to flow by gravity to the treatment system, so small pump systems are

required to convey the wastewater to the treatment and/or disposal systems. In these residential or community systems either a dual or triple chamber septic tank is installed on the branch line upstream of the main pressurized sewer line. The purpose of the septic tank is to remove settleable solids before they enter the pump vault.

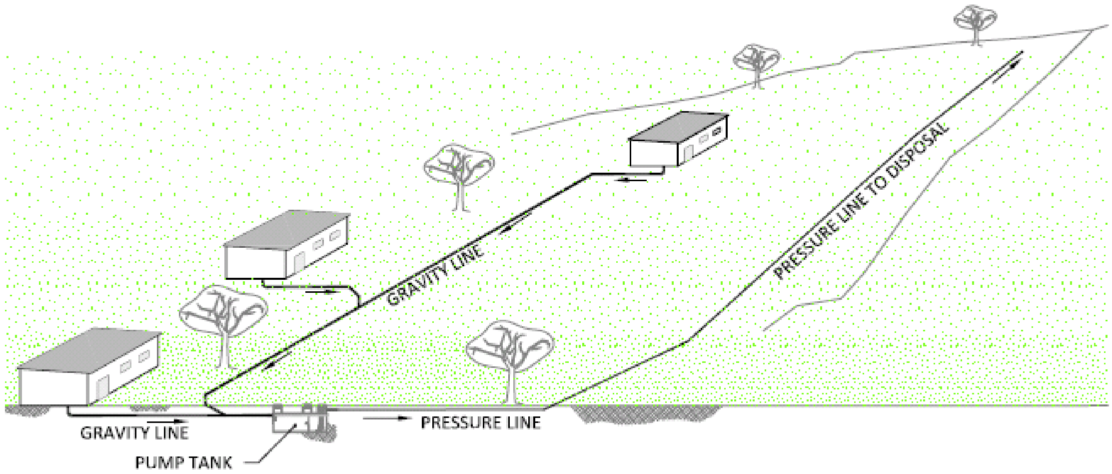


Figure 3.13. Septic Tank Effluent Pumping System (SGS-STEP)

3.5.2. Centralized Wastewater Treatment Systems

Centralized wastewater treatment systems consist of multi-stage processes to remove debris, trash, soluble organic material, nutrients, and other potential pollutants from the wastewater. A common small community wastewater system is composed of two basic processes: a pretreatment process to remove garbage, debris, sand and grit; and a biological treatment process to remove soluble and degradable organic material, nutrients, and other pollutants. Additional treatment may be required to meet environmental standards, the type of disposal requirements, and/or to reuse the water. In some instances the treated water may need to be filtered and disinfected if it is going to be reused. Figure 3.14 shows a schematic layout of a simple small community wastewater treatment system.

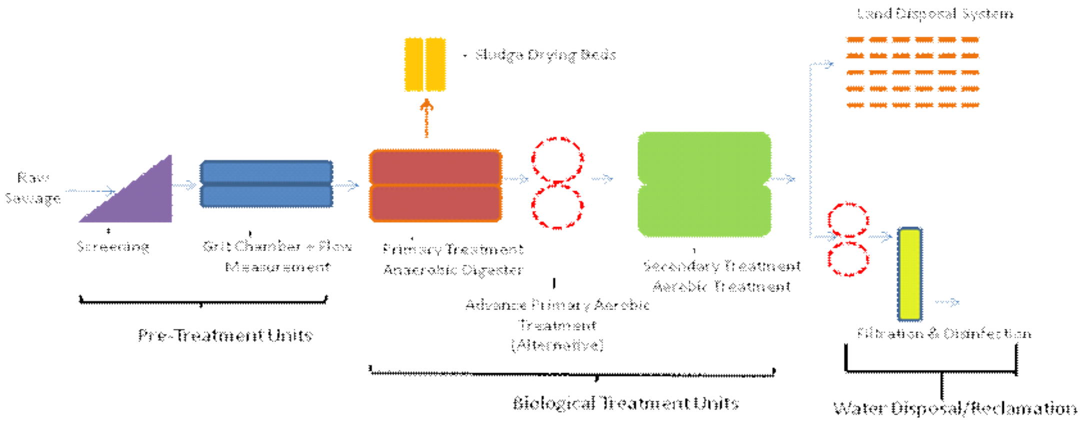


Figure 3.14. Schematic of Centralized Wastewater Treatment System

3.5.2.1. Pretreatment

In rural village wastewater systems pretreatment systems typically include bar screens, shallow grit chambers or sedimentation tanks. The purpose of the pretreatment system is

to remove debris, garbage, sand and grit before this matter enters the biological treatment system. In general, this material is not biodegradable and can foul electro-mechanical equipment, including pumps and aeration equipment.

The pretreatment should be designed so that it can be easily cleaned. (Installing screens and grit chambers in deep concrete vaults is not recommended and these structures will not likely be maintained, causing sewage to back up in the main sewer lines resulting in poor drainage and potential breeding of vectors (e.g. mosquitoes) in the collection system.)

Pretreatment systems including bar screens and grit chambers should be installed on all treatment systems accommodating flows over 100 cubic meters per day (m3/d) or shall be an integral component of the package treatment system. For small village systems, with flows less than 100 m^3/day, a small sedimentation tank may be sufficient to capture grit and debris before the wastewater enters the biological treatment systems. Figure 3.15 shows the layout of a bar screen and grit chamber system installed in Honduras, Central America. Figure 3.16 shows the design of a covered screen and grit chamber that would be appropriate for rural village systems in China.

Figure 3.15. Typical Bar Screen and Dual Channel Grit Chamber (Oakley, 2003)

Bar Screens. Guide raked bar screens are designed to capture and remove trash and debris that can foul a wastewater treatment system. A bar screen is typically designed so that the bars are spaced between 15 to 25 mm and inclined to 60 degrees to the horizontal. A key provision is that the screen should be designed to allow for daily cleaning and in such a manner so that screenings may be removed and liquid can drain back to the entrance of the treatment works. Typical bar screen configurations are shown below in Figure 3.16.

Figure 3.16. Typical Bar Screen Installations

Grit Chambers. Guide cleaned horizontal flow shallow grit chambers are well suited for village wastewater systems to remove sand and grit from the wastewater. The grit chambers are designed with at least two channels so that one may be closed for maintenance or cleaning. The grit chamber can be covered with a steel or fiberglass cover that can be opened or removed for routine cleaning to minimize odors. A typical two channel grit chamber layout is shown in Figure 3.17.

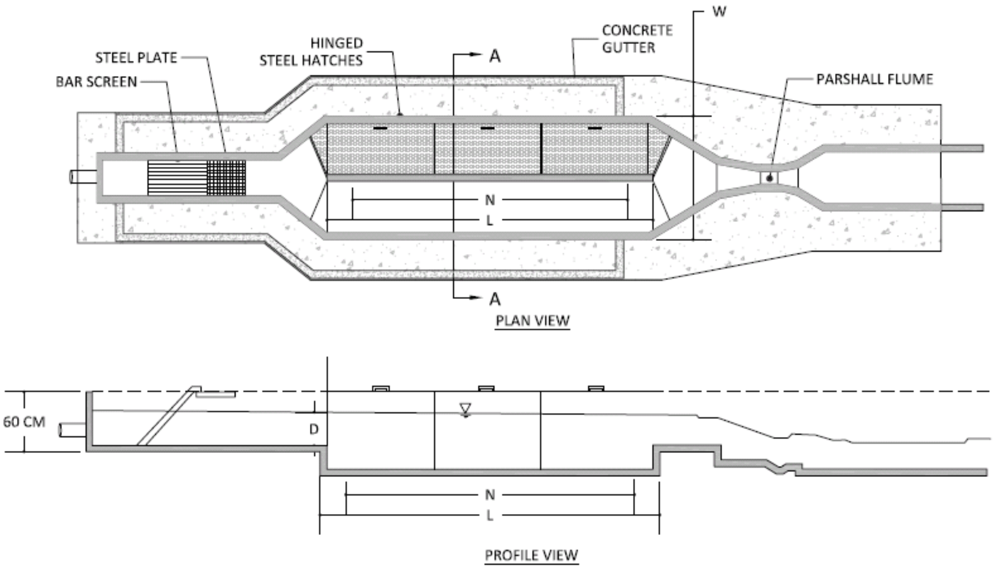


Figure 3.17. Covered Horizontal Flow Shallow Grit Chamber Configuration

3.5.2.2**.** Primary Treatment

Primary treatment processes are used to settle solids and remove oil and grease. A typical primary treatment system may remove 60 to 65% of suspended solids, and 30% to 35% of the organic material (commonly expressed as the biochemical oxygen demand (BOD)) from the sewage. Small primary treatment systems used in village scale projects are typically anaerobic processes that digest the solids with anaerobic bacteria that survive without oxygen. Common primary treatment systems include septic tanks, upflow anaerobic sludge blanket digesters, imhoff tanks, and anaerobic ponds.

Septic Tank. A septic tank is commonly a rectangular tank that is divided into two or three chambers separated by a baffle. The first chamber is typically two times the size of the subsequent chambers. The septic tank should be designed so that it can be easily cleaned using a septage pumping system and each compartment of the tank should have an access riser to allow for easy access. Usually the tank should be sized with a hydraulic residence time (HRT) of at least 24 hours. The inlet and outlet of the tank should be baffled or configured to maximize sedimentation of solids and to trap debris and garbage. The placement and configuration of the outlet of each chamber is critical for the proper treatment of solids in the tank. In a properly designed septic tank, three treatment zones will form, including a sludge zone on the bottom of the tank, a clear water zone in the middle, and a scum layer on the top of the tank. Figure 3.18 shows the typical configuration of a dual chamber septic tank. In China a pre-fabricated concrete or fiberglass three-chambered septic tank is a common primary treatment system, as shown in Figure 3.19.

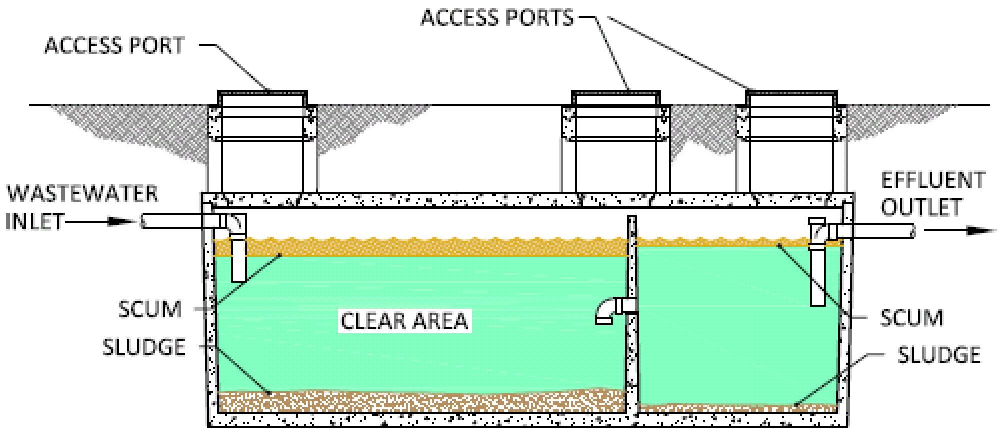


Figure 3.18. Dual Chambered Septic Tank

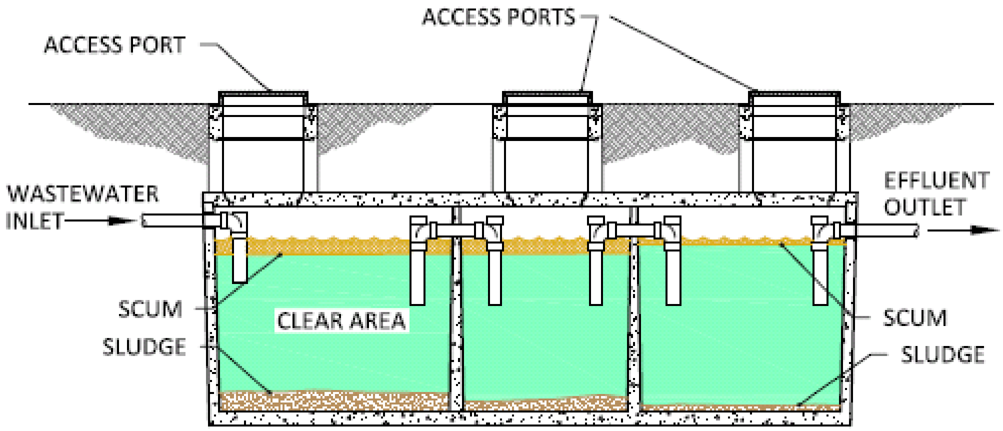


Figure 3.19. Three chambered Septic Tank

Anaerobic Baffled Reactors (ABRs). ABRs are upgraded septic tanks which aim to enhance the removal efficiency for non-settleable and dissolved solids. Similar to septic tanks, ABRs are based on a physical treatment (*settling*) and a *biological treatment*. An ABR consist of a tank and alternating hanging and standing baffles that compartmentalise the *reactors* and force liquid to flow up and down from one compartment to the next, enabling an enhanced contact between the fresh *wastewater* entering the *reactor* and the residual *sludge*,

containing the *microorganisms* responsible for *anaerobic digestion* of the *organic* pollutants. The compartmentalised design separates the *solids retention time* from the *hydraulic retention time*, making it possible to anaerobically treat *wastewater* at short retention times of only some hours. The baffled design of the ABR ensures a high solids retention resulting in high treatment rates, while the overall *sludge* production is characteristically low. They are simple to build and simple to operate, as well as very robust to hydraulic and *organic* shock loading. Yet, both *sludge* and *effluent* still need further treatment.

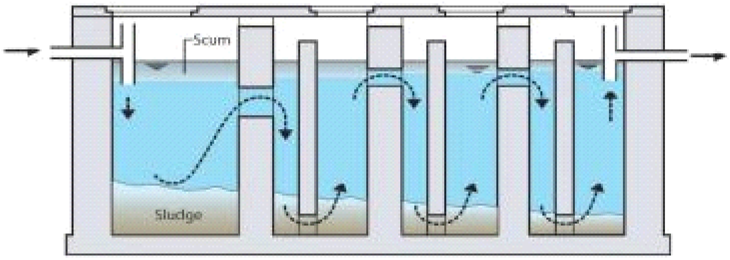


Figure 3.20. Schematic Cross-Section of Up-Flow Anaerobic Baffled Reactor *(*ABR)
(Morel & Diener, 2006)

Upflow Anaerobic Sludge Blanket Digester (UASB). A UASB is an advanced design mechanized anaerobic treatment process that can provide a higher level of treatment removing 65% to 85% suspended solids and 50% to 70% BOD. UASB systems are more sensitive to temperature and may not be an appropriate technology in certain regions of China. The anaerobic processes of the UASBs form a granular sludge blanket in the main digester compartment. Wastewater flows upwards through the blanket and is treated by anaerobic microorganisms. The tank is also configured to concentrate the biogas in a collector in the middle of the tank and water flows to the outside. The advantage of the UASB is that it can achieve a higher level of BOD removal compared to other primary treatment systems, so that the aeration requirements in subsequent aerated treatment processes can typically be cut in half, leading to substantial energy savings if mechanized aerated treatment is used. Figure 3.21 shows the configuration of a UASB system.

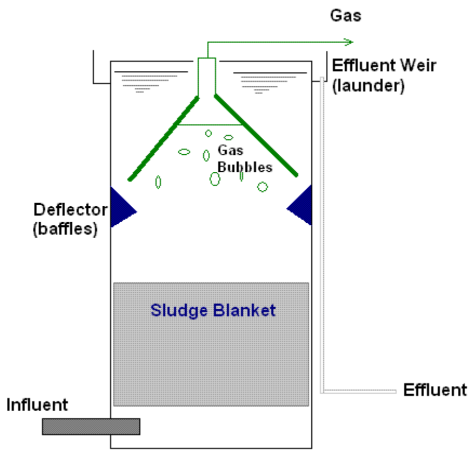


Figure 3.21. Upflow Anaerobic Sludge Blanket Digester

Anaerobic Lagoons. An anaerobic lagoon is a simple treatment system and is a deep impoundment essentially free of dissolved oxygen that promotes anaerobic conditions. Anaerobic lagoons are not aerated, heated, or mixed. The typical depth of an anaerobic lagoon is greater than three (3) meters. Anaerobic ponds can achieve up to 60% BOD removal. They are designed to have detention times of 1 to 2 days in warm climates. Because the anaerobic process is sensitive to temperature this treatment scheme is generally not applicable in areas where temperatures drop below 15°C during the winter. Anaerobic ponds are often used in combination with other ponds (facultative and oxidation ponds) to provide additional treatment as shown below. Figure 3.22 shows the configuration of an anaerobic pond.

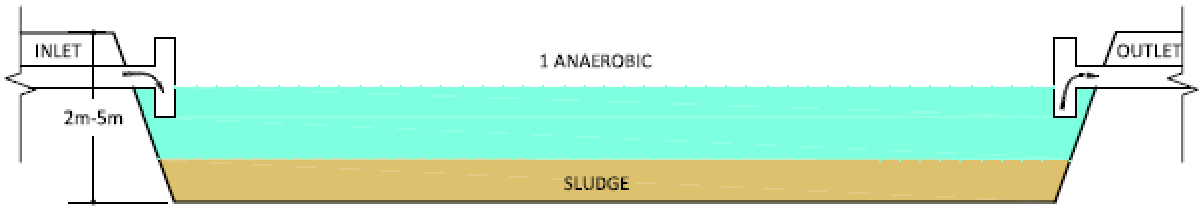


Figure 3.22. Anaerobic Lagoon

3.5.2.3**.** Secondary Treatment

Secondary treatment processes are used to further process the wastewater by removing organic matter and in some instances to reduce nitrogen. Common secondary treatment systems include attached growth filters, suspended growth systems (activated sludge), waste stabilization ponds.

Attached Growth Filters

Attached growth wastewater treatment processes are biological treatment systems that utilize an inert media or substrate that support microorganisms that remove the organic matter from the wastewater. In contrast, systems in which microorganisms are sustained in a liquid are known as suspended-growth processes. Attached growth systems can be designed in various configurations and are typically aerobic processes. The biggest difference between the different attached growth systems is the type of substrate utilized, which can include "engineered media" that has a specific surface area to air ratio commonly used in trickling filters, or sand, gravel and textile media used in packed-bed filters. Attached growth filters are effective treatment systems that generally require relatively low energy inputs and small land area for the installation. The following sections describe several attached growth filters that would provide appropriate technology in rural villages in China.

Trickling Filters. Trickling filters (TFs) are used to remove soluble organic matter from wastewater. A multi-stage TF system can also be used to nitrify ammonia in the wastewater for enhanced treatment and nitrogen removal. The TF is an aerobic treatment system that utilizes microorganisms attached to a medium to remove organic matter from the wastewater. This type of system is common to a number of technologies, such as rotating

biological contactors and packed bed reactors. The advantages of the TF systems are that they are simple, reliable, biological, low energy, appropriate for small and medium-sized communities, compact and therefore require small area for installation, cost-effective with relatively low capital cost, and can meet secondary standards. TFs require a moderate level of skill and technical expertise to manage and operate the system. Figure 3.23 shows a typical TF used for small community wastewater treatment employing a static spray nozzle distribution system.

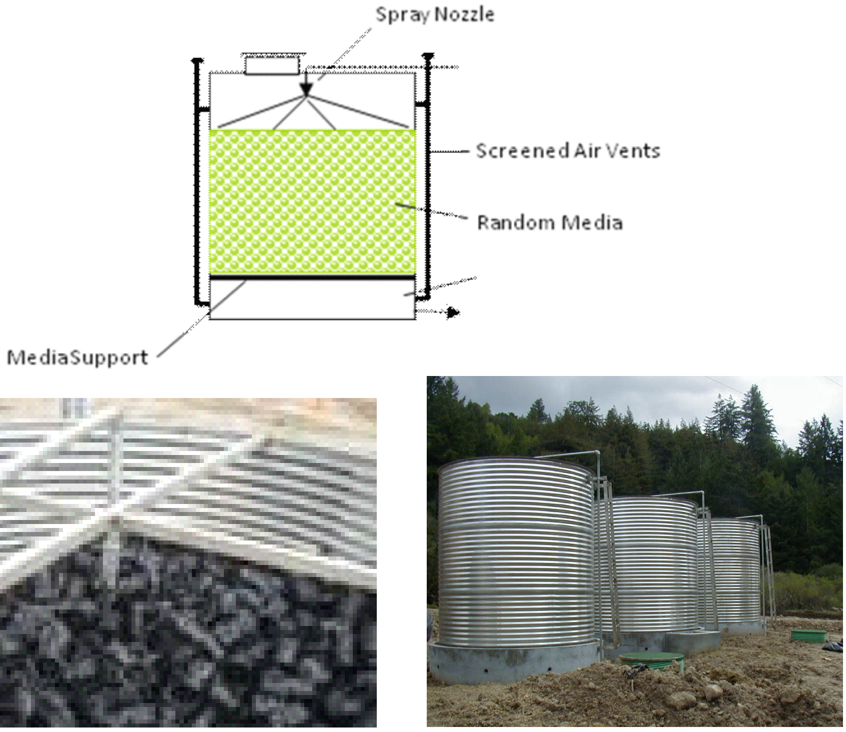


Figure 3.23. Trickling Filter System

Sand Filter Systems. Sand filters utilize a 24 to 3-inch deep filter bed to treat the wastewater. A sand filter can be designed as a single pass (or intermittent) or recirculating filter design. The primary difference between these two systems is the size of the sand media; however, in both cases, well graded and clean sand is critical to the operation and maintenance of the system. Sand filters are typically built below grade in an excavated and lined basin. Sand filters can achieve high BOD and suspended solids reduction, commonly less than 10 mg/L, and good reduction of pathogens. Sand filters may require some electrical energy if designed as a recirculating filtration system, do not require chemicals, and can be expanded through modular design to increase the treatment capacity. The construction costs are moderately low and costs are highly dependent on the availability of a good source of sand. The systems require expert design and construction supervision and a moderate skill level for routine operation and maintenance. Sand filters can be prone to clogging. Figure 3.24 shows the layout of an intermittent sand filter system

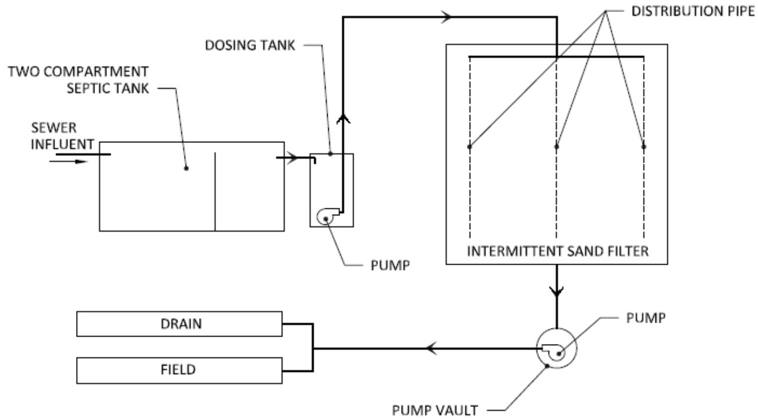


Figure 3.24. Intermittent Sand Filter System

Suspended Growth or Activated Sludge (Aerobic Treatment Units)

An aerobic treatment unit (ATU) treats wastewater by adding air to break down organic matter, reduce pathogens, and transform nutrients. By bubbling compressed air through liquid effluent in a tank, ATUs create a highly oxygenated (aerobic) environment for bacteria, which uses the organic matter as an energy source. In an ATU, the bubbler agitates the water so solids cannot settle out, and floating materials stay mixed in the liquid. In another stage, bacteria and solids settle out of the wastewater and the cleaner effluent is discharged to the final disposal system or filtered and reused for a beneficial purpose. Well-designed ATUs allow time and space for settling while providing oxygen to the bacteria and mixing the bacteria and its food source (sewage). Any settled bacteria must be returned to the aerobic portion of the tank for mixing and treatment.

There are three basic ATU operation styles: suspended growth, fixed-film reactor, and sequencing batch reactor. *A suspended-growth system* has a main treatment chamber where bacteria are free-floating and air is bubbled through the liquid. The second chamber where the solids settle out is separated from the main tank by a wall or baffle. The two chambers are connected at the bottom or by a pump, and settled bacteria from the second chamber are brought back into the main treatment chamber. This return and mixing is critical for proper operation. Though simple, the system can be prone to have problems with bulking (the formation of chains or colonies of bacteria that don't settle or sink to the bottom as they should). Bulking is caused by changes in wastewater strength or quantity. When too much water/wastewater is added to the system, the bacteria can run out of food or become overloaded. Bulked bacteria remain suspended in the liquid and can clog the outflow. Figure 3.25 shows the general configuration of a standard ATU system.

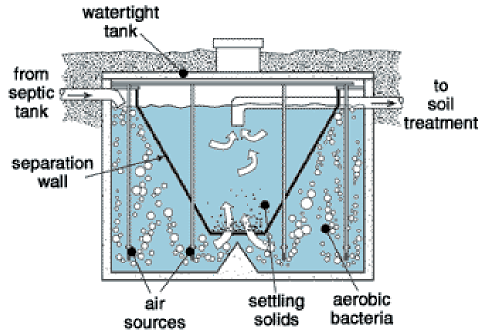


Figure 3.25. Aerobic Treatment Unit (ATU)

A *fixed-film reactor* has bacteria growing on a specific surface medium and air is provided to that part of the tank. The bacteria can grow on any surface including fabric, plastic, Styrofoam, and gravel. Decomposition is limited to this area, and settling occurs in a second chamber. Figure 3.26 shows the layout of a fixed film ATU system.

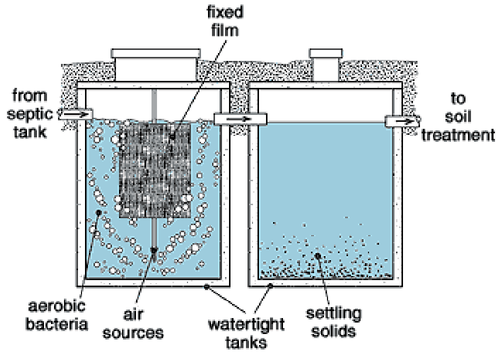


Figure 3.26. Fixed Film ATU

In a *sequencing batch reactor (SBR),* aerobic decomposition, settling, and return occur in the same chamber. Air is bubbled through the liquid during the decomposition cycle. The bubbler shuts off, and the wastewater goes through a settling cycle. Once the bubbler turns back on, the tank reenters the decomposition cycle, and settled bacteria mixes back into the aerobic environment. After settling of bacteria and solids, the treated effluent is discharged to the disposal system or filtered and reused. Figure 3.27 shows the operation of a SBR system.

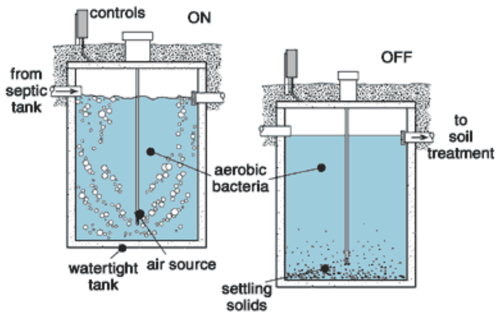


Figure 3.27. Sequencing Batch Reactor (SBR)

ATUs are usually compact and require a small area for installation. Energy demand and costs are substantially higher than an attached-growth or land-based treatment system. Some systems can produce odors that need to be managed if the system is located in close proximity to the village or residences. These systems can be relatively noisy due to blowers running. ATUs routinely meet secondary treatment requirements. Sludge management is

critical to the operation of the system. Capital cost for these treatment systems is quite variable and moderately priced compared to other systems. These systems can be labor-intensive and require a semi-skilled operator.

Waste Stabilization Ponds (WSPs)

WSPs are large, constructed basins that are effective in treating wastewater and can reduce BOD and SS to the same levels as mechanical treatment plants (e.g. Activated Sludge Treatment). The ponds are filled with wastewater that is then treated by naturally occurring processes. Additionally, because of the longer residence time of wastewater in the lagoon (days), removal of pathogenic bacteria and viruses by natural die-off is greater than in an activated sludge treatment plant (residence time usually several hours). Cysts of parasites and helminth eggs are also usually removed through sedimentation in the lagoons. There are three common types of ponds, (1) anaerobic, (2) facultative and (3) aerobic (maturation), each with different treatment and design characteristics. For the most effective treatment, WSPs should be connected in a series of three or more ponds from the anaerobic pond to the facultative pond, and finally the aerobic pond as shown in Figure 3.28.

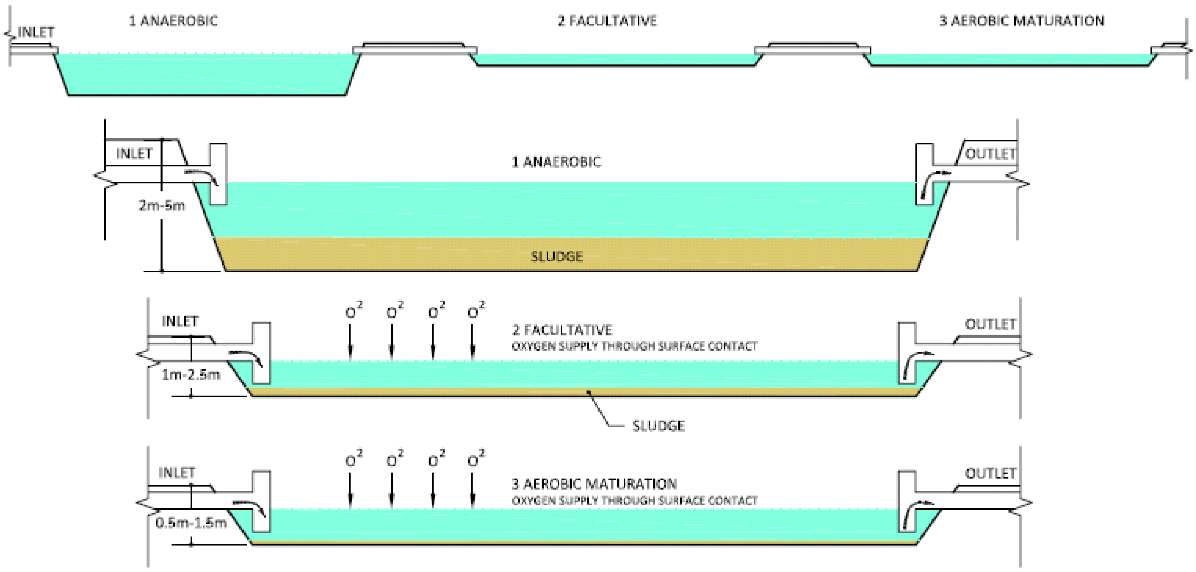


Figure 3.28. Multi-Pond Waste Stabilization System (After Tilley, 2008)

A lagoon is a shallow excavation in the ground (1 to 2 m deep). Depending on the native soil conditions, a pond/lagoon is may need to be lined with a layer of clay or with an impermeable plastic membrane to reduce infiltration if protection of groundwater is desired. Wastewater lagoons are also called 'waste stabilization lagoons', because the organic substances in the wastewater are converted to more stable (less degradable) forms. Lagoon performance is affected by temperature. At a higher ambient temperature (e.g. in the tropics) a shorter residence time of wastewater in the lagoon is required to achieve the same level of treatment compared to when the temperature is lower. Oxygen transfer from the atmosphere into lagoons can be increased by mechanically agitating the surface of the water. Using a vertically mounted impeller can increase the oxygen transfer, and the lagoon becomes more like the aeration tank of an activated sludge process.

WSPs can achieve a high reduction in pathogens, can be built and repaired with locally available materials, have a low operating cost, generally do not require electrical energy, and do not have problems with flies or odors, if designed properly. These systems require expert [illegible] nd, and require [illegible] nown in Figure 3

Figure 3.29. Waste Stabilization Pond System - Anaerobic and Facultative pond (Nicaragua, Central America)

Plant-Based Treatment Systems

Plant-based treatment systems include secondary or tertiary level treatment processes that incorporate living plants to provide advance treatment of the water to reduce the BOD, nutrients, pathogens, and other potential pollutants. All of these systems require that the wastewater be pretreated prior to discharge to the system to avoid overloading the system with too much organic matter. These types of systems generally include: free-water surface constructed wetlands, horizontal or vertical flow vegetated gravel bed (subsurface flow wetlands), and floating plant ponds.

Free-water surface (FWS) constructed wetlands are designed to replicate natural wetlands combining both emergent and submerging plants to create both shallow and deep zones providing both anaerobic and aerobic zones to treat the wastewater. By creating different zones and different plant types, a FWS wetland can achieve very high levels of treatment and provide several ancillary benefits, including recreational areas, wildlife habitats, and water features. A properly designed FWS wetland can achieve a high reduction in BOD and pathogens, can be built with locally available materials, does not require electrical energy, has low operational requirements, and if not overloaded, a FWS wetland will not have odor or vector nuisance problems. These systems generally require expert design and construction supervision, take up to a year for plant establishment, and require large land area. Plant material can be selected and grown as a value added product for floraculture, animal feed, or other agricultural based products. A FWS constructed wetland is shown in Figure 3.30.

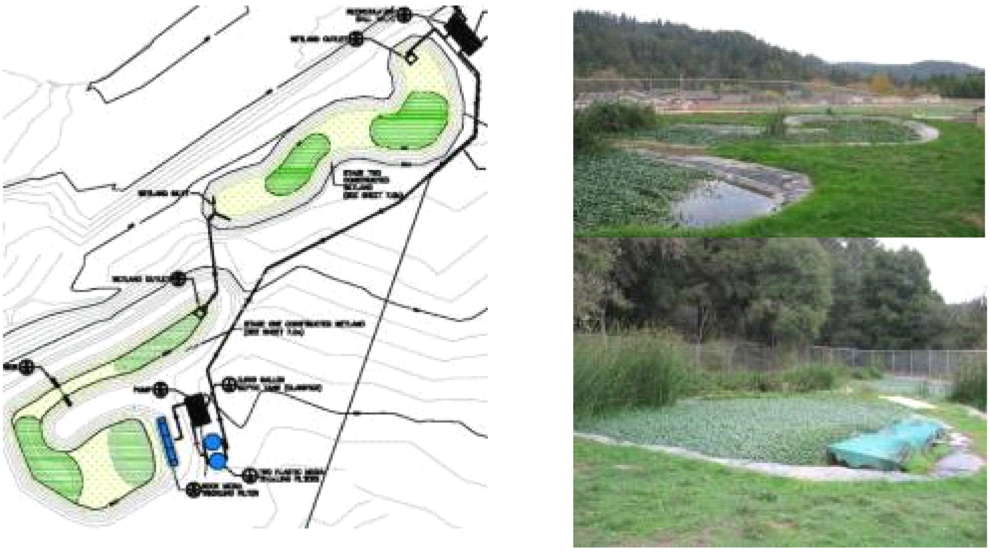


Figure 3.30. Free-Water Surface Water Wetland System

Vegetated gravel bed (VGB) (subsurface wetland) is a large gravel and sand-filled basin that is planted with aquatic vegetation. As wastewater flows through the basin, the gravel and sand filter the water and microorganisms degrade organics in the wastewater. These systems are anaerobic processes that can effectively reduce the BOD and total suspended solids in the water, but are not effective at reducing nutrients or pathogens. The VGB can be built with locally available materials, does not require electrical energy, and does not require a highly skilled operator to be maintained. These systems are relatively expensive due to the cost of clean sand and gravel that is fundamental to the system, are prone to clogging within a relatively short period, require a large area for installation, and require expert design and supervision for construction. Plant material can be selected and grown as a value added product for floraculture, animal feed or other agricultural based products. A VGB subsurface wetland is shown in Figure 3.31.

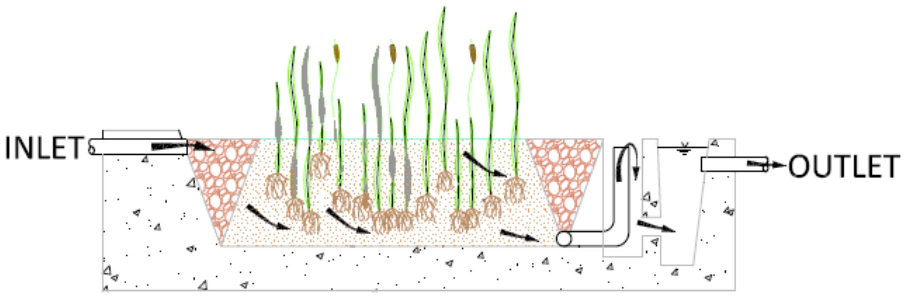


Figure 3.31. Vegetated Gravel Bed (Subsurface Flow Wetland)

Floating Plant Pond is a modified aerobic pond with floating (macrophyte) plants. Plants such as water hyacinths or duckweed float on the surface while the roots hang down into the water to uptake nutrients and filter the water that flows by. These systems can provide high reductions in BOD, TSS and nitrogen. They have a low to moderate capital cost, require expert design and construction supervision, require large land area, but they can be built with locally available materials and labor. Plant material can be selected and grown as a value added product for animal feed or other agricultural based products. A Floating Plant Pond is shown in figure 3.32.

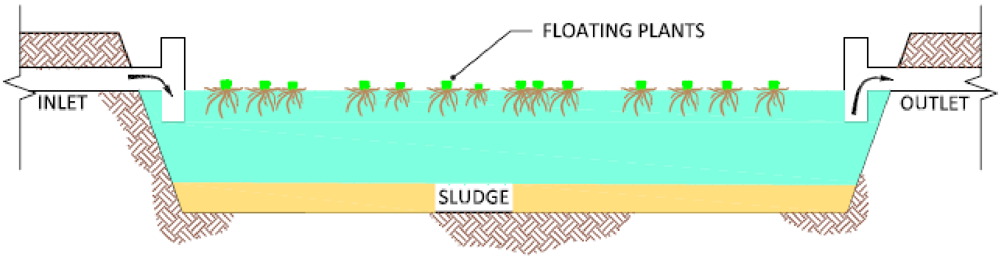


Figure 3.32. Floating Plant Treatment Unit

3.5.3. Subsurface Disposal Systems

3.5.3.1. General System Requirements

Subsurface disposal systems are simple, stable, inexpensive, and protect public health and the environment. They are usually considered to be the best method for treating and dispersing effluent from on-site wastewater treatment systems and small village treatment systems. In many areas local residents and health officials are familiar with these disposal systems and understand their advantages and their potential limitations.

As the wastewater percolates or moves down through the soil, a variety of complex physical, biological, and chemical processes combine to provide additional treatment. Particles in the wastewater are filtered by, adhere to, or chemically bond or react to the soil. Bacteria and other organisms in the soil consume the residual organic matter in the wastewater and perform most of the treatment. Although some treatment may also occur in the gravel layer, most of the work is accomplished in the soil. As a drainfield matures, organisms in the wastewater and soil multiply and form a dark layer called the biomat on or near the infiltrative surface. The biomat is a miniature ecological system. If oxygen is present, organisms such as worms and parasites feed on the bacteria as well as material in the wastewater. The biomat is also where most pathogen removal occurs. When the drainfield system is in balance, these organisms prevent the biomat from becoming so thick that it clogs the system completely and allow the wastewater to flow through the soil below at a slow, but steady rate. The biomat also aids the treatment process in medium and coarse soils by maintaining unsaturated conditions in the soil layers below the drainfield and above the groundwater.

There are various subsurface disposal systems that are well suited for small village wastewater systems. The selection of the most appropriate system depends on several site specific factors including the type and condition of the soils, depth to groundwater and

bedrock, slope and stability of the land, and presence or proximity of any potential geologic hazards (primarily landslides).

Safety Distances to Natural and Manmade Features. It is important to maintain adequate distances from overly steep slopes, landslides, and/or shallow groundwater and bed rock. It is also important to maintain minimum distances from manmade features, including water supply wells and springs, waterlines, and building foundations. Typical minimum distances adopted in the United States and Canada is summarized in Table 3.2 below.

Table 3.2. Recommended Minimum Distances of Rural Wastewater Systems

Minimum Distance Required From:	Building Sewer	Wastewater Treatment System	Wastewater Disposal System
1. Building and structures	0.6 m	15 m	15 m
2. Water supply wells	25 m	50 m	50 m
3. Surface water sources (streams, rivers, lakes and springs)	15 m	50 m	50 m
4. Domestic water lines	3 m	3 m	3 m
5. Large trees	5 m	4 m	5 m
6. Steep slope (>50%)	2 m	30 m	30 m

Soil and Groundwater Investigation. Before a subsurface disposal system is selected and designed, a soil and groundwater investigation should be conducted to determine that the area selected for the system has suitable conditions. An experienced soil or civil engineer should conduct the soil investigation. The investigation should include the characterization and testing of soils to determine the adsorptive capacity of the soils in the area of the proposed disposal system. The investigation should assess shallow groundwater conditions and identify any potential geohazards, such as, landslides, which need to be avoided. Based on the results of the investigation, a subsurface disposal system can be selected and designed.

System Redundancy and Expansion Areas. All subsurface disposal systems should be sized to accommodate at least 200% of the daily average wastewater flow to the system. The system should also be divided into different zones so that only a portion of the zones are operating at one time and the zones not in operation are allowed to rest. Typically, the disposal may be divided into several zones, such as four zones that can each accommodate 50% of normal flows. During normal operation, only two zones would be in operation at a time, for example for a period of three to six months, and then the next set of zones are turned on and the zones that were in use are allowed to rest for the same period. The mode of operation will prolong the life of the disposal system and keep it from clogging up

too fast. For long-term planning it is also important for a community to set aside an area for future expansion or replacement of the disposal system, in the event the installed system fails or cannot effectively accommodate all of the water.

Subsurface disposal systems can be designed in different configurations. They can operate under gravity if there is sufficient fall or elevation difference between the treatment system and the disposal site, or using a small dosing pump system to pressurize the disposal system. The type of subsurface disposal system is usually selected based on the soil, groundwater and topographic conditions found at a site. The following is a list of the most common type of subsurface disposal systems:

- Gravity trench drainfield
- Pressure dosed trench drainfield
- Mound or filled disposal system
- Gravelless trench system
- Irrigation (Surface and Subsurface drip dispersal systems)

3.5.3.2. Gravity Trench Drainfield

A gravity trench drainfield consists of a number of trenches connected in parallel. Each trench consists of a 100mm perforated pipe that is laid on a trench filled 1-meter depth of 20 mm to 50 mm drain rock. About 30 cm of rock covers the distribution pipe and this layer of rock is covered by a 10 cm layer of straw or layer of geotextile fabric to prevent small particles from plugging the pipe. A final layer of topsoil covers the fabric and fills the trench to ground level. Treated effluent from the treatment system flows via gravity to a distribution box(s) that distributes the flow equally to each trench. If the soil conditions are good, a drainfield receiving treated wastewater should have a 20 to 30 year life span. The capital cost and operational costs are low. They generally require an expert to evaluate soils, design the system and supervise the construction. In sandy soils or areas of high groundwater, the long-term use of drainfields can impact groundwater quality. Figure 3.33 shows a typical detail of a gravity trench drainfield.

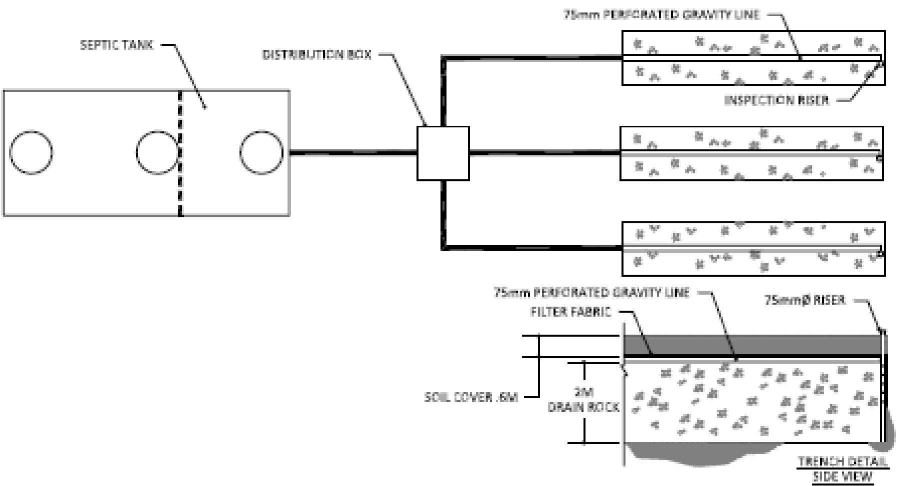


Figure 3.33. Gravity Flow Drainfield System

3.5.3.3. Pressure Dosed Drainfield

A pressure dosed drainfield is similar to a gravity flow drainfield with the exception that a small dosing system pumps the effluent under pressure into the drainfield. The pressure dosed pipe typically has a smaller diameter and smaller perforations than the gravity trench drainfield pipe. A timer usually controls the dosing cycle or number of time the drainfields receive effluent (usually 4 to 8 times per day). A pressure dosed drainfield system is superior to a gravity flow system because it ensures that the whole length of trench is utilized and that aerobic conditions are allowed to recover between dosings. A pressure dosed drainfield will have a 20 to 30 year lifespan, should be designed by an expert, and have relatively low capital and operational costs. Figure 3.34 shows a typical detail of a pressure-dosed drainfield.

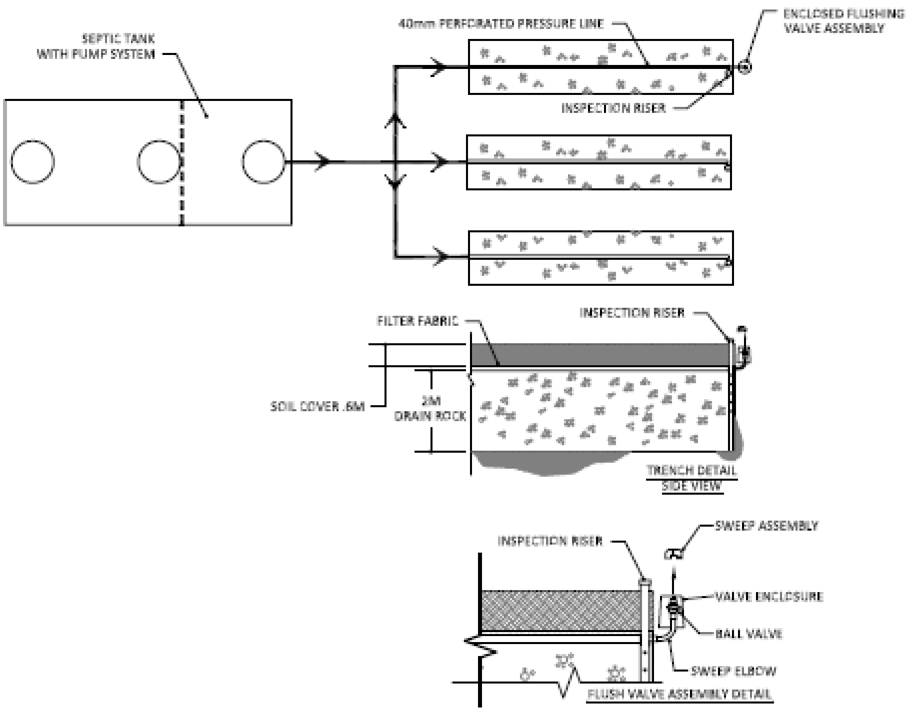


Figure 3.34. Pressure-Dosed Drainfield System

3.5.3.4. Evapo-transpiration (ET) Mound

In areas where the water table is near the surface or the soil percolation capacity is insufficient, an evapo-transpiration (ET) mound can be substituted for a conventional drainfield. A typical ET mound consists of a sand bed that is approximately 9 mts wide and 12 mts long or larger. The sand bed is approximately 0.6 meters deep. A 0.40 meter deep rock bed is installed on top of the sand bed that is 3 meters wide and three perforated pipes are laid out over the rock. The pipe is covered with 0.1 meters of rock and the rock is covered by a layer of straw or geotextile fabric. The entire mound is than covered with 0.15 meters of topsoil and is seeded with grass. An ET mound system will generally have a 20 to 30 year life span; however, the capital cost to install these systems, particularly for large villages, is expensive because clean and washed sand and rock is essential in their

construction. A trained expert should design an ET mound system. A typical mound system is shown in Figure 3.35.

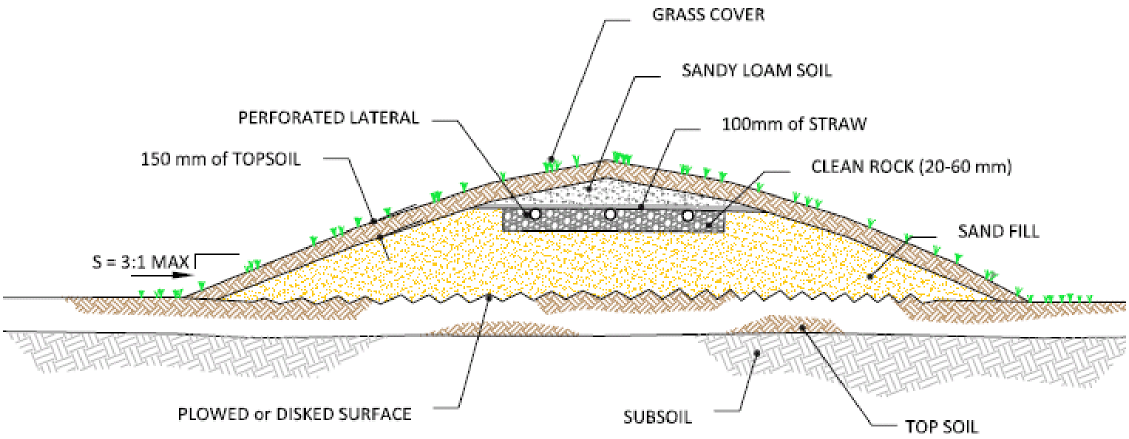


Figure 3.35. Evapo-Transpiration Mound System

3.5.3.5. Gravelless and Chambered Drainfield Systems

As the name suggests, a gravelless system is a subsurface disposal system that does not use gravel in its drainfield trenches. Instead, these systems may use alternative materials in place of gravel, such as rubber, sand, fiber membrane, plastic, glass, or expanded clay, shale, or polystyrene foam chips. The alternative media in gravelless systems can function similarly to gravel. It can support the sidewalls of the drainfield trenches and prop up the perforated drainfield pipes so they do not lie directly on the soil and clog. When soil is saturated from the weather or surge wastewater loadings occur, the effluent can be stored in the trench until the soil absorbs it. Like gravel, the alternative media can also help to distribute the wastewater along the length of the trenches.

Chamber systems, sometimes called leaching chambers, are a type of gravelless drainfield becoming increasingly popular. A *chamber* refers to the open-bottomed pipe used in these systems. They are commercially available and usually constructed of high-density plastic. Chambers also may be constructed of fiberglass, block, or brick. The chambers are molded into a dome-like shape. Their design usually is proprietary and manufacturer recommendations should be followed regarding system design, installation, operation, and maintenance. Figure 3.36 shows a detail of the gravelless and chambered drainfield systems.

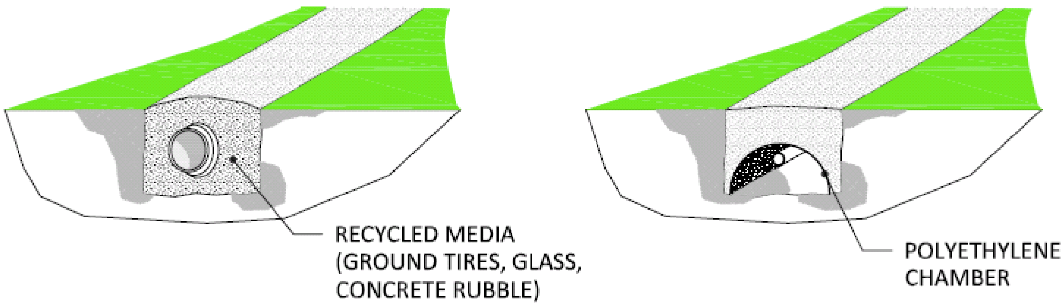


Figure 3.36. Gravelless and Chambered Drainfield Systems

3.5.4. Irrigation/Water Reuse

To reduce dependence on freshwater and to maintain a constant source of irrigation water throughout the year, treated wastewater can be used as a reliable source of irrigation water to a wide variety of crops. Generally, only water that has received secondary treatment (i.e. physical and biological treatment) should be used, to limit the risk of crop contamination and the health risk to farmers and consumers. There are two commonly employed irrigation techniques for the reuse of treated wastewater, including drip irrigation where the water is dripped slowly on or near the root zone of the plant, and surface water irrigation where water is routed overland in a series of dug channels or furrows. To minimize evaporation and contact with pathogens, spray irrigation is not recommended unless the water has received additional treatment (i.e. filtration and disinfection). Reusing properly treated water for crop irrigation can significantly reduce dependence on freshwater, and/or improve crop yields by supplying increased water and nutrients to plants.

Generally, surface and subsurface drip irrigation is the most appropriate irrigation method for reusing treated wastewater. The control and management of the water is easier and safer with a drip system and reduces the potential exposure of pathogens to the farmers.

Crops such as corn, alfalfa, fibers (cotton), tobacco, fruit trees, and foods requiring processing (sugar beet) can be grown safely with treated effluent. More care should be taken when growing fruits and vegetables, such as tomatoes, lettuce and others that could come into contact with the water or with crops where the root is consumed, such as carrots or potatoes. Energy crops like eucalyptus, poplar, willow, or ash trees can be grown in short-rotation and harvested for biofuel production. Since the trees are not for consumption, this is a safe, efficient way of using treated effluent.

3.5.5. Sludge Management

Coarse primary solids and secondary biosolids accumulated in a wastewater treatment process must be treated and disposed of in a safe and effective manner. Primary solids are typically treated in the primary anaerobic digesters, such as a septic tank or UASB system. The digestion of the sludge is important to reduce the amount of organic matter and the number of disease-causing microorganisms present in the solids. Once digested, the sludge can be removed from the digester and either managed on-site or hauled away as septage to a regional treatment plant. In regions where farmers rely on nightsoil as a source of fertilizer for their crops, collecting sewerage in a centralized system may deprive them of a valuable resource.

3.5.5.1**.** On-site Sludge Management

The on-site management of sludge is a feasible and cost effective method for rural villages. Sludge drying beds are the most common and easily managed method for sludge drying and treatment. A sludge drying bed is a simple, permeable bed that, when loaded with sludge,

collects percolated leachate and allows the sludge to dry by evaporation. Approximately 50% to 80% of the sludge volume drains off as liquid back to the treatment plant. A drying bed system usually includes at least two drying beds, used alternately to make sure the solids are adequately dried and stabilized before the sludge is removed. The bottom of the drying bed is lined with an impermeable liner or concrete, and has a perforated pipe on the bottom to collect and convey leachate back to the treatment works. Figure 3.37 shows the typical layout of a sludge drying bed system. Above the pipes are layers of gravel and sand that support the sludge and allow the liquid to drain freely to the underdrain pipe. When the sludge is dried it can be removed and used as an organic soil additive or added to compost for additional treatment and as a bulking material. In urban settings biosolids can contain elevated levels of heavy metals and other contaminants. In most rural settings the sludge should not contain metals or contaminants unless cottage industries in the villages produce potentially toxic wastes that enter into the wastewater stream. In this latter case the village must decide if sludge is safe to use soil amendment. In cold and/or wet regions, the sand bed can be either installed in an enclosure or under a roof to minimize inundation from rainfall.

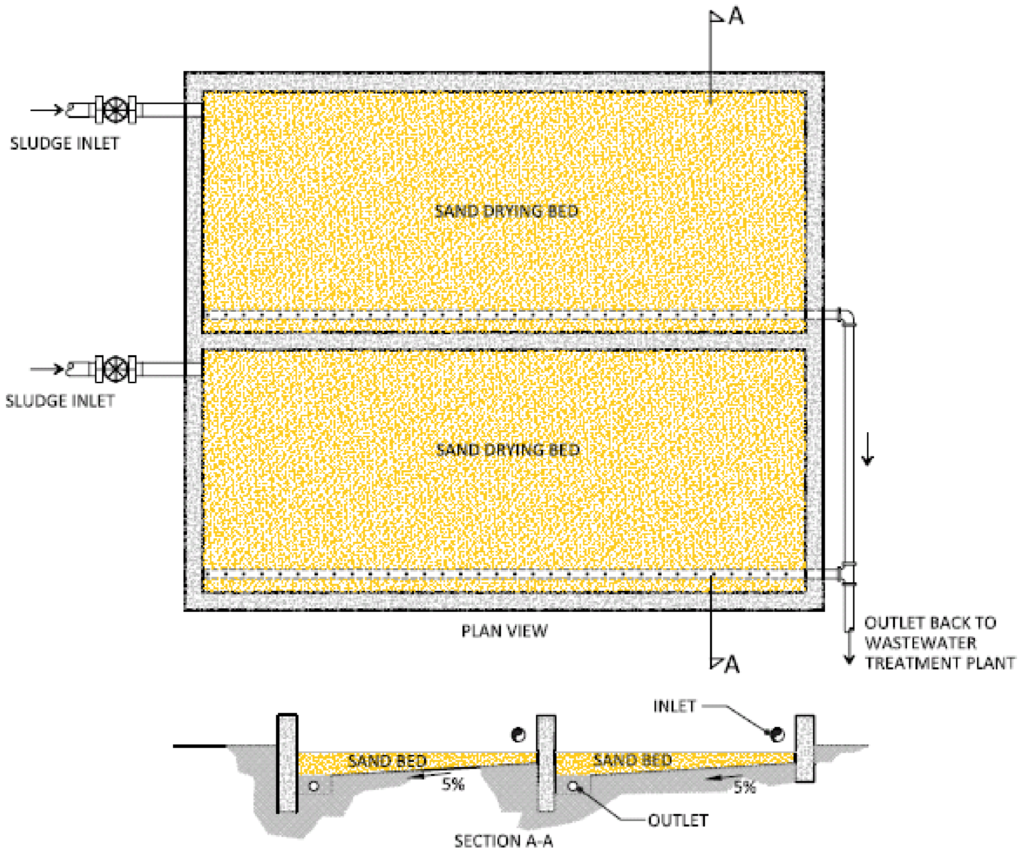


Figure 3.37. On-site Sludge Drying Bed

3.5.5.2. Off-site Sludge Management

Many villages may choose to have the sludge hauled away by pump trucks to a regional treatment facility. When sludge is hauled away it is commonly referred to as septage, which has a variable quality that is highly organic with significant levels of grease, grit, hair and debris. A haul-away system usually relies on a vacuum truck or another vehicle equipped with a motorized pump and a storage tank for emptying and transporting septage to a

regional treatment facility. If this haul-away system is going to be utilized, it is critical that the treatment system be located and designed so that a vacuum truck can access the site.

This approach is fast and generally an efficient mode of management and provides an essential service to unsewered areas. The initial capital and long-term operation and maintenance costs are high due to the specialized equipment. Additional costs depend on the distance between the village and the regional treatment facility. Accessibility is very critical because most vacuum pumps can only suck down tanks that are 2 to 3 meters deep and need to be able to approach within 30 meters from the tank to be pumped. Incentives may be needed for septage haulers so that deposit the sludge at the designated site rather than the nearest river or ravine.

> Box 3.1. The Ningbo New Countryside Development Project criteria for selecting an on-site sanitation system versus a centralized sewer collection system was based on the distance between each home. If the space between each home was greater than 50 meters, then an on-site sanitation system was required.

3.6. Selection Criteria for Sanitation Options

As outlined in the previous sections there are a variety of sanitation technologies that can be employed in a rural village. In order to select the most appropriate approach or technology several factors and their influence on technology need to be considered. The key factors include: (1) water supply service level; (2) housing density; (3) soil and/or groundwater conditions; (4) wastewater flows; (5) water resource protection; (5) land availability; (6) climatic factors; (7) financial constraints: costs versus ability and willingness to pay; (8) user preferences, and lastly (8) institutional constraints.

3.6.1. Water Supply Service Level

Village water supply systems can include simple hand-carried supplies, yard taps or internal plumbing. It has been found that when neighborhood standpipes are installed water use averages20 to 25 liters per capita per day. When a yard tap is provided, water use increases to 50 liters per capita per day, and when water is supplied to internal plumbing inside the house, water use can increase to 50 to 100 liters per capita per day (Kalbermatten et al., 1982).

Hand-Carried Supplies. A household that is reliant on a hand carried supply of water is unlikely to have sufficient water available to use a water-based sanitation system, such as a pour-flush or cistern-flush toilet. Ecological sanitation, dry toilets, ventilated improved pit (VIP) latrines, or double pit composting toilets are more appropriate technologies in these settings.

Yard Taps. Having a water supply available at each yard will allow for a pour flush latrine to become a feasible option. If wastewater generation exceeds 50 liters per capita per day, sewered pour flush toilets and kitchen sinks are also feasible options.

In-house Plumbing. Once a house has internal water supply internal fixtures, such as cistern-flush toilets or bath and kitchen sinks, showers are commonly installed in the home and water usage increases. Once this level of service is achieved in a village, the need for higher capacity sanitation is required and may include installing individual septic tanks and drain fields or soakaways, or eventually installing a community sewer system.

3.6.2. Housing Density

A key aspect to selecting what type of sanitation technology is appropriate is to determine whether or not there is sufficient space on the plot to install an on-site sanitation system. If the plots are too small and tightly packed together then a community sewer system may be more appropriate. On-site systems may be appropriate with population densities less than 250 to 300 persons per hectare. At higher densities, a clustered or community sewer system may be more appropriate. In the United States, local health agencies generally restrict on-site systems to two homes per 0.4 hectares. Three or more homes per 0.4 hectares are usually required to be served by a clustered or central wastewater system.

3.6.3. Soil and Groundwater Conditions

As previously discussed, soil and groundwater conditions need to be adequately assessed to determine the most appropriate sanitation technology for a rural village. In areas where the soil and groundwater are suitable, and there is sufficient space, an on-site sanitation technology may be the least-cost and most appropriate solution for the village.

In other locations, the soil and groundwater conditions may not be suitable for subsurface disposal systems or an on-site solution. In these areas above-ground pit latrines, such as the UDDTs, may be an appropriate and cost effective solution. In some instances, a centralized solution may be appropriate to collect and convey the wastewater to a treatment and community disposal system that can be installed in an area where more suitable soil or groundwater conditions exist.

3.6.4. Wastewater Flows

The type and level of wastewater treatment may depend on the size of the community, the water supply, and the corresponding volume of wastewater generated. For example a small community that produces less than 50 cubic meters per day (m^3/d) of wastewater could employ a simple two-stage anaerobic digester system to treat the wastewater. For larger communities that generate over 50 m^3/d of wastewater, an enhanced wastewater treatment system should likely be employed that includes both primary and secondary treatment processes.

3.6.5. Water Resource Protection Zones

Many rural villages are located in sensitive water supply watershed areas. These areas are commonly referred to as water resource protection zones. In order to protect these sensitive zones, enhanced wastewater treatment systems are required to protect water

quality. In Ningbo, China enhanced wastewater treatment (primary and secondary treatment) is required when flows exceed 10 m^3/d. When flows are less than 10 m^3/d simpler, two-stage anaerobic digesters can be used before the treated water is discharged to a constructed wetland and then to a subsurface disposal system.

3.6.6. Land availability

Another significant factor is the availability of land to construct either an on-site or central village sanitation system. In many villages, most land is used for agricultural, aquaculture, and housing. To construct a central treatment and disposal system may require that some land be converted from agricultural use to a wastewater management system. Although land not suitable for other uses may be well suited for constructing a wastewater treatment system. If land availability is a significant constraint, a more mechanized and compact wastewater treatment system may be required to minimize the conversion of land. However, in some instances, constructed wetlands or a combination of a mechanized wastewater system and constructed wetlands may be appropriate. Also, wetland systems can be designed to grow an agricultural product, so that the project will not significantly reduce the agricultural production in the village.

It is also important to keep in mind that acquiring large land lots for wastewater management may become more difficult for rural villages in the future. Therefore, to secure larger land areas initially and employing a natural treatment system, such as ponds or wetlands, may be a useful strategy. In the future, if the village population were to expand, the village would have land available to upgrade or modify the wastewater treatment and/or disposal system to accommodate the larger community. This form of land banking is a very important consideration for villages, particularly for villages located in per-urban regions that may be experience significant economic growth. Tied to this strategy is the fact that land value over time will likely appreciate, so a village that can secure several hectares of land to construct a land based (pond/wetland) treatment system initially, will find that the land value will be higher after 20 or 30 years, which may be valuable to the village for other future uses. In contrast to this when a village opts to install a small and compact mechanized plant on a small area of land when the plant serves its useful life (20 to 30 years) the overall value of the project will have depreciated significantly and the village may not have sufficient land secured to expand or replace the treatment works.

3.6.7. Socio-Cultural Factors

There are several socio-cultural factors that need to be taken into consideration when selecting an appropriate sanitation technology. These include the villager's perceptions of the present situation, interest in or susceptibility to change, and their level of participation in the project. User preferences and practices should also be taken into account, for example, the type of anal cleansing materials (water, paper, and other materials). And the cultural acceptance of a particular technology by a villager, such as, the use of composting latrines or UDDT should be understood. Considering the placement of sanitary systems in close proximity to important cultural resources, such as religious or historic buildings or cemeteries is critical to avoid potential conflicts.

It is important to understand if there have been any previous attempts to upgrade sanitation conditions in the village, and if so, the reasons for acceptance or rejection of these previous efforts should be well understood. Understanding the level of hygiene education in the village is also an important factor to consider. Are there any cultural factors that would affect hygiene practices and technology choice? Can the system be maintained by the local village or will support services be required? Only after these fundamental questions have been answered can an effective approach be selected and endorsed by the community.

3.6.8. Economic Factors

The World Bank estimates that the investment cost for on-site latrines typically lies between 200 and 400 RMB (30 and 60 USD) per capita, with an annual operating costs of 20 to 70 RMB (3 to 10 USD) per capita per year, whereas capital investment costs for a sewer connection would be in the range of 800 to 1,100 RMB (120 to 160 USD) per capita, with annual operating costs of 40 to 100 RMB (5 to 15 USD) per capita. In 2009, the average annual income of Chinese farmers surpassed 5,000 RMB (732 USD). The cost to adopt improved sanitation at each household represents a significant percentage of their average annual income and will compete with other non-avoidable expenses, such as food and health care. Therefore, significant community education may be required to garner sufficient villager participation and their willingness to pay for the future services.

Before any sanitation system is selected for a community, several economic questions must be answered, such as: What are the capital costs? Who will pay for the initial capital costs? Will the project be funded by a grant or loan? What are the operational and maintenance costs and who will pay them? What is the community's "willingness to pay" for the new services? What can the community afford to pay? If the project includes value added benefits, such as agricultural production or water reclamation facilities, will these benefits offset the costs of the facility? And if so, by how much?

Improving sanitation in rural villages has significant merit and external benefits that are difficult to quantify economically. A properly maintained sanitation system will result in improved public health, improved environmental conditions, protection of water resources and potentially allow for income-generation opportunities. All stakeholders, including the villagers, engineers, planners and community health facilitators need to understand the benefits and costs for improved sanitation and these external factors need to be weighed into the overall decision making process.

3.6.9. Complexity of the Technology and Technical Capacity of the Village

It is important to select a sanitation technology that is not complicated and beyond the ability of the village to manage. Selecting a solution should take into consideration the villager's ability to properly operate and maintain the system, including being able to afford replacement parts or equipment. The simplest solutions that rely on the least amount of mechanized equipment will be the most sustainable and resilient solution for rural villages. Introducing solutions that can be integrated to the existing setting and capitalize on the cultural knowledge of the villagers is important. For example many rural villagers

throughout China have highly evolved agricultural practices that utilized ponds and hydroponic agricultural based practices. In these areas the use of waste stabilization ponds and/or constructed wetland systems are very appropriate because the local farmers will understand the operation and management of vegetation or plant based systems.

Employing sophisticated wastewater treatment systems that rely on chemicals or sophisticated equipment may not be the most appropriate solution for a village and may be financially difficult for the village to maintain.

3.6.10. Energy Requirements and Availability

The availability and requirements for electrical energy should be considered when selecting any sanitation system. Utilizing passive systems that require minimum external energy sources have been shown to be more reliable options for rural villages. Sanitation systems that require a lot of energy are commonly bypassed when the villages decide that they are unwilling to pay the high energy demand for the system resulting in severe water quality problems downstream of the projects.

CHAPTER 4 – INSTITUTIONAL, POLICY AND REGULATORY FRAMEWORK FOR RURAL SANITATION DEVELOPMENT

4.1. OVERVIEW

In the early 1950's the National Patriotic Health Campaign Committee (NPHCC) was established as a coordinating committee to formulate national policies and resolutions for the planning, implementation and management of rural water supply and sanitation projects. The NPHCC consists of senior representatives from nearly 30 different ministries and commissions. The NPHCC also has similar committees at provincial and county levels, and leaders of local governments are also directors of the local public health campaign committees (PHCC). The NPHCC's role as a national advocate for improved rural sanitation in China has been instrumental in emphasizing the need to improve sanitation conditions throughout China.

China's campaign to implement improved rural water supply and sanitation began on a large scale in 1980. Many different national, provincial and local agencies are involved in improving rural sanitation. However, there is no single agency or ministry that has an overall mandate for rural sanitation and wastewater management. The absence of a well-established institutional framework hampers coordination and implementation. This leads to an overlap of responsibilities and limited supervision of activities in the sector.

Demonstration projects are underway by local, national and international development institutions to set up more refined and coordinate sanitation projects. Through these efforts more defined roles and responsibilities of the various agencies and institutions are be defined and implements. Some of the areas of these efforts are focused on capacity building, funding and oversight responsibilities, regulatory oversight, supervision and coordination.

The next section provides an overview of the general roles and activities of the various governmental and non-governmental institutions involved in the rural sanitation sector. The final section describes a demonstration project currently underway in the municipality of Ningbo, Zhejiang Province. The Ningbo Project can serve as a good model for the formulation and implementation of local rural wastewater management programs throughout China.

4.2. Institutional Roles

National Agencies. Many national ministries have different roles and responsibilities related to the rural sanitation and wastewater sector. These agencies generally work on planning, policy and economic development issues and provide limited oversight at the municipal or village level. The national government is also involved in research and development activities related to appropriate technologies for rural sanitation and wastewater management. The key national agencies working in the rural sanitation sector are:

- **The National Development and Reform Commission (NDRC)** is responsible for approval of national implementation plans, preparation of five year national social development and economic construction plans, and identification and approval of foreign-financed development projects.
- **The Ministry of Health (MOH)** is responsible for preparing mid- and long-term plans; developing programs and standards/criteria; providing guidance for implementation; carrying out field monitoring, supervision, inspection, and evaluation; conducting regular meetings related to rural water supply, sanitation and latrine improvement, and dissemination of lessons learned in connection with rural water supply and sanitary latrines.
- **The Ministry of Finance (MOF)** is responsible for all national budgeting and financial issues, and management of foreign loans.
- **Ministry of Commerce (MOC)** is responsible for the management of the multi-lateral and bilateral funded projects.
- **Ministry of Environmental Protection (MEP)** is responsible for the protection and enhancement of surface water and groundwater resources and water quality.
- **Ministry of Agriculture (MOA)** is responsible for development of the agricultural sector and supports the construction of rural water and sanitation projects, including the biogas latrines.
- **Ministry of Water Resources (MOWR)** is responsible for development of water resources schemes and management of rural water supply systems in water scarce villages.
- **Ministry of Education (MOE)** is responsible for improving water supply and sanitation in rural schools.

Provincial and County Government. At the Provincial and local levels many different agencies oversee, plan and execute rural sanitation and wastewater management projects. Historically, provincial and municipal governments have overseen the financing of rural sanitation projects. Some provincial governments have developed general technical guides describing alternative sanitation technologies and practices. Provincial, municipal and county environmental branch offices supervise and regulate the construction and operation of rural wastewater projects.

Local and Village Organizations. At the township level the Local Patriotic Health Campaign Committee (LPHCC) organize and coordinate rural sanitation and latrine improvement projects under the leadership of the NPHCC and local government. The township and village governments are responsible for the construction, operation, and maintenance of rural sanitation and latrine projects.

Educational Institutions. Many technical universities throughout China are involved in research and design of alternative sanitation and wastewater management projects. The universities also provide training and technical support to municipal, county and local governments.

Private Sector. There are a variety of private or semi-private enterprises that work on rural sanitation and wastewater management projects including: state-run design

institutes, engineering consulting firms, construction firms and private operating contractors. The private sector is primarily involved in the technical studies, design, construction and operation of rural wastewater management projects.

Non-Governmental Agencies (NGOs). The central government of China encourages support and participation of NGOs in developing and executing rural sanitation projects. Rural communities also welcome their participation. NGOs include both domestic and international agencies and governments. For example, since 2000 a large-scale domestic program focused on improving rural water supply, implemented by the Women Federation of China, is estimated to have benefited over 1 million people in rural villages.

Typically, rural sanitation projects launched by NGOs are jointly organized and managed by both NGO staff and local governments in the project areas.

Over the past several decades, many rural sanitation projects have been financed and supervised by various international organizations and foreign government development agencies. The United Nations Development Program (UNDP) has provided monetary and technical assistance for rural sanitation projects. The World Bank has provided substantial financial and technical assistance in the rural water supply and sanitation sector. UNICEF has funded rural sanitation demonstration projects in over 24 counties in 10 provinces. The World Food Program (WFP) has donated substantial food assistance to assist villagers working on rural sanitation projects. The World Health Organization (WHO) provides technical assistance and training to improve public health, sanitation and water quality in rural areas of China.

In general, central and local governments have recognized that efforts by domestic and international NGOs have had positive impacts on sector development. Development projects undertaken by various NGOs have led to the introduction of innovative technology, adoption of modern project planning, management and administrative techniques, with an emphasis in operation, maintenance and evaluation practices, which, in turn, have resulted in long-term sustainability of completed systems.

Figure 4.1 presents a general institutional framework showing the activities of both governmental and non-governmental institutions. As shown in the figure, there are many opportunities for institutional overlap and duplication of effort indicating the need for good coordination between the various institutions and organizations.

Figure 4.1. Institutional Framework for Rural Wastewater Management Activities

4.3. Decentralized Institutional Approach

Rural governments at the County and township levels have major responsibilities for the provision of rural services. The national and provincial governments provide mandates for service provisions, along with the fiscal resources through revenue assignments and transfers, but it is the rural governments at the municipal and county levels that deliver the services (World Bank, 2007). The actual division of responsibility for the provision of rural sanitation and wastewater management has been evolving and differs across provinces, given the absence of any central and formal assignments among local governments. Nevertheless, the municipal, county and village governments are the key government level for the implementation of comprehensive wastewater management programs.

In 2009, the Municipality of Ningbo in Zhejiang Province partnered with the World Bank to implement the Ningbo New Countryside Development Project. A key component of the project is a five-year program to improve rural wastewater management in 150 to 200 rural villages in the municipality of Ningbo. The project is being undertaken as a demonstration project. It is the intention of the National Government and the World Bank to use this project as a model for rural wastewater projects that will be undertaken in other municipalities in China.

The institutional framework adopted as part of the Ningbo Rural Wastewater Management Program (NRWWMP) can serve as a good model for other municipal rural sanitation and wastewater programs. The NRWWMP will involve three levels of local government, including municipal, county and village governments. The following summarizes the responsibility of each level of government.

Municipal Government. At the municipal level there are three key offices involved in the implementation of the rural wastewater program, including the Ningbo World Bank Project Management Office (PMO), the newly formed Ningbo Rural Wastewater Management Office (NRWMO) (which is administered under the Ningbo Rural Affairs Office), and the Municipal Environmental Branch office (MEB).

The primary responsibilities of the PMO include:

- Preparation of the initial project documentation (including project feasibility analysis, preliminary engineering plans, environmental assessment documents, and financial plan) to secure project funding;
- Preparation of procurement plan tender documents, and management and supervision of the procurement process;
- Preparation of annual project reports for the World Bank and Central Government; and
- Assistance with the transfer of assets to the village.

The responsibility of the NRWMO will be to supervise county rural wastewater management offices that will be set up in five separate counties. The NRWMO will provide technical and administrative support to the county rural wastewater

management offices and review project plans and related technical information. The NRWMO will also monitor and evaluate the implementation of new rural wastewater projects.

The responsibilities of the MEB office are to review environmental assessment documents for the projects and to develop standards for rural wastewater management practices in the municipality.

County Government. At the county level there will be two different institutional agencies involved in rural sanitation and wastewater management projects, a County Rural Wastewater Management Office (CRWMO) and the County Environmental Branch (CEB).

The responsibilities of the CRWMBO are to work directly with villages to screen and select projects, to conduct community assessment studies, to coordinate community participation efforts, to assist with the planning, design and implementation of sanitation/wastewater management projects, to provide ongoing technical assistance to rural villages, and lastly to provide ongoing monitoring and evaluation activities.

The CEB is responsible to assist with the environmental review and approval of rural sanitation/wastewater management projects. The CEB supervises the construction, operation, and maintenance of the new projects and provides on-going environmental regulatory monitoring and evaluation of the projects. The CEB is responsible for enforcing local and national environmental requirements.

Village Government. Within each village, a wastewater management committee (VWMC) is formed. The members of the committee are generally selected by the leadership of the village to be on the committee. The committee is responsible for participating in all phases of the project beginning at the community participation and project assessment phase through design, procurement, construction, and most importantly in the operation, maintenance and management of the project. The committee is expected to:

1. Coordinate pre-project community meetings and educational and training sessions;
2. Work with the County and Municipal wastewater management program staff on planning and review of the project;
3. Work with community members to determine the extent of monetary and non-monetary cost sharing that will be provided by the villagers to construct the project;
4. Negotiate and establish sewer use rates or tariffs;
5. Hire skilled and unskilled labor to operate and maintain installed wastewater treatment systems; and
6. Manage the administrative and financial aspects of the project.

Figure 4.2 shows the general institutional framework of the rural wastewater program current underway in Ningbo, Zhejiang Province.

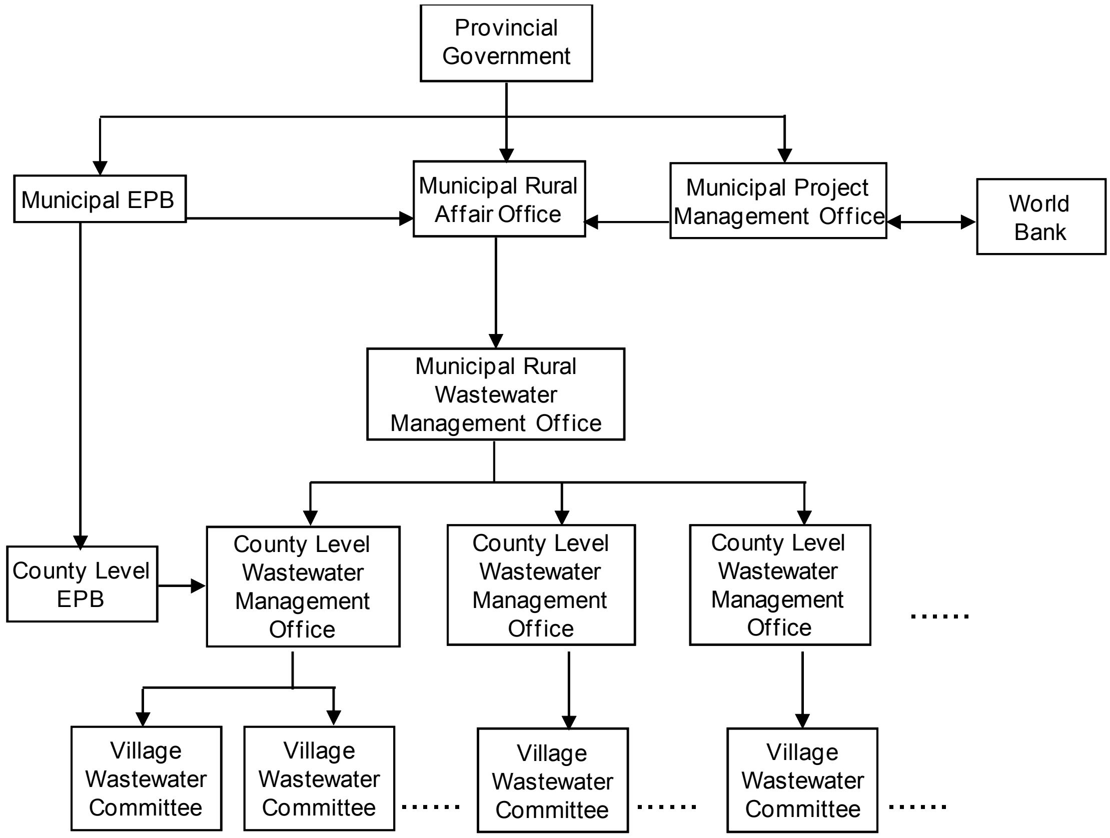


Figure 4.2. Institutional Framework of Local Wastewater Management Program in Ningbo, Zhejiang

4.4. Policies and Regulations

National and regional policies that address rural sanitation and wastewater management have been adopted in China. These policies are broad and, in general, set targets to increase coverage of basic services.

At the local level, more specific policies are required to clarify decision making, to prioritize activities, and to ensure that key members of the community are represented and included in the decision making process.

As local wastewater management programs are developed, it is important that the staffs implementing the programs be familiar with these policies as they apply to their particular program and setting.

This section summarizes Central Government policies pertaining to rural sanitation and wastewater management.

The primary goal of a rural wastewater management program is to dispose of wastewater from villages in a manner that does not pose a threat to surface water quality, groundwater quality or public health. The disposal of wastewater to subsurface disposal systems and/or the reuse of treated wastewater are, in most instances, the most environmentally sustainable practices to protect water quality and public health. Presently, there are no national or provincial regulations that regulate rural village wastewater systems that discharge treated wastewater on to land. In Annex 1, model local regulations on the disposal of rural wastewater to land can be found. These regulations were adopted by the Ningbo Environmental Protection Branch as part of the Ningbo Rural Wastewater Management Program. These regulations are offered as model regulations that can be adopted by other municipal and county governments.

4.4.1. Central Government Policies

At the national level, many different policies have been adopted over the past two decades to improve environmental and public health conditions in rural parts of China. The following sections describe key policies that have been adopted by the Central Government.

New Socialist Countryside Development Strategy

In October of 2005, the Fifth Session of the CPC Congress approved the Outline of China's Eleventh Five-Year Plan. A key provision of this plan was the adoption of the New Socialist Countryside (NCD) initiative or strategy. The NCD strategy aims at reducing the economic and developmental disparity between urban and rural China, balancing urban and rural development, and promoting human-centered, quality-based, resource-saving, and eco-friendly growth in the countryside. The objective of the initiative is to strengthen the social, economic, democratic, cultural and legal framework in order to improve the environment and the living conditions in the rural countryside. To move the initiative forward, the Central Government has placed an emphasis on the responsibility of developed, urban areas to actively commit resources to the development of the surrounding rural countryside.

Draft Wastewater Tariff Guidelines

Financing of wastewater management in both urban and rural areas is a significant issue in China. To address sanitation and wastewater management in rural villages in China will require a significant investment for both the capital improvements and for long-term operation and maintenance of the future improvements. Administrative efficiency and good governance require tariff structures that are clear and understandable to villagers, simple to calculate, and easy to implement and operate (Clark, Huang and Liu, 2006).

In 2002, the Central Government through the Ministry of Government prepared national wastewater tariff guidelines (WTG). Although the guidelines have primarily

been formulated to assist urban areas to adopt tariffs for wastewater management, the guidelines are well suited to assist counties and villages to adopt wastewater tariffs as rural wastewater management programs mature and ultimately need to be self-funded enterprises. Like cities and towns, rural villages need tariff revenue to cover operations and maintenance costs for centralized solutions, and a portion of the initial capital costs to develop new wastewater systems.

The wastewater tariff reforms outlined in the draft guidelines are part of much broader economic and structural reforms taking place within China. These reforms attempt to overcome uncertain funding and do away with subsidies that many rural areas have depended on in the past. The guidelines acknowledge that the willingness to pay for rural services may be very low, so that setting tariffs must be realistic and take into consideration water availability, water usage, socio-economic conditions, and other factors.

The purpose of wastewater tariffs is to promote financial sustainability of public wastewater systems in China. Thus, the proposed tariff structures are designed to achieve full cost recovery through revenue obtained from the users and beneficiaries of the wastewater system. The tariff guidelines support the evolution of wastewater entities from subsidized services to fully self-sustaining and in some instances commercial autonomous enterprises. This allows Government to become a service regulator rather than a micro-managing service provider. The tariff structures and institutional arrangements attempt to lay the foundation for future private/public partnerships, as the need for additional sources of capital, expertise and management efficiency become recognized by local and provincial governments.

Some of the key policies in the tariff guidelines include:

- Adoption of the principles of “the polluter pays’, and “the beneficiary contributes”;
- Users’ charges to be increased progressively to full cost recovery, subject to affordability and local circumstances;
- Wastewater charges to be based on metered water usage;
- Wastewater charges being initiated before wastewater improvements are completed to aid in financing of construction; and
- Prohibitions against exemptions, discounts, or delays in payment of arrears by politically-well-connected individuals.

The tariff guidelines give preference to a tariff structure that is based on the actual costs incurred for each type of customer, rather than cross-subsidies between customers.

The guidelines propose that the combined bill for water supply and wastewater should always be less than 5% of household income. Under the most stringent

circumstances the average household would pay 1.5% to 2.9% of income, while a low-income household would pay 2.2% to 3.6%.

National Rural Biogas Construction Plan

The Biogas Construction Plan was initiated in 2003. The plan was adopted to increase substantially increase the use of biogas digestors in rural households throughout China. The Plan was set to increase biogas-digestor use to 30 million by 2010 and more than 50 million by 2015.

4.4.2. Provincial Policies

Thousands of Villages for Demonstration among Millions being Renovated

In 2008, the Agricultural Affairs Office of the Provincial Government, Zhejiang implemented this plan as the first step to implement the national strategy of building a new socialist countryside. According to the plan, a total of ten thousand villages in Zhejiang province will be renovated during the initiative to improve environmental and living conditions in rural areas. Initially, the goal of the policy is to improve conditions in 10% of the rural villages. The policy also directs municipalities to develop local implementation plans to assist rural villages within their jurisdictions to comply. The implementation period of the project is from 2008 to 2012. The priorities of the project are to improve roads and accessibility, improve solid waste management, construct sanitary latrines and construct rural wastewater systems. Depending on site conditions and local economic capability, either centralized or decentralized wastewater collection and treatment systems are recommended. Any system selected is required to serve at least 50% of households in its service area.

4.4.3. Local Policies

Developing local policies is essential to the strategic planning and implementation of the wastewater program. Common barriers that impact the planning process leading to improved sanitation and wastewater management exist in many local governments. Tayler et al., 2003 identified four barriers that need to be overcome in the development of local policies that support rural sanitation and wastewater projects, these are:

1. Low importance given by the local offices to the need to improve sanitation and wastewater management in their regions;
2. Lack of political will or interest to adopt new policies or planning strategies to address sanitation and wastewater management;
3. Limited or inappropriate policies to support the development and long-term implementation/sustainability of the program; and
4. Insufficient institutional capacity to develop and implement policies.

Increasing the Importance of Sanitation and Wastewater Management. Serious recognition of the importance of good sanitation, particularly among those who are responsible for making policy decisions, is required if sanitation services are to improve. Where this recognition does not exist, efforts are needed to raise awareness of sanitation. Sanitation awareness is raised when the public fully and explicitly understands the full range of benefits achieved through improved sanitation. The benefits of improved sanitation encompass improved public health, a cleaner environment, and potential economic and social benefits. Raising sanitation awareness in a local area is more likely to be effective if a wide range of stakeholders, including local politicians, civil servants, teachers, NGOs, community members, and others are engaged in a process to discuss, strategize and promote improved conditions in their villages.

Developing Strategic Policies. Policies must be based on a thorough understanding of the existing situation, utilizing accurate and relevant information. Policies are likely to be more effective in responding to needs if they draw upon the insights and experience of all those who are working to develop improved sanitation services (Tayler et al., 2003). The policies should also promote the use of the most cost-effective and appropriate approaches and options that protect human health and the environment. More complicated and more expensive is not necessarily better, especially where it is not sustainable. A stakeholder working group that is representative of the community, local government, and non-government organizations is a good forum to develop policies that ultimately will have broader support than policies originating only in a government agency. Policies should be supported by clear objectives and principles set out by the stakeholder group. Policies should be nurtured through actions designed to ensure that they are implemented as intended. These may include changing laws and accepted practices in order to remove barriers to the implementation of policy and to provide incentives for achieving policy objectives. Another crucial supporting action is developing or securing external funding sources. Figure 6.1 shows the stages that are commonly involved in developing and implementing policies.

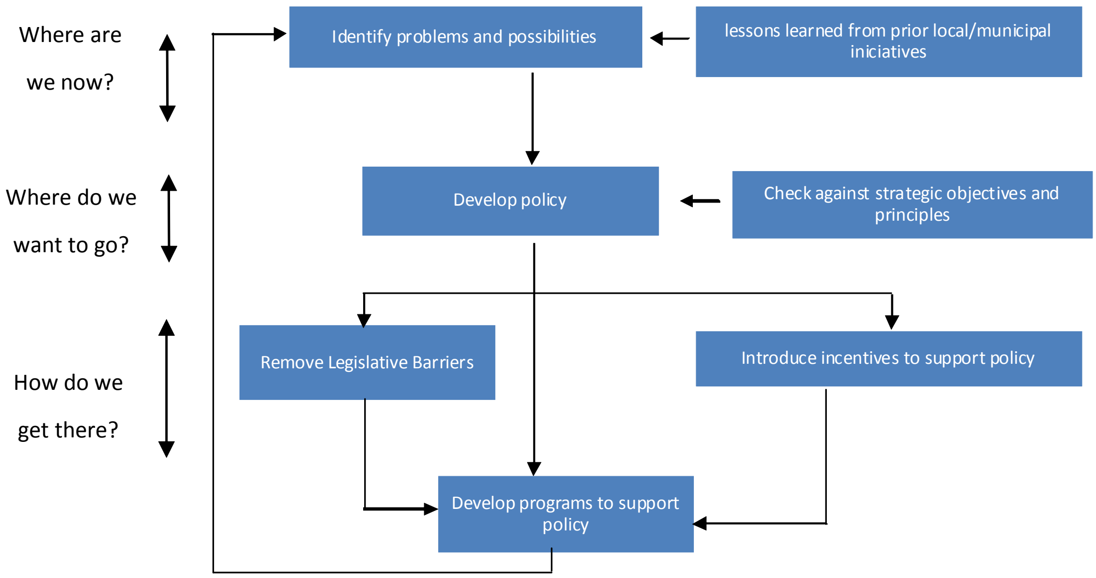


Figure 4.3. Stages in Developing and Implementing Policy (Tayler et at., 2003)

Appropriate Policy Development and Communication. A policy will only be implemented and have a real impact upon sanitation conditions if the stakeholders are aware of the policy, understand its implications and are willing and able to implement it. Stakeholders can only be expected to support and adopt a policy if representatives of the stakeholders are involved in its development and if knowledge of the full implications of the policy is widely circulated. Some complex policies may need to be supported by written guidance on their implications and how to implement them. Workshops can be an effective forum to present policies. Demonstration projects and training courses are also good methods that can be used to "test" the effectiveness of a policy and/or to develop strategies for successful implementation.

Institutional Capacity Building. In rural areas throughout China resource constraints are likely to place serious limitations on the ability of local governments and other local organizations to develop and implement strategic policies and plans. Where limited resources are a constraint, higher levels of government, such as higher municipal or provincial agencies may assist local county and rural villages groups to formulate the policies that are essential to a wastewater program. Local capacity can be reinforced through human resource development or by creating a role for the private sector to deliver sanitation services. Involving the private sector may provide access to capital and skills that are not available in the public sector. Training is the most obvious means to build capacity in the local institutions provided that it is available to key stakeholders and that the training materials are both relevant and well delivered. It is important to include an allowance for training for capacity building in the funding provided for projects.

Incentives as a Support to Policy. Appropriately targeted incentives can help to achieve policy goals. Examples are provisions of subsidies to increase the level of community participation in a particular project or rewards for good performance.

Formulating Local Wastewater Management Policies and Procedures. As local governments develop rural wastewater management programs they will need to formulate local policies and procedures to address several important institutional, financial, technical management and environmental issues. As local jurisdictions move forward with the development of their wastewater program, they will need to establish policies and procedures addressing some of the following issues:

- The village selection criteria for participation in the wastewater program;
- The formation of village wastewater stakeholder committees or management committee (VWMC);
- Clear definitions of the role and responsibilities of the various stakeholders involved in the program and the villages, including the VWMC;
- Clear specification of which entities have the responsibility to administer, operate, and maintain the wastewater project;
- Assurance that there is diverse representation on the VWMC, including different genders, and in some regions, different ethnic groups;
- The amount and/or type of monetary and non-monetary cost sharing that will be required to be paid by counties and villages;
- The type and level of incentives and/or subsidies provided by the local, provincial and/or central governments;
- The type of procurement method(s) that will be employed to retain design and construction firms to design, build, and operate the project(s):
- The use of local labor during project construction phase;
- The transfer of assets back to a rural village;
- The setting of wastewater tariffs to construct and manage the project(s);
- The policies and procedures for land acquisition and resettlement of impacted populations;
- Environmental management policies and procedures, including water quality standards and policies for the disposal of sewage sludge or septage from latrines/toilets;
- Policies and procedures for conflict resolutions; and
- Other potential issues.

4.4.4. Ningbo Rural Wastewater Management Project

Several local policies have been adopted as part of the development of the Ningbo Rural Wastewater Management Program. These include polices for selecting villages, responsibilities of the villages, design institutes, land acquisition, resettlement and construction site selection, village labor services, environmental management, conflict resolution, asset transfer and other issues summarized in the following paragraphs.

Municipal and County Working Group. A wastewater working group, consisting of both municipal and county staff, is required to initiate the village solicitation and selection process. Once the working group is formed its primary responsibility is to visit rural villages and to conduct the preliminary discussions with village leaders to ascertain if the villages are interested and prepared to implement a rural wastewater project.

Formation of the Village Wastewater Committee. Prior to being selected to participate in the wastewater program, a village is required to form a wastewater management committee or working group.

Municipal Policy for Village Selection. The Municipality of Ningbo, in consultation with the World Bank, formulated a policy and specified criteria that need to be met before a village can be selected to participate in the rural wastewater program. This policy requires the following:

- At least 80% of the population in the village must agree to participate in the rural wastewater management project, where participation could mean either connecting to a new community sewer system or installing an individual wastewater system;
- The village committee agrees to take over (**transfer of assets)** the ownership of centralized wastewater systems after the commissioning and initial startup period (this would not be the care for household level facilities);
- The village committee agrees to take over the responsibility for the administration, operation and maintenance of the centralized wastewater system;
- Any system installed at a single family residence will become the responsibility of the homeowner and a signed agreement between the homeowner and the village wastewater committed will be completed;
- A formal agreement will be drawn up specifying the responsibility by the village committee or individual homeowners for the annual pumping of septic tank sludge (septage);
- All agreements for transfer of assets, management and operation responsibilities will be presented to the County project management office;
- The villages are expected to take on the long-term operation and maintenance of the new project. If the project is completed at the household level, it is the responsibility of the individual home owner to maintain the system, and if the project is centralized and serves the entire village, the responsibility will be shared by the entire village; and
- During the village selection process community members in the village are expected to cooperate and assist the municipal, county and design institutes complete the initial community assessment and pre-design work.

Design Institute Requirements. Once a village is selected, the Design Institute will conduct a feasibility study and subsequent engineering designs for the selected wastewater system improvements. At the onset, the Design Institute must be

consultation with the villagers to decide the option or options to be explored in the feasibility study and subsequent engineering work. The Design Institute is expected to communicate with the village on an ongoing basis and present and obtain approval for the schematic, preliminary designs. The final engineering solution shall be approved by means of a formal agreement reached between the Design Institute and the Village. Important points that are required to be approved by the village include:

- The layout and route of the sanitary sewer system, if required;
- The type and location of the wastewater treatment system;
- The method and location of the land disposal system;
- The potential financial and environmental impacts of the project;
- The temporary and permanent land areas requirements;
- The potential resettlement of community members;
- The monetary and non-monetary costs for the villagers;
- The expected voluntary work requirements; and
- The expected operation and maintenance costs.

Land Acquisition, Resettlement and Construction Site Preparation. The County Project Management Office (PMO) will be responsible for the administrative and regulatory process for land acquisition and resettlement. The village wastewater committee is expected to communicate and coordinate any land acquisition or resettlement agreement and negotiate any compensation. The committee is also responsible to coordinate and supervise the site clearing.

Household Connection Policies. Two key policies have been adopted to increase the participation of villages in the project. These are a sewer connection subsidy and a project construction condition. The Municipality of Ningbo and Counties have agreed to provide a one-time grant (connection subsidy) of 600 RMB to be provided to each household to pay the majority of the costs to connect houses to a new sewer system. This funding will come from the municipal and county counterpart funds. The connection subsidy will only be paid to the homeowners after the physical connection to the new system is completed.

The Municipality and Counties have also adopted a policy that will not allow any construction of the new wastewater project (such as the new sanitary sewer, wastewater treatment or disposal systems) to begin until the individual home connections are understood and agreed to by the homeowners.

Village Labor Services. The Municipality and Counties have adopted a policy encouraging the retained contractor to hire local village labor to work on the construction of the project. The policy allows the contractor the discretion to hire local labor if the contractor deems that the local laborers have sufficient skills to complete the work to the quality specified.

Villager Training. The Municipality and Counties have set an 18-month "startup" period that will require the contractor to operate and maintain during this period. The policy also requires that the contractor will conduct trainings for village designated operators who will eventually take over the O&M responsibilities after the "start-up" period.

Asset Transfer. After the 18-month startup period the village committee is responsible for taking over the wastewater project. The village will enter into an agreement with the County PMO for asset transfer and the village will be responsible for administering, operating and maintaining the system.

Environmental Management. The Municipality has outlined specific responsibilities and tasks to be completed by the Municipal and County Environmental Protection Branch (local EPB) during project planning, construction and operation phases. During the project planning phase the local EPB is responsible for reviewing and approving the environmental impact appraisal (EIA) and for adopting local requirements for wastewater treatment and disposal. During the project construction phase, the local EPB is responsible for conducting monthly site inspections to assure that any environmental mitigation measure proposed in the EIA, as well as other local and national requirements are being implemented. During the operational phase of the project the EPB is responsible for providing technical assistance and public education about local and national environmental management policies. The content of this assistance and education should include environmental monitoring, supervision of wastewater projects, investigation and response to pollution events, conflict mediation, public education and outreach efforts related to technical training, operation and maintenance and environmental hygiene activities.

Conflict Resolution. A policy has been formulated that indicates that a special Leader Group will be established to hear and resolve complaints by affected persons or communities with respect to any proposed or completed projects. The Conflict Resolution (Leading) Group will have representatives from the Ningbo Agricultural Office, Ningbo and County EPBs, and Municipal and County PMOs. The policy includes procedures that stipulate the time frame at which complaints are heard by the Leader Group and the means for further review if the decision is not accepted by the affected person or village.

CHAPTER 5 - COMMUNITY PARTICIPATION AND EDUCATION STRATEGIES

5.1. Introduction

5.1.1. Community Participation

The participatory community concept and approach has been widely adopted in China since the late 1980's (CWMP, 2007). Participation empowers communities. Through the community participation process the main stakeholders exert influence and control over the direction taken in development. Community members work together to decide how to use their common resources. The Participatory Concept encourages community groups and individuals to participate in the planning, selection, design, implementation, and management of their community development project.

Community participation is a necessary, but not a sufficient component of sanitation program planning. It is fundamental to involve the benefiting community so they have a vested and long-term interest and stake in the outcome. But community participation alone is not sufficient for the successful design and implementation of a sanitation program. Institutional support by government is also needed to supply technical expertise and support services not available in the community.

Effective community participation is achieved through personal contacts and dialogue between the project sponsors and community members. Its goal is that the sanitation technology selected matches the preference and financial capacity of the village and that it should be accessible to all members of the community regardless of gender, socio-economic status or location.

Some basic principles of community participation are:

- All stakeholders take part in the whole process of project implementation. The project stakeholders are not limited to the beneficiaries, but also include local and regional agency staffs, decision-makers, neighbors, and other interested parties.
- The process is inclusive of women, ethnic minorities, and the poor; thus it promotes social fairness and harmonious development.
- Community participation is a capacity building tool. The process strengthens the community's self-development capabilities. Participation in planning, decision making, and implementation forces the community to formulate its own policies or regulations on managing its own resources. The result is an enhanced capability to undertake future development projects.
- Community participation produces its own consensus based decisions on local matters without the need for central or local government's imposition.
- The process integrates local or indigenous knowledge into the project selection, design and implementation activities, such as the use of locally

available construction techniques or building styles, if they are appropriate for certain aspects of a project.

The process respects local culture and customs and takes advantage of norms and codes which are easily accepted by the community.

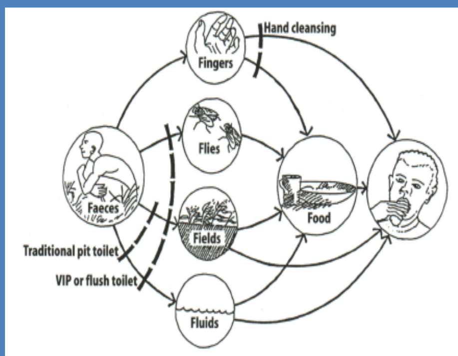
5.1.2. Public Health Promotion

Public health Promotion comprises a broad range of activities aimed at changing attitudes and behaviors, to break the chain of disease transmission associated with inadequate water and sanitation. Public health promotion targeting improved sanitation is a key element of the community participation process. Communities in rural China need help in explicating the linkage between improved sanitation, public health and environmental conditions.

Health awareness is achieved when people can describe how diseases are transmitted in their environment and through their behaviors. Once people understand how transmission occurs, they can identify the different ways to block transmission routes. They can also weigh the advantages and disadvantages of blocking those routes in their households and communities. They can conceptualize the costs in terms of trouble, time and money and weigh them against the benefit of reduced illness.

Box 5.1 - Barriers to Diarrheal Diseases

Diarrhea is generally caused by eating food or drinking water that is contaminated with human feces. Infants may suffer from diarrhea after being hand-fed by someone with dirty hands, or after having put dirty objects into their mouths. The diagram below shows the usual ways diarrheal germs reach people: via fingers, flies (insects), fields and fluids, foods, or directly into the mouth. The figure also shows the relatively simple barriers that can be put in place to prevent diarrheal disease.



Public health promotion informs community members about proper water and sanitation strategies in the household. It has been shown that the single most effective hygiene measure people can take is washing their hands at critical moments, e.g., after using the toilet or before preparing food. It has also been shown that it is more effective to concentrate on a very few messages and not try to cover all aspects of hygiene. The most effective actions in preventing the transmission of fecal-oral diseases such as diarrhea are hygienic latrine or toilet use, consumption of safe, potable water, and handwashing

at critical times. Any educational or promotional campaigns should focus on these three messages only.

Public health promotion is an indispensable part of sanitation projects and ensures lasting improvements in public health and sustainability of a system after the technical experts' assistance has been withdrawn.

It is essential to understand the attitudes and behaviors of rural communities In China towards water and sanitation. The central government provides basic infrastructure such as improved water and sanitation to many rural communities. But this is not a total solution. It is necessary for the communities themselves to contribute towards the sustainability of their projects and to develop an appropriate behavior change program. It is at the community level that real decisions on public health education need to be made. But communities need information to be able to put into action their particular aspirations, desires and needs.

The principal objectives of a public health promotion program are:

- To conduct a basic sanitary survey aimed at understanding the knowledge, attitudes and sanitation practices employed in rural villages
- To develop and implement a public health education curriculum that targets each group within the community with tailored lessons informing them of the linkage between hygiene, fecal-oral route disease transmission and barriers to transmission and promoting behavior change.

To monitor the program and evaluate whether it has influenced a change in public health and environmental conditions in the villages. Villages should be supported to develop sanitation action plans to evaluate their activities and assess if conditions are actually improving or not. Based on their assessments they can adapt the plan/program to address problems or issues that have been identified.

There are several established public health models that can be used by villages to improve public health awareness and promotion, include the Who PHAST, FOAM, SaniFOAM, CLTS, TSS and others. A summary of these various models is presented in Appendix C.

5.2. Institutional-Community Linkage

Many aspects of the community participation/education process will depend on support from municipal and county agencies, non-governmental organizations (NGOs), as well as from private consultants/contractors to facilitate and provide community training and education. Institutional support will focus on community organization, outreach, education, monitoring and evaluation of each phase of the project. Some of the institutional steps that may be required to support the community participation process will include:

- Facilitate and support the formation and training of village wastewater management committees;
- Establish design and operating standards for new sanitation and wastewater treatment facilities.
- Develop criteria and requirements for conducting engineering and other technical studies, as required;
- Train community workers in on-site, decentralized and centralized, low-cost sanitation solutions, hygiene promotion, and community organization;
- Assist community workers and VWMC to form work groups to participate in the construction of the new project;
- Assist the community during the construction of the project(s);
- Maintain community workers to assist with ongoing operation and maintenance activities and to monitor completed projects;
- Provide ongoing technical assistance, as required;
- Monitor and evaluate the operation and performance of the project on an ongoing basis; and
- Provide continued training programs for both community workers and village staffs.

5.3. Community Participation Activities

The implementation of a rural wastewater management project is a very involved process that requires a concerted effort from the benefiting community and villagers. Technical support from the Municipal or County Rural Affairs Office and Environmental Protection Branch (EPB) may be necessary to help a village understand and create the appropriate framework for this work. The overall process starts with the initial formation of a village wastewater management committee and continues through various intermediate phases to the ongoing operation, maintenance and administration of the final sanitation solution selected by the village.

Once a village forms a wastewater management committee it will likely need ongoing support from the County agencies providing financial and environmental oversight of the specific projects. Both at the initial onset and throughout the life of the project there should be a long-term relationship established between the various agencies and the villagers (i.e. stakeholders) to identify and resolve issues as they arise and to plan for the implementation and management of the projects.

The various phases of the project in which the community must participate include:

1. Community organizing and planning phase;
2. Data gathering and assessment of existing conditions phase (the village sanitary survey);
3. Project planning and evaluation of alternatives phase (the villages involvement in the completion of the project feasibility analysis);
4. Project selection phase;

5. Project Implementation phase; and
6. Project management phase.

The following sections of this chapter outline the various community participation activities involved in each phase of the wastewater management project.

5.4. Community Organization Planning

Forming the Village Wastewater Management Committee. The formation of a community-based organization is the first step in creating a community supported project. One of the most important elements of Village government is its committee structure. The creation of a Village Wastewater Management Committee (VWMC) that represents the interest of the community is critical.

Each village will need to develop procedures for selecting committee members with assistance from the County Wastewater Management Office or other supporting institutions. It is important that the procedures for selecting members are considered by the villagers to be equitable and transparent, to avoid potential conflicts. The VWMC should broadly represent the community in all its diversity. It must include women, minorities, and different age groups among its members. The VWMC should also include members from different sectors, including local business, agricultural, education, health and public service leaders

Committee Roles and Duties. Once the VWMC is formed, it will need to define its role and duties. The primary function of the VWMC is to oversee activities, mobilize community members, implement sanitation and hygiene promotional programs, and facilitate villager’s participation and contribution to the project. Once the project is constructed, the primary role of the VWMC will be to oversee the operation, maintenance and administration of the wastewater system. The VWMC is responsible to report to the Village Assembly or Village Representative Assembly on a regular basis to inform the leaders of the village of the status and progress of the project.

Operating Rules. Initially, the VWMC will need to formulate the rules or by-laws required to conduct business and make decisions. The VWMC will also need to formulate procedures for conducting business, such as holding public and closed-door meetings, presenting information and reporting back to the community, or collecting and/or disseminating information from the community, institutions, and/or consultants. Establishing clear rules and procedures avoids potential or perceived conflicts and streamlines decision making processes.

5.5. Data Gathering and Assessment (Village Survey)

Once the VWMC is formed the committee members will collaborate with the County Wastewater Program office and project consultant to conduct a village survey. The purpose of the survey is to assess the environmental sanitation status of the village. The survey is undertaken to gather basic information related to the level and type of

sanitation coverage in the village, the behavior and perception of sanitation conditions in the village, and the interest by villagers to improve sanitation in the village. Other issues addressed by the survey relate to land tenure and availability, and the willingness and ability of households to pay for and support improved sanitation.

Data Gathering and Assessment involves four components:

1. The first part involves basic data collection;
2. The second part is a village assembly or meeting to introduce the project and the initial results of the data collection and assessment work;
3. The third part may involve forming focus groups to consider different issues, such as identifying land for a wastewater treatment and land disposal systems if needed, selecting sanitation systems, and assessing the financial capacity and willingness to pay for improved services; and
4. Lastly, working with the County Agency and Project Consultant to complete the problem assessment and demand analysis that defines existing sanitation in the village and the perceived demand for improvements to environmental and public health conditions.

5.6. Preliminary Planning – Deciding the way forward

A more comprehensive planning effort will be undertaken by the sponsoring agency and design team once the VWMC is operating and the project has gained community support. At this preliminary planning stage the involvement of the VWMC or a subcommittee of the VWMC is essential, because at this critical stage various project goals and objectives are defined, and different project alternatives are considered.

During this phase of the project the VWMC should work closely with the project sponsor and design team to actively review alternative project solutions and to understand what various opportunities and constraints pertain to each alternative. This process will mean that the VWMC meets regularly to review information and participate actively in the decision making process. At this stage some key questions requiring answers will arise:

- What different options are available to improve sanitation? What are their advantages and disadvantages? Are they culturally acceptable?
- Is there enough information to make an informed decision about the different options?
- Is the individual household or neighborhood (decentralized) or the centralized sanitation system more appropriate for the village?
- How much land will be required and what land will it be?
- How much labor and money will be required from the community? Are the willing and able to provide them?
- For each alternative considered, what is the capital cost and what are the ongoing operating and maintenance expenses? What human resources and

skills will be required? What spare parts and other materials, such as chemicals, are required? Are they available?

- How long will it take to implement the project?

During the project planning stage a series of focused meetings will be required. The use of planning charettes (Todd and Lindsey, 2009) is a good forum or venue to introduce and vet alternative projects (see Box 5.2). The meetings should be conducted when different milestones are completed by the design team, such as the following:

- Conducting and completing a technical feasibility study;
- Preliminary project plans to present the recommended solutions;
- Design development plans to present a more detailed implementation plan and to identify the potential physical impacts or constraints in the village (such as the location and required setbacks from important archeological, cultural and/or biotic resources, floodplains or other features); and
- Final designs to review and discuss timelines and logistic concerns.

If issues arise that will require input from the entire community than periodic community meetings should be hosted by the VWMC. For example, this type of meeting may be required when the design team is considering the placement and use of land in the community. A mandatory role of the VWMC is to organize and run all of the community meetings.

Another role of the VWMC is to review and eventually accept or reject, if needed, the feasibility study. It's the VWMC's responsibility to present the feasibility study to the village leaders and the community at large and to preside over a final community review of the project. It's also the VWMC's responsibility to identify any policies or regulations related to cost-sharing, labor, and other project participation requirements for each household , that might be required by any and each variant of the project .

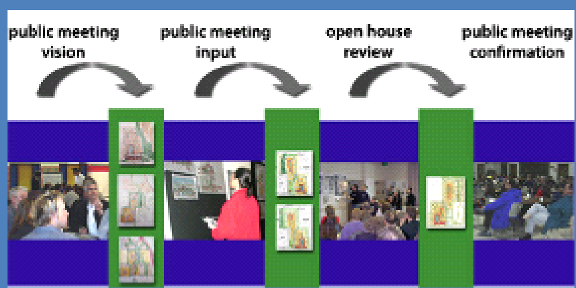
5.7. Project Selection – Adopting the sanitation improvement plan

With the feasibility plan completed and the nuances of different project options explained, the VWMC and community will be required to select the final project option. Ideally by this stage the VWMC has been thorough in the review of alternatives and has been able to engage the community through meetings and possibly a planning charter. A planning charter is a concise document that outlines the group's responsibilities, how they will operate and respond to input from individuals, the community or other groups, how they will identify and resolves issues, how they will make decisions, when they will meet, and other process and planning related topics. At this point the VWMC and community will select a project alternative that they consider to be financially and technically appropriate for the community. The project selection process should preferably be conducted in an open community meeting. During this meeting the VWMC should present a

summary of its analyses of alternative sanitation improvement projects, discuss the review process and describe how and what project alternative has been selected. The VWMC should also explain what financial, labor and potential environmental impacts may occur as a result of the project. The VWMC should also indicate at this stage if any special considerations or arrangements will be required by to implement the project. For example many remote villages may need to rent a material storage space in another village that is closer to a good road, so that materials can be transported slowly by individuals or horses to the construction site. After the VWMC has presented the project an open discussion, a process should be undertaken to solicit input and quite possibly to allow the community to select the preferred alternative.

Box 5.2 – Planning and Design Charettes

The word *charrette* refers to a collaborative effort in which a multi-disciplinary group of designers, planners and community stakeholders work together in multiple sessions to plan and design a project. A charrette typically involves intense and possibly multi-day meetings that ultimately promote joint ownership of solutions between the villagers, the project sponsors and the design team. The process allows villagers to participate throughout the planning process. Charettes provide a forum for planning the project with those who can influence the decisions and final design concept. It provides an opportunity for project sponsors or designer to introduce previous projects and share experiences to inform the planning process. The process can encourage agreement on project goals, and promote "collective enthusiasm " for a project with early and realistic goals and direction.



5.8. Project Implementation

5.8.1. Design Plan Review

Once a project has been selected by the community the design team will proceed to prepare the final engineering design plans. During the design phase the VWMC will schedule and facilitate design review meetings at critical milestones, such as at 30% completion (conceptual plans), 60% completion (design development) and 100% completion (construction design package).

5.8.2. Project Bidding and Procurement

Once the engineering design plans are approved the project will likely be "put out to bid" to select a contractor to build the project. The VWMC should have representatives involved in this process to review the Bid documents and to assist with the selection of the contractor. This is important so that the VWMC and community understand and support the bidding process. Including the VWMC in the selection process will create a transparent and fair procurement process that hopefully avoids any doubt or conflicts in the final selection of the contractor.

5.8.3. Project Construction (Project mobilization and coordination)

The role and responsibility of the VWMC during this stage of the project will depend on the ultimate project type. For example, if the project solution is to install latrines at each household, than the VWMC may be responsible to coordinate the purchase and distribution of materials and the inspection of latrines during and after construction. If the project will involve a centralized sewer, wastewater treatment and land disposal system, the VWMC may have additional responsibility related to collecting and managing funds from individual households and coordination of community labor.

During the project construction phase the VWMC will have an active role in the day to day activities of the project. The VWMC is the community representative and will negotiate any logistical, financial or construction related matter between the contractor and the community.

Successful project mobilization and coordination result from timely and effective communication, and good community participation. Therefore, the community workers may need to train and assist VWMC members in the areas of project management, coordination and scheduling activities.

5.9. Project Administration and Community Updates.

At this stage the VWMC should probably have a record keeping system and bank account to be able to schedule and track the community labor force. The VWMC is also responsible for collecting and recording funds from the individual households participating in the project. Funds collected are used to pay for recurring expenses, such as monthly wages, electricity bills, and/or other costs to repair or replace equipment or materials.

Providing routine project and financial updates via meetings and public notices is an important role of the VWMC. Committee reports should be regularly scheduled, e.g. monthly to keep the community well informed of the progress of the project and to inform them ahead of time of any unresolved issues or matters being considered that would affect any or all of the households.

5.10. Project Mobilization and Coordination

Once project construction is underway the VWMC is responsible to coordinate and supervise the local labor force. This will likely require that the VWMC prepare a construction schedule and, as previously mentioned, a record keeping system to account for labor hours expended by each household. The VWMC may also need to conduct *ad hoc* meetings, particularly if a special event or condition arises that will require additional labor requirements, for example the off-loading of materials from a transport vehicle to a storage warehouse.

5.11. Project Management

Once the project has been constructed, the role of the VWMC will shift to that of operator/caretaker/administrator. During the commissioning and startup a representative from the VWMC should participate in the inspection of the new system(s) and the startup and testing of the system, as required. The VWMC will be the system administrator and will be responsible to oversee the project and inform the community about the condition and status of the project.

System Operation. If the new project includes the installation of a centralized wastewater treatment system, the VWMC should hire a local person from the village to conduct routine operation and maintenance activities to maintain the new treatment system in good working order. In many instances the contractor who installed the new treatment system may be responsible to operate and maintain the system for a prescribed period of time, such as, the first year. During this initial operating period the locally hired operator should work closely with the private operator to become trained and knowledgeable of the system.

Project Administration. The VWMC will also be responsible for the ongoing administration of the project. The administrative activities will include:

- Managing the funds and accounts for the wastewater project;
- Setting and collection of monthly users fees or tariffs;
- Preparing monthly, quarterly and/or annual reports for the community.

Ongoing meetings. The VWMC should conduct regular community meetings to report on the status of the project, including performance of the treatment works, the financial state of the committee and project in general and any other issues or matters that need to be discussed and resolved. Conducting routine community meetings is important to maintain open and transparent communication with the community at large and as a way to involve the community and residents in a participatory process related to the wastewater project.

5.12. Community Workshops and Meetings

The project sponsor and VWMC will need to conduct workshops and meetings to engage the community and stakeholders in the participatory process. Workshops are needed to bring people together to share knowledge, make decisions and assign responsibility for action (Tayler et al., 2003). This section outlines the steps that should be considered to hold an effective participatory workshop and include five major steps involved in conducting a workshop: first determining how and when workshops can be used; preparation for the workshop; workshop logistics; conducting the workshop; and recording the outputs of the workshop.

5.12.1. How and When to Conduct a Workshop

At the beginning of the planning and policy development process, a workshop can be used to bring the various stakeholders together in order to introduce the project and planning process, to understand and define priorities and concerns, and to assign responsibilities for investigating the existing situation and other case studies or lessons learned in the region.

Later workshops are important to ensure that everyone remains committed to the process and that stakeholders remain aware of each other's activities and concerns. Workshops provide an opportunity to review and agree on proposed plans, obtain feedback on the proposed plan and to review progress in implementing a plan or policy.

5.12.2. Preparing for a Workshop

When preparing for a workshop some basic questions need to be answered about the expected outcome, who should attend, and how it will be organized. The workshop will only be successful if there are clear objectives and targeted outcomes. Achieving desirable outcomes requires that there are clear roadmaps to follow-up activities that respond to problems or issues identified in the course of the workshop, and that responsibilities are delegated for carrying out and coordinating follow up activities, and that arrangements are put in place for managing the follow up activities.

Number of Attendants. The number of people attending the workshop should not exceed about 50 people. The best results will normally be achieved with 25 to 30 participants.

Workshop Attendants. The attendees to the workshop should broadly represent the community in all its diversity, and include both, women and men, people from different parts of the area to be covered by the project, and a range of ages and occupations. The attendees should be notified at least one to two weeks prior to the workshop and attendees should be told what the topic will be, the length of the workshop, and if any preparation is required before attending it.

Workshop Facilitator. The success or otherwise of the workshop will depend on the way in which they are chaired and facilitated. The role of the chairperson is to ensure that everyone has a chance to talk, that sessions do not overrun and that the participants do not stray away from the subject of the session. The same person does not have to chair every session of the workshop. The basic requirement of a good chairperson is that he or she is firm and fair. The facilitator's role is to ensure that people know what they are meant to be doing in the workshop and then to help them to do it. It is important that the facilitator has knowledge of the participatory approaches and methods and good communication skills.

Length of Workshop. The workshop needs to be long enough to give people time to come together as a group to address problems and issues in a participatory way. On the other hand, for most participants, time spent attending a workshop is time that is not being used productively elsewhere. Two days is typically a good length of time for a workshop – it allows one day for problem identification and analysis and one day for the identification of possible solutions. Later workshops may be shorter, lasting at most one day and perhaps only half a day, and are usually focused on a more defined topic.

5.12.3. Workshop Logistics

The workshop will only run smoothly if the organizers pay careful attention to the workshop logistics prior to the workshop. Some key logistic issues that need to be considered include the workshop location, the available space, seating arrangements, and the equipment and materials used during the workshop. Any per diem or travel costs must also be decided and payment procedures put in place.

Workshop location. The workshop should be located in an easily accessible location for attendance, but in a location that is away from the attendee's normal place of work. Taking the attendees away from their place of work will allow the participants to focus their attention on the workshop with minimum distractions.

The physical location of the workshop should have sufficient space to allow people to disperse into small groups for discussions and group exercises. The space should have wall space for displaying poster boards, and a reliable electrical power supply if electronic computers or projectors are used.

Seating arrangements. The seating arrangement for the workshop should provide the attendees with a reasonable level of comfort given that they may be attending a two-day workshop. The seating arrangements should allow for flexibility, so that the attendees can face each other and be mixed to encourage engagement of all participants. The workshop organizers may choose to assign seats if the attendees are selected with a purpose to mix up genders and different interest group.

Presenting and sharing information. A workshop is a means of allowing participants to work with and present information. In order for them to do this effectively, arrangements have to be made for presenting, working with and displaying information. Options include flipcharts, chalk boards, whiteboards, and overhead projectors. Flipcharts, chalk boards, and whiteboards are good media for community members to use since they are easy to use and do not rely on electricity or computer skills.

5.12.4. Conducting the Workshop

The structure of most workshops will include an introduction, sessions devoted to the collection, presentation and analysis of information, assessment of available resources, and agreement on action to be taken and allocation of responsibilities.

Introduction and Setting the Stage of the Workshop. The introduction of the workshop is important to set out the objectives of the workshop and to set out any potential ground rules for the sessions. For example cell phone use during the workshop sessions may be a significant distraction to many attendants, so the organizers may request that cell phones be turned off during sessions. It is also a good idea to start the workshop proper with an icebreaker session, designed to introduce workshop participants to one another and to ease them into the active role that they will be expected to plan in the workshop.

At the introduction of the workshop the facilitator will explain what each session is about as clearly as possible and restate this at the beginning of each session. Where necessary the facilitator may provide background information and concepts to get the sessions rolling and to engage discussion and enquiry. The facilitator may also need to intervene periodically to move the discussion forward and to keep it on track. At the end of a session the facilitator should provide a recap of findings and outcomes of the session. This may be done in writing on a flipchart or other means as a way to review and reflect on the key issues discussed or raised during the session. This is a critical outcome of the overall workshop and helps to define follow up activities.

Staying the Course of the Workshop. Issues may arise once the workshop has begun and there may be calls to change the structure or topics of the workshop. Do not rush into such changes. It will be better to come back to these after the group has had a break and time to consider possible changes and impacts to the workshop. The workshop organizers should be flexible in the structure of the workshop, but should be cautious in modifying the topics since they likely spent substantial time preparing the content of the workshop. If may be more appropriate to schedule a new workshop or meeting to discuss the new topics raised during the workshop, so that sufficient time is available to prepare and understand these new issues.

Follow-up Action. The workshop will only have been worthwhile if the actions agreed in the course of it are implemented. With this in mind, task identification and allocation should lead into discussion of the timetable for follow up action. A time and date for a follow-up meeting at which the various stakeholders will report on progress with their tasks should also be agreed.

5.12.5. Recording the outcome of the Workshop

The main topics and outcomes of the workshop should be recorded and then summarized in a short report, which should be circulated to the workshop participants and to any other individuals or organizations with a possible interest in the workshop findings. The report should be produced as soon as possible after the workshop is completed in order to maintain focus and direction to follow up activities. The report is also important to review during a subsequent workshop or meeting and allows the participants a way to assess if the goals set out at the previous workshop were met.

CHAPTER 6 - TECHNICAL ANALYSIS AND DESIGN

This chapter outlines the required steps to assess, plan and design an appropriate sanitation project for a rural village. This undertaking has two parts. The first part consists of the pre-design studies:

- a thorough community assessment involving compilation and analysis of geographic, population, economic, and other data,
- consideration and comparison of all conceivable means of achieving the project goals to reveal which is the most feasible, and
- identify any potential environmental impacts, assess their importance, and specify mitigation measures.

The second part is the preparation of engineering designs for the final project.

6.1. Overview of the Pre-design Studies

During the pre-design study phase several complimentary studies are undertaken, including a community assessment and data collection study, baseline engineering/survey studies, and preparation of a feasibility study including a preliminary cost analysis. Figure 6.1 outlines the structure of the pre-design activities and completion of a feasibility study.

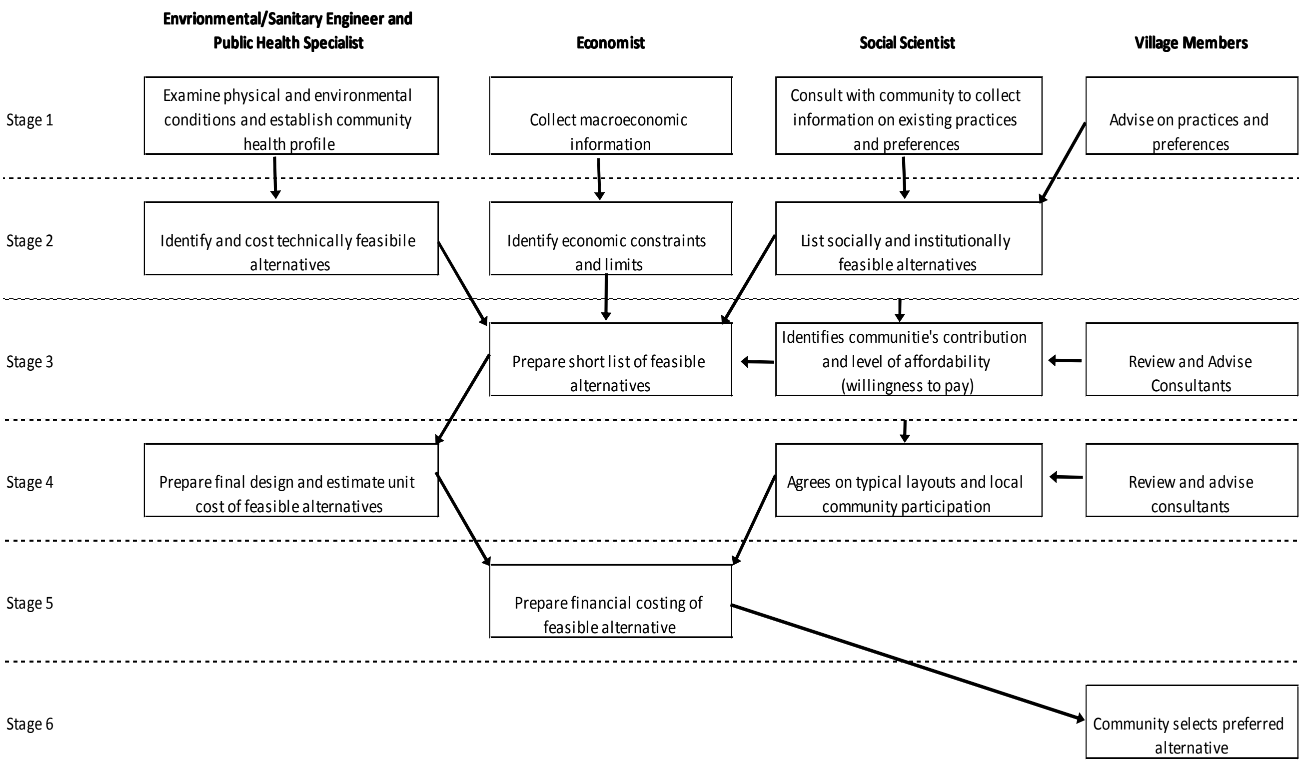


Figure 6.1. Structure of Pre-design Studies and Feasibility Study (After Kalbermatten et al., 1982)

The following sections describe these tasks conducted during the pre-design and feasibility studies phase of the project.

6.2. Community Assessment and Data Collection

The first action on a project is to determine the community resources and needs. Assessing and determining the physical resources and social structure of the community can be accomplished using the participatory rapid appraisal (PRA) method (Mihelcic et al., 2009). The PRA has several underlying principles.

First of all the PRA work should not be construed as a comprehensive community participation process. It is intended to allow the lead project proponents (governmental or non-governmental) to determine if the village has the interest and capacity to successfully implement and maintain a project. Once a village is selected to participate in a wastewater management program a comprehensive community participation program should follow. Chapter 8 presents a more detailed description of the elements of a comprehensive community participation process. The remaining sections outline the basic community assessment work that is needed to support the completion of a technical feasibility study and engineering design plans; however, during the development of the technical studies the selected communities should actively participate.

Respect for the community. The assessment team should respect the local culture and knowledge of the community. All team members should concentrate on listening to the community members and gaining insight about the local experience and insight. A fundamental goal at the outset is to gain the respect and confidence of the community, which will be a key to the successful execution of the project.

Triangulation. Triangulation is the use of many different types of people, both outsiders and community members, to interact with the community and gather basic information. A diverse group of people with mixed genders and possibly different ethnicity will put together a richer description of the resources and needs of a community. The team should be made up of a multi-disciplinary team including an engineer, social scientist, health worker, and possibly a teacher from the community, a member of the local government council, local merchants, and other leaders and key members from the village. The assessment team should not be too large a group, so that the

collection and processing of information is not too broad and difficult. It is important to keep in mind that community assessment methods can be subject to bias. Bias may occur when a team member only speaks to one or two groups within the community; for example, a male member may not be comfortable approaching a women's group or members of a different ethnic group. For this reason forming a team with broad representation and using triangulation techniques can reduce such bias and the attendant inaccuracies.

Information Needs. The assessment team needs to set realistic goals for the amount of information needed. It is not possible to list every piece of information about a community or about an individual within a community. Nor is it necessary. A good participatory process stops when sufficient information is available to move on to the next stage of the project. Gathering too much information wastes precious resources including the patience of the community members.

Flexibility. Engineers and project designers must accept to listen to community members and be ready to incorporate their concerns and ideas in the earliest stages of a project. This consideration means that the engineer may have to discard preconceived notions and design a project that meets the needs and fits within the constraints of a community. Throughout a project, unexpected obstacles and opportunities may present themselves. The engineer and community must be ready to assess them and make appropriate changes to the project.

6.2.1. Assessing the Communities Interest and Basic Resources

At the initial community assessment stage basic information is sought to ascertain if the village is a good project candidate. Key types of basic information include the following: the existing situation, people's attitudes, opinions on change, and available resources.

The existing situation - what facilities and services exist? How do they perform? And who has access to them?

People's attitudes – What are people's views on sanitation? Are they willing to pay for improved facilities? Is there a perceived need to improve public health and environmental conditions in the village? Are local villagers inconvenienced by the lack or unreliability of sanitation services? What are villagers' perspectives and confidence level with regard to local and visiting political and technical authorities? Is there importance attached to local autonomy that might be lost if a higher authority were to assume part or all of the responsibility for funding, fee collection, construction,

administration, operation and maintenance of the improved facilities? Is there any preference for private or individual solutions versus centralized solutions?

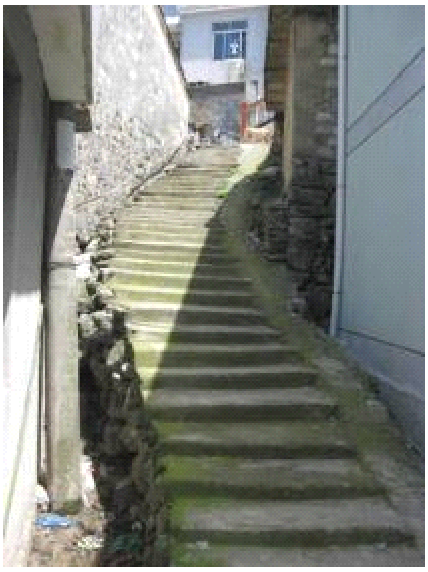
Opinions on change – Is the community interested or prepared to adopt new techniques or technologies? Are there any potential cultural barriers?

Available resources – What can the community contribute in the way of physical, financial, institutional and human resources?

It is important to bear in mind that at the initial assessment stage the key to informed decision making is to have access to sufficient information to allow the main issues and options to be identified.

6.2.2. Physical Layout of the Village and Community Resource Mapping

Assuming the basic information has been reviewed and it has been decided to proceed to the next stage of project planning, then more specific physical information is required. Acquiring a fundamental understanding of the physical setting and layout of the village will help the selection of an appropriate sanitation solution for the village. Some key information that can be collected at the early stage of planning includes:



1. The physical setting. Is the village in a mountainous, valley or coastal setting? What's the slope of the terrain? How deep is groundwater? What's the nature and depth of bedrock?
2. The age and type of building construction. Older earth-built buildings can be difficult to retrofit with sewer connections, as compared to more contemporary construction techniques using concrete block or timber frame construction.
3. The density and size of home sites. For example, if the homes are tightly spaced with small lots the use of decentralized, on-site sanitation systems may not be viable.
4. Vehicle and pedestrian accessibility in the village. Many older villages have very narrow paths so that sewer construction would need to be done using guide labor or small hand power tools.

5. Topography. In the coastal plains the villages are on relatively flat land so that the layout of sewers may not be complicated; however in mountainous regions lot elevations vary significantly resulting in complex and costly sewers.
6. Geology, soil and groundwater conditions will all have a significant influence on the sanitary solution found to be appropriate for the village.
7. Identifying any potential geologic hazards, primarily landslides, at an early stage of project planning can hopefully avoid serious problems that could occur if wastewater is directed into a potentially unstable area.
8. Identifying flood zones is also important to avoid constructing any improvements in areas that are prone to flooding.

Community Resources Mapping. An effective method to document the conditions, options and solutions in a village is to develop simple maps that illustrate the information obtained at each stage of planning. These maps will serve as important visual tools illustrating physical conditions, natural resources and important features in the community. The maps also serve to document each step of data gathering and decision making processes in a simple and understandable format for the villagers. A good example of a community map is shown in Figure 6.2.

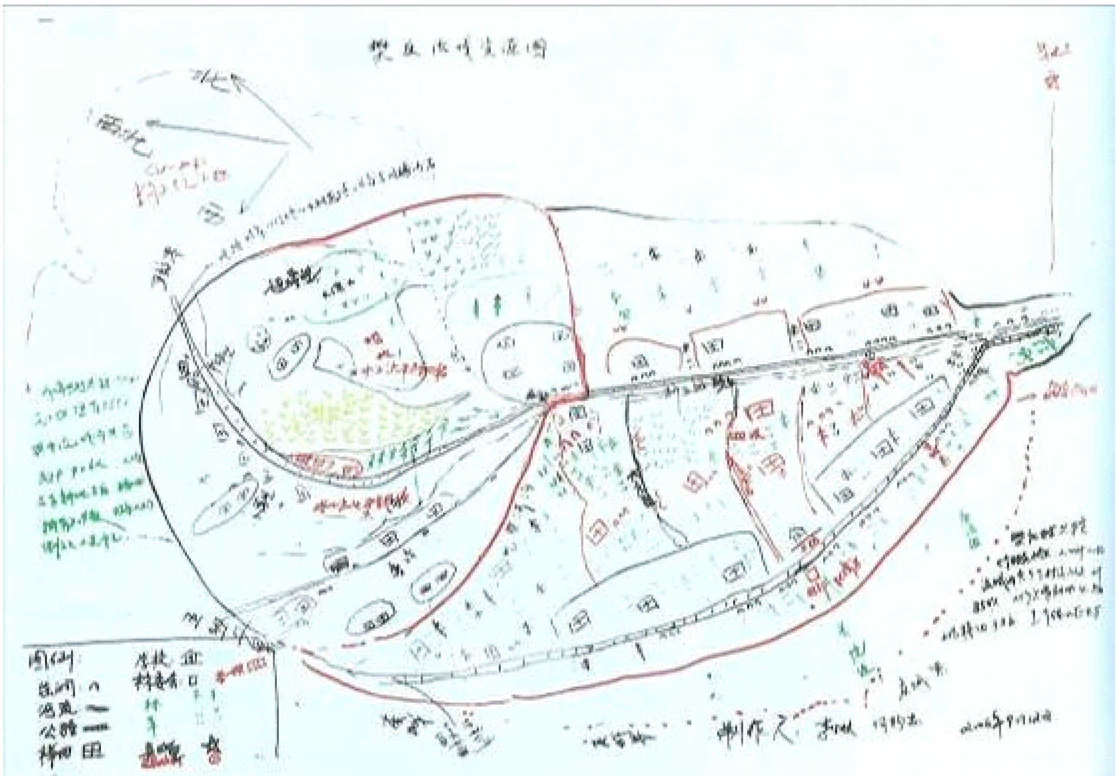


Figure 6.2 Example of a Community Resource Assessment Map (CWMP, 2007)

6.2.3. Identifying Community Leaders

Projects need the support of the community to be successful. This step requires the support, or at least the approval, of the influential members of the community. Some influential community members may be obvious, such as a mayor or government officials; however, others may not be evident to someone new to the community. A key role of the assessment team is to work with community members to develop a list of key institutions and community members. Once the list is prepared the assessment team can ask people which organizations or projects were successful and who was critical to the success. Those individuals identified are likely to be good leaders for a development project. The leadership may include both formal and informal leaders. Questioning people about the quality of leaders can be a delicate endeavor, but it is often worthwhile (Mihelcic et al., 2009).

It is important to understand the commitments of potential leaders. Some leaders are over-committed and over-burdened and they may not be effective in their role. So caution must be used to protect such people from over-commitment when introducing a new leadership role. Organization of a management committee can begin with a core group selected from the group of critical positive people, while attempting to avoid influential people and obstructionists who hinder projects.

6.2.4. Assessing a Community's Capacity for Project Success

During the initial assessment phase of the project it is important to determine the current capacity of the community to manage a sanitation improvement project. The assessment team can evaluate what current or recent projects have been implemented in the village, and how successful have they been. The team should find out if the project(s) has continued after the initial funding and support ended. If so, what has attributed to the success, and if not, what factors contributed to the failure?

A useful way to gather this basic information is to develop a simple community map and ask community members to locate each past project on the map and describe why the project was either a success or failure. Again, triangulating to obtain views of different groups within the community will give more reliable and robust information.

Capacity also includes the ability to pay for on-going operating costs of a development project. It is often not the initial capital costs that are the financial downfall of a project, but the on-going costs of administering, operating and maintaining the system. Capital costs are often subsidized by the government, a non-governmental organization or other financial entity, where as operation and maintenance costs are not. At this initial stage it is important to determine the income sources and levels in the village and to determine the community's willingness to pay for improved services. A simple economic survey of current expenditures of households can provide insight into the financial profile for the community. In many rural villages they may have also community income generating

enterprises that will offset the cost of a project. For example, many rural villages in Ningbo operate small hotels, restaurants and in some mountainous regions small hydroelectric stations that provide a steady income to the community that can support, in part, the on-going costs to operate and maintain small wastewater projects.

6.3. Baseline Engineering/Survey Studies

Once the community assessment study is completed field engineering and surveying work is required to obtain accurate baseline information about each village. This work will involve the following tasks:

1. **Topographic Survey and Base Map.** Conducting a topographic survey and preparation of an accurate base map of the village and potential land disposal areas. The land survey should be completed to an appropriate scale and sufficient detail to allow for planning and ultimate design of the improvements. The contour interval of the topographic map should be as small as feasible. In very steep terrain with significant topographic changes a contour interval of 2 to 4 meters may be sufficient, whereas, in low gradient areas a maximum of 0.5-meter intervals should be used. The topographic survey should show major features including buildings, roads, paths, bridges, water courses (streams and rivers), drainage courses, large trees, utilities and other features that may affect the project.

2. **Geology, Soil and Groundwater Study.** A geotechnical investigation is required to evaluate soil and groundwater conditions at village. The investigation may be focused to evaluate soil and groundwater conditions in areas selected for individual home (decentralized) and/or for community (centralized) land disposal systems. The geotechnical investigation should also identify any potential geological hazards, such as landslides or other natural features that potentially could impact the project. The scope of the geotechnical investigation will depend on the size of the community and complexity of the geology, soil and groundwater conditions.

3. **Field Engineering Assessment.** Once the topographic survey is completed the design engineers should conduct a field engineering study to assess and refine the definition of field conditions, housing density, site accessibility, and constructability issues or constraints that should be considered in the selection of appropriate sanitation improvements.

6.4. Feasibility Study, Environmental Impact Assessment, and Preliminary Cost Analysis

Once the initial community assessment and field engineering is completed the Design Institute (DI) or a private consulting team will complete a feasibility study report (FSR) and environmental impact assessment (EIA) for the project. In general the purpose of the FSR is select and screen appropriate sanitation and wastewater

solutions for the village, to estimate the cost of the selected project, to evaluation potential environmental impacts and related mitigation measures, and to determine if the project proponent and village can financially support the construction, administration, operation and maintenance of the project. An EIA is required to evaluate any potential environmental impacts that may arise from the project and to present an environmental management plan that is designed to mitigate or avoid environmental impacts from occurring. A comprehensive cost estimate is important to be able to compare and select alternative village wastewater improvement projects. The following sections outline the information that should be provided in a FSR and EIA. A separate section is also provided that outlines procedures for estimating costs that DI's or consultants should use in order to prepare realistic and consistent estimates that conform to national standards.

6.4.1. Preparation of the Feasibility Study Report (FSR)

The FSR summarizes a comprehensive effort by the DI, the village, and the lead government and non-government agencies to develop and document the preferred wastewater management improvement project for the village or in some cases group of villages. The FSR will include the following information:

1. An **introduction** describing the proposed project, the purpose and scope of the FSR document, and the layout of the report;
2. An overview of the **project background and rationale**;
3. The **project setting** including the existing conditions and physical setting, any environmentally sensitive and/or resettlement issues, or other potential opportunities or constraints;
4. A review of **village selection criteria** used to screen and select villages to participate in the project;
5. **Design Criteria and Standards** such as definition of the service area and population served, wastewater design flows and water quality, and relevant design criteria and standards.
6. **Analysis of Alternatives** for proposed village wastewater management improvements, including identification of appropriate solutions (such as decentralized or centralized wastewater management schemes), a screening of alternative approaches and wastewater systems based on technical and economic comparisons, and a selection of the preferred alternative;
7. A summary of the **Environmental Impact Assessment** (EIA) study and recommendations;
8. A description of the **institutional framework** of the wastewater management program and project(s);
9. An **economic analysis** of the project(s) including the final project cost estimate and institutional arrangement for project funding and a description of the type and level of subsidies;
10. A description of the **project implementation plan** that outlines how the project will be organized, what documents and plans will be completed, and an implementation schedule;

11. The **financial analysis** that describes the financial arrangements for programmatic and financial implementation and operation of the projects; and
12. The **conclusions and recommendations.**

The following sections provide a more detailed description of the various elements of the FSR.

Introduction. The introduction of the FSR should provide a description of the project setting and existing conditions including the current level of rural development or services available in the village(s). The introduction should clearly state the project objectives and goals, and summarize any potential environmental sensitivity and required mitigation measures. This section should describe the scope of the feasibility study and describe how the information is presented in the report.

Project Background and Rational. This chapter of the report should provide background information that describes the proposed project, the general conditions encountered in the village(s), and the rational and purpose of the proposed project. The chapter can discuss the development objectives that will be achieved by implementing the project. This section may also present an opportunity and constraints analysis that summarizes the recommended approach to overcome any potential barriers that could impact project implementation.

Project Setting. The section should provide a thorough description of the project setting, including the physical conditions of the village, including the terrain and topography, geology, the size and density of housing, level of education, the economic conditions and income levels, primary source of revenue, the existing utility services including water, electricity, sanitation, transportation and road conditions.

Village Selection Criteria. The FSR should describe the policy and criteria used by the Municipality and County governments to screen and select villages. An example of village selection criteria adopted by the Municipality of Ningbo is summarized in the following text box.

Design Criteria and Standards. The FSR should identify and summarize the relevant design criteria and standards that apply to the proposed wastewater management improvements. Example design criteria would include projected per capita water use and wastewater flows; setbacks of sanitary/wastewater improvements from water courses, wells, shallow groundwater, and property lines; soil application rates for different soil conditions and different wastewater strengths (untreated versus treated wastewater), and wastewater discharge standards for discharge to land, surface water and for wastewater reuse.

Analysis of Alternative Wastewater Projects. This section should describe the criteria used to decide if a decentralized or centralized wastewater project will be used in a village. The section will also summarize the results of the technical screening leading to the selection of the appropriate system for the village. Typical screening criteria used to evaluate alternative wastewater technologies include:

a. Capital costs;
b. Operation and maintenance costs;
c. Reliability;
d. Required operator skill level; and
e. Energy demand.

Box 6.1. Village Selection Criteria Applied in Ningbo Rural Wastewater Management Project

In the development of the wastewater demonstration project in the Municipality in Ningbo the municipality and World Bank Staff agreed to the following criteria for the selection of a village:

1. **Villages located in water resource protection areas are given a high priority for selection**
2. **At least 80 percent of all households in the village must agree to participate in the rural wastewater program and install**
3. **At least 80% of the households agree to install a decentralized wastewater system or connect to a central sanitary sewer**
4. **It is the individual households responsibility to pay for any repair or construction work within the homes.**
5. **The Village must formally agree to take over ownership, operation and maintenance of the communal assets created.**
6. **The Village must agree to establish a tariff to pay for the long-term operation and maintenance of the wastewater system(s).**
7. **The Village Committee must agree to arrange to empty the sludge from the communal septic tank(s) at least once a year.**

A formal agreement must be submitted in a form satisfactory to the Ningbo Municipal Project Management Office.

As part of the FSR prepared for the Ningbo Rural Wastewater Management Plan, an analysis of alternative wastewater treatment schemes was completed. The analysis of alternative wastewater projects compared the capital costs, the operation and maintenance costs, and the equivalent annual costs for three alternative wastewater

treatment technologies considered to be appropriate for small centralized village wastewater projects. The results of the analysis are summarized in Table 6.1, which shows the project capital costs for three different treatment systems sized to treat four different design flows, 25, 50, 100 and 150 cubic meters of wastewater per day (m^3/d).

Capital and Operation and Maintenance Costs. The capital costs information includes the costs for materials and equipment, labor, and the purchase of land. The operation and maintenance costs include the costs for skilled and unskilled labor, equipment maintenance, servicing and replacement, electrical energy costs, and sludge removal and disposal.

Equivalent Annual Cost (EAC). To compare each alternative treatment scheme the equivalent annual cost (EAC) is calculated. The EAC is the cost per year of owning and operating an asset (i.e. wastewater treatment system) over its entire life span. The EAC is a good tool to use to evaluate alternative technologies that have different capital and operation and maintenance costs. EAC is calculated by dividing the net present value (NPR) of a project by the present value of an annuity factor as follows:

$$EAC = \frac{NPV}{A_{t,r}}$$

Where: EAC = equivalent annual costs

NPV = net present value = sum $(R_t/(1+i)^t$

R_t = net cash flow at time t

t = time interval

i = discount rate

$A_{t,i}$ = annuity factor = $[1-1/(1+i)^t]/i$

The example economic analysis for the Ningbo Rural Wastewater Management Program indicates that although the trickling filter and free water surface wetland treatment system has the highest capital cost compared to the two other alternatives it has the lowest EAC over the life span of 20 years with a discount rate of 5% used for all project configurations evaluated. A comparison of the EAC for all three projects is also shown graphically in Figure 6.3.

Environmental Impact Analysis (EIA). The FSR should summarize the results and environmental management measures outlined in the EIA. The EIA section should describe the current sanitation conditions in the villages and discuss the project improvements in water quality, public health and overall pollution reduction. The FSR should discuss how and by whom the management measures will be implemented. The FSR should also summarize the environmental monitoring program prescribed in the EIA. The FSR should include an environmental management plan matrix that summarizes the potential environmental impacts and management measures required during each phase of the project, including design, construction and operation periods. The matrix should also identify the entity responsible to implement the measure and provide the regulatory oversight of the

same. Table 6.2 presents an example of an environmental management plan prepared for the Ningbo Rural Water Management Plan. The FSR should also include a matrix of the prescribed environmental monitoring plan. The environmental monitoring plan will usually include air, water, soil and biotic monitoring as required based on the scale and scope of the project.

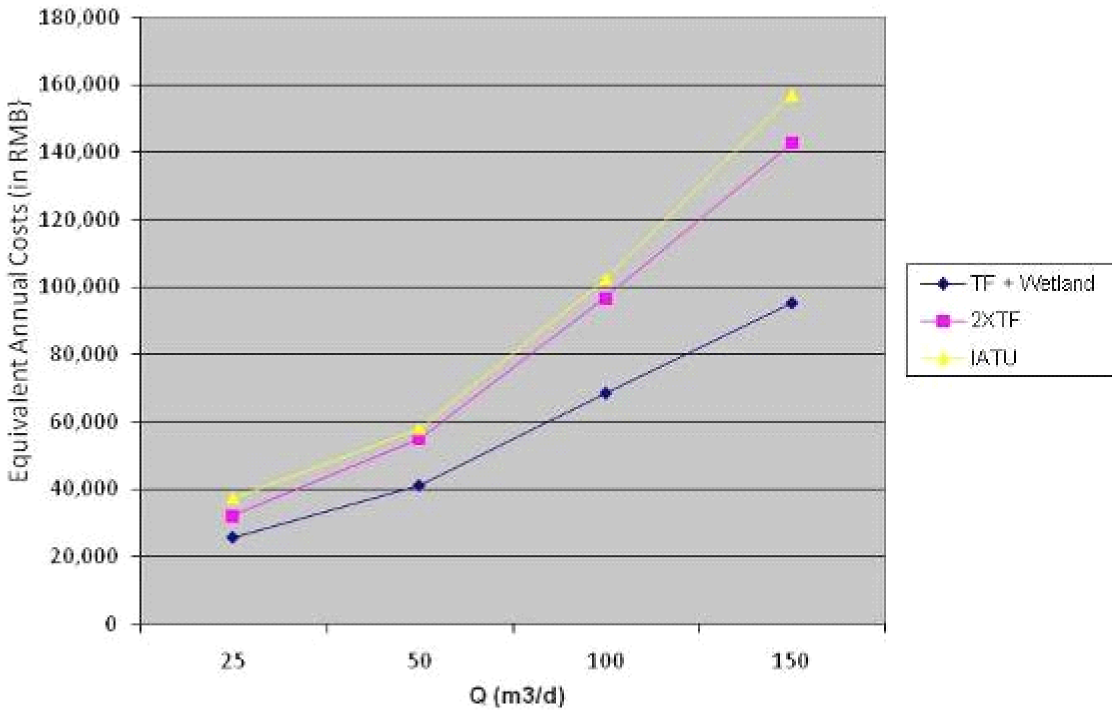


Figure 6.3. Equivalent Annual Costs (EAC) of Alternative Wastewater Treatment Systems for Different Wastewater Flows

Table 6.1. Economic Analysis of Alternative Wastewater Treatment Systems

Capital Costs for Alternative Wastewater Treatment Systems

Alternative Wastewater Treatment System	Design Flow			
	25 m^3/day	50 m^3/day	100 m^3/day	150 m^3/day
	Capital Costs (RMB)			
Trickling Filter and Free Water Surface Wetland	150,817	259,860	419,449	642,329
Integrated Aerobic Treatment Unit	194,278	249,597	351,896	445,194
Two-Stage Trickling filter	168,800	287,997	443,050	794,848

Operational and Maintenance Costs

Alternative Wastewater Treatment System	Operation & Maintenance Costs (20 year period)			Total OM Costs (RMB)
	Labor	Equipment	Energy Costs	
Trickling Filter and Free Water Surface Wetland				
25 m^3/d	87,294	3,707	86,897	**177,898**
50 m^3/d	87,294	4,236	173,795	**265,325**
100 m^3/d	103,166	5,957	347,589	**456,712**
150 m^3/d	103,166	6,619	463,452	**573,237**
Integrated Aerobic Treatment Unit				
25 m^3/d	63,487	14,827	208,554	**286,867**
50 m^3/d	63,487	15,886	417,107	**496,480**
100 m^3/d	119,037	16,945	834,214	**970,197**
150 m^3/d	119,037	18,600	1,448,289	**1,585,926**
Two-Stage Trickling filter				
25 m^3/d	63,487	7,414	173,795	**244,695**
50 m^3/d	63,487	8,473	347,589	**419,549**
100 m^3/d	95,230	11,915	695,179	**802,323**
150 m^3/d	95,230	13,238	926,905	**1,035,373**

Equivalent Annual Costs (EAC) (20 year life cycle at 5% interest)

Alternative Wastewater Treatment System	Capital Costs	O&M Costs (RMB)	EAC (RMB)
Trickling Filter and Free Water Surface Wetland			
25 m^3/d	150,817	177,898	**$25,697**
50 m^3/d	259,860	265,325	**$41,128**
100 m^3/d	419,449	456,712	**$68,560**
150 m^3/d	642,329	573,237	**$95,350**
Integrated Aerobic Treatment Unit			
25 m^3/d	194,278	286,867	**$37,512**
50 m^3/d	249,597	496,480	**$57,970**
100 m^3/d	351,896	970,197	**$102,381**
150 m^3/d	445,194	1,585,926	**$156,923**
Two-Stage Trickling filter			
25 m^3/d	168,762	244,695	**$32,242**
50 m^3/d	287,997	419,549	**$55,172**
100 m^3/d	443,050	802,323	**$96,866**
150 m^3/d	794,848	1,035,373	**$142,906**

Table 6.2. Example EIA Management Plan Matrix

Stage	Potential Impact	Management Measures	Implementating Agency	Project Owner	Regulatory Agency
Design Phase	Existing wastewater pollution	Develop appropriate sanitation project	Design Institute/Consulting Firm	Project owner/village	Municipal and/or County EPB
Construction Phase	Site disturbance and soil erosion	Prescribe erosion and storm water control measures	Project Owner, constuction company and village	Project owner/village	Municipal and/or County EPB
	Spillage and leaks of hazardous materials and fuels	Prescribe material storage and spill prevention meaures			
	Air pollution (dust and diesel exhaust)	Prescribe dustr control and air pollution control measures			
	Noise pollution	Prescribe noise control limits and measures			
	Land occupation	Develop compenstation measures for land occupation requirements			
	Construction waste generation	Prescribe solid waste management measures			
Operation Phase	Wastewater spills	Prescribe measures to reduce accidents and spills, susch as provisions for backup power generators, regular maintenance and cleaning of sanitary sewers and wastewater treatment systems to avoid clogged lines and backup conditions	Village wastewater committee and/or private operator	Village	Municipal and/or County EPB
	Odor problems	Prescribe odor control measures			
	Vectors (moquistoes) and pests (rodent infestation)	Prescribe vector and pest control measures			

Institutional Framework. The FSR should describe the institutional framework, role, and responsibilities of the various governmental and non-governmental agencies involved in the project. The section should highlight what project responsibilities will be undertaken by different entities during the design, construction and operational phases of the project.

During the design phase of the project several different key tasks will be required including village screening and selection pre-design work, preparation of tendering documents, and preparation of final designs. This work will most likely fall on the municipal and county level wastewater management agencies, the retained design institute or engineering consulting firm and village wastewater committee. During the construction phase of the project the key players will be the project manager/supervisor, the construction firm retained by the project proponent, and the village wastewater committee. Once the project is constructed the responsibility will transfer to the village wastewater committee and possibly a private operator, if one is retained by the village.

Cost Analysis. The cost analysis presents a comprehensive estimate of all of the project related costs, including cost for pre-design and planning studies, engineering design, project management, administration, and monitoring, construction costs, and operation and maintenance costs. This section should describe the basic parameters used to formulate the cost estimates including: the price base (the date of the prices (month and year); the rate of inflation and interest rates used for long-

term projections; any potential agency or financial related fees; any information related to loan sources and percentages; and any exchange rates used if foreign funds are used.

The FSR should include a preliminary cost estimate for project management and monitoring costs that include:

- Construction management and supervision;
- Field engineering and surveying, including geotechnical investigations;
- Preparation of FSR and EIA;
- Preparation of engineering design plans and specifications;
- Preparation of tendering documents; and
- Construction supervision and administration.

The FSR should include a preliminary cost estimate for construction of the project. The costs estimate should include material, equipment, labor costs. The cost estimate should be prepared by an experienced cost engineer familiar with infrastructure projects and national cost estimation standards. The cost estimate should conform to national standards for the preparation of project costs and should use unit costs for materials and labor representative of the region of the project.

Project Implementation Plan. The FSR should outline the activities involved in implementing the project, including:

- Engineering design;
- Bidding and procurement;
- Project management and supervision
- Project construction;
- Project startup and commissioning;
- Initial operating period;
- Project evaluation; and
- Final asset transfer.

A key element of the implementation plan is the development of an implementation schedule. The schedule should identify the major activities required to complete the design, obtain bids, award a contract and construct the project. The schedule should identify the time required to complete each task and the entity responsible for its completion. Figure 6.3 shows a typical implementation schedule.

No.	Task	Duration	Start Date	Finish Date
1	Preliminary Design Report	30 days	8/1/2010	8/31/2010
2	Design Review	15 days	9/1/2010	9/15/2010
3	Final Design & Construction Documents	60 days	9/16/2010	11/15/2010
4	Bidding Document	30 days	11/16/2010	12/16/2010
5	Bidding Document Review	15 days	12/17/2010	12/31/2010
6	Issuance of Bidding Document	30 days	1/1/2011	1/31/2011
7	Open Bids	7 days	2/1/2011	2/8/2011
8	Bid Review Period	7 days	2/8/2011	2/14/2011
9	Award Contract	7 days	2/14/2011	2/12/2011
10	Project Mobilization	14 days	2/14/2011	2/28/2011
11	Construction	150 day	3/1/10011	8/1/2011
12	Startup and Commissioning	30 days	8/1/2011	8/31/2011
Total Project Duration		396 days		

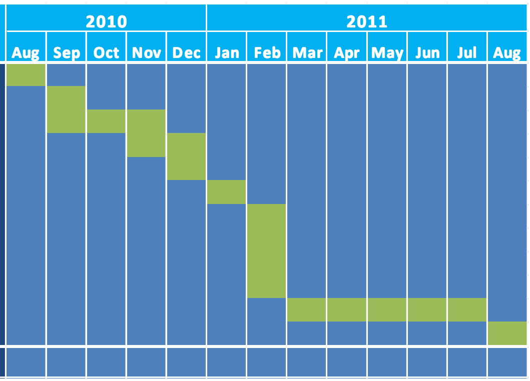


Figure 6.4. Example Project Implementation Schedule

Financial Analysis. The financial analysis is conducted to ascertain the financial viability and sustainability of the proposed project during the implementation and operation period. The financial analysis evaluates three areas including: i) the source of funds; ii) the financial capacity of the entity managing the funds; and iii) the project specific funding.

1 **Source of Funding.** The financial analysis should identify what sources of funds are available to support the project through implementation and construction. In many instances theses source may be a combination of a loan from an international financial institution, such as the World Bank or Asian Development Bank, funds from the national, provincial or local governments, and/or cost sharing from the village.

2 **Financial Entity.** The financial analysis should identify the entity or organization that will secure and administer the primary funds for the project and administer the cost recovery of a loan over the loan term period (i.e. such as a 20-year return period). The analysis should evaluate the capacity of the entity to properly manage and administer the funds and to service the loan if there is one.

3 **Project Level Analysis.** The financial analysis should evaluate the financial capacity of the village to service a loan. This is normally accomplished by calculating the financial internal rate of return (FIRR) of the project and comparing this to the cost of capital (if the overall project includes multiple subprojects or villages that will be serviced by a single loan then the weighted average cost of capital (WACC) should be used). The net present value (NPV) of each project should also be computed over the projects estimated economic life (typically 20 to 30 years depending on the terms of the loan). If the FIRR exceeds the CC (or WACC) and the NPV is positive, the proposed project is financially viable.

Conclusions and Recommendations. The final section of the FSR should summarize the findings of the technical studies completed in support of the project, including but not limited to the pre-design community assessment and engineering studies, the analysis of alternatives study, the EIA, the institution analysis, and the cost and financial analysis study. The results of the FSR and final recommendations should ascertain if the project is viable and should be conducted under the terms and conditions of the various players involved.

6.4.2. Development of Project Cost Estimate

Once the FSR is completed and the preferred project is selected a more detailed cost estimate should be prepared. The cost estimate should include the construction costs, costs for final engineering and design, project management and supervision, project startup and commissioning and an initial operating period (such as an 18-month period) prior to transferring the project to the local village.

The final cost estimate should be prepared by a cost engineer and should conform to national standards for preparing a Bill of Goods. The final cost estimate should utilize current unit costs reflecting actual costs in the region where the project will be constructed.

Construction Costs. The construction costs should include material, equipment, labor, and contractor markup and profit. The construction costs may include ancillary costs, such as transportation of materials, setting up of temporary housing and per diem for laborers (if the project is in a remote location and requires an external source of labor), rental space to store materials, and other foreseeable costs. At this stage a 10 to 15% contingency costs should be added to the construction costs to provide some additional funds that may be required to cover unforeseen costs that are common to infrastructure projects.

Engineering Costs. The fees for preparing the final engineering design plans should be included in the final costs estimate. These costs should include the professional fees, the reproduction costs of the final plans, and other foreseeable costs.

Project Management and Supervision. The cost estimate should include costs for the overall project management and supervision of the project and should include the costs for coordinating, attending and documenting construction meetings, preparation of requests for information (RFIs) by the construction contractor, preparation of supplemental information (Sis) for the construction contractor, and to assist with the startup and commissioning of the new wastewater facility.

Project Startup Period. An initial startup may be included in the project, such as an 18-month startup and training period. During this period of time a private contractor may be retained by the Municipality or County wastewater management program to assist the village to operate and maintain the new project. The costs for these services should be included in the final cost estimate. Additional monthly and annual

costs for electricity, pumping and disposal of sludge and potential other costs should be included in the final cost estimate.

6.5. Engineering Planning and Design

Once the FSR, EIA and final cost estimate are completed and the project is determined to be feasible the Design Institute or Consulting Engineering Firm is engaged to prepare the final engineering design plans and specifications. At this stage it is fundamental that the engineering plans and specifications are accurate and comprehensive to avoid mistakes and costly overruns or change orders to complete the project.

Once a project has been approved and moves into the final design stage, the design engineers will likely need to spend additional time in the village to gather more specific field information and/or to resolve undecided approaches that may affect the final design. If the proposed project will require electrical power to operate any mechanical equipment (pumps or aeration equipment) the design engineer should determine the type of power that is available in the community and how the power will be supplied to the equipment.

Another critical issue to resolve as the final design phase is undertaken is to finalize any decisions about the placement of improvements with the villagers. It is common that during the pre-design phase of the project villagers may not decide where they want final improvements to be made, such as the location of a small wastewater treatment system. This decision may not be made by the villagers until the project and related funding has been approved by all involved parties, such as the national governmental or World Bank, etc. Therefore, it is important that once the design engineer is retained to complete the final designs that the basis of design reflects the final decisions of the villagers and actual field conditions.

Once the design engineers have completed their subsequent field investigation the final engineering plans should be prepared. This work is commonly divided into two phases of design, including: (1) the **Design Development** plans, which represent plans that are completed to the 60% level of completion, and (2) the final **Construction Documents**, which includes the plans completed to 100% and the supporting specifications and include the Bid documents.

Design Development (DD) Plans. The DD plans present a well developed and comprehensive plan set that will include:

i. A cover sheet including a vicinity and site location maps, the existing topographic survey of the village, general construction notes, a list of technical references used as part of the basis of design, a list of consultants, and a sheet index, and other information that may be required by the funding agency or reviewing governmental agency;
ii. A site improvement plan that shows all of the proposed improvements included in the project. The site improvement plan should be presented at

an accurate scale and should denote essential features that may require site specific or special consideration, such as stream or river crossings, bedrock conditions, roads, paths, trees, and required setbacks;

iii. Detailed engineering designs for the decentralized or centralized wastewater improvements, including the details of a standard pour flush latrine, EcoSan toilets, septic tanks and leachfields, plan and profile of sanitary sewer systems, the layout and hydraulic profile of a wastewater treatment system, the layout of the subsurface disposal system. The plans should include notes, including the specifications and power requirements for any pumping, aeration or other mechanical information.

The number of details and associated sheets is dependent on the complexity of the project; however, the more detail and clearer the presentation is made at each step of the project the more it will avoid confusion and costly overruns once the project is in construction.

Once the DD set is completed it should be presented to the local wastewater management office and the village for review and comments. Once the plans have been reviewed the design engineers should meet with the reviewers to discuss all of the comments and to resolve any potential conflicts with the designs.

Construction Documents (CDs). Once the DD plans have been completed and reviewed the design engineers will prepare the final engineering design plans and specifications. The design plans will address comments received by the project reviewers on the DD plans and will present the complete engineering designs for all site improvements, including geotechnical, electrical, structural and civil engineering improvements, and temporary facilities, as required, and erosion control measures. The construction documents should include specifications that include general requirements, such as provisions for environmental management measures specified in the EIA, material and equipment specifications, construction specifications, and startup, testing, operational and training specifications. The CDs should include provisions for the contractor to provide “as-built” plans once the project has been completed. The CDs should require that the Contractor should demonstrate that the system is operating as designed over a final startup period commonly 15 to 30 days prior to final approval by the design engineer and local Environmental Protection Branch (EPB).

CHAPTER 7 - FINANCING, SUBSIDIES, AND COST RECOVERY

This section of the Guide outlines the financial components that need to be considered as part of a comprehensive wastewater management program. Financial components of a wastewater management programs encompass all of the following:

1. Programmatic Costs
2. Project implementation costs:
3. Project financing;
4. Project subsidies; and
5. Cost Recovery.

The following sections describe these components in more detail.

7.1. Programmatic Costs

The programmatic costs are the costs associated with establishing and maintaining a rural wastewater management program, either at the municipal or county level. These include staffing or human resources, office space, equipment, vehicle(s), and reimbursable expenses for materials, petrol, and travel expenses. Other programmatic costs may include special expenses for retaining domestic and/or international consultants to conduct workshops or technical studies, such as feasibility studies and sector specific studies (social, resettlement, and environmental impact assessments).

Staff Costs. Staffing costs will vary depending on the structure and size of the municipal and county rural wastewater management offices. In general, staffing costs or wages are the highest programmatic costs and will range from 60% to 70% of the overall programmatic costs.

The structure or staffing requirements usually will depend on the size of the municipality and the number of counties and rural villages administered by the different wastewater offices. A municipal level wastewater program will likely include a program director together with technical and administrative support staffs. In a large municipality, the Program Director may be supported by a technical director or chief engineer and administrative director and an administrative secretary. Staff reporting to the technical director may include an assistant or field engineer plus one or two water and sanitation promoters/educators. The administrative director may also have support staffs that may include a program analyst and administrative assistant. In a more rural or smaller municipal office the Program Director may be required to assume the role of technical and administrative director who is supported by a small cadre of technical and administrative staffs, likely to include a field engineer, water and sanitation promoter/education, an administrative assistant and program analyst and possibly a technician/mechanic. Figure 7.1 presents the institutional framework for a large municipal wastewater management program.

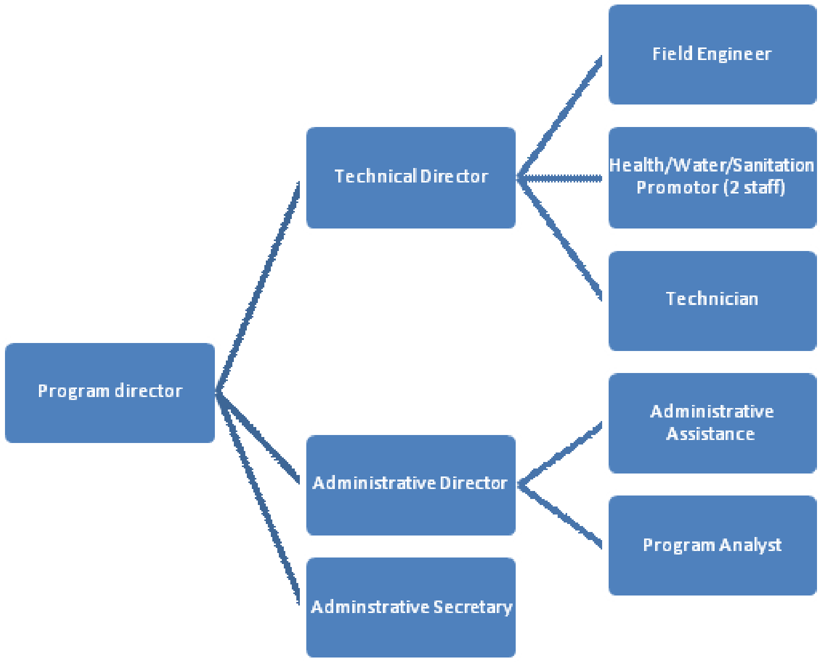


Figure 7.1. Institutional Framework of a large Municipal Wastewater Management Program

Fixed Costs. Fixed costs are generally one-time or ongoing overhead costs related to the physical and operational requirements of the program. These costs typically include the monthly rental for office space and related utilities (water, electricity, and garbage), purchasing of vehicles, computer equipment (computers, printers, network, and other related equipment), office furniture, telephone and cellular phone equipment and service, employee benefits (health insurance and retirement benefits). These costs will vary regionally, but in general will represent 20% to 30% of the monthly operational budgets.

Reimbursable Expenses. The reimbursable expenses include costs for expendable goods and services consumed over an operating period, such as a month or quarter and include the costs for office supplies (paper, pens, printer cartridges, and other related goods), fuel for vehicles, staff travel, accommodation, and per diem expenses. These routine expenses typically represent 10% to 20% of the monthly programmatic expenditures.

Special Funding or Soft Costs. Special Funds or soft costs are expenses incurred to conduct periodic workshops, to pay for consulting fees and special studies, and possibly to fund demonstration or pilot projects. Special funding is usually provided through public funds from the Municipal or Central Governments, grants, or loans from the international financial institutions (such as the World Bank and the Asian Development Bank) and non-governmental organizations (such as UNDP or UNICEF). These costs are considered discretionary or "soft" monies, because they are typically intended for a specific project for a short period of time, such as for a 1 to 5 year period and are commonly used to pay for technical studies, such as engineering studies and designs, feasibility and sector studies, workshops, project preparation

technical assistance (PPTA). These funds may also pay in part for fixed works elements of a project.

Table 7.1 presents a summary of the common programmatic costs that would be required to staffs and operate a municipal wastewater management program office.

Table 7.1. Summary of Programmatic Costs

Staffing and Wages (60 to 70% of Costs)	Fixed Costs (20 to 30 % of Costs)	Reimburseable Expenses (10 to 20% of costs)	Soft Costs
•Program Director •Technical Director/Chief Engineer •Administrative Director •Administrative Secretary •Administrative Assistant •Program analyst •Field Engineer •Health, Water and Sanitation Promoters/Educators •Technician	•Office •Vehicles •Computers equipment/software •Office furniture and equipment •Field Equipment •Cellular Phones •Insurance •Retirement benefits	•Materials and reproductions •Petro •Vehicle maintenance •Travel and accomomdations •Per diem	•Workshops •Consulting Fees •Special Services •Demonstration or pilot projects

7.2. Project Implementation Costs

Project implementation costs include the direct costs associated with the administration, planning, design, construction, construction contingencies, operation, maintenance, monitoring and evaluation of a community or village wastewater project.

7.2.1. Project Administration, Planning, Design, and Supervision

The implementation of the project will incur costs from a variety of administrative activities during the various phases of the project: engineering design, construction, and post-construction activities (operation, maintenance, monitoring and evaluation). The following sections indicate the costs (as proportions of the overall budget) necessary to successfully complete a project. Administrative activities are expected to consume approximately 25% of the total project costs. Table 8.2 summarizes the proportional costs for each of the principal administrative activities, which are described below.

Table 7.2. Proportional Costs for Project Implementation

Activity	Proportional Costs (in % of Total Budget)
Project Administration and Management	10 %
Community Outreach and Education	1.5%
Feasibility Study Report (FSR) and related technical studies	3.5 %
Engineering Design Plans	5 %
Construction Supervision	5%

Project Administration and Management. A fundamental expense of any project is the overall administration and management costs. This budgetary component of the project includes a range of tasks, including:

- accounting;
- supervision;
- coordination;
- scheduling;
- reporting;
- procurement;
- monitoring; and
- evaluation.

Collectively, these tasks will consume approximately 10% of the total project budget. The actual costs will depend on the complexity and scope of the project, and the administrative requirements of the funding agency.

Community Outreach and Education. The local wastewater management agency will undertake a series of community meetings and trainings once a community has been selected. The activity would normally be undertaken by a community development worker or a water and sanitation promoter. At this initial stage of a project, community outreach and education is critical and should occur in each village to assist the community to organize a wastewater committee and to acquire community specific information. This component of the project typically will

consume 1.5% of the project budget. The majority of costs are associated with staff time, transport, materials and reproductions.

Feasibility Study Report (FSR) and Related Studies. As discussed in Chapter 6, the feasibility study report (FSR) and related supporting studies (community assessment study, topographic survey, geotechnical investigation, environment impact assessment (EIA)) are undertaken to determine the community(s) needs. The feasibility study may be undertaken by the local agency or by a consulting enterprise, such as a design institute or engineering consulting firm. The cost of a FSR and related studies will again depend on the size and complexity of the project(s) and usually consumes approximately 3% of the total project budget.

Engineering Design Plans. Once the FSR is completed the next phase of work is to prepare detailed engineering design plans and specifications. The engineering design plans generally consume approximately 5% of the project budget. However, if the project is set up under a design and build procurement contract, an engineering entity (DI or consulting firm) may be retained to prepare performance specifications for the engineering contractor, who ultimately will prepare the design plans for the project as part of the construction costs. The costs of the performance specifications would normally cost in the range of 1.5% of the total project budget. These costs will depend on the complexity of the project.

Construction Supervision. Once a project has been awarded to a contractor for construction the local lead agency will need to dedicate staff resources, and in many instances may retain an outside consultant to supervise the construction of the project. At this stage, the DI or consulting firm responsible for preparing the engineering design plans is normally under contract to inspect the project and to address any issues or unanticipated conditions that may arise during construction. The overall costs for construction supervision will usually be approximately 5% of the overall project budget.

7.2.2. Project Construction

The construction costs are the biggest project specific costs and normally are approximately 65% of the total budgeted project costs. The construction costs include:

- Mobilization and staging;
- Project construction;
- Waste management and pollution control;
- Project startup and testing;
- Operator training; and
- Contractor profit and overhead.

Table 7.3 summarizes the proportional costs for each of the construction activities and the following paragraphs discuss each in detail.

Table 7.3. Proportional Costs for Project Construction

Activity	Proportional Costs (in % of Total Budget)
• Mobilization and Staging	1.5%
• Project Construction	50%
• Waste Management and Pollution Control	2%
• Project Startup, Testing and Training	1.5%
• Contractor Profit and Overhead	10%

Mobilization and Staging Costs. The contractor incurs these expenses to mobilize their equipment, materials, field office and personnel to the project or job site. This cost is typically estimated as 1.5% of the total project cost.

Project Construction. The physical construction of the project is the largest of the project-specific costs. It includes labor and material costs for constructing the fixed works, for example a new sewer collection system, wastewater treatment facility and land disposal system. The physical construction costs consume approximately 50% of the total project budget.

Waste Management and Pollution Control. During and after construction of any new project, debris and solid waste will be generated. Minimizing, managing, recycling, and/or disposing of this debris and waste incurs costs. Additional air and water pollution and erosion control measures are also needed to minimize construction-related environmental impacts. Costs of these controls typically amount to approximately 2% of the total project costs.

System Startup, Testing, and Training. If it includes any mechanical equipment or controls, such as a central wastewater treatment system, there may be a short period of time required to start-up and test the new system after completing construction, Projects involving decentralized sanitary waste systems, such as Eco-San latrines or gravity flow septic systems may not incur project start-up or testing costs. However, all projects will require some level of technical training and education to assure the proper operation and maintenance of the new system regardless of the technology installed. As part of the startup of the project, the Contractor is expected to provide the village wastewater committee with an operation guide and manufacturer’s information for all equipment installed. These activities typically consume 1.5% of the total project costs. Depending on the type, complexity, and scale of the project this proportion can vary.

Contractor Profit and Overhead. The final construction related costs include contractor’s markup costs to cover their profit and overhead, which may also include any costs associated with project bonding and insurance. These expenses typically amount to 10% of the total project budget.

7.2.3. Contingency Costs

Contingency costs are assigned to cover any unanticipated or unplanned expenses that may arise during the project planning and implementation periods. For example, unforeseen site conditions, such as difficult terrain or soil conditions may require alternative construction methods and change orders to construct the project as designed. Another example may be the modification of the engineering plans to incorporate mistakenly omitted components. Such cases may increase the final construction costs of the project. Typically, a contingency fund/reserve of approximately 10% to 15% of the project costs should be set aside to draw on, as necessary, to cover unforeseen expenses.

7.2.4. Operation and Maintenance Costs

Operation and maintenance cost items for a rural wastewater project include:

- Labor for routine operation and maintenance,
- Sludge treatment and disposal,
- Electrical power,
- Equipment repair and/or replacement,
- Expendable materials (such as for disposal gloves, cleaning products),
- Routine water quality testing,
- Administration and reporting, and
- Follow up and training.

Labor Costs. All sanitary systems require some level of routine maintenance to properly operate. The skill level of operating and maintenance personnel depends on the type and complexity of the waste management system. Decentralized sanitary systems generally require a lower level of maintenance. Household or on-site wastewater systems are typically maintained by household members. A neighborhood or clustered system requires a higher level of maintenance and may be maintained by a designated and trained community member or a private operator. A centralized wastewater system requires more maintenance than a smaller decentralized system. Daily operation can usually be performed by a previously unskilled community member trained for the task with weekly or monthly supervision by a skilled professional operator from either a private or governmental organization.

Sludge Treatment and Disposal. The costs associated with the handling and disposal of sludge from the village sanitation systems depends on the type of sanitation system (decentralized or centralized) and the method of sludge treatment, disposal or reuse. For example, the use of on-site composting toilets requires household members to clean the toilet, remove the sludge, transport the stabilized sludge to the final land application site, and spread and turn sludge into the soil. These activities are usually conducted by the household members voluntarily and do not have monetary costs associated with them.

Limited data are available for the cost for sludge management of village wastewater systems. Pinjing He (2008) reports that the cost for land application of sludge ranged from 150-200 RMB/ton of dewatered sludge (corresponding to 0.13-0.18 RMB/m^3-sewage).

Sludge management involves removing the sludge from the treatment units and either directing it to sludge drying beds or a small composting system within the facility or hauling it offsite to a regional treatment facility. Sludge management costs depend on which of these methods pertains. The labor cost required to remove the sludge from the treatment units is the same in each case but the cost of subsequent handling varies. The cost of the sludge drying bed operation is very low. It requires one to two days of unskilled labor every three to four months.

Operating a composting system is more involved and therefore more expensive than operating a sludge drying bed. However, the quality of the product is expected to be higher than simple dried sludge, and the compost can be sold as an agricultural product to recover the management and production costs.

Haulage of septage waste from the village wastewater treatment system will incur fees for pumping, transport and disposal. The pumping costs are dependent on the size of the facility and time required to remove the septage. The transport costs will depend on the distance between the village and the septage treatment facility and the treatment/disposal fees are set by the company operating the regional treatment facility.

Electricity Costs. Sanitation systems using electromechanical equipment, such as pumps, aerators, blowers or motors, will consume electricity, which is billed directly to the community by the electric utility. The electrical demand will vary depending on the size and energy requirements of the equipment employed.

Equipment Repair and Material Replacement. Periodic cost will be incurred by the village to repair or replace damaged equipment or to purchase parts. For this reason, it will be important for the Village to set up an operation and maintenance account that allows a portion of wastewater tariffs to be deposited in an account specifically to be used when equipment needs to be repaired or new equipment is needed. An additional cost will be to purchase basic supplies for cleaning and maintenance, including safety gloves and coveralls, hoses, cleaning supplies (bleach, soaps, and detergents), and other expendable goods. It is important that these relatively inexpensive items are maintained on site to encourage the operators and unskilled labor to use good health and safety procedures at the wastewater facility to protect their own and the public's health.

Water Quality Testing. If a village installs a clustered or central wastewater treatment and disposal system, routine water quality testing will be required by the county level Environmental Protection Branch (EPB). The monitoring program will consist of testing of the performance of the wastewater treatment system and groundwater monitoring up and down gradient of the community land disposal

system. The costs for wastewater and ground water testing will include the labor required to collect and transport water samples to an approved testing laboratory plus the fees of the laboratory. The laboratory fees will depend on the type and frequency of tests performed.

Administration and Reporting. The operation and maintenance of a wastewater facility requires administrative support to manage the tariffs or fees collected, to manage the system in order to pay the system operator and laborers, ant to pay for electricity and the other expenses discussed above. A system administrator may also be responsible for scheduling water testing and the preparation of monthly or quarterly reports that will be required by the EPB. A system administration position is typically a part time position; however, the amount of time required to administer the system will depend on the size of the village and the overall responsibility of the administrator. For example, in some villages the administrator may be responsible for visiting each household to collect the monthly tariff, which can be a time consuming activity. Alternatively, the administrator may require the villagers to make the payment on a specific day each month and bring the money to the administrator at a specified location.

Follow-up and Training. The village wastewater committee may incur costs related to training and technical assistance activities. At a minimum, anyone filling a technical role in the operation of the system, even a part-time role, should periodically attend technical workshops relevant to refreshing or upgrading his/her skills.

7.3. Project Financing

7.3.1. Background

In terms of rural village infrastructure, channeling funds to the final users through the various layers of the central and local government has been a significant challenge in China. According to the World Bank, China differs from many other developing countries in that there is not a history of the central government providing large subsidies for the financing of rural water supply and sanitation. Instead, there has been a greater emphasis on self-reliance with rural people using their own contributions and resources to improve water supply and sanitation in their villages. This financing structure causes poor rural areas to "accurately match their ability to pay with the proper type of systems and level of service", i.e. to choose sanitation solutions that they can afford. According to the World Bank, as a result of the local financial schemes employed, "China has been held up as a model for other developing countries". However, in some regions of rural China, the level of sanitation is undesirably low and many local governments do not have financial or institutional resources to meet the demand for improved sanitation.

As part of the New Socialist Countryside initiative, the Central Government is allocating funds to the local governments to improve sanitation infrastructure in rural villages. Initially, the big rural sanitation push was started by the Ministry of

Health in 2004 and more fully supported by the Central Government in 2009. Based on the NSCI, the Central Government is allocating approximately 1.6 billion RMB (approx USD 234 million) to improve sanitation in rural villages. Subsidy levels from the Central Government have been set at 400 RMB (58 USD) per latrine to the poorest households, and 300 RMB (44 USD) for the slightly better off. The average price of a sanitary latrine is about 1,000 RMB (146 USD). The remaining 600/700 RMB (88/102 USD) need to be contributed by provincial and/or local governments, as well as the households. Households can contribute cash or in-kind contributions such as labor. For households that cannot provide labor (such as those with only elderly and children - a common feature in Chinese rural areas as the parents migrate to urban areas for work), a solution is generally found whereby the local Technical Unit of the Provincial Patriotic Health Campaign Committee Offices (PPHCCO) provides the labor for them.

7.3.2. Alternative Sources of Funds

As China moves forward with its ambitious programs to expand coverage of sanitation throughout rural areas, a variety of funding sources will be employed to support these efforts. As discussed above, the Central Government will be allocating substantial funds to the sanitation sector; however, additional funds will be needed in various locations to address the site-specific requisites to improve sanitation. To support its efforts, the Central Government will be relying on local municipalities, counties, and villages to contribute finances. Households will also be expected to contribute monetary and/or non-monetary contributions to complete projects. This section describes the alternative funding sources and mechanisms commonly used to finance sanitation projects. These funding sources apply to both capital expenditures (CAPEX) or operation expenditures (OPEX) related to on-site or off-site (centralized) sanitation facilities.

In general, there are three common funding sources to pay for sanitation projects:

- User or private funds,
- Public or taxpayers funds, and
- External funding sources from non-governmental organizations, philanthropic organizations.

Table 7.4 outlines the sources and type of financial mechanisms that are commonly employed based on information outlined by Tremolet (2007).

Table 7.4. General Financing Sources (After Tremolet, 2007)

Sources of Funds	Type of financing mechanism using those funds
Users of the service (private)	• On-site solutions the household will invest to install the sanitation system and will pay for the operation and maintenance of the system; • In a centralized or network based solution tariffs may be paid to the service provider for connecting to the system, for some portion of the overall capital improvement and ongoing for operation and maintenance
Tax Payers (Public)	• % public subsidy for project planning, design, construction and training • Subsidy credits or loans to households for investment in on-site sanitation facilities • Subsidy credits or loans to service providers • Community-level rewards (e.g. grants to local governments or service providers)
External Sources (NGOs, INGOs, charities)	• Grants or loans to central or local governments to match or merge with public funds for project planning, construction, and training • Grants or loans directly to users or service providers • Subsidized credit to government, users or service providers

Within the development community there are debates as to what sources of finances should be used to cover the cost of different components of a project. Many government institutions and NGOs view on-site sanitation facilities as home improvements and therefore investments should be financed by households. Nevertheless, the reality is that many households in rural areas do not have the financial resources to pay for sanitation facilities. The Central Government has taken the initiative to assure that publicly funded subsidies will be an important component of the financial strategy adopted in China. Given that sanitation is a public good (poor sanitation conditions impact public health, the environmental and economic development), subsidies or external funds are sometimes appropriate when needed to expand coverage. The common reason that sanitation needs to be subsidized is to make it affordable to the poorest households in a community.

Financing options for rural village sanitation projects summarized in Table 7.4 include private or self financing, a combination of private and public funds, and purely public funds. Evans et al. (2009) have prepared a summary of the various financing options for different rural sanitation options (on-site and centralized systems) including the advantages and risks associated with each. Table 7.5 presents this information for rural on-site sanitation facilities and Table 7.6 presents this information for off-site or centralized village wastewater facilities.

Issues for consideration in financing rural on-site sanitation systems. In more traditional on-site sanitation systems, the capital costs are typically lower than a centralized wastewater system. Subsidies of these projects are often justified as a way to encourage demand for improved services. Another popular approach is to provide a revolving fund which theoretically allows poorer households to 'borrow' funds to construct a sanitation system and to pay the funds back over time, thereby enabling another household to benefit later. However, without a good peer support/pressure program, many revolving-fund-based projects have failed when the households have failed to repay the loan. A major problem with these approaches is related to targeting – it is often not the poorest and most disadvantaged that are able to access and/or make use of these funds. A second problem is that these programs may skew technology choices, encouraging households to build systems that may not be appropriate (i.e. installing pour flush latrines in communities that do not have piped water to the households).

Issues for consideration in financing centralized or off-site systems. Off-site systems usually consist of household connections to a conventional or small-bore sewer network, a small treatment works and a land disposal system. The cost for connecting to the sewer is usually borne by the household or partially funded by the household and government. The costs for the sewer network, treatment works and disposal system are publicly funded recognizing that these improvements are for the public good. Two major problems have been common to this approach. First, the high cost of a connection often means that poor or unserved households are unable to access the publicly financed network service. The simplest mechanism to offset high initial connection costs is to amortize this cost through surcharges to the monthly sewer service bill. Another option is to establish a progressive connection fee based on income and allow for cross-subsidies so as to allow higher income households to assist poorer households to connect to the sewer.

The second problem is that the coverage of the sanitary sewer may be limited by design, focused on the central portions of a community and not serving topographically low or poor districts on the fringe of a small town. Adopting small bore sewers and appropriately scaled and lower-cost solutions can be used to increase coverage of a rural community.

Table 7.5. Financing Options for Rural On-site Sanitation Facilities (After Evans et al., 2009)

Financing Mechanism	Advantages	Risks
Financing Source: Purely Private (Users of Service		
Self Financing: households invest in their own facilities	• Majority of latrine projects in China funded this way • Responds to demand • Maximum leveraging of household resources • Maximum leveraging of market-based sources (if available)	• Poor quality of construction • Does not fully consider environmental impacts • Suppliers may not be available/poor quality • Unaffordable for the very poor • Household may not have access to sludge management services
Financing Source: Combination of Private and Public Funds		
Support for software with low/no subsidy for hardware: Support for project soft costs, planning, engineering, training and health promotion	• Subsidy can be linked to outcome based goal (i.e. number of latrines installed) • Focuses public funds on public benefits • Based at community level: can build community cohesiveness	• May result in unaffordable sanitation for the very poor • Sustainability is a risk once initial attention and support is withdrawn
Micro-finance to households for sanitation improvements	• Can be used to finance upfront costs	• Demand for these funds may be a low requiring promotion and/or marketing
Loans to small-scale providers	• Lift constraints for small scale service providers to enter the market	• Services may not reach the very poor • Demand for services may remain low
Non-financial support to small scale providers: training, product-development, business development services	• Boost private sector (supply side options)	• Service may not reach the very poor • Demand for services may remain low
Output-based aid: grants to households or communities or to small scale service providers based on successful construction and use of facilities	• Subsidy linked to outputs – high level of accountability	• Requires pre-financing which may not be available
Community cross-subsidies: users contribute to the most needy households in cash or kind	• Removes affordability constraints for the poor	• May result in unsustainable service for poor and less-able households
Partial infrastructure subsidy: users contribute in cash or kind	• Enhances ownership of the facility • Improved affordability (removes access constraint)	• May result in unaffordable sanitation for the very poor
FINANCING SOURCE: PURELY PUBLIC FUNDS		
Full hardware subsidy (CAPEX – capital expenditures)	• Removes affordability constraint	• Can ignore or 'crowd out' households own investments • Facilities may not be used if there is not the demand for improved services • Results in unsustainable (too expensive) technology choices

Table 7.6. Financial Options for Centralized Village Wastewater Projects

Financing Mechanism	Advantages	Risks
Financing Source: Purely Private (Users of Service		
Self Financing: households invest in their own facilities	• Responds to demand • Maximum leveraging of household resources • Maximum leveraging of market-based sources (if available)	• Poor quality of construction and bad system planning • Does not fully consider environmental impacts • Unaffordable for the very poor • Only an option if networked sewers are available and close to household
Financing Source: Combination of Private and Public Funds		
Support for software with low/no subsidy for hardware: Support for project soft costs, planning, engineering, training and health promotion	• Subsidy can be linked to outcome based goal (i.e. number of houses connected to sewers) • Focuses public funds on public benefits • Based at community level: can build community cohesiveness	• May result in unaffordable sanitation for the very poor • Sustainability is a risk once initial attention and support is withdrawn • Will have limited or no impact unless working sanitation system is available
Micro-finance to households for sanitation improvements	• Can be used to finance upfront costs	• Demand for these funds may be low requiring promotion and/or marketing • Will have limited or no impact unless working sanitation system is available
Loans to small-scale providers	• Lift constraints for small scale service providers to enter the market • Can encourage service expansion into unserved areas (particularly into poor and or underserved areas)	• Services may not reach the very poor • Demand for services may remain low • Can create tension or unintended competition with public or other private utilities • Lack of regulatory capacity or oversight
Non-financial support to small scale providers: training, product-development, business development services	• Boost private sector (supply side options) • Encourages expansion or services to increase market	• Service may not reach the very poor • Demand for services may remain low
Output-based aid: grants to households or communities or to small scale service providers based on successful construction and use of facilities	• Subsidy linked to outputs – high level of accountability • Can increase the number of households connecting to the sewer system	• Requires pre-financing which may not be available
Community cross-subsidies: connection charges paid for from general revenue of the service provider or local utility	• Removes affordability constraints for the poor • Increases participation in the project	• May result in unsustainable service for poor and less-able households • Funds availability may be constrained by political willingness to raise tariffs for wastewater management services

Financing Mechanism	Advantages	Risks
		• Some communities may be unwilling to give up ability to collect connection fees
Partial infrastructure subsidy: users contribute in cash or kind	• Enhances ownership of the facility • Improved affordability (removes access constraint) • Increases participation in the project by reducing household costs	• May result in unaffordable sanitation for the very poor
FINANCING SOURCE: PURELY PUBLIC FUNDS		
Full hardware subsidy (CAPEX – capital expenditures)	• Removes affordability constraint • Increase participation in the project by all economic sectors	• Results in unsustainable (too expensive) technology choices • Rarely sustainable in the long run and results in severe underinvestment in the system

7.3.3. Non-Monetary Costs

For many community development projects, households are expected to contribute non-monetary support or costs (NMC) towards the project. NMC may include providing a set number or quota of hours for labor, providing local raw materials (sand, gravel, wood, and other materials), donating land to construct the project or to store materials during the construction of the project. Other NMC may include providing or transporting of heavy equipment or materials to the site, providing room and board for outside construction workers. NMC may include time spent to attend project meetings and for project administration and coordination time in the village maintaining an accounting of workers and schedules and other logistical aspects of a project.

Prior to expending any NMC, it is important for the village and the project sponsor to clearly establish the valuation of the NMC, such as, the equivalent monetary rate for one hour of labor or the cost per ton of sand provided. Establishing the exchange rate of NMC upfront will avoid potential conflicts and misunderstandings later. It is also very important for a village to maintain a good accounting of all the NMC expended on the job, including the accounting of these expenses, if they are being completed voluntarily and as NMC.

7.4. Subsidies

7.4.1. Overview and Issues

An investment in sanitation by an individual household has benefits for society as a whole (by removing pathogens from the environment). But an individual household's decision to invest in sanitation provides little benefit to themselves, if others do not

make similar investments. This consideration, combined with high costs leads many households to under-invest in sanitation. The public sector has an obligatory interest in changing individual choices to increase the level of investment in sanitation and move society towards universal sanitation because investment in sanitation produces high levels of societal benefit (Evans et al., 2009).

Poor households have limited funds and tend not to give high priority to investments in sanitation. Many governmental and non-governmental organizations argue that to improve sanitation in rural parts of China will require substantial investment and subsidies. It is important to understand that while the use of subsidies can encourage and increase the rate of investment in sanitation, if the subsidies are poorly designed, targeted, and delivered they may not achieve the intended goals and in some instances may decrease the long-term sustainability of the project.

Reliance on highly subsidized financial schemes can have several unintended results, including:

1. High cost solutions are implemented that the community may not be financially able to support from a long-term operation and maintenance standpoint;
2. Subsidies displace other sources of funds. Given the prospect of a subsidy, households will elect to wait for ‘free’ goods rather than paying their own way from savings or through accessing credit.
3. Subsidized programs are usually designed and managed by the subsidizing entity. That implies the type of sanitation solution will be decided by outside expertise. This approach can prevent or stifle local innovation or can lead to the selection of inappropriate technologies.
4. Many subsidy programs are simply not financially sound and there is not enough money to pay for them. Subsidy schemes that are not well financed eventually cease to function, resulting in low coverage or poor sustainability and lots of un-served people who are dis-incentivized/de-motivated to pay for their services since their ‘neighbors’ were given a subsidy.
5. Poorly targeted subsidies may result in the subsidy benefiting a biased selection of households. Depending on how the subsidy scheme is setup, the more wealthy households may be more adept at capturing the subsidy to the detriment of the poorest households.
6. In some instances material subsidies can create a ‘false’ demand for services, as when, for example, a household takes a subsidized toilet or service because it is available, while there is no demand or need for it. This is likely to occur when there is sufficient funding for the hardware, but limited or no funding for the software (community education and promotion).
7. Many subsidy programs are limited in duration. After the end of the program, potential users who didn’t benefit from the program may wait for another subsidy program rather than financing their own sanitation, as they might otherwise have done.

One of the main problems with the design of sanitation financing appears to be that the disparate objectives of any public subsidy remain non-explicit (Evans et al., 2009). Different project proponents attach different levels of priority to different objectives. For instance the main objective of a subsidy scheme might be to ensure inclusion and empowerment of certain disadvantaged groups, but it may equally be to protect the environment or to improve public health. These issues highlight the need for care and caution in the overall design of the public financing of sanitation. The design of any subsidy needs to take into account not only current, but also future considerations, and not only the intended but unintended consequences including those identified above.

The Water Supply & Sanitation Collaborative Council/World Health Organization (WSSCC/WHO, 2005) Programming Guide publication sets out the following principals, which are useful and valid for the design of sanitation subsidies:

1. **Subsidies should achieve the intended policy outcome**: this requires not only smart subsidy design but clarity upfront about what the policy objectives area. Choices and tradeoffs need to be made between different interest groups, the wealthy and the poor, and short- and long-term objectives.
2. **Subsidies should reach the intended target groups:** this again requires clarity on who is the intended target group and how they can best be reached. It is also requires that rigorous monitoring is in place to track how subsidies are reaching intended groups.
3. **Subsidies should be financially sustainable:** this requires a solid understanding of the potential scale of needs and the costs of the program. Costs include both upfront capital costs and long-term operational and maintenance costs. It also requires a good understanding of how to get the best possible leverage (increase) in funding from other sources (typically households and market sources). Only on this basis can a sustainable financial regime be put in place.
4. **Subsidies should be implemented in a clear and transparent manner:** finally, since they involve the use of large sums of public money, subsidy programs need to be clear and transparent, enabling eligible households or communities to access them and providing clear recourse mechanisms in cases where there is a suggestion of impropriety. Proper monitoring and evaluation is an essential element of such transparency and must be fully financed as part of the subsidy program.

7.4.2. Types of Subsidies

There is a wide array of subsidy mechanisms that can be used to deliver public financing to sanitation. Through the Water Supply & Sanitation Collaborative Council, Evans et al. (2009) prepared a Primer on public funding for sanitation. The Primer provides a comprehensive overview of the different types of subsidies, how they work, how they benefit and the advantages and disadvantages of each. The following section provides an overview and summary of the key information

presented in the Primer. For a more in depth review of this information the reader is encourage to review the Primer.

Evans et al. (2009) identified ten (10) types of subsidies, including:

1. Direct subsidies;
2. Infrastructure subsidies;
3. Connection subsidies;
4. Operational subsidies;
5. Subsidies to small scale operators;
6. Cross-subsidies;
7. Consumption subsidies;
8. Output-based subsidies;
9. Regulatory subsidies; and
10. Subsidized credit.

Direct Subsidies. Direct subsidies involve payment (in the form of cash or vouchers) directly to the recipient household, which is then able to 'spend' to access a range of services. Direct subsidies have been not widely used as a single sector intervention because of the high costs to identify needy households. However, if the poorest households can be accurately identified, direct subsidies are both efficient and effective.

Infrastructure Subsidies. The use of public money to construct new infrastructure is one of the most common forms of subsidies. In rural areas, infrastructure subsidies are utilized to pay part or all of the costs for household or 'private' elements of the project, such as toilets. The cost is justified on the grounds that these expenditures are the most significant barrier to certain households accessing services. A general problem with infrastructure subsidies is that inadvertent targeting may occur because particularly advantaged groups (e.g. those with land tenure, or those who are literate and can apply for a subsidy) are disproportionately benefited.

Connection Subsidies. Many urban utilities charge households to connect to networked sewage services. Households are often charged a 'fee' for the new connection, plus part or all of the capital costs of connecting the house to a sewer in the street and often must also pay a 'deposit' on some of the street repairs and often must also pay a 'deposit' on some or all of the assets provided. Typically these connection costs can be very high and are often regarded by utilities as an important income stream. From the householder's point of view, however, high one-off connection fees can form a very real barrier to connecting to the public services. The levying of such fees is inherently anti-poor since the poor are the least able to pay.

The barrier created by high costs of connections can be easily removed either by amortizing the costs of new connections across all utility bills, by providing credit, in the form of staggered payments over months or by the provision of a direct subsidy to targeted households to cover the costs (a connection subsidy). Output-based arrangements are particularly well suited for the delivery of connection subsidies. All

of these have progressive outcomes and promote rational decision making by the utility.

Operational Subsidies. Operational subsidies involve the payment of money to a private service provider to offset some or all of the costs of supplying the service. Operational subsidies for utility operations and software services are often ignored in policy debates. They are rarely fully transparent but often represent a very significant transfer of public funds to the sanitation sector. In addition, they can end up encouraging inappropriate capital investment in infrastructure with very high running costs, because the service provider has no incentive to strive for cost effectiveness or efficiency of the service. If the utility or public agency funding this subsidy charges a very low tariff the subsidy may be very large and as it recurs every year it places a heavy burden on the public budget. If there are insufficient funds to maintain the subsidy the utility will be forced to under-invest in maintenance, resulting in poor operation of the sanitation system, which in turn may pose risks to public health and the environment.

Subsidies to Small-scale Operators. A less common form of operational subsidy is provided to bring down the costs of operation of small-scale service providers (the types of small enterprises that build latrines or empty latrines or septic tanks for example). These can be provided in the form of subsidized training and the provision for small business development services, such as business planning, book keeping, accounting, and auditing. These subsidies may be appropriate to subsidize and/or guarantee loans to purchase startup equipment for small operators, which will have the effect of reducing the costs of services to the end user. Subsidies to small-scale operators can be highly effective in some locations, but it is important to have a good understanding of the market for their services and the availability of suitable entrepreneurs with capacity to absorb and make use of any subsidies on offer.

Cross-Subsidies. A cross-subsidy occurs when one group of users contribute to part of the costs of providing services to another group. Cross-subsidies through the tariff in the water sector are relatively common and theoretically in some urban areas the is also a cross subsidy for sanitation – with a high-volume water consumer paying more for water and sewage services than those who consume less, even though each group benefits equally from the operation of the sewage network and treatment plant. In rural areas some programs use cross subsidies designed and wholly generated within the community to support the poorest and least-able households to construct or purchase new latrines or connect to a sewer line. This type of cross subsidy uses households' own money directly; the flow of funds is not through public funds. Cross subsidies within the community do have some possible negative side effects, as they can interfere with the social relations between different groups and may put some households in 'debt' in some subtle ways to others. The process of accessing needs at the community level through a community-led wealth ranking exercise was at least as, if not more, important than the existence of external subsidy in determining equitable outcomes in a sanitation program, suggesting that cross-subsidies may work well when the facilitation of the process is good.

Consumption Subsidy. Consumption subsidy reflects a poorly conceived and unsustainable tariff structure where tariffs for sanitation services are kept artificially low. This represents a subsidy towards the cost of 'consumption' of the service, or consumption subsidy. When prices are kept low in this way, the service provider will inevitably sustain losses. These losses must either be covered through operational subsidies to the supplier or they will result in systematic underinvestment leading to a failure of the facility and service, leading to impacts to public health and the environment.

Output-Based Subsidies. Output based subsidies are delivered against services successfully delivered (effective sanitation) rather than inputs (excavation, pipes, and toilets). Thus an output-based subsidy might be paid to a utility or service provider when they have connected poor households to the sewerage network and demonstrated that a service is being provided for a pre-agreed period. Output based subsidies can also be provided to operating companies running sewage treatment facilities or private pit-emptiers (for instance through voucher schemes) if they meet the required discharge standards or the volume of sludge pumped from on-site facilities. The advantage of output-based subsidies is that they are only paid once services have successfully been delivered – thus removing one of the major drawbacks of more conventional infrastructure subsidies that may be paid to a service provider who fails to deliver a working service. However, under this scheme the cost of services may rise due to the fact that the service provider must finance the investment upfront and only recoups the costs once the services are being delivered. Like other forms of subsidies, output-based subsidies rely on good quality verification and monitoring. However, unlike other forms, the verification process can be driven by the users themselves and their demand or verification that services are being delivered as agreed.

Regulatory Subsidies. Inadvertent subsidies occur when policy is used to favor certain types of services. For example in a large scale project the central or local government may favor a large company or design institute to complete the work by making the regulations or requirements too arduous or difficult for small companies to compete locally for the work. These subsidies are usually hidden and in many instances unintentional, but can result in higher costs to fund large inefficient service providers; ultimately they cost the households and villages a high rate.

Subsidized Credit. A final mechanism for the delivery of public funding into the sector is through subsidies and guarantees to micro-finance institutes (MFIs) who can then lend money for sanitation investments to households at reduced interest rates. MFIs may also provide other important services, such as micro-saving and micro-insurance, which can also enable households to make needed investments and manage their sanitation facilities over the long term. Channeling public money through MFIs has the dual advantage that it stimulates the development of micro finance services and leaves households in control of decisions about the type and cost of services to be paid for. It also has the advantage of not interfering with the

supply-side market for goods and services. MFIs may also be better than government at assessing whether households can afford the tong-term costs of their investments.

7.4.3. Subsidy Partnerships with Local and Community Cost Sharing

In the past, reliance on household subsidies and subsidized sewerage has tended to displace two important additional sources of finance – the household itself, and the market. This outlook is now beginning to change and there is increasing recognition of the possibility of greater household and community resources being mobilized through full or partial cost sharing and technical innovation as part of a well-designed financial strategy (Evan et al., 2009).

More directly stated, public subsidies can be used to leverage much greater investment if they are used along with other sources of funds for more appropriate goods and services. This approach recognizes that subsidies are most effectively spent on promotion, enabling, planning, community participation, education and training – commonly referred to as the software costs – with limited or targeted funding directed to infrastructure or hardware where required. Leveraging household and community finances requires a shift in funding away from direct or infrastructure subsidies to alternatives, such as subsidized credit, support for small-scale providers and more focused and efficient funding of public elements and infrastructure. In an environment of scarce resources, public funds go further if they are targeted in ways that encourage investments from other sources. However, leveraging of local funding requires an understanding of what households themselves are willing and able to invest. Initiating a successful cost sharing approach will empower the community and households to take active ownership and long-term responsibility of the investment. Although these investments may be difficult for individual households in the short run, the long-term gains to sanitation will improve the local economy through improved public and environmental health conditions.

7.5. Cost Recovery

Once a project is completed and taken over by the village, it will be imperative that the village sets up a cost recovery scheme for the sustainable operation, maintenance, administration and upgrade of the sanitation facility in the long term. As a village begins to develop cost recovery schemes, the World Health Organization (2000) has identified seven key principals of sustainable cost recovery that should be considered and include:

1. Identifying the cost implications of the project's characteristics and the environment;
2. Maximizing the willingness to pay;
3. Clarifying financial responsibilities;
4. Optimizing operation and maintenance costs;
5. Setting an appropriate and equitable tariff structure;
6. Developing an effective financial management system; and

7. Organizing access to alternative financial sources.

<u>7.5.1. Project and Environmental Implications on Cost Recovery</u>

The way the project has been set up, and its institutional and legal characteristics, are elements that can have a direct implication on cost recovery, particularly with regard to the following (WHO, 2002):

- Technology selection
- Community aspects
- Management options
- Local, regional and national policies
- Support to and or by the community
- Economic conditions

Technology Selection

Appropriate technology selection is a key factor in sustainable cost recovery. The ratio between capital and recurrent costs can be the determining factor, in the way that a technology with higher capital costs could be chosen because of lower O&M costs. Therefore, when communities select a technology for their sanitation service with external financial support, the community must have clear information about the costs and required charges needed to recover the financial obligations (loan payments) and the operational, maintenance, and administrative costs. Communities should be aware of the financial implications of choosing a particular technology.

Community Aspects

The major community aspects may include community awareness, level of interest or demand for the project, and willingness and capacity to pay for improved services. Other factors may include availability of materials or replacement parts, access to skilled labor and the community organization.

Management Options

The management system for O&M can directly influence the way cost recovery will be organized. For instance, the sanitation system can be managed and operated by local labor (skilled and unskilled labor) and/or by a private company retained by the village. Each of these approaches will have different interests, capacity and ultimately costs.

Policies

Different policies can affect how decisions or actions are taken in a village. For example a national policy that sets tariffs or includes subsidies for poorer households can influence the decisions and financial obligations of a village, but they may also result in a more equitable level and coverage of service.

Support to the Community

In many instances the villages will need training and support for administrative activities (such as book-keeping, establishing a rate structure, and contracting), technical activities for operation and maintenance, and other capacity building needs.

Economic Conditions

Many regions of China are very poor and have limited financial resources. Therefore, developing realistic cost recovery mechanisms is important to recoup the investment in a financially sustainable and effective way.

7.5.2. Maximizing the Willingness to Pay (WTP)

Willingness to pay (WTP) is an expression of the community's demand for services, and is a strong prerequisite for the financial sustainability of a sanitation system. The WTP is a useful measure to assess the projects long-term feasibility, and depends on a number of factors:

- Demand for services and the level of participation of the village;
- Level of income;
- Community cohesion (this refers to the community level of trust or cooperation between households and community members and leaders);
- Perception of ownership and responsibility;
- Service level and quality (or standard);
- Price for services;
- Relative costs for other community services (ex. Water service, electricity, transportation, and other services or goods);
- Reputation of the agency assisting the community;
- Transparency of the financial agreements and management;
- The community's perception of benefits;
- Existing conditions; and
- Policy and standards.

The WTP is strongly influenced by several cultural, social, institutional and financial factors that complicate the ability to simply measure it. The village wastewater committee, with assistance from the County and Municipal Wastewater Management Offices, will need to work closely with the community members to

determine the WTP, through a participatory process of community meetings and interviews.

7.5.3. Optimizing Operation and Maintenance Costs

As previously discussed above in Section 10.2.4 the sanitation project will have recurring operation and maintenance costs. An important aspect of the cost analysis to establish a sustainable recovery rate is to optimize and maintain the O&M rates as low as possible, while still providing the sufficient level of service to properly operate and maintain the system and pay for the labor. O&M costs can be reduced in the following ways:

- Choosing a technology with inexpensive spare parts, materials, energy, staff and/or other operating costs;
- Reducing the transport costs to go and buy spare parts and materials;
- Reducing the dependence on fuel and electricity to operate and maintain the system;
- Implementing an effective preventive maintenance program to keep equipment in good working condition, rather than waiting for it to break and require repair or replacement. This may imply that a ‘maintenance culture’ needs to be instilled in the community and professional staff; and
- Installing proper administrative and financial support and control mechanisms.

7.5.4. Setting an Appropriate and Equitable Tariff Structure

Tariffs are used primarily to recover costs and achieve financial sustainability, but also for efficient allocation of scarce sector resources, equitable distribution of income and benefits, and fiscal viability. Tariffs for sanitation services should be set taking into account the socio-economic situation of the community, the ownership of assets, responsibility for operation and maintenance, the level of service, and the willingness and ability to pay. Other factors may also be relevant. There could be merit in a special tariff setting process that would lead to different tariffs being applied for different income brackets and users in the community. Such a scheme requires that categories of users are readily identifiable and that the tariffs can be applied effectively. Some tariff structures impose higher fees for volumes of water above a basic amount – several such steps can be imposed. For example, up to 10 cubic meters the water costs $1.00 per cubic meter, for water from 10 to 20 meters cubed, $1.20 per meter cubed, and for volumes over 20 meters cubed the cost could be $1.50. This also encourages conservation.

Setting up a tariff should be done with and by the community, as it will allow the community to bear full responsibility for applying the decisions made, and it will be better accepted since the community knows why this tariff was fixed as it is. However, this process may require technical support from county or municipal agencies.

Tariff design should consider several factors, including equity, demand for services, agreements on the costs to be recovered, deciding who will manage the tariffs, gender considerations, and possibly user or sector classifications. Once these factors have been addressed, hopefully a realistic and community supported tariff can be put in place.

Equity. Designing a tariff requires that equity be considered in conjunction with the affordability of the service, so that all members in the village (rich/poor, men/women) will have access to improved sanitation. O&M costs can only be recovered from users if they are both able and willing to pay for the services.

Demand for the services. Tariffs for improved sanitation can be designed to regulate demand for the improved services, based on the assumption that consumers behave rationally and are aware of and value the benefits realized by the improved services. It should be possible to make the case that ultimately the tariffs are cost saving for the public, because of the improved public and environmental health.

Agreements on costs to be recovered. While setting up a tariff, it is important for the entity that is listing the costs requiring recovery to present to the community all of the costs and the methods used to derive them. This transparency will avoid confusion and curtail future disputes once the village has adopted the fees.

Who manages the tariff? It is also important for the village wastewater committee to specify to whom the tariff will be paid and how it will be managed and used. This process will require the tariff 'manager' to set up organized and clear accounting systems that can be reviewed at least annually to avoid potential conflicts and maintain trust in the community. It is also important that the community agrees with the selection of the tariff 'manager'. Provisions should be adopted so that the tariff 'manager' provides financial reports to the village wastewater committee and community as a whole on a regular basis, such as annually.

User classification. User class designations will depend on the complexity of the service provided and on any special administrative, legal or tiered tariff structure. A village wastewater committee may need to set up different tariffs if there are different types of users in a village, including residential, commercial, institutional, government, and industrial users. For example, these may include: small restaurants or hotels, schools, community centers, government buildings, small industries, and other users that may have a higher use or demand on the sanitation system than a single household. In these cases a tiered or block system tariff may be appropriate to apply tariffs in proportion to the actual flow or load discharged to a system.

7.5. 5. Options for Charges

There are five tariff structures commonly used:

- non-metered flat rates;
- non-metered graded rates;
- block rates,
- metered rates, and
- mixed rates.

In many instances, a sanitation tariff is tied to metered water use, since it is easier, less expensive and more practical to meter domestic water. In this case, wastewater tariffs are usually calculated as a percentage of the actual water use. Of course, this is not the case if a flat rate is charged.

Non-metered Flat Rates

In a non-metered flat rate system, each user pays a fixed amount of money, regardless of the volume of water used or sewage generated. In its simplest form, the total amount of money needed for the upkeep of the improved water supply system is divided equally over the number of households using the system. Payments may be per month, per season, or per year, depending on what is most convenient for the users of the service. Flat rates are generally easy to set up. Major disadvantages of non-metered flat rates are: (a) they are not equitable in the sense that low-income households pay the same amount as higher income household that may have higher water usage; and (b) they do not discourage waste of water or incentives for rational water use. They are, however, easy to administer.

Non-metered Graded Rates

Under a graded rate system users and households are classified into several categories based on estimated differences in water use and sewage generation and income. The advantage of a non-metered graded rate structure is that it takes into account the consumption/wastewater volume and payment capacity of users, and therefore could reach a more equitable tariff structure. It is also a way to account for rough estimations of consumption/wastewater generation without investing in a metering system. The introduction of graded rates is easiest when clear and valid indicators of water use and wastewater generation can be identified. Some indicators may include the number of water and sanitation fixtures in a household (plumbed sinks, showers/baths, and flush toilets), the type and level of service for a commercial business (i.e. number of tables in a restaurant), the number of employees and type of industry and the associated water usage and wastewater volume. A graded rate tariff system is a more equitable system that allows for cost recovery in proportion to the service provided. It may require, however, more in-depth review and acceptance from the community at-large to avoid potential conflicts or disputes. It also does not encourage water conservation.

Block Rates

Block rates set tariffs based on incremental or tier water usage. A baseline rate is set according to the volume of water consumed, e.g. 0-10 m^3, and higher or incremental rate increase are set for higher consumption. Sanitation or wastewater tariffs would parallel this structure.

Metered Rates

While graded rates based on social and financial indicators have the advantage that they avoid the introduction of complex metered connections, water meters enable the charges to be made according to the actual volume consumed. If properly enforced, metering induces users to avoid wasting water, which may help to reduce long-term costs or unaccounted-for water losses. Individual household meters are not only expensive to install, they also need to be read regularly, which adds to the work of the administration. The administrative staff also needs to process the data to generate water bills, which can be a time-intensive process. The added cost of installing and operating meters, as well as billing and collection, may outweigh the benefits of the system, notably in rural communities (WHO, 2002). Another factor is the high connection cost associated with metered service to individual households. One way to alleviate this problem is to spread the connection fee over a period of time, which can be included with monthly bills.

Mixed System

In some instances there may be advantages to adopt both a graded flat rate structure for households and metered services for large consumers, such as hotels, institutions (schools), and small industries. The expense for the meters can be absorbed by the enterprise and lead to lower waste and to adoption of a realistic tariff proportioned to the actual usage.

CHAPTER 8 - PROCUREMENT AND IMPLEMENTATION

8.1. Introduction

Public procurement is the process by which host government agencies purchase vital public-sector investments (World Bank, 2001). Those investments, both in physical infrastructure and in strengthened institutional and human capacities, lay foundations for national development. In procurement terms, those inputs are generally grouped into three categories:

- Civil works - for example, water and wastewater treatment works, roads, bridges and buildings, harbors and highways;
- Goods - typically equipment, materiel and supplies, commodities, textbooks, medical supplies; and
- Services - expert advice and training, conventionally labeled Technical Assistance, as well as such services as building maintenance, computer programming, etc.

The quality, timeliness, local appropriateness and affordability of the procured inputs can largely determine whether the public investments will succeed or fail. So the beneficial impact and contribution of the input, particularly in the case of technical assistance services, can exceed their direct costs by several orders of magnitude. Yet procurement costs can be substantial, consuming scarce resources of tightly constrained government budgets. Often the required funding must be borrowed. Moreover, the process consumes scarce skilled public-sector human resources. It takes time, not merely for procurement planning and contracting but also for contract supervision and execution. And much of this process is highly visible, as well as controversial, exposing government employees or departments to scrutiny and second-guessing for procurement choices they made, deferred, discarded, or borrowed, with due attention to economy and efficiency. The World Bank (2001) has identified five basic concerns that govern its procurement policies, as follows:

- To ensure that the goods and services needed to carry out the project are procured with due attention to economy and efficiency;
- To ensure that the loan is used to buy only those goods and services needed to carry out the project;
- To give all qualified bidders from the Bank's member countries an equal opportunity to compete for Bank-financed contracts;
- To encourage development of local contractors and manufacturers in borrowing countries; and
- To ensure that the procurement process is transparent.

These procurement policies and procedures have been designed to promote fairness and equal treatment. In summary the principal hallmarks of proficient public procurement are as follows:

- Economy;

- Efficiency;
- Fairness;
- Reliability;
- Transparency; and
- Accountability and Ethical Standards.

Economy. Procurement is a purchasing activity whose purpose is to give the purchaser best value for money. For complex purchases, value may imply more than just price, since quality issues also need to be addressed. Moreover, lowest initial price may not equate to lowest cost over the operating life of the item procured. But the basic point is the same: the ultimate purpose of sound procurement is to obtain maximum value for money.

Efficiency. The best public procurement is simple and swift, producing positive results without protracted delays. In addition, efficiency implies practicality, especially in terms of compatibility with the administrative resources and professional capabilities of the purchasing entity and its procurement personnel.

Fairness. Good procurement is impartial, consistent, and therefore reliable. It offers all interested contractors, suppliers and consultants a level playing field on which to compete and thereby directly expands the purchaser’s options and opportunities.

Transparency. Good procurement establishes and then maintains rules and procedures that are accessible and unambiguous. It is not only fair, but should be seen to be fair.

Accountability and Ethical Standards. Good procurement holds its practitioners responsible for enforcing and obeying the rules. It makes them subject to challenge and to sanction, and is an inducement to individual and institutional probity, a key deterrent to collusion and corruption, and a key prerequisite for procurement credibility.

A sound procurement system is one that combines all the above elements. The desired impact is to inspire the confidence and willingness-to-compete of well-qualified vendors. This directly and concretely benefits the purchasing entity and its constituents, responsive contractors and suppliers, and the donor agency providing the project finance (World Bank, 2001).

In sum, proficient public procurement is not difficult to describe in principle or to distinguish from its antithesis in practice. But it does require varied professional and technical know-how to establish, as well as discipline and determination to administer.

This chapter provides an overview of alternative procurement methods and outlines the procurement planning process. The information is very general and presented to introduce the local agency to the key issues and elements related to project

procurement and implementation. Depending on the source of funds secured by the local agency to implement a project, procurement procedures may need to be followed that are specified by the funding agency (financial institution), such as the Minister of Finance, World Bank or Asian Development Bank (ADB). Because detailed procurement procedures are readily available from the different financial institutions, the reader is advised to review documents provided by the institution supporting the project.

8.2. Procurement Alternatives

Procurement describes the activities undertaken by the local agency to obtain the design, construction and operation of a project. There are many different methods of design, construction, and operation procurement; however the three most common types of procurement are:

1. Traditional (Design-bid-build and transfer);
2. Design and Build (Design-build and transfer); and
3. Design, Build and Manage (Design-build-manage (or operate))

Rural wastewater projects can be designed, built, and managed employing any one of these approaches. The selection of the most appropriate approach will typically depend on several factors, including the size and complexity of the project, the number of projects, the qualifications and experience of available engineering and construction firms, the capacity of the local “owners” of the project, and/or the requirements of the project funding agency.

Traditional Design-Bid and Build. The design-bid and build (DB&B) method of procurement is the most traditional method of construction procurement and is well established and recognized. In this arrangement, the engineer typically acts as the project coordinator during the design phase of the project. His or her role is to design the works, prepare the specifications, produce construction drawings, and administer the contract to tender the works. A contractor is hired to build the project. Commonly, the design engineer is hired by the client to provide construction management and/or supervisory services.

Design and Build. The design and build (D&B) approach has become more common in recent years. In this case a contractor is retained to execute the complete project, including design, construction and startup of the new facility. In some cases, the D & B package can also include finding the site, arranging funding and applying for all necessary statutory consents or permits.

The client produces a list of requirements for a project, giving an overall view of the project's goals. Several D&B contractors present different ideas about how to accomplish these goals. The client selects the approach or ideas they prefer and hires the appropriate contractor. Once a contractor has been retained, they begin to design and possibly initiate the building the project. This is in contrast the DB&B contract, where the project is completely designed by the client’s designer (engineer

or architect), then bid on, and then completed under a separate contract with a contractor.

Design, Build and Manage (and Transfer). In this arrangement the client hires a D&B firm to construct and subsequently manage and operate the project, such as in the case of a wastewater treatment facility. In some instances, the contractor may have a long-term contract to operate the project for 5 to 7 years. Other contractors may specify a one year management contract; after this initial time period the project is transferred back to the client or, for example, to the local municipality or village to manage and operate.

The following sections provide a more detailed description of the alternative procurement methods and identify the potential benefits and constraints offered by each method.

8.2.1. Design-Bid and Build (DB&B)

The Design-Bid and build (DB&B), also known as design-tender, is a traditional project delivery method in which the client contracts with separate entities for each the design and construction of a project. There are three main sequential phases to the DB&B delivery method:

- The design phase;
- The bidding (or tender) phase; and
- The construction phase.

Design Phase. In the design phase, the client retains an engineer to design and produce tender documents on which an engineering contractor will in turn bid, and ultimately be utilized to construct the project. For rural wastewater projects, the engineer will work with the client and local villagers to evaluate site conditions and develop preliminary designs and or alternative plans for the client and village leaders to review. Once the preliminary plans are approved, the engineer will prepare the complete documents (drawings and specifications). These documents are then coordinated by the client and engineer and put out for tender to several contractors for competitive bids.

Bid (or tender) Phase. At the bid or tender phase, the contractor(s) submit financial bids for the construction of the project. Once bids are received, the client and engineer typically review the bids, seek any clarifications required of the bidders, and ensure all documentation is in order (including bonding, if required). At this stage the client and engineer will typically rank the bids based on various criteria, such as qualifications, experience, references and costs. If the bids fall in a range acceptable to the client, the client and engineer will typically select the most cost-effective and qualified contractor.

In the event that all of the bids do not meet the goals of the owner, the owner may elect to reject all bids. The following options become available:

- Abandon the project.
- The engineer may revise the design in an effort to reduce the cost of the project. The revised documents can then be re-tendered.
- The client may elect to select the lowest qualified bid's contractor to join the design team to try and identify value engineering options to reduce project costs.

Construction Phase

After the project has been awarded to the contractor, the construction documents may be updated to incorporate addenda or changes, and they are issued for construction. Prior to initiating the construction of the project all necessary approvals (such as the building permit) must be obtained from all jurisdictional authorities for the construction process to begin. Once the permits and final contracts are in place the contractor and their subcontractors can mobilize and construct the project.

The design engineer routinely acts as the client's agent to review the progress of the work, to issue site instructions, change orders and/or other documentation necessary to the construction process.

Potential Problems of Design, Bid & Build

Inherent with any construction projects, the DB&B based project can experience some problems, including:

- A failure of the design team to be aware of and/or sensitive to construction costs and to any potential cost increases during the design phase that could cause project delays if the design needs to be modified to reduce costs.
- Redesign expense can be disputed should the engineer’s contract not specifically address the issue of revisions required to reduce costs.
- Development of a "cheaper is better" mentality amongst the general contractors bidding the project, so there is the tendency to seek out the lowest cost sub-contractors in a given market. In strong markets, general contractors will be able to be selective about which projects to bid, but in lean times, the desire for work usually forces the low bidder of each trade to be selected. This usually results in increased risk (for the general contractor) but can also compromise the quality of construction. In the extreme, it can lead to serious disputes involving quality of the final product, or bankruptcy of a sub-contractor who may have under-bid the project, but was on the brink of insolvency and desperate for work.
- As the general contractor is brought to the team after the designs are completed, there is little opportunity for input on effective alternates to designs that are being presented.
- Pressures may be exerted on the design and construction teams, which may lead to disputes between the engineer and the contractor.

Benefits of Design, Bid & Build

The potential benefits of the DB&B approach include:

- The design team is impartial and looks out for the interests of the client.
- The design team prepares documents on which all general contractors place bids. With this in mind, the "cheaper is better" argument is typically rendered invalid, since the bids are based on complete documents.
- The DB&B process typically ensures fairness to potential bidders and improves decision making by the client by providing a range of potential options.
- Assists the client in establishing reasonable prices for the project.
- Uses competition to improve the efficiency and quality for clients.

8.2.2. Design and Build (DB)

Design-build (or design/build, and abbreviated DB accordingly) is a construction project delivery system where, in contrast to DB&B, the design and construction aspects are contracted for with a single entity known as the design-builder or design-build contractor. The design-builder is usually a consortium of engineering and general contractor firms or a joint venture. This system is used to minimize the project risk for a client, and to reduce the delivery schedule by overlapping the design and construction phases of a project. On small projects it is sometimes used as an incentive to attract qualified DB firms or teams. Where the design-builder is the contractor, the design professionals are typically retained directly by the contractor. The most efficient design-builder has design and construction professionals working in the same company directly.

Although this approach is seemingly a recent development in the construction industry, it is actually a very old form of construction that reflects the "Master Builder" approach. Historically, under the Master Builder approach, a central figure, such as the principal architect, held total project accountability. From inception to completion, the master builder was the key organizational figure and strictly liable to the client/owner for defects, delays, and losses. The design/build system is a return to some of the fundamentals of the Master Builder approach. For nearly the entire twentieth century, the concept of Design-Build was classified as a non-traditional construction method in the United States, which is the last country to still embrace the old standard of Design-Bid-Build.

Overview of Process

DB focuses on combining the design, permit, and construction schedules in order to streamline the traditional DB&B process. Generally, this approach may not shorten the time it takes to complete the individual tasks of creating construction documents (working drawings and specifications), acquiring building and other permits, or actually constructing the building. Instead, a DB firm will strive to bring together

design and construction professionals in a collaborative environment to complete these tasks in overlapping fashion time frames, so that some parts of the construction can begin while different parts are still being designed.

Typically the main advantage of the DB project is that one organization is responsible for both design and construction of the project. If this organization is a contractor, the process is known as *"Contractor-led Design-Build"*. If the organization is a design firm, the process is known as *"Design-led Design-Build"*.

Potential Problems of Design-Build

Potential problems of the design-build process include:

- Premature or inaccurate cost estimating,
- Short-cutting in the design process,
- Decreased accountability by the service provider, and
- Correction of work.

Cost Estimating. Cost estimating for a design-build project is sometimes difficult because design documents are often preliminary and may change over the course of the project. As a result, design-build contracts are often written to allow for unexpected situations, and the price of the completed project may vary greatly from the original estimate.

The uncertainty of the early estimate requires the client to rely a great deal on the integrity, acumen, and competence of the design-builder. As the certainty of estimate decreases, the reputation of the design-build firm becomes more important. Estimates should be accurate, and reasonably verifiable in order to minimize risk.

Design Short Cutting. Short-cutting the design process may restrict regulatory review efforts to a potentially cursory overview. Projects that are designed as they are built can result in those with the responsibility of oversight little time to review completed plans and specifications. Projects completed before they are fully designed and approved can be forced into costly change orders to bring the project into compliance with regulatory requirements.

The short-cut design process may also create an ill-defined scope of the work. Since the purpose of the design documents is to describe the project's desired outcome, an abbreviated design process can result in leaving out some details of the quality, workmanship, or other attributes of the project, and making it impossible or very difficult to hold the design-builder accountable for the desired level of quality. Once again, the client must rely on the reputation of the design-builder for a satisfactory product.

Decreased Accountability. The design-builder is given a great deal of control over the entire process, both of how the project is configured and how it is completed. With no third-party observer, such as, an independent engineer to administer the

process, the design-builder may sacrifice the quality of materials and systems in order to pad profits at the expense of the client.

Correction of Work. Since the client may not have the expertise to evaluate the quality of portions of the work, he/she must trust the design-builder to properly design a facility that will meet the needs of the client, and to execute the design properly, according to codes, and consistent with industry-standard specifications. Unless the builder agrees with the client's assessment of the situation, the client may have no means to insist on correction of work done improperly, but to go to some form of formal dispute resolution such as litigation, or arbitration.

In exchange for the ability to save money, the client assumes the risk and responsibility to review contract documents, such as plans, specifications, and agreements for services, and to hold the design-builder accountable to design and deliver a quality product. By contrast, under the typical DB&B model the supervising engineer is in a better position to reject work not performed according to the standards set forth in the plans and specifications.

Benefits of Design-Build

It is important to note that the design-build method, while not focused on saving the client construction costs, nonetheless often saves the client on the overall project. Another important aspect is that for many small scale rural projects in China the profit margins for design services is very low, so that the incentive to attract qualified engineering firms or institutes is very low. Taking a DB approach can increase the overall profitability of the project and creating more incentive to attracted qualified design-builder teams or companies.

Other potential attributes of the DB approach include:

- Enhanced communication between the design-builder and the client;
- Increased accountability by the design-builder;
- Single source project delivery; and
- Integral value based or value engineering project feedback system.

Enhanced Communication. Because the design parameters of a project are being developed along with the budgetary goals - construction methodologies and budget conditions being weighed simultaneously - a project is more likely to be realized than with a pure design approach. The client generally has greater access to the project "team" as the project is being developed. This efficiency is not a negative "short cut" as a rule, but rather the keystone to the success of the DB model.

Accountability. Rather than a fragmented level of responsibility of the classic DB&B, DB provides an integrated solution for the client. This moves projects away from the "finger-pointing" that is often commonplace in contemporary construction projects, and allows the client to look to one entity with any questions or concerns.

Single Source. Instead of having several contractors and consultants, in a DB project the client has just one entity to deal with. Design revisions, project feedback, budgeting, permitting, construction issues, change orders, and billing can all be routed through the DB firm. This single point of contact allows a certain degree of flexibility for the client. Most design-builders will leverage that flexibility for the client's benefit by continually refining the construction program to maximize the client's value at the completion of the project.

Value-based project feedback. Typically, in order for a contractor to bid on a project, very specific details relating to the methods and materials must be given to avoid any ambiguity and to make an "apples to apples" comparison of bids. In a design-build context, the client, the client's other consultants, and the design-builder can work together to determine what methods and materials will maximize the client's value. In instances where marginally more expensive materials, designs, or construction methods might yield a higher return on investment for the client than those of lower cost, the client is free to adjust the project's program without having to re-bid the entire project.

8.2.3. Design, Build and Manage (and Transfer)

In this arrangement the client hires a Design & Build firm to construct and subsequently manage and operate the project, such as in the case of a wastewater treatment facility. This is generally considered a “turn-key” project - starting from project concept and carried through to full scale operation. Under this model two different approaches have been taken: first a long-term management scheme; or secondly a short-term “startup” contract that transfers the operation back to the client or a public entity.

Under either model the design-builder is also the operator of the facility or commonly referred to as a DBO. This arrangement is setup so that the DBO designs, builds, and operates the project under a short- or long-term concession. Short–term contracts may range from 1 to 2 years, whereas long-term contracts can typically last for at-least 5 to 7 years. Short-term DBO contacts are commonly used to make sure the plant is operational, meets the regulatory requirements, and provides the client or public entity time to become trained on the operation and maintenance of the new facility, before the facility is transferred back to the client for long-term O&M.

In some instances the DBO is a co-permittee with the client/owner or responsible entity, and has a shared responsibility to meet all regulatory requirements. In other cases only the client/owner has the legal responsibility to meet the requirements.

After the initial contract period the client and DBO will review and commonly renegotiate the terms of the operational contract, or the client may elect to go out for competitive bid for these services. However, in some instances the DBO may design and build a project that employs a proprietary technology that secures them

copy-righted license agreements for the long-term operation and maintenance of the facilities.

8.3. Procurement Planning

Procurement planning may take either of two fundamentally different approaches, depending on whether it is for a specific investment project or one of the more programmatic types of lending operations. Regardless of which type of project, however, it is essential to develop a plan that clearly sets out the framework in which procurement will be done.

The conventional approach for specific investment projects -- finite projects of known design and content -- is to start by compiling a list of all known goods, works and services needed to complete the project. This list then becomes the basis for deciding how these items should be combined or divided into contract packages, what method of procurement should be used for each, and the scheduling for procurement activities. Even this seemingly straightforward preparation of the list of needs already implies a strategic decision about how procurement and contracting will be done.

Consider, for example, a project to improve wastewater service in a specific area, consisting of installing a sewer collection system, treatment plant and land disposal system. The entire project might be done using a turnkey or a design/build approach: the full responsibility for designing and installing the system improvements given to a single contractor. This single contract would comprise the whole list of needs. On the other hand, the project could be divided into separate contracts for design consulting services, construction of the sewer, treatment works and disposal system -- each of these representing a “need” for the procurement list. The extreme case would be to list quantities of different pipe sizes, wastewater treatment equipment, etc. for materials purchases, separate contracts for installation, contract manager services, etc. In this case, the procurement list could run into dozens or hundreds of items -- not a very efficient approach, incidentally -- for exactly the same project. The degree of detail in the list will depend on how the project is intended to be implemented.

Rather than focusing on the finite elements of details of a project it may be more appropriate to approach procurement through a well structured planning process that focuses on the procedures, responsibilities and criteria for determining project components or sub-projects and for choosing appropriate procurement arrangements. The procurement planning process will involve several steps, including:

1. Organizing a project management/implementation team;
2. Defining the scope of work;
3. Developing a procurement schedule;
4. Preparing and packaging the bid and contract documents;
5. Advertising and notification of the procurement opportunities;

6. Qualifications of bidders;
7. Evaluation and Comparison of Bids for Goods and Services (technical and evaluation);
8. Finalize contract terms with selected firm;
9. Award and signing of the contract; and
10. Project monitoring and audits.

8.3.1. Project Management and Implementation Team

The local implementing agency will need to form a team to plan and prepare the procurement documents. The team will also be responsible to review submit bids and select a firm(s) to complete the desired work. The team should likely be a multi-disciplinary group to provide both financial and technical input and review in the process.

In some regions or local municipalities members of a procurement team may have limited experience with the planning and execution of a public procurement project or be familiar with the requirements of the funding agency. In these cases it will be important for the funding agency to provide training and capacity building to the support the local team to develop procurement documents that meet both the requirements of the project and funding institution.

8.3.2. Scope of Work

The first step in the procurement planning process is to develop a scope of work that clearly identifies the various tanks or activities and fixed works that encompass the project. As outlined in Chapter 6 the work related to a rural wastewater management project will normally encompass three phases of work: (1) the planning and design phase; (2) the construction phase; and (3) the operational phase. Depending on the type of procurement method selected will depend on the scope of work. For example, selecting the design, bid and build (DB&B) method would require at least a two phases of procurement, the initial phase to complete the project planning and engineering design work, and the second phase to construction and possibly operate the project for a prescribed period. However, if a design-build and manage (DBM) procurement strategy is adopted the scope of work would reflect this approach with all of the elements of the project described in the scope of work.

8.3.3. Developing a Procurement Schedule

Once the scope of work has been defined a procurement schedule can be developed that outlines the key elements of the projects and the estimated time frame for their execution. Figure 8.1 shows the key elements and time frame usually allocated to complete each one.

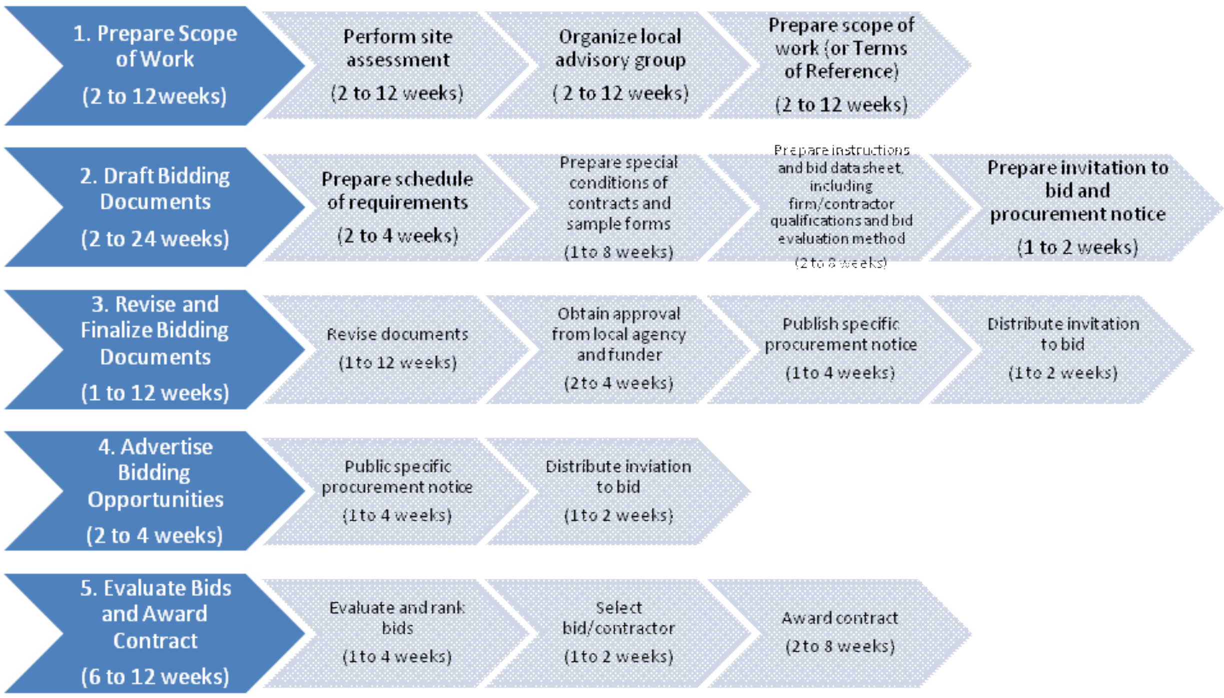


Figure 8.1. Outline of Procurement Schedule

8.3.4. Preparing Bid and Contract Documents

Once the scope of work has be defined and approved bidding documents will be prepared to reflect the scope of work. The bid documents are essential to inform and instruct potential bidders, suppliers and contractors of the requirements expected of them for the particular procurement opportunity. The bid documents need to be prepared clearly and complete so that bidders can submit responsive bids. Bid documents should clearly define the scope of works, goods or services to be supplied, the rights and obligations of the buyer and of suppliers and contractors, and the conditions to be met in order for a bid to be declared valid and responsive. They should also set out fair and non - discriminatory criteria for selecting the winning bid.

The detail and complexity of bidding documents vary according to the nature and size of the contract but they generally include the following:

- **Invitation for Bid** - to invite potential bidders to present their bids for the project at hand, and it describes the Borrower and source of financing and indicates the goods, works or services to be procured.
- **Instructions to Bidders** - providing information to bidders regarding the form, procedure and timing of bidding.
- **The Bid Data Sheet** - which specifies the parameters of the Instructions to Bidders for the particular procurement including source of funds, eligibility requirements, procedure for clarification, bid preparation form, number of

copies to be submitted, language of the bids, pricing and currencies and currency conversion mechanism, instructions on modification and withdrawal of bids, bid submission procedures, closing date bid validity period opening, evaluation and award of contract procedures, procedure for correction of mathematical discrepancies in bids, purchaser’s right to accept any bid and reject any or all bids; award criteria; notification of award and procedures for signing of contract.

- **Evaluation and Qualification Criteria** - this section specifies the criteria that the buyer will use to evaluate the Bids post-qualify the lowest evaluated Bidder.
- **The General Conditions of Contract** – which sets out the general provisions of the contract between the buyer and the bidder awarded the contract.
- **Special Conditions of Contract** - which modify the General Conditions of Contract for the particular procurement.
- **Schedule of Supply** - which specifies the quantities, delivery locations, and dates for the items required by the buyer.
- **The Technical Specifications and drawings** - which detail the characteristics of the technologies and technical services required (as well as specify the common format which bidders must present their materials).
- **Bidding Forms** - which typically include a Bid Submission Sheet and Price Schedules, the Bid Security Forms, the Contract Form, the Performance Security Form, possibly a the Bank Guarantee Form for Advanced Payment, and the Manufacturer’s Authorization Form.

8.3.5. Technical Specifications

Precise and clear specifications are prerequisite for bidders to respond realistically and competitively to the requirements of the Purchaser without qualifying or conditioning their bids. The specifications should make a clear statement of the required standards of workmanship to be provided, standards of plant and other supplies, and performance of the goods and services to be procured. Only if this is done will the objectives of economy, efficiency and fairness in procurement be realized, responsiveness of bids be ensured, and the subsequent task of bid evaluation be facilitated.

For the goods, plant and other supplies to be incorporated in the works, the specification should require that they be new, unused, and of the most recent or current models and that they incorporate all recent improvements in design and materials unless provided otherwise in the contract. For works contracts, a clause setting out the scope of works is often included at the beginning of the Specifications, and it is customary to give a list of the Drawings. Where the contractor is responsible for the design of any part of permanent works the extent of his obligations must be stated.

In the case of procurement of goods or the Supply and Installation of Plant and Equipment, reference to brand names, catalogue numbers or other details that limit

any materials or items to a specific manufacturer should be avoided as far as possible. Where unavoidable, such item description should always be followed by the words “substantially equivalent. Technical specifications in this instance should be descriptive and give the full requirements in respect of, but not limited to, the following:

- Standards of materials and workmanship required;
- Details of all factory tests required (type and number);
- Details of all work required to achieve completion;
- Details of all pre-commissioning and commissioning activities to be performed by the Contractor; and
- Details of all functional guarantees required and liquidated damages to be applied in the event that such guarantees are not met.

8.3.6. General Conditions of Contract (GCC)

The GCC in the bidding documents establish an accepted basis for similar procurement contracts under the project. The GCC will typically outline the operational, protective, variations and remedy clauses that are established between the purchaser and the supplier/contractor.

Appendix E outlines general contract and bidding procedures that are appropriate for public sector and village projects.

CHAPTER 9 – SYSTEM ADMINISTRATION, OPERATION, MAINTENANCE AND MONITORING

9.1. Introduction

A rural wastewater management project consists of three phases of development as shown in Figure 9.1. These include the planning and design phase, the construction phase, and most importantly, the operation and maintenance (O&M) phase. Commonly, development programs executed by national governments and non-government organizations (NGOs) will focus on the first two phases of development and leave the last phase of the project to beneficiaries of the project. This approach has commonly resulted in a high failure rate of projects for several reasons, including a lack of proper training of the local community on the O&M requirements of the system, inadequate ongoing monitoring and evaluation by the regulatory community, the introduction of inappropriate technology that cannot be financially or technically supported by the community and other possible reasons. Therefore, project sponsors need to consider all three phases: planning and design, construction, and O&M as integral to sustainable development projects, so that their projects support each phase equally and effectively.

An operation and maintenance (O&M) program is to provide for and improve the efficient and effective sanitary service. O&M activities encompass technical, managerial, financial, and institutional issues that must be attended to, to achieve reliable and uninterrupted service.

The introduction of a sanitation system such as a simple pit latrine at a household or a more complicated wastewater treatment technology for an entire village will all require maintenance over the life of the system. A pit latrine will require that the latrine is cleaned regularly and fecal sludge is removed before the system is full and the sludge is taken to an appropriate treatment and final disposal site. However, in general, the household will be responsible for maintaining it’s own facilities. Pit emptying can be done by the household itself, especially for composting or drying latrines where the pathogens have died off, or by private entrepreneurs, or by local authorities. However, if septage is to be treated or disposed of to land, communities or local authorities may need to oversee its correct treatment and/or disposal, including O & M of treatment facilities or disposal beds, to protect public health and the environment.

A village wastewater treatment system may require daily, weekly and monthly operation and maintenance activities to operate properly and provide effective treatment of the wastewater.

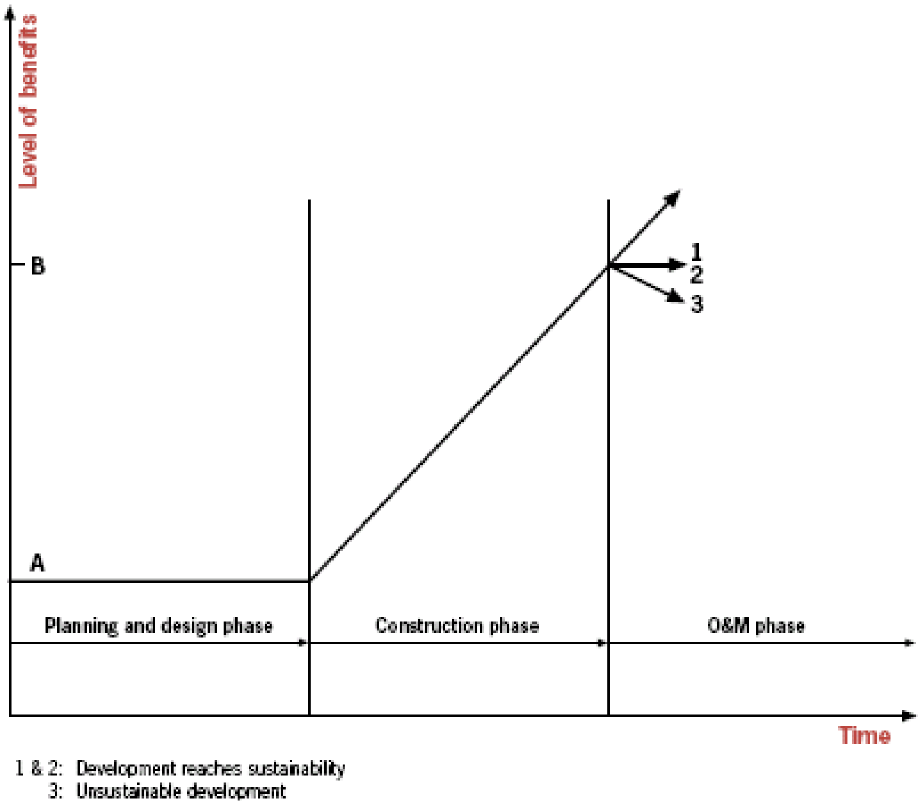


Figure 9.1. Development Project Phases (WHO, 2003)

Operation refers to the everyday running and handling of a wastewater system including the proper handling of facilities by the users to ensure long-life of the collection, treatment and/or disposal equipment. Maintenance refers to the activities required to sustain the sanitation/wastewater system in proper working condition. Maintenance activities can be broken down into three separate categories that reflect when the maintenance activities occur: preventive maintenance includes regular inspections and servicing to preserve assets and minimize breakdowns; corrective maintenance includes minor repairs and replacement of broken and worn out parts to sustain reliable facilities; and crisis maintenance that includes unplanned responses to breakdowns and user complaints to restore a failed supply.

9.1.1. O&M in the Context of Sustainability

Sustainability depends to a large extent on effective and efficient operation and maintenance. However, it is important to note that the sustainability of a project will also depend on selection of technology introduced into a community at the onset. Many factors and processes that contribute to sustainability have a direct influence on operation and maintenance (WHO, 2003).

Sustainability can be analyzed in time, as shown in the Figure 9.1. A service is sustainable when:

1. it is functioning and being used;

2. It is able to deliver an appropriate level of benefits (*quality, quantity, convenience, comfort, continuity, affordability, efficiency, equity, reliability, health*);
3. It continues over a prolonged period of time (*which goes beyond the lifecycle of the equipment*);
4. Its management is institutionalized (*community management, gender perspective, partnership with local authorities, involvement of formal/informal private sector*);
5. Its operation, maintenance, administrative and replacement costs are covered at local level (*through user fees, or alternative financial mechanisms*);
6. It can be operated and maintained at the local level with limited but feasible external support (*technical assistance, training, monitoring*); and
7. It does not affect the environment or public health negatively.

9.1.2. Factors Contributing to Sustainable and Effective O&M

Sustainability relies on four interrelated factors: a) technical factors, b) community factors, c) environmental factors, and d) the legal and institutional framework (WHO, 2003).

The **technical factors** which are likely to influence operation and maintenance as well as sustainability as a whole are: technology selection; complexity of technology; its capacity to respond to a demand and a desired service level; its impact on the environment; the technical skills needed to operate and maintain a system; the availability, accessibility and costs of spare parts and materials; and the cost of maintenance.

The **community factors** which are likely to influence operation and maintenance as well as sustainability as a whole are: availability of technical skills to operate and maintain a service, and to implement preventive maintenance activities and small and big repairs; capacity and willingness to pay; participation of all social groups in the community including both men and women; financial and administrative management carried out by a legitimate and organized community structure; the felt need for an improved service; socio-cultural aspects related to water, sanitation and hygiene; and individual, domestic and collective behavior regarding hygiene and sanitation.

The intersection between the technical and community factors indicates the level of ownership and responsibility of communities towards the service. **Ownership and responsibility** are the key prerequisites for sustainable operation and maintenance.

The **environmental factors** which are likely to influence operation and maintenance as well as sustainability as a whole are: the geologic setting, soil and water conditions and temperature, which all have a significant bearing on the type of sanitation solution selected for the community.

The intersection between the environmental and community factors represents the way the community will manage water resources and especially the impact on the environment of community behavior in terms of sanitation and management of used waters. Water resources management, pollution control, hygiene behavior, and proper wastewater management are all crucial components to which operation and maintenance must contribute.

All these factors evolve within a **legal and institutional framework**. At the national level there must be clear policies and strategies towards operation and maintenance, which can be implemented. Support activities, such as technical assistance, training, monitoring, water quality control, and the setting up of alternative financing mechanisms are all likely to influence operation and maintenance activities.

Financial factors are key components inherent in all the above factors (technical, community, environmental, and institutional).

9.1.3. Processes Influencing Sustainable O&M

Processes differ from factors since they focus on the approach and the methodology of working. In the past, it was thought that the development or consolidation of factors alone could contribute to greater efficiency, effectiveness and sustainability. Now, however, it is realized that processes also have an important role to play. Among the processes can be listed the following:

- Demand from the communities;
- Responsiveness from supporting institutions and agencies;
- Participation of communities (men and women) through the whole project cycle;
- Linking technology choice with operation and maintenance;
- Integration of water, sanitation, health and environment;
- Planning with a gender and equity perspective;
- Communication among all stakeholders;
- Public/ private partnership;
- Co-responsibility between community and municipality; and
- Capacity-building at all levels.

Demand for an improved service by the communities is a prerequisite for sustainability.

It is an expression of their commitment, and a way to make communities responsible for their choices and future tasks. However, demand should be promoted because communities must be made aware of the different technology options available, and of their financial consequences. The concrete expression of demand varies from one country to another and from one development agency to another. Demand can be manifested in the form of an initial contribution in cash or in kind to the capital costs,

or in the form of a written solicitation from an organized community group to the municipality.

Responsiveness of support institutions and agencies is the capacity of municipalities, nongovernmental organizations (NGOs), and other institutions and agencies to respond adequately to the needs and demand of rural communities. In many regions of China municipalities and counties need to be coordinated and organized in their ability to support rural communities.

Participation of communities (including both men and women and other marginalized groups) throughout the whole project cycle is essential to motivate, make responsible and build the capacities in their new tasks and functions.

Linking technology choice with operation and maintenance requirements at the planning stage is critical in the technology selection process, so that communities are able and willing to operate, maintain, administrate and finance the new service.

Planning with a gender perspective implies that the roles and functions of both men and women are clearly defined for management, operation and maintenance, since these might also highlight the need for specific capacity-building activities. Equity, to ensure that all people have access to services without regard to their economic or social status, should also be taken into account.

Communication from central to local level and vice versa, and between private agencies and development agencies, is important for coordination of activities and implementation of policies. Proper information and monitoring systems rely on effective communication channels.

Public / private partnership can have an important role in the operation and maintenance of improved sanitation services, where the private sector can operate, maintain, and manage the service under contractual agreements. Communities must have a clearly defined role in monitoring the private sector partner, as well as the capacity to do so.

9.1.4. Operation and Maintenance (O&M) Program

An O&M program will include management, administrative, operation, maintenance and monitoring activities. The basic management and administrative activities are related to the coordination and management of staff, administrative tasks including accounting and book keeping, procurement of spare parts, materials and material, preparing regulatory reports, and coordination with other organizations. Operation and maintenance activities include the technical activities related to operating equipment, routine cleaning and maintenance activities, and repairing of equipment or facilities, as required. Monitoring activities may include conducting inspections of the facilities and/or water testing required by the local environmental protection agency or a project sponsors monitoring and evaluation (M&E) requirements. The following sections outline these activities.

9.2. Management and Administration

The first and essential step in forming an effective O&M program is to put in place the management and administrative elements. Program management involves the **control and organization of a service** and encompasses the following main functions:

- Establishing an institutional framework;
- Organization and mobilization of resources, including ongoing procurement;
- Financial management, including accounting and bookkeeping;
- Human resources management, including leadership and motivation of personnel;
- Planning; and
- Establishing Ordinance and Rules.

9.2.1. Institutional Framework

Forming a clear institutional framework for the long-term management, administration and O&M of the village sanitation service is fundamental. The institutional framework for any O&M program will involve both several different sectors of society, including village committees, county agencies, and private enterprises. Figure 9.2 shows an institutional framework for a rural wastewater management program that outlines the responsibility of function of each entity involved.

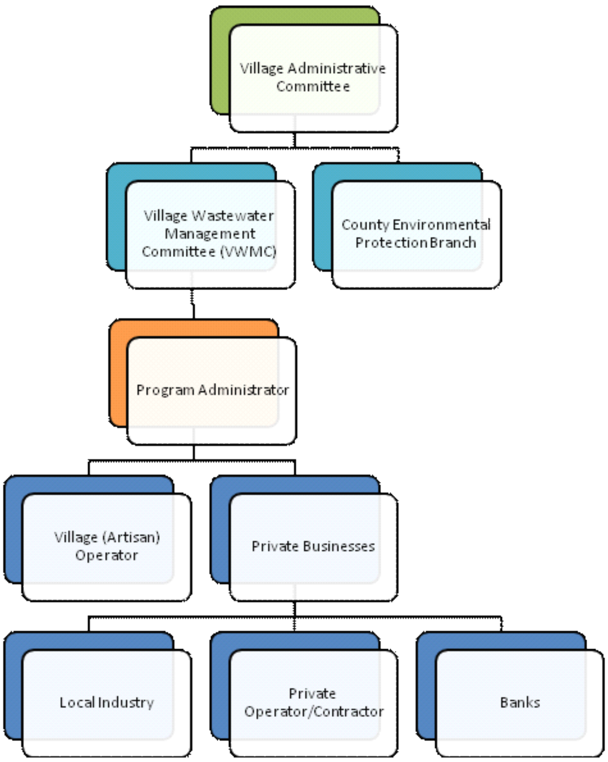


Figure 9.2. Institutional Framework for Wastewater Management Operation and Maintenance

As illustrated in Figure 9.2, the institutional framework of wastewater management will involve both public and private enterprises. The hierarchy will involve the formation of the village wastewater management committee (VWMC) under the main village administrative committee. Under the VWMC, a project administrator would be put in place to oversee the managerial, financial and technical aspects of the program. Under the project administrator there will be a local village (artisan) operator who will be responsible for the day to day operation and maintenance activities. Several private enterprises will be involved for additional servicing, maintenance and repair activities and banking requirements to manage funds administered by the program, if any. In the case of decentralized sanitation, this framework can be simplified after construction is complete.

Village Wastewater Management Committee. They have many ongoing responsibilities during the O&M phase of the project including:

- Developing a vision and strategy to sustain the wastewater management program in the village.
- Setting policies and regulations at the village level;
- Hiring and firing employees;
- Reviewing and resolving issues or conflicts that may arise related to the wastewater systems in the community;
- Reviewing and adopt requirements promulgated by the local regulatory agency;
- Formally responding or interacting with the village administrative committee, and governmental agencies, and NGOs; and
- Other committee level functions.

During the O&M phase the VWMC would conduct routine committee and/or community meetings to review, consider and discuss outstanding issues.

Program Administrator. The Program Administrator (PA) would be responsible to supervise and coordinate the overall administrative, technical and financial functions of the village wastewater management program. The functions of the system administrator would include:

- Develop and implement the wastewater financial (billing and accounting) system;
- Hire, coordinate, and supervise local staff and private enterprises;
- Prepare administrative and financial reports for the VWMC; and
- Coordinate activities with the local regulatory agency and other organizations.

Village (artisan) Operator(s). In the case of a centralized or communal system, the local village operators are responsible for day-to-day operation, preventative and corrective maintenance activities, and some repair work depending on the availability of skilled labor, such as mechanics, plumbers, builders and electricians.

For a decentralized system, the household will generally be responsible for its own latrine or toilet.

Private Operators/Contractors. The project sponsor or village may elect to hire a private operator to operator and service the village wastewater system. Given the remote setting of many projects the role of a private operator may be two-fold, first as a supervisor to train and oversee the village operator who is conducting the day to day operations, and secondly to conduct more complex operation and maintenance activities that are beyond the skill level of the local operator.

Private Industries. Local or regional industries/vendors will be needed on occasion to supply, repair and/or manufacturer spare parts, materials, and equipment.

Banks. A local bank may be used to deposit program funds (from fees collected from the village) or possibly for the village to secure a loan for future project upgrades, expansion of service or emergency repairs.

Environmental Protection Bureau (EPB). The local EPB is responsible for regulatory oversight and inspection of the facilities. The EPB may also provide technical support and training for capacity building in the village.

9.2.2. Organization and Mobilization of Resources

As discussed above, a key role of the Program Administrator (PA) is to hire, coordinate and supervise both local and outside contractors and operators to properly maintain and operate the facility. The amount of time required to undertake this work will depend on the type and complexity of the sanitary system installed in the village. A small village that is using on-site latrines or septic systems will not require significant administrative oversight, unless the management of the systems is performed by the VWMC and they are responsible for the removal and management of fecal sludge for these facilities. For a more complicated centralized wastewater system, the System Administrator may need to dedicate a more substantial amount of time to supervise local and private operators and other outside contractors.

The PA may also be responsible to find and provide training and capacity building opportunities to the program staff, including the program administrator, operators, and committee members. The PA will likely be in a leadership role and asked by village leaders to adopt practices that motivate personnel to work professionally and to respect other employees, villagers and private partners.

The PA will also be responsible to coordinate activities with governmental and NGOs and in many instances will be the village liaison with these different groups.

9.2.3. Financial Management

The PA will be responsible to develop and maintain a financial management program that includes a system to collect user's fees, and a book-keeping system to maintain financial records and prepare financial reports, as required. The PA may be responsible to establish a cost recovery system (user fee schedule) that would be presented and adopted by the VWMC. The PA will be responsible to open a bank account and maintain the accounts. If the village acquires a loan, the Program Administrator may be responsible to manage the loan payments and other loan service requirements.

The PA will need to gain skills in financial management, which will allow them to organize, implement, and control a cost recovery system in an efficient way. Table 9.1 summarizes the basic aspects and issues and possible options of a financial management system, which have to be considered by a VWMC and PA.

9.2.4. Planning

Another important administrative function of the VWMC and PA is to adopt a forward thinking perspective or trajectory for the wastewater management program. In some regions of China, villages may experience growth and development that will require expanded service or coverage by a wastewater system. In other instances sanitation projects may not achieve the intended goals or may fail, and will require system upgrades or retrofits. Whatever the particular circumstances that may be encountered in a village, the VWMC and PA should be planning for the future. This planning effort is usually included in the administrative activities of the wastewater management program.

9.3. Operation and Maintenance

The O&M requirements of the sanitary or wastewater system will depend on the type and complexity of the system. An on-site or household system generally requires less operation and maintenance than a clustered or centralized village wastewater system that includes a sanitary sewer collection system, a wastewater treatment and land disposal system.

The O&M program includes user education and outreach, ongoing inspection and maintenance activities, septage or residual management, monitoring and reporting requirements. This section outlines the basic elements of a village level O&M program targeting both on-site and central wastewater management programs. Given the wide array of sanitation and wastewater technologies available, this section provides general guidance. A more detailed operation and maintenance plan should be provided by the design consultant for the site specific systems installed in a particular village.

9.3.1. Education and Outreach

Public involvement and education is a critical component of the O&M program to ensure public support for program implementation and funding. When community members have an understanding of the importance of the system operation and maintenance they will be more inclined to support the program materially and financially. When selecting the sanitation option, the community should have been fully informed about the O & M costs and requirements of the options, and used that information to help select the technology.

The village wastewater management program should provide households with information about the operation and maintenance of the sanitation or wastewater system employed in the village. Both before and after construction, this information can be provided through community meetings and reports, or by providing a brochure or small guide describing the type of wastewater management system employed either at a household or in the community. The guide should describe the system components, maintenance needs, and frequency of service activities. If a clustered or centralized wastewater system is installed the guide may explain what households can and cannot dump into the sewers, the procedures for connecting the house to the village sewer system, and restrictions to prevent storm water connections to the sanitary sewer system.

Fecal Sludge/Septage Management. The proper functioning of on-site sanitation and wastewater disposal systems often requires that fecal sludge/septage is pumped out on a regular basis. Therefore, the wastewater management program requires that village residents are well informed about pumping and proper disposal of fecal sludge/septage. The VWMC needs to inform residents about the frequency of septage pumping, the requirements for using a licensed pumping contractor /hauler, and the expected costs for this service. The contractor and hauler must also be monitored for compliance with requirements for proper disposal.

9.3.2. Maintenance Program Elements

Maintenance is essential to the sustainability of every wastewater system. A preventative maintenance program combined with good operational practices will reduce the need for corrective or emergency maintenance. A good preventative maintenance program will service not only mechanical and electrical equipment, but also the collection, disposal and residual management systems (NYSDEC, 2007).

Maintenance includes all functions required to keep a facility operating in accordance with its original design capacity and performance. This includes repairs to broken, damaged, or worn-out equipment (emergency maintenance), and the periodic replacement of equipment and facilities that have reached the end of their design life (corrective or replacement maintenance).

Table 9.1. Basic Aspects of Financial Management System
(After WHO, 2003)

Financial Management Issues	Possible Options
1. Budgeting	
What cost to budget for?	■ Remuneration ■ Tools and spare parts ■ Small repairs only ■ All repairs ■ Extension, rehabilitation ■ Fuel, power supply, etc. ■ Depreciation ■ Etc.
What sources of income to use?	■ Regular user payments (monthly, sale per unit) ■ Village funds ■ Voluntary contributions ■ Credit schemes ■ Government subsidy
How to pay the operator or mechanic?	■ Per job ■ Per month (fix + % of sales) ■ Per year after harvest ■ In cash/kind
2. Organization of Financial Flows	
How to collect the money?	■ Billing ■ Collection at water point ■ Fund-raising when breakdown ■ Taking money from a fund
When to collect the money?	■ Per service provided ■ Monthly ■ After harvest ■ Beginning of financial year
Who collects the money?	■ Operator ■ User group ■ Village Water Committee ■ Community leaders
Where to keep the money?	■ In a safe ■ In the village account ■ In a bank account ■ In a development fund
3. Financial Administration	
How to register movements of expenditures and incomes?	■ Log book ■ Daily journal ■ Book-keeping ■ Bank statements
Who administers the funds?	■ Program Administrator or Treasurer (man or woman) ■ A village accountant ■ Bank accountant
What are funds used for?	■ Payment of expenditures related to O&M of water point ■ Generating bank interest ■ Use for other future wastewater management projects
Who orders payments?	■ Program Administrator/Treasurer ■ VWMC ■ Village leaders
Financial Control and Monitoring	
What type of financial control?	■ Receipts from book-keeping ■ Regular meetings of VWMC ■ Double signature for disbursement of funds ■ Checking with bank statements ■ Registered auditors
How to monitor?	■ Use of log book ■ Make a quarterly review and overview of the situation on expenditures, incomes, and % of people who do not pay

General Maintenance Program Elements

A comprehensive maintenance program for a centralized or communal system will include the following components:

- An Operation and Maintenance Plan prepared by the Designer of the wastewater system;
- An inventory (and list) of equipment, components and spare parts maintained on the site;
- Manufacturer's literature for all key components used in the system (piping, valves, pumps, float switches, controllers, blowers (if used), pond liner materials, and other pertinent equipment);
- Preventative maintenance task list and calendar;
- Maintenance Log (records of maintenance activities performed); and
- Tools, materials, and equipment for conducting routine maintenance activities; and
- Scheduling of maintenance activities.

Operation and Maintenance (O&M) Plan. For a centralized or communal system, the VWMC should receive at least two copies of an O&M Plan prepared by the system designer. The O&M Plan should include the following information:

a) General description of the wastewater system;
b) Copies of the environmental permit and standards;
c) Description of the operation and maintenance requirements of the collection, treatment and disposal systems;
d) Maintenance procedures
e) Description of the sludge management procedures;
f) A monitoring and laboratory analysis program;
g) Record keeping and reporting requirements;
h) Emergency operating and response plan;
i) Safety plan; and
j) Manufacturer's literature for the equipment specified in the design.

The O&M Plan should be kept current at all times and updated every two to four years if substantial changes have occurred.

Inventory of Equipment, Components and Spare Parts. A fundamental part of the maintenance program is to maintain an inventory of all system components, equipment and spare parts. An inventory of spare parts and mechanical equipment, such as backup pumps is required for preventative maintenance, as well as corrective and emergency maintenance. Procedures should be put in place to make sure that parts are replaced in the inventory as they are used.

Manufacturer's literature and Warranties. The system operator shall maintain copies of the all manufacturer's literature and related warranties for equipment and

materials selected and used in the system (piping, valves, pumps, float switches, controllers, blowers (if used), pond liner materials, and other pertinent equipment). This information should be provided by the Contractor at the end of the project.

Preventative Maintenance Task List. Once all of the equipment and components have been itemized and the manufacturer's literature has been collected, it is time to develop the comprehensive list of preventive maintenance tasks and to schedule them. Working systematically through each component of the facility, and remembering to address additional areas such as building and grounds maintenance, all preventive maintenance tasks must be identified and a frequency for scheduling should be assigned.

Maintenance Logs. Records must be kept indicating which maintenance tasks have been performed and when. This is helpful for two reasons. First, it is imperative to verify the completion of each maintenance task. Second, to schedule future maintenance activities or to verify the condition of certain equipment, it is always helpful to be able to refer back to the record of past maintenance performed.

Tools and Equipment. Every wastewater system must have suitable tools and the required specialized equipment available to perform maintenance. These tools and equipment should be of good quality, because they are likely to be used for many years.

Scheduling of Maintenance Activities. A very important part of the preventive maintenance program development and improvement is appropriate scheduling of maintenance activities. Preventive maintenance schedules must consider variations in plant and equipment utilization. For example, in wastewater systems, this may involve scheduling to accommodate seasonal wet weather flows or intermittent industrial discharges.

Scheduling should consider weather and its effect on maintenance activities and personnel. Whenever possible, outdoor maintenance activities should be scheduled when favorable seasonal weather conditions can be expected.

9.3.3. Sanitation System Maintenance

All wastewater systems whether they are individual household systems or centralized village wastewater systems require routine inspections in order to determine the condition and maintenance requirements of the system. However, the frequency and time required to inspect the system will vary depending on the size, complexity and potential use of the system.

On-site Sanitation Systems

On-site sanitation systems can include simple pit latrines, ventilated improved pit (VIP) latrines, pour flush latrines, EcoSan toilets, septic systems and in some instances enhanced wastewater treatment units for individual parcels (more

commonly used in institutional uses, such as schools, health clinics, or small commercial centers not connected to a centralized system).

Latrines are commonly connected to a single or dual pit disposal system. A single pit system will require cleaning when it is full, usually once or twice a year, depending on the number of users, the pit volume, and site conditions. These systems should be inspected at least monthly to determine when they should be pumped out. Note fresh excreta contain pathogens and should be handled and disposed of carefully, to avoid spreading disease. If the latrine is connected to a dual pit system than the use of each pit should be rotated when it is full, , and the pit that had been is use should be allowed to 'rest' while the excreta dries or decomposes for a period of at least six months. The sludge would be removed after decomposing or drying, before that pit is put back into operation. Most of the pathogens will have died during decomposition or drying, and the resulting material is safe to handle and to re-use.

Given the different design configurations and end uses for the urine and composted sludge, EcoSan toilets have design-specific O&M requirements, which should be provided by the promoter and/or supplier of the toilet.

A properly sized septic system will include a septic tank and a subsurface land disposal system (drainfield) or constructed wetland. The septic tank should be inspected each year and should likely be pumped out every three to five years (Kahn et al., 2003). The sludge from the septic tank (septage) should be pumped out by a licensed septage hauler and taken to a permitted treatment facility for treatment and disposal. The drainfield should be mostly maintenance free unless the solids or sludge in the septic tank enters the drainfield lines, which normally happens if the tank is not pumped out when full of sludge. The drainfield should be inspected at least annually. Lush plant growth over the drainfield may be a sign of sewage surfacing. If the system has a dual drainfield with a diverter valve, the use of the fields should be alternated every six to 12 months to allow the drainfield lines to 'rest' and dry out.

Clustered or Centralized Wastewater System

In many villages, clustered or centralized wastewater system will be installed. The operation and maintenance of these systems will be more frequent. These systems will typically include a sewer collection system to collect and convey wastewater from each household to a centralized treatment system. From the treatment system the treated effluent will either be disposed of in a subsurface disposal system or constructed wetland, or reused for a beneficial purpose such as irrigation.

The inspection, operation, and maintenance of the centralized wastewater system will require both unskilled and skilled labor to conduct routine maintenance and repairs. The frequency and extent of maintenance activities will depend on the type and complexity of the systems installed.

Sewer Collection System

The O&M requirements of the collection system will depend on the design, type and complexity of the collection system. A simple gravity flow system with sewers that are installed with good fall or slopes (generally over 1% to 2%) will likely not require frequent cleaning. However, low gradient sewers with interceptor tanks will normally require more frequent inspections and cleanings. Sewer cleaning should be scheduled on a regular cycle, for example, 100 percent of the sewer lines should be cleaned every three to five years or approximately 20% to 30% of the sewer lines should be cleaned every year (Arbour and Kerri, 1998).

In some instances the collection system will include pump stations and forced main sewers. Sewer systems with pump stations and force mains will require more frequent inspections, cleaning and maintenance activities. Pump stations can be complex and the operators who maintain them should be skilled. There are generally two levels of maintenance associated with wastewater pump stations: (1) inspection, and (2) mechanical and electrical maintenance. The purpose of the scheduled inspection of the pump station is to monitor and assess the operation of the pump station. An inspection usually involves a variety of tasks, such as verifying control system operation, observing electrical and mechanical equipment for signs of abnormal operation, performing preventive maintenance tasks (such as cleaning the pump), and recording operational information. Inspection verifies that the pump station is operating as intended and that there are no existing or impending problems that will affect pump station operation and reliability.

The purpose of electrical/mechanical preventive maintenance is to maintain the integrity of the mechanical and electrical systems to keep the station operating reliably and/or to restore the system components to their original condition and functionality. Pump stations have numerous electrical component including electrical motors, controls, protective devices such as circuit breakers and overloads, wiring systems, lighting, heating and ventilation. Electrical preventive maintenance should be performed at scheduled intervals based either on running time (for example every 2,000 hours of operation), or by calendar (once every three months, for example). Scheduled repairs and replacement of both electrical and mechanical equipment are also part of the preventive maintenance program. Certain components of electrical and mechanical equipment (such as wear rings, mechanical seals, packing, and pump impellers) are subject to wear and require periodic inspection and replacement. Overload relays on electrical equipment need to be inspected and replaced periodically. Electrical motors require periodic overhauls. Scheduled maintenance is also necessary on force main isolation, air and vacuum relief valves.

Wastewater Treatment System

The specific operation and maintenance requirements of the wastewater treatment system will be outlined in the Operation and Maintenance (O&M) Plan prepared by

the designer, and the O&M requirements will depend on the type, size and complexity of the system.

A small wastewater system using septic tanks, such as for a small cluster treatment system for a neighborhood, may only need to be inspected once a month or every three months to inspect and measure the accumulation of sludge and to schedule sludge pumping and removal. On the other hand, a wastewater system that includes a more active treatment scheme, including a headwork (with a screen(s) and grit chambers), a primary sedimentation tank, and biological unit processes will require at least daily visits to clean the screen and to make sure the system is operating normally. A conventional biological treatment system will commonly require weekly and monthly maintenance activities.

Subsurface Land Disposal System

A subsurface land disposal system general requires routine inspection of the surface soil conditions on the top of the subsurface disposal system and the water levels, which are measured in the risers installed in the drainfield trenches.

Depending on the type of subsurface disposal system installed, additional maintenance activities may be required. For example the pressurized lateral lines in a pressure dosed drainfield should be flushed out at least once year and possibly more frequently.

A properly designed drainfield should be divided into different zones that can be turned 'off and on' to allow the trenches to 'rested', by allow a certain amount of time to pass between use (i.e. 6 months per year). The operator will need to rotate the fields and make sure they are working properly.

The subsurface land disposal system should be inspected on a routine basis. Drainfields installed in areas of marginal clayey soil conditions and prone to wastewater surfacing should be inspected frequently – typically on a monthly basis. If the land disposal system is constructed in well draining soils, such as in sandy soils, then the system may only need to be inspected once or twice a year.

Groundwater monitoring wells installed in the area of the subsurface disposal system will need to be monitored on a regular basis typically 2 to 4 times per year,

9.3.4. Sludge and Residual Management

All wastewater treatment systems generate residual solids that require either on-site treatment or removal to an off-site sludge treatment facility. The O&M Plan should provide basic information pertaining to the management of sludge; however, the system operator may need to review and update these procedures once the plant is operating. For any process in the treatment system that either generates or stores sludge, an expected removal frequency and means of removal shall be provided.

The system operator will need to learn how to measure the depth of solids accumulating in different unit processes, so that the solids can be removed before the level of solids impacts the performance of the treatment unit.

9.3.5. Emergency Response Planning

An emergency response plan and the ability for an operator to respond to emergencies and problems in a timely and effective manner are critical to protect public health and the environment. This section provides a general overview of the key elements that need to be included in the preparation of an Emergency Response Plan. More detailed information should be presented in the site specific Operation and Maintenance Plan. Decentralized systems, such as latrines, may not require all of the elements described here.

An appropriate emergency response plan should detail procedures to be followed in the event of a power outage, storms, floods, earthquakes, hydraulic overloads/pipeline rupture, fire, explosions, equipment failure, hazardous materials spill, maintenance shutdown, and personnel injury. A description of who should be should be notified, and when, for each emergency situation should be provide along with the appropriate telephone.

The emergency response plan should include a risk assessment of the wastewater system and identify the critical components of the system, such as pumps, generators, blowers, pipeline crossings over waterways, and the potential component failure modes of the critical equipment. The risk assessment should estimate the frequency of failure for the equipment and develop strategies to respond to these failures.

The emergency response plan should include formal procedures to respond to alarm conditions or emergencies, including identifying who the first responder will be and the procedures they can take to respond to different conditions. These procedures should include specific provisions for both normal working hours and non-working hours.

9.3.6. Safety

The skilled and unskilled system operators should receive safety training in the following topics, as appropriate to the type of system:

a) Potential biohazards and bacterial infections;
b) Proper use and storage of hazardous materials (such as chlorine);
c) Proper use and testing of electro-mechanical equipment;
d) Risks of explosions;
e) working in confined spaces;
f) Oxygen deficiencies; and
g) Use of safety equipment, including recommended training and re-training schedules.

9.4. Reporting and Monitoring

9.4.1. Reporting

Reporting and monitoring will depend on the type of system; for example, the requirements for decentralized, household level systems may not require all of the measures described below.

Operations and Monitoring Report. The Village Wastewater Management Program will likely be required to prepare monthly or quarterly reports for the County and Municipal Environmental Protection Branch. The purpose of the report is to provide a status of the system operation over the reporting period. The report should discuss what maintenance activities were conducted and if any problems and/or failures occurred during the reporting period. Water test results and flow information should be included in the report. If the village is required to conduct groundwater testing then this data should also be included in the quarterly reports.

Financial Report. The Program Administrator (PA) should prepare semi-annual and annual financial reports for the VWMC. These reports include information about the amount of funds recovered (via tariffs or fees) over the previous six month period, and include profit and loss statements and a balance sheet in order to track expenses. This information allows the PA and VWMC understand what the direct costs are to operate the program by tracking the expenses. This is important to determine if the sources of funding via users fees or other village enterprises is covering the operating cost of the program. And if not, the PA and VWMC should choose to adjust user's fees and/or find alternative means to fund the program.

9.4.2. Water Testing and Flow Monitoring

Water Testing. If the village installs a wastewater treatment system, then the EPB will require routine testing of the raw wastewater entering the system (influent) and the treated water leaving the plant (effluent). The frequency of testing will be prescribed by the EPB, but is commonly monthly during the startup phase, which may be a 3 to 6 month period, and after the treatment system is shown to be working properly the testing may be conducted quarterly. The basic tests that should be conducted on a regular interval include:

- Biochemical oxygen demand (BOD)
- Total suspended solids (TSS)
- Ammonia-nitrogen
- Organic nitrogen (Total Kjeldalh Nitrogen)
- Total phosphorus
- pH

Flow Measurements. The wastewater treatment system should include a flow measuring device, such as a weir plate or a flow meter, so that the village operator can record daily flows.

Groundwater Monitoring. A groundwater monitoring network will be required to monitor shallow groundwater conditions down gradient from the land disposal system. This will usually involve installing at least three monitoring wells: one well installed upgradient from the land disposal system and two wells installed down gradient of the land disposal area. A minimum of three wells is needed to determine the horizontal direction of flow of shallow groundwater. [The wells should be installed a sufficient distant away from the land disposal system so that the wells are monitoring groundwater and not effluent from the drainfields. The groundwater monitoring wells should be monitored on a quarterly basis for the following parameters:

- Groundwater levels
- pH
- General minerals, including:
    - Sodium
    - Chloride
    - Potassium
    - Magnesium
    - Sulfate
    - Bicarbonate
    - Fluoride
    - Nitrate (as N)

9.4.3. Equipment Monitoring

If the village installs a wastewater treatment system that includes any pumps or blower systems, this equipment will be connected to a control panel. The control panel should be designed to include an hour meter and event counter that records the hours and the number of times a piece of equipment operates. This information is important to track the use of the equipment and to detect if the condition of the equipment changes. For example, if a pump becomes clogged, the flow rate through the pump will be reduced and the pump will need to operate for a longer duration to convey the same volume of water. The operator should be monitoring these meters and others on a regular basis so that they are familiar with the normal operating conditions and can detect when conditions change, which would indicate the need for maintenance or repair of the equipment.

If float switches are used to control any equipment, the floats should be checked at least quarterly to make sure they function properly. The design life of a float switch can be anywhere from 1 to 5 years, depending on the quality of the switch.

The system operator should maintain an equipment log book where the operator can write down the meter readings and record when equipment was tested, serviced or replaced.

9.4.4. Remote Monitoring (Telemetry and SCADA)

In larger more complex system the use of remote monitoring and operation of treatment systems can be a very beneficial approach to operate the system. Including telemetry or supervisory control and data acquisition (SCADA) into the control system for a treatment system allows the system operator to have remote access and control. The system can include capacity for automatic call-out to pagers, cell phones and internet (e-mail) capable devices during alarms, and data logging with the ability to export data into commonly used spreadsheet and word processing programs. The use of telemetry or remote monitoring systems can be a very efficient and effective means to monitoring the status of the system and to provide early warning or alarm of a problem in the system and help to avoid major accidents, such as sewage overflows.

9.5. Operator Training and Support

Communities should consider employees working on the village wastewater systems as important as funding for equipment repair and replacement. Local village leaders must realize that an adequate, well-trained staff is necessary both to provide cost effective O&M of their facilities and to ensure compliance with all regulatory requirements. Good training will result in substantial payback over the years in terms of well-run facilities. Far-sighted village leaders will make sure that O&M budgets provide adequate funds for staffs to be trained. This may mean sending operators to off-site training events, and paying the cost of course registration as well as travel expenses (NYSDEC, 2007).

Another training option is to contract on-site training at the community. It is important to keep in mind that not all required training is technical in nature. Training programs relating to management, supervision, and other important skills, such as accounting, report writing and use of computers, are also important in developing a good management team.

CHAPTER 10 - REGULATORY OVERSIGHT

10.1. Introduction

Environmental management typically proceeds from the recognition by a community that it has an environmental problem. The problem may be self-evident to community members or they may be helped to recognize it through the efforts of government officers with a mandate to protect public health and the environment. In any event, compliance and enforcement programs are integral parts of the effort to mitigate the problem once there is governmental acceptance of the need to do so. Sooner or later, government establishes specific environmental goals for the community and selects a management approach or approaches to reach those goals. Typically the management approach includes mandatory requirements and it is incumbent on the government to establish the legal basis for imposing and enforcing these requirements. It is also incumbent on the government to establish compliance and enforcement programs to ensure that the regulated community adheres to its requirements. Once a program of compliance and enforcement begins, there should be a process through which evaluations and adjustments can continually update and improve the process.

The local or regional environmental protection bureau (EPB) and local wastewater management programs (WMPs) play important roles in the promotion, surveillance, and regulation of water and sanitation services. The EPB and WMPs support, advise, and promote programs intended to extend sanitation coverage and improve environmental quality. In general the regulatory aspects of the wastewater management program should:

- Establish and implement the governance and regulatory framework for the program;
- Ensure common understanding of the rules and standards;
- Provide effective monitoring, evaluation and sharing of information;
- Provide institutional support and develop capacity within both the pertinent regulatory agencies and the regulated villages;
- Promote ownership and accountability within the villages; and
- Assist with sound fiscal planning and asset management.

EPB and WMP staffs link the agencies to the communities. There must be enough of them and they must have adequate transportation to cover vast rural areas. It is essential that they be skilled in community outreach techniques. Another important requirement for a successful agency is adequate budget to carry out its mandate. Staff salaries, administration, equipment, transportation, and training must all be funded. Attractive salaries and benefits are necessary for retaining good workers since the private sector often competes for their skills (WHO, 2000).

The EPB and WMP should have procedures in place to assure compliance and, if necessary, to take enforcement actions. Local regulatory agencies need clear

authority to inspect wastewater systems and order remedial actions for systems that fail to meet standards set by laws and rules. Elements of enforcement procedures typically include:

- A process for reporting and responding to problems;
- A defined set of conditions that constitute violations of program requirements;
- Establishment of inspection procedures to investigate problems;
- Use of informal and formal corrective action measures;
- Establishment and implementation of alternative compliance measures; and
- Establishment of an appeal process (hearings, etc.)

Public involvement in the development of an enforcement and compliance program, with input and consent from the regulatory agencies, can minimize disputes and set rules and standards that are appropriate for prevailing conditions. It is important that the villages served by the regulatory program have clear, consistent, and specific expectations for program and system management (USEPA, 2010).

10.2. Principles of Environmental Compliance and Enforcement

The International Network for Environmental Compliance and Enforcement (INECE) has formulated common principles for effective compliance and enforcement programs. These principles fall into in to five categories: (1) environmental results and shared responsibilities; (2) goals and strategies; (3) good governance, rule of law and compliance; (4) structure and resources; and, (5) continuous evaluation and improvement. (INECE, 2009).

10.2.1. Environmental Results and Shared Responsibility

Environmental compliance and enforcement requires strong and consistent institutional and societal commitments to resolve specific public health and environmental challenges through effective implementation of environmental laws. Effective compliance and enforcement systems need to operate within an overall framework of the environmental regulatory apparatus: recognition of specific environmental problems, selection of a management approach, development of a legal basis, implementation of mechanisms to assure compliance, assessment of results, and program evaluation.

Strengthening environmental compliance and enforcement requires the collective efforts of institutions and individuals. *Government officials* must exercise public authority according to the standards of good governance, including providing sufficient resources and independence to compliance and enforcement programs. *Legislators* must create clearly written legislation that is sufficiently stringent to meet its environmental goals. The *judiciary* is responsible for upholding the rule of law and ensuring that laws are interpreted and applied fairly, efficiently, and effectively. The *regulated community* is responsible for complying with the letter and

spirit of the law. *Non-governmental organizations* play a leading role in public education and assisting enforcement agencies. The *media* is responsible for raising awareness by presenting objective information and analysis. The international community – including *donors, international organizations, and networks* – is responsible for strengthening domestic efforts through capacity development and the promoting of conditions enabling more effective compliance and enforcement.

10.2.2. Goals and Strategies

Effective environmental compliance and enforcement programs are guided by a clearly stated vision and realistic and measurable goals that are consistent with the organization's mission. The goals should be congruent with targets that describe the results a program is expected to achieve in a given time period.

Environmental compliance and enforcement programs should utilize a balance of strategies to assure compliance: education and assistance; compliance incentives; monitoring and inspections; and fair and differentiated non-compliance responses. The balance of strategies should consider the social, cultural, economic, and political norms of the society, in addition to the society's broad environmental goals.

Competent authorities should communicate these strategies to the regulated community, civil society, and other government agencies in a comprehensive, comprehensible, and transparent manner. Governments should create conditions for public participation and information exchange that will build capacity for improved environmental compliance.

10.2.3. Good Governance, Rule of Law, and Compliance

Effective environmental compliance and enforcement depend on good governance, which is characterized by institutions that are open, participatory, accountable, predictable, and transparent. Good governance requires consistent, visible, and transparent efforts against corruption through supporting a culture of integrity, including a no-tolerance policy for corrupt practices.

The rule of law forms the basis for effective environmental compliance and enforcement. Broadly speaking, 'rule of law' refers to the presence of legal requirements that are transparent and fairly applied. The rule of law depends upon an independent judiciary that interprets and applies the law in an impartial and transparent manner.

Effective environmental compliance and enforcement programs deter illegal conduct by creating negative consequences for violators of the law. Deterrence is strengthened by timely, predictable, and appropriate enforcement actions that cause potential violators to determine that the risk of detection and punishment outweighs the potential benefits of non-compliance. This is achieved through the implementation of penalties – including non-monetary penalties such as jail time –

that exceed the economic benefit of non-compliance - making non-compliance ultimately costlier than compliance.

10.2.4. Structure and Resources

Transparent and unambiguous policies and procedures that are based on the law should be adopted in order to define the roles of competent authorities, their structural units, and personnel; clarify jurisdictions of local authorities; ensure coordination and sound decision-making, particularly where this process is likely to be flexible or discretionary; and ensure steady information flows.

Competent authorities should have access to the physical, technical, and financial resources that are adequate to their mandate and scope of work. Management should ensure high levels of professionalism through proper remuneration, motivation, and professional development opportunities for program staffs.

10.3. Role of the Environmental Protection Bureau (EPB) and Other Local Agencies

10.3.1. Role of EPB

The EPB is responsible for the approval of the village wastewater management program and provides regulatory oversight of the program and of the village wastewater systems. The EPB establishes operational standards for wastewater treatment facilities; and directs the technical development and regulatory oversight for wastewater treatment plant operator training.

The EPB develops and implements surveillance strategies that direct field inspector activities at wastewater treatment facilities; and directs compliance and enforcement responses to violations identified at wastewater facilities.

The EPB also provides technical support to the village wastewater management program by providing training and technical resources to the VWMC and system operators.

10.3.2. Role of the Municipal and County Wastewater Management Program

The Municipal and County (Local) Wastewater Management Programs (WMPs) are responsible to assist with the coordination and oversight of the village wastewater projects from project inception, planning, construction and operation and maintenance. The WMPs provide financial, administrative and technical oversight to the village wastewater management projects. The WMPs are set up to provide technical assistance and to monitor and evaluate the village projects.

10.4. Standards and Regulations

The EPB is responsible to set local standards and regulations for the village wastewater systems. The standards are important to guide the planning and design

process undertaken by the WMPs and the villages. Standards and regulations for village wastewater systems include:

- Provisions requiring the village to maintain the wastewater system in fully operational and clean condition;
- Requirements to have a trained wastewater operator to supervise the operation of the treatment system (if installed);
- Performance (effluent) standards for any enhanced treatment system;
- Setback requirements from natural and manmade features, including depth to groundwater, water supply wells, surface water courses, buildings; slopes, and other features; and
- Monitoring and reporting requirements.

10. 4.1. Performance-Based Standards

Performance-based codes or standards are regulations requiring that wastewater treatment systems meet specific measureable or demonstrable performance-standards, but do not prescribe the methods or required site conditions. Performance standards specify measureable or demonstrable treatment requirements, usually in the form of effluent pollutant concentrations set at a specified performance boundary, such as at the point of discharge or the treatment plant or 100 meters from the point of discharge. Designers are required to meet the standards by assembling an appropriate treatment technology that may include a combination of treatment and soil-based processes that address the pollutant limits specified. This regulatory approach does not require the regulatory authority to specify the treatment methods and places the burden of compliance on the system designer and ultimately the village.

The advantage of this approach is that it allows for a site-specific approach that matches the risk reduction strategies to the site conditions (soil characteristics, depth to groundwater, pollutant transport and fate, and other factors). This can lead to simpler, lower cost solutions, if the potential risk of exposure or environmental impacts is low. The disadvantage of this approach is that it can require more in-depth study and analysis of site-specific conditions, requiring the designer to tailor the wastewater project to match those conditions. However, the final design will likely lead to a more appropriate and sustainable solution.

10.4.2. Resource Conservation or Reuse Based Standards

The regulatory requirements should encourage the reuse of treated wastewater for acceptable beneficial uses, such as irrigating ornamental landscaping, agricultural reuse for selected food and/or forage crops, reuse for aquaculture production, or other acceptable reuse applications. Encouraging the reuse of wastewater has several advantages: first by creating a resource from a waste (resource recovery) the treated water will have a economic value, which in turn will encourage the village to operate and maintain the wastewater system to provide a high quality effluent. This

approach has been successfully applied in small village wastewater projects in Southern Mexico.

10.5. Wastewater System Approval and Operating Permit

With assistance from the local WMP the villages will submit an application and engineering plans for the village wastewater improvement project. These will require review and approval from the EPB. Once the project is approved an Operating Permit will be issued that includes the site specific conditions of approval, such as any potential operating standards, monitoring and reporting requirements, and other special conditions that may be required for the particular project.

10.6. Enforcement Activities

Compliance with local environmental and public health protection rules should be a priority of any wastewater management program. A crucial function of the EPB is the enforcement activities that are required after the wastewater project has been completed. The EPB undertakes all of the following:

1. Inspections and testing;
2. Monitoring, surveillance and ranking; and
3. Enforcement and compliance actions.

10.6.1. Inspections and Testing

Once a wastewater project has been completed the EPB conducts routine inspections of the system. Inspections are important to identify potential problems and to make sure that the villages are operating and maintaining the facilities correctly. Inspections assist the villages to improve their operations. The inspections encompass not only the physical improvements but also a review of the administrative reports summarizing operation and maintenance logs, water testing results, copies of monthly or quarterly reports, and permitting. Review of the administrative information can indicate to the EPB inspector whether or not the village wastewater program is actually setup correctly and functioning properly.

If the village wastewater project includes a centralized wastewater treatment system, the EPB should collect influent and effluent wastewater samples to evaluate the performance of the wastewater system.

10.6.2. Monitoring, Surveillance and Ranking

Developing and implementing a monitoring, surveillance and risk (MSR) based analytical program is a critical step for the wastewater management program. A MSR program should be low cost, simple to setup and to use. A good example is the eWQMS developed by the Institution of Municipal Engineering of Southern Africa (IMESA). The eWQMS is an open-source software electronic database, information dissemination, and management tool, which guides community leaders to proper

management of water and sanitation projects and access to water quality data. The eWQMS allows local wastewater management programs and environmental protection agencies to track the status of village wastewater systems and to rank the potential threat to public health and the environment. Ultimately this allows the regulatory authorities to prioritize their limited resources and target remedial activities. Pilot testing of the program resulted in an improvement of operation, maintenance and compliance at 9 of 15 communities (60%) within 3 months of implementation (Wensley et al, 2009).

The MSR program should be developed so that it can guide EPB or WMP staffs to collect information that will enable them to rank or characterize the performance of the village wastewater management system. The main categories of information are:

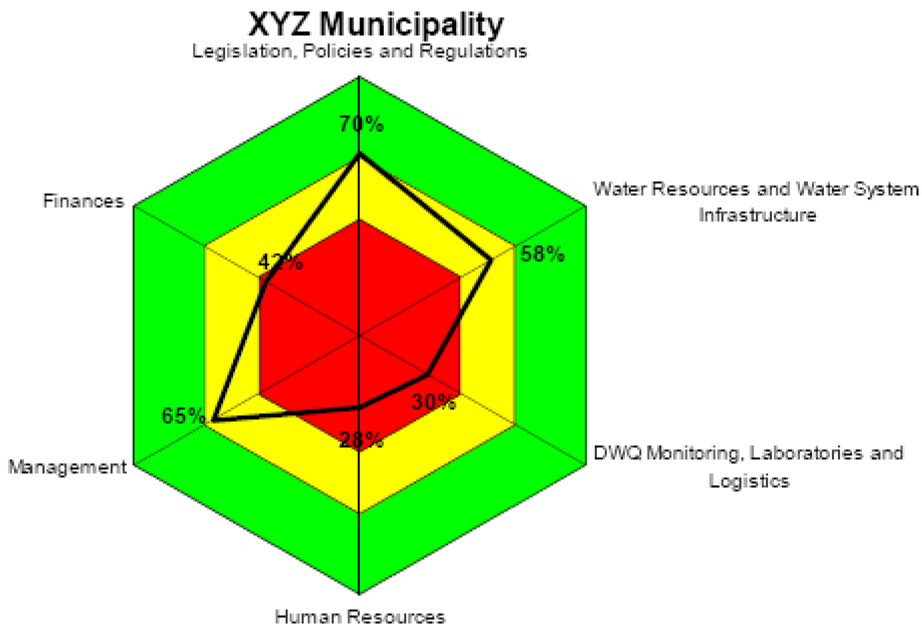
1. The level of understanding villages have of regulations and standards and the degree to which they comply with them;
2. Operation, maintenance and condition of the wastewater facilities;
3. Performance data (influent and effluent water quality and groundwater quality data);
4. Human resources (staffing skills, staff numbers, and capacity);
5. Management (adequacy and function of administrative activities); and
6. Financial (adequacy of accounting and cost recovery systems).

Using risk based methodology information captured in each category can be ranked and scored to summarize the current status of the particular category and highlight where capacity building efforts should be focused. The scoring can be illustrated in a so-called "spider diagram", which can readily communicate to village leaders the current standing and risk profile the village poses for the different categories. Figure 10.1 shows an example "spider plot" developed using the eWQMS program.

10.6.3. Enforcement and Compliance Approaches

Compliance with existing regulations and standards should be a priority of the EPB and the WMP. The local regulatory agency needs to have procedures in place to take enforcement or compliance actions to remedy problems as they are encountered. The elements of the enforcement procedures typically include:

- A defined set of conditions that constitute violations of program requirements
- A process for the regulatory authority to contact and report problems to the village;
- A process for villages to respond to enforcement actions;
- Establishment of inspection procedures to investigate problems; and
- Use of corrective action measures and compliance schedules to negotiate compliance deadlines.



Category Score	Characterisation	Comment
70% – 100%	Acceptable	Usually requires minor interventions to ensure sustainability
45 – 69%	Marginal	Sustainability is in question if interventions are not implemented
<45%	Poor	Effective and sustainable WQM is not possible without external support and intervention

Figure 10.1. Example of a Spider Plot used as part of an MSR program (source: Wensley et al., 2009)

10.7. Technical Support and Training

Village wastewater management is a relatively new field of practice in China and there are many challenges remaining in the development of a well-trained environmental health workforce. Ongoing education, training, and competence building are critical in developing and sustaining a workforce that can effectively implement and regulate a sustainable wastewater management program. As part of the WMP, the Central and Municipal Government and Non-Government Organizations will need to support strategic education and training needs that close gaps in the knowledge and skills of those engaged in assuring compliance with the local and national laws.

Developing the breadth and depth of expertise needed to run an enforcement program is painstaking. There are no easy paths to obtaining the right skill mix. Enforcement is such a highly specialized area that some training must occur on the job, either formally, through training programs, or informally, e.g., by pairing a new employee with a more experienced employee performing the same function.

Integrated training (i.e., training designed to develop basic skills in a variety of expertise areas) is valuable to develop the interdisciplinary skills essential to enforcement, and also to build team spirit and the mutual understanding and knowledge essential for future cooperation. Environmental requirements are changing and complex. Specialized training is often also needed to build depth of expertise in various program areas and to retrain staffs as requirements change or as program strategy is modified.

Fairness and equity are important elements of an effective enforcement program. Training program staffs in professional standards of conduct leads to program credibility.

A major issue for enforcement programs is training inspectors. Many enforcement programs rely on on-the-job training, with junior staffs learning in the field from senior inspectors. For completely new programs, many inspectors learn by experience with each inspection. As experience is gained, inspection guidelines and checklists can be developed.

Training for a new and emerging wastewater management program should include:

1. A review of environmental standards and permitting;
2. A review of alternative wastewater treatment, disposal and reuse systems;
3. A review of sludge management and disposal practices;
4. Conducting compliance inspections of facilities;
5. A review of documentation/recordkeeping and reporting;
6. Sampling, water testing and interpretation of results; and
7. Steps in taking enforcement actions.

CHAPTER 11 – BIBLIOGRAPHY

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APPENDICES

Appendix A

Wastewater Effluent Discharge and Re-Use Standards

Currently, the Central Governmental has not adopted specific requirements for wastewater discharge standards or a water re-use standard for rural areas. Therefore, the national standards set for municipal wastewater treatment facilities are considered to be appropriate when a village treatment system will discharge the wastewater to a surface water body and/or reuse the treated water for a beneficial purpose.

Similarly, the Central Government has not adopted standards for land disposal of individual or community wastewater. As previously mentioned, as part of the Ningbo Municipal Wastewater Management land disposal requirements were developed and approved by the Ningbo EPB. These requirements are presented in the section as an example of land disposal requirements that could be adopted by other municipalities during the development of rural wastewater management programs.

The following sections summarize the national discharge and reuse standards and the local standards established by the Ningbo Environmental Protection Bureau as part of the Ningbo Rural Wastewater Management Program.

A.1. Integrated Wastewater Discharge Standard (GB 8978-1996)

This standard was adopted to regulate effluent discharged from various industries. The standard regulates sixty nine (69) pollutants and sets maximum allowable discharge concentrations for these specific parameters. Given the large number of parameters included in the standard they are not listed here.

A.2. Discharge Standard of Pollutants for Municipal Wastewater Treatment Plants (GB 18918-2002)

The standard has been adopted to regulate treated effluent discharged from municipal WWTP, industrial WWTP, and package treatment system installed in residential or industrial areas. The standards have been developed for four different discharge conditions or levels. Level 1A pertains to effluent discharged to a scenic water body or the reuse of the treated effluent; Level 1B pertains to effluent discharged into Class III Surface Water Functional Area (except for source water protection zones and swimming zones) as stipulated in GB 3838, Class II Marine Functional Areas as stipulated in GB 3097, or closed or semi-closed water body like lakes or reservoirs; Level 2 applies to effluent discharged into Class IV or V Surface Water Functional Area as stipulated in GB 3838, or Class III or IV Marine Functional Area as stipulated in GB 3097; and Level 3 standards apply to effluent discharged into a normal pollution control zone or non-source water protection zone. A summary of the parameters regulated are listed in Table A.1 below.

Table A.1. Effluent Discharge Standards for Level 1A, 1B, 2 and 3 Receiving Waters

No.	Primary Controlling Pollutants		Level 1		Level 2	Level 3
			Level 1 A	Level 1 B		
1	Chemical Oxygen Demand (COD) (mg/l)		50	60	100	120 [1]
2	Biochemical Oxygen Demand (BOD_5) (mg/l)		10	20	30	60 [1]
3	Suspended Solids (SS) (mg/l)		10	20	30	50
4	Oil and Grease (mg/l)		1	3	5	20
5	Total Petroleum Hydrocarbons (mg/l)		1	3	5	15
6	Anionic Surfactant (mg/l)		0.5	1	2	5
7	Total Nitrogen (as N) (mg.l)		15	20	N/A	N/A
8	Ammonia Nitrogen (as N) (mg/l)		5 (8)	8 (15)	25 (30)	N/A
9	Total Phosphorus (as P) (mg/l)	Built before Dec.31, 2005	1	1.5	3	5
		Built since Jan.1, 2006	0.5	1	3	5
10	Color (times of dilution)		30	30	40	50
11	pH		6 – 9			
12	Fecal Coliform (capita/100 ml)		10^3	10^4	10^4	N/A

A.3. Standards for Irrigation Water Quality (GB 5084-2005)

The central government has adopted standards for water used for irrigation purposes. The standards regulate the source water, including surface water, groundwater, and treated effluent from municipal and industrial wastewater treatment plants. The numerical limits specified in this standard are summarized in Table A.2.

Table A.2. Irrigation Water Quality Standards

No.	Item	Aquatic Crops	Dry Crops	Vegetables
1	BOD_5 (mg/L) ≤	60	100	40[a], 50[b]
2	COD (mg/L) ≤	150	200	100[a], 60[b]
3	SS (mg/L) ≤	80	100	60[a], 15[b]
4	Anionic Surfactant (mg/L) ≤	5	8	5
5	Water Temperature (℃) ≤	35		
6	pH	5.5-8.5		
7	Total Salt (mg/L) ≤	1000[c](non-saline soil), 2000[c] (saline soil)		
8	Chloride (mg/L) ≤	350		
9	Sulfide (mg/L) ≤	1		
10	Total Mercury (mg/L) ≤	0.001		
11	Cadmium (mg/L) ≤	0.01		
12	Total Arsenic (mg/L) ≤	0.05	0.1	0.05
13	Hexavalent Chromium (mg/L) ≤	0.1		
14	Lead (mg/L) ≤	0.2		
15	Fecal Coliform (capita/100mL) ≤	4,000	4,000	2,000[a], 1,000[b]
16	Ascaris Eggs (capita/L) ≤	2		2[a], 1[b]

Note: a. Applies to pared or cooked vegetables,
b. Applies to fresh vegetables, cucurbit or herbaceous fruit,
c. Refers to areas with basic irrigation system, or source water for flushing out salt contained in soils.

A.4. Jiangsu Agricultural Products (Food) Water Quality Standards - (DB32/T343.1-1999)

The government of Jiangsu Province has adopted a provincial standard (DB32/T343.1-1999) that specifies the water quality requirements for the reuse of treated effluent for food producing agricultural crops in the province. Table A.3 summarizes the standards adopted by Jiangsu:

Table A.3. Effluent Quality Reuse Standards for Agricultural Products.

No.	**Item**	**Parameter**		
		Aquatic Crops (mg/L)	**Dry Crops (mg/L)**	**Vegetables (mg/L)**
1	Chloride ≤		250	
2	Cyanide ≤		0.5	
3	Fluoride ≤		3.0	
4	Copper ≤		1.0	
5	Zinc ≤		2.0	
6	Mercury ≤		0.001	
7	Lead ≤		0.1	
8	Cadmium ≤		0.005	
9	Cr(VI) ≤		0.1	
10	BOD_5 ≤	80	150	80
11	COD ≤	200	300	150
12	Kjeldahl nitrogen ≤	12	30	
13	Total phosphorus ≤	5.0	1.0	
14	Total arsenic ≤	0.05	0.1	0.05
15	pH		5.5～8.5	

A.5. Water Recycling Standards for Scenic Environment - Water Feature (manmade lakes and rivers) Uses(GB/T18921-2002)

Water recycling standards have been adopted that regulate the re-use of treated effluent discharged into scenic and artificial waterways (rivers or lakes). The recycled water quality standards are summarized in Table A.4 presented below.

Table A.4 Water Recycling Standards for Reuse of Water for Scenic-Manmade Lakes and Rivers

No.	**Item**	**Scenic Water Body**			**Recreational Water Body**		
		Watercourse	Lake	Waterscape	Watercourse	Lake	Waterscape
1	pH	6-9					
2	BOD_5 (mg/L) ≤	10	6		6		
3	SS (mg/L) ≤	20	10		—[a]		
4	Turbidity (NTU) ≤	[a]			5.0		
5	DO (mg/L) ≥	1.5			2.0		
6	Total Phosphorus (as P) (mg/L) ≤	1.0	0.5		1.0	0.5	
7	Total Nitrogen (mg/L) ≤	15					
8	Ammonia Nitrogen (as N) (mg/L) ≤	5					
9	Fecal Coliform (capita/L) ≤	10,000	2,000		500		Not detectable
10	Residual Chloride[b] (mg/L) ≥	0.05					
11	Color (times of dilution) ≤	30					
12	Petroleum (mg/L) ≤	1.0					
13	Anionic Surfactant (mg/L)≤	0.5					

Note: a "—" means no requirement
b means contact time is no less than 30 minutes.

A.6. Water Recycling Standards for Miscellaneous Urban Uses (GB/T 18920-2002)

Water recycling water quality standards have been adopted for various miscellaneous uses including, toilet flushing, road cleaning, fire fighting, ornamental landscaping, vehicle washing, and construction and dust control. A summary of the water quality standards adopted in the regulation are summarized in Table A.5.

Table A.5. Water Recycling Standards for Miscellaneous Urban Uses

No.	Item	Unit		Toilet flushing	Road cleaning and fire fighting	Landscaping	Automobile Washing	Construction
1	pH			6.0~9.0				
2	Color	dilutions	≤	30				
3	Odor			No uncomfortable feeling				
4	Turbidity	NTU	≤	5	10	10	5	20
5	TDS	mg/L	≤	1,500	1,500	1,000	1,000	—
6	BOD_5	mg/L	≤	10	15	20	10	15
7	Ammonia-N	mg/L	≤	10	10	20	10	20
8	Anionic surfactant	mg/L	≤	1.0	1.0	1.0	0.5	1.0
9	Iron	mg/L	≤	0.3	—	—	0.3	—
10	Manganese	mg/L	≤	0.1	—	—	0.1	—
11	DO	mg/L	≥	1.0				
12	Residual chlorine	mg/L		30 minutes after contact≥1.0, end of pipe≥0.2				
13	Total coliform	MPN/100 ml	≤	3 (this looks like a mistake)				

A.7. Ningbo Municipal Land Disposal Requirements

As part of the Ningbo Rural Wastewater Management Program local standards were adopted by the Ningbo Environmental Protection Bureau (EPB) that set standards for decentralized and centralized village wastewater treatment systems. The standards are set for both land disposal and surface water disposal discharges and are summarized below.

A.7.1. Land Disposal Discharge Standards

Decentralized Wastewater System. A system installed to serve an individual home, such as a latrine, a pour-flush latrine, a double-urn or pit style system, and a septic system shall meet the following requirements:

a. The minimum distance between the bottom of the land disposal system and groundwater shall be at least one (1) meter.
b. The minimum distance between the septic tank and land disposal system to a well or surface water shall be at least fifty (50) meters.

Centralized Wastewater System. A central wastewater treatment system installed at a village that discharges to a land disposal system must meet the following effluent limitations:

- COD ≤ 100 mg/L;

- BOD $\leq$ 30 mg/L;
- TSS $\leq$ 30 mg/L; and
- Total Nitrogen $\leq$ 25 mg/L

The land disposal system must also meet the minimum groundwater, surface water and well separation criteria required for decentralized systems described above.

A.1.7.2. Surface Water Discharges

Any surface water discharge proposed by a village is required to comply with the effluent limitations and standards set forth in the National Pollution Control Standards GB8978-1996.

Appendix B

Base Tariff Calculation Model

This section outlines the elements and steps for establishing a basic flat-rate tariff. There are three fundamental elements of a tariff, including (a) the operation, maintenance and administration costs (functioning costs (FC)); the replacement and extension costs (usually considered to a percentage of the functional costs); and funds for the recovery of investment costs (RIC).

To begin, the minimum tariff is simply the functioning costs divided by the number of households:

$$\text{Minimum tariff} = \frac{\text{Functioning costs per month}}{\text{Number of households}}$$

When such a tariff is chosen, it is important to consider with the community how to cover the other costs, such as the replacement and extension of service costs. At a minimum these should represent at least 25% of the FC. Therefore, a more realistic (real) cost tariff would be calculated as follows:

$$\text{Real cost tariff} = \frac{\text{(Functioning costs + repl. \& ext. costs)}}{\text{Number of households}} = \frac{\text{(1.25 x FC)/month}}{\text{Number of households}}$$

The tariff may need further adjustment to generate funds for the recovery of investment costs (RIC), if the community is expected to repay on a loan. This adjusted tariff is commonly referred to as a total tariff, as follows:

$$\text{Total cost tariff} = \frac{\text{(1.25 x FC) + RIC/month}}{\text{Number of households}}$$

Finally, a comprehensive tariff should account for depreciation costs related to risks and inflation. The final tariff is referred to as the efficient tariff, as follows:

$$\text{Efficient cost tariff} = \frac{\text{(1.25xFC) + RIC + Depreciation/month}}{\text{Number of households}}$$

Table A.1 presents a simple example of a tariff setting for a small centralized village wastewater system.

Table A.1. Example Tariff Setting for Communty Wastewater System

(Serving 500 households)

Example of Tariff Setting
Community Size = 500 households
Centralized Wastewater System (Small gravity sewer, two-stage trickling filter, and final subsurface land disposal)

Equipment	**Life Cycle (LC)**	**Yearly O&M Costs, as % of the initial investment costs**	**Initial investment (IV)costs in RMB**
Gravity sanitary Sewer System	30	1%	700,000
Two-stage Trickling Filter System			
Primary clarifier (90,000 liters)	25	3%	125,000
Stage 1 - Pumping system	10	5%	75,000
Stage 1 - Trickling filter	25	1%	150,000
Secondary Clarifier (90,000 liters)	25	2%	125,000
Stage 2 - Pumping System	10	5%	75,000
Stage 2 - Trickling Filter	25	1%	150,000
Final Effluent Tank (30,000 liters)	25	1%	50,000
Effluent Pumping System	10	3%	75,000
Subsurface Disposal System			
Distribution Box	25	1%	15,000
Subsurface disposal trenches	25	1%	350,000
		Total	**1,890,000**

TARIFF SETTING

Cost Item	**Formula**	**Calculation**	**Result in RMB (rounded)**
Monthly Amortization Costs (RMB/m)	∑(IV/LC)12	[700,000/30+125,000/25+75,000/10+150,000/25+125,000/25+75,000/10+150,000/25+50,000/25+75,000/10+15,000/25+350,00/25]/12	5,986
Monthly Energy costs (RMB/m)	[HPx0.746] x hours/day x 30 days x price per KW	[3 pumps x 2HP x 0.746] x 24 hrs/d x 30 d x 0.50 RMB/KW	1,611
Monthly Personnel Costs (RMB/m)	Salary/day x #days worked/month	[50 RMB/day x 22 d/mon + 50 RMB x 10 d/mon]	1,600
Monthly Maintenance Costs (RMB/m)	∑(IV*maintenance %1)/12	[700,000x1%+125,000x3%+75,000x5%+150,000x1%+125,000x2%+75,000x5%+150,000x1%+50,000x1%+75,000x3%+15,000x1%+350,00x1%]/12	2,250
Total Monthly O&M Costs (RMB/m)	∑All monthly costs above	71,833+1,611+1,600+2,250	11,447
Contingency fund	10% of month O&M costs	11,447 x 10%	1,145
Total Costs per month	∑O&M Costs + Contingency costs	11,447+1,145	12,592
Tariff/household/month	**Total costs/month/# households**	**12,592/500**	**25 RMB/Month**

Facts:
Pumps: Three pump systems with 2 HP each, Each operating ing 8 hours per day (24 hours total)
Energy costs: 0.5 RMB/KW
1 HP = 0.746 KW
Daily salary of operator: 50 (working 4 hrs per day 22 days per month0
Daily salary of Project Administrator: 50 RMB/Day (working 4 hours/day 10 days/month)

Appendix C

Public Health Models

C1. OVERVIEW

Various international public health organizations (World Health Organization) and development agencies have develop public health models to assist local governments implement public and environmental health programs to improve sanitation and hygiene in small and rural communities. These programs are good tools that go well beyond “education” and after they are implemented communities should consider adopting action plans for improving sanitation and hygiene, including, for example, latrine construction and campaigns for hand washing. This is an evolving part of any sanitation promotion, and the user of the guide should keep in mind that these models are only examples and health promoters are encouraged to research and adopt models that fit their situations.

The following sections describe three different public health models, including the following:

- The Participatory Hygiene and Sanitation Transformation (PHAST) approach developed in 1998 by the World Health Organization and World Bank
- FOAM (Focus on Opportunity, Ability and Motivation) and SaniFOAM (Sanitation FOAM) are conceptual frameworks to help program managers and implementers understand and analyze handwashing and sanitation behaviors in rural communities.
- Community led total sanitation (CLTS) is an innovative methodology for mobilizing communities to completely eliminate open defecation (OD). Communities are facilitated to conduct their own appraisal and analysis of open defecation (OD) and take their own action to become ODF (open defecation free).

C1.1. PHAST – A Public Health Education Model

In 1998, the World Health Organization, in collaboration with the World Bank, introduced the Participatory Hygiene and Sanitation Transformation (PHAST) approach to working with communities. PHAST is an innovative participatory-approach public health education curriculum designed to promote hygiene behaviors, sanitation improvements, and community management of water and sanitation facilities using specific participatory techniques.

PHAST seeks to help communities improve hygiene behaviors, prevent diarrhoeal diseases, and encourage community management of water and sanitation facilities. It does this by demonstrating the relationship between sanitation and health issues, increasing the self-esteem of community members, and empowering the community to plan environmental

improvements and to own, operate, and maintain water and sanitation facilities. The PHAST approach has been shown to help people feel more confident about themselves and their ability to take action and make improvement in their communities. Feelings of empowerment and personal growth are important and usually needed before physical changes such as cleaning up the environment can occur and be sustained by the community as a whole.

PHAST is a participatory public health education model that encourages participation of individuals in a group process, no matter what their age, sex, social class or education background. PHAST has been especially useful for encouraging the participation of women, who in some regions are less likely to be literate and are reluctant to express their views by participating in community decision making processes.

Seven steps to community planning for the prevention of diarrhoeal disease

STEP	ACTIVITY	TOOL
1 Problem identification	1. Community stories 2. Health problems in our community	1. Unserialized posters 2. Nurse Tanaka
2 Problem analysis	1. Mapping water and sanitation in our community 2. Good and bad hygiene behaviours 3. Investigating community practices 4. How diseases spread	1. Community mapping 2. Three-pile sorting 3. Pocket chart 4. Transmission routes
3 Planning for solutions	1. Blocking the spread of disease 2. Selecting the barriers 3. Tasks of men and women in the community	1. Blocking the routes 2. Barriers chart 3. Gender role analysis
4 Selecting options	1. Choosing sanitation improvements 2. Choosing improved hygiene behaviours 3. Taking time for questions	1. Sanitation options 2. Three-pile sorting 3. Question box
5 Planning for new facilities and behaviour change	1. Planning for change 2. Planning who does what 3. Identifying what might go wrong	1. Planning posters 2. Planning posters 3. Problem box
6 Planning for monitoring and evaluation	1. Preparing to check our progress	1. Monitoring (checking) chart
7 Participatory evaluation	1. Checking our progress	1. Various tool options

PHAST – Seven Steps to Community Planning to Improve Sanitation

C1.2. FOAM and SaniFOAM frameworks

FOAM (Focus on Opportunity, Ability and Motivation) and SaniFOAM (Sanitation FOAM) are conceptual frameworks to help programme managers and implementers understand and analyse handwashing and sanitation behaviours.

The FOAM and SaniFOAM frameworks were developed by the Water and Sanitation Program (WSP) and its partners with funding from the Bill and Melinda Gates Foundation. FOAM was developed during a workshop in Hanoi in March 2007 by participants from the Global Scaling Up Handwashing Project and SaniFOAM at a workshop in Durban, South Africa in 2008 attended by participants from six organisations including UNICEF, LSHTM, USAID and AED/HIP.

The purpose of the frameworks is to help practitioners in accomplishing the following:

- Analyzing the results of available formative studies;
- Informing the design of new research;
- Prioritizing the behaviors to be changed and the populations to be targeted;
- Understanding and considering the range of factors that influence a particular behavior;
- Focusing and prioritizing interventions on particular factors for behavior change;
- Improving the effectiveness of interventions aimed at changing the behavior; and
- Identifying the appropriate indicators to monitor.

Both FOAM and SaniFOAM identify the factors that influence the behaviors and classify these under the categories of Opportunity, Ability and Motivation. Examples of determinants under each of these categories are as follows:

- Opportunity: convenient access to soap and water or a toilet;
- Ability: affordability of soap or toilet options; and
- Motivation: beliefs about soap or faeces.

The F in FOAM and SaniFOAM stands for Focus, which serves to identify what target population and behavior is being analyzed. Thus the frameworks can be used to analyze multiple behaviors, including handwashing at various critical times (e.g. after using a toilet,

C1.3. Community Led Total Sanitation (CLTS)

Community led total sanitation (CLTS) is an innovative methodology for mobilizing communities to completely eliminate open defecation (OD). Communities are facilitated to conduct their own appraisal and analysis of open defecation (OD) and take their own action to become ODF (open defecation free).

At the heart of CLTS lies the recognition that merely providing toilets does not guarantee their use, nor result in improved sanitation and hygiene. Earlier approaches to sanitation prescribed high initial standards and offered subsidies as an incentive. But this often led to uneven adoption, problems with long-term sustainability and only partial use. It also created a culture of dependence on subsidies. Open defecation and the cycle of fecal–oral contamination continued to spread disease.

In contrast, CLTS focuses on the behavioral change needed to ensure real and sustainable improvements – investing in community mobilization instead of hardware, and shifting the focus from toilet construction for individual households to the creation of “open defecation-free” villages. By raising awareness that as long as even a minority continues to defecate in the open everyone is at risk of disease, CLTS triggers the community’s desire for change, propels them into action and encourages innovation, mutual support and appropriate local solutions, thus leading to greater ownership and sustainability.

CLTS was pioneered by Kamal Kar (a development consultant from India) together with VERC (Village Education Resource Centre), a partner of WaterAid Bangladesh, in 2000 in Mosmoil, a village in the Rajshahi district of Bangladesh, whilst evaluating a traditionally subsidized sanitation program. Kar, who had years of experience in participatory approaches in a range of development projects, succeeded in persuading the local NGO to stop top-down toilet construction through subsidy. He advocated change in institutional attitude and the need to draw on intense local mobilization and facilitation to enable villagers to analyze their sanitation and waste situation and bring about collective decision-making to stop open defecation.

CLTS spread fast within Bangladesh where informal institutions and NGOs are key. Both Bangladeshi and international NGOs adopted the approach. The Water and Sanitation Programme (WSP) of the World Bank played an important role in enabling spread to neighbouring India and then subsequently to Indonesia and parts of Africa. Plan International, WaterAid and UNICEF have become important disseminators and champions of CLTS. Today CLTS is in more than 20 countries in Asia , Africa, Latin America and the Middle East.

CLTS has a great potential for contributing towards meeting the Millennium Development Goals, both directly on water and sanitation (goal 7) and indirectly through the knock-on impacts of improved sanitation on combating major diseases, particularly diarrhoea (goal 6), improving maternal health (goal 5) and reducing child mortality (goal 4).

In addition to creating a culture of good sanitation, CLTS can also be an effective point for other livelihoods activities. It mobilizes community members towards collective action and empowers them to take further action in the future. CLTS outcomes illustrate what communities can achieve by undertaking further initiatives for their own development.

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- Ten Steps to Total Sanitation (WaterAid)

Appendix D

Case Studies in Rural Wastewater Management

D1. INTRODUCTION

This annex has been prepared to present examples of existing rural wastewater management programs and wastewater treatment technologies that are being implemented in different regions of the world.

D2. WASTEWATER MANAGEMENT PROGRAMS

Case Study 1 – Nantai Island Clean River Program, Fuzhou City, Fujian Province, China – Example of a Community Driven Development Project

In 2005, Asian Development Bank and the Fuzhou Municipal Government launched the Fuzhou Environmental Improvement Project to rehabilitate the city's water supply, sanitation, and wastewater management systems, including Nantai Island's inland rivers. To support the project, the municipal government implemented a sanitation awareness campaign and river cleanup program involving Nantai Island's communities.

Rivers of Trash. Located at the Min River Delta in the southeastern coastal area of the People's Republic of China, Fuzhou City is the provincial capital, as well as the political, economic, and cultural center of Fujian Province. The Fuzhou Environmental Improvement Project aimed to improve the living conditions and public health of about 1.4 million people in Fuzhou City through the construction of sewer networks in Yanglai and Lianban districts, the rehabilitation of Nantai Island's inland rivers, and empowerment of communities to oversee project-related activities. About 12 interconnected inland rivers, with a combined length of about 48 kilometers, were rehabilitated. This involved dredging and excavating 2.2 million tons of earthworks and constructing stone-lined rectangular channels. Eight existing floodgates were also repaired. Nantai Island, located at the heart of Fuzhou City, has a population of 480,000 packed in only 142 square kilometers of land, and with no centralized wastewater treatment facilities.

Its inland river system, consisting of more than 40 inland rivers, became the dumping site of all domestic and industrial wastewaters, and households' solid waste. People simply just dumped their trash in the rivers, unmindful of their practice's harmful effects. The rivers that ran

through Nantai's urban communities naturally carried urban waste along before emptying into the Min River that surrounds the island—until the rivers got clogged, became putrid, and turned black. The deterioration of the inland rivers' water quality and the potential threat to public health prompted the Fuzhou Municipal Government to seek assistance. The PDA Facility provided the much-needed support to raise Nantai Island communities' awareness on how better sanitation and hygienic practices can help them and their rivers reach the pink of health.

Changing Community Mind-sets

Using a Community-Driven Development (CDD) approach developed by the Fuzhou Project Management Office, the "Clean River Program for the Urban Poor in Nantai Island" set out to increase public awareness among urban households on the benefits of improved household-level hygiene and sanitation practices and facilitate active participation of all stakeholders in managing and maintaining a clean river program. CDD involves the implementation of complementary community development activities that lead to improvements in people's knowledge, attitudes, and behaviors. It requires the creation of Village Committees that would encourage local communities to implement change action. The CDD approach implemented in Nantai Island included:

- Training workshops for community leaders to become hygiene promoters. About 75 community leaders that led the Village Committees of 29 villages participated in the training programs with the express aim of leading the various awareness-raising and river cleanup activities; and

- Community awareness campaigns through various media, bazaars, household visitations, audiovisual materials, and surveys. The campaign covered 42 villages located along 13 selected inland rivers and also targeted primary and secondary schools. Through the CDD approach, villagers' attitudes and behavior toward sanitation began to change. They realized that better sanitation and hygienic practices can help them and their rivers become healthier. They have stopped randomly throwing garbage and discharging wastewater into the rivers. Some people even openly criticize those who still carelessly dump trash in the rivers.

With mind-sets changed, Nantai's urban communities launched into a flurry of clean-up activities. They have established a specialized cleaning group responsible for each village's cleanliness. Community-based rubbish disposal points have been set up, catering to more than 21,000 households in 30 villages. Solid wastes are now transported regularly to landfills.

Nantai's communities also established a hygiene monitoring group, conducted village sweeping events, and trained more villagers. While the local government provided half the necessary funds for these activities, each village raised the other half of the finances required. Overall, communities have now cultivated better hygiene practices. By partnering with the local government, communities now have concrete roles in maintaining the water quality of Nantai Island's inland rivers.

The project demonstrated that changing community mind-sets is possible with the right approach and the willingness of communities. In Nantai Island, the change in people's mindsets was remarkable. The infrastructural changes and communities' new outlook toward their environment can prove to be just the right combination that will save Nantai Island's rivers.

Case Study 2 – Catskill Watershed Corporation's Hudson River Water Quality Protection Program, New York, USA

The Catskill Watershed Corporation (CWC) is a local development corporation established to protect the water resources of the New York City (NYC) Watershed west of the Hudson River. The purpose of the CWC is to preserve and strengthen communities located in the region, and to increase awareness and understanding of the importance of the NYC water system.

Background

Ninety percent of the 1.3 billion gallons of water consumed daily by 9 million residents of New York City and suburban communities comes from six reservoirs in the five-county Catskill Mountain/Delaware River Region of New York State. The Hudson River watershed is also home to 72,000 full- and part-time residents who live in small towns among forested mountains and river valleys.

The CWC was formed Jan. 17, 1997 with the signing of the landmark New York City Watershed Memorandum of Agreement between city, state, federal and environmental entities, and local municipalities. To help offset the costs and restrictions of increased regulations and land purchases by the City, the CWC was charged with developing and implementing several City-funded programs, including a Community Wastewater Management Program (CWMP).

The CWMP is intended to fund the planning, design and construction of community septic systems and/or the creation of septic maintenance districts to provide ongoing inspections and permitting of onsite wastewater systems used in several West-of-Hudson communities.

Each of the projects involves defining, designing and constructing the type of wastewater handling and management system to be employed; establishing septic district boundaries, creating and mapping the district, engaging in environmental review, adopting appropriate use ordinances, determining funding, acquiring property, obtaining easements and rights of way and advertising for bids and finally building the project.

The CWMP will fund the planning, design and construction of community septic systems, including related sewerage collection systems, and/or the creation of septic maintenance districts, including septic system replacement, rehabilitation and upgrades as well as operation and maintenance of the district. If community septic systems or septic maintenance districts are not practicable due to site conditions, and there is a demonstrable water quality problem due to failing septic systems, New York State's Department of Environmental Protection, in consultation with CWC and the Participating Community may elect to allocate program funds for the project to construct a new wastewater treatment plant, including related sewerage collection systems.

Outline of the Community Wastewater Management Program

The CWMP is divided into four phases: (1) the study phase, (2) pre-construction phase; (3) construction phase; and (4) operation and maintenance phase.

1. STUDY PHASE

During this phase, the CWC examines the technical feasibility, cost, planning and implementation issues for each selected community wastewater project. The study phase will include the following.

a. A determination of the preferred project option for each community.
b. The overall project funding requirements
c. The study shall delineate a service area for a proposed project
d. Identify possible sites for the construction of the community septic system(s);
e. Determine its feasibility by investigating available land and performing soil tests, percolation rate tests, and a groundwater mounding analysis;
f. Estimate the design and construction costs for each community wastewater project identified, including costs for the acquisition of necessary property, as well as legal and administrative fees;

g. A draft annual operation and maintenance plan so that the community septic system(s), and the related sewerage collection system, continues to function properly for its projected useful life;
h. Project an annual budget for the costs of such operation and maintenance with a proposal for assessing charges to property owners (residential, business and municipal) within the proposed service area. Develop a sewer use fee schedule to provide adequate funding to implement such operation and maintenance plan;
i. A project schedule with milestones for the design and construction;
j. plan for connecting existing houses and other structures within the service area to the new community wastewater;
k. Identify any and all necessary permits and regulatory requirements that will need to be obtained or satisfied as a condition prior to the design, construction, installation, operation and maintenance.

2. PRE-CONSTRUCTION PHASE

Once the CWC approves a planned Project and funding is secured the project enters the Pre-Construction Phase. The Pre-Construction Phase shall consist of the following items completed by CWC:

a. Design a final engineering plan consisting of complete plans and specifications for the planned project, including, without limitation, complete final design, final cost estimate, bid documents for construction of the project, all required regulatory approvals for the project under all applicable regulations (except those customarily obtained by the construction contractor during the course of construction);
b. The legal formation of a wastewater maintenance district for the purpose of collecting rates and charges to operate and maintain the project;
c. Acquisition of options, on behalf of the Participating Community, for all property interests, including easement interests, necessary for the completion, operation and maintenance of the project;
d. Management of the bid process on behalf of the Participating Community for the construction of the project;
e. Revision of the Final Engineering Plan, subject to CWC and DEP approval, if the bid(s) received for the Construction Phase exceed available funds under the Block Grant Amount for the Participating Community;
f. Revision, if necessary, of the final annual operation and maintenance plans and budgets developed during the Study Phase, as well as revision, if necessary, of the schedule; and
g. A written commitment by the Participating Community to complete the Construction Phase

3. CONSTRUCTION PHASE

During the Construction Phase, CWC facilitates, in cooperation with the Participating Community, performance of the following work:

a. Assisting the Participating Community in awarding contracts based upon bids received for construction of the project, in conformance with the Final Engineering Plan;
b. Coordination of any pre-construction work, such as pumping out of existing or failing septic tanks;
c. Coordination of all project construction work as detailed in the Final Engineering Plans; and
d. Assisting in processing invoices for the disbursement of Program Funds.

4. OPERATION AND MAINTENANCE PHASE

The Operation and Maintenance Phase commences following project and includes the following:

a. The Participating Community shall own, or have sufficient interest(s) in real property, to implement the on-going operation and maintenance including the related sewer collection system, for the useful life of the system(s) in accordance with an approved Maintenance Plan;
b. The Participating Community shall be responsible for ensuring the operation and maintenance of any community wastewater system including the related sewerage collection system, wastewater treatment system, and disposal systems are maintained in good working order and in accordance with the Maintenance Plan and shall keep such system(s) in good working order for the useful life of the system(s);
c. The Participating Community shall establish and implement an equitable system of sewer rates and charges so that each property in the district pays its fair share of annual operation and maintenance costs, based on usage. This rate is periodically be reviewed, adjusted, and collected from users of the community wastewater system(s). The sewer rates and charges are set to provide sufficient funding to comply with the operation and maintenance obligations;
d. During the Operation and Maintenance Phase the Participating Community shall carry out the following:

    i. Regular and ongoing servicing the system(s) within the service area;

    ii. Pump-outs of the septic systems within the district and the rehabilitation, replacement

    iii. Maintain the wastewater maintenance district in good working order for a period of at least thirty (30) years.

    iv. Schedule periodic reviews, to adjust (if necessary) and collect sewer rates and charges so as to maintain a sufficient balance in the Maintenance Fund to comply with the foregoing obligations.

Additional information about the CWC's Community Wastewater Management Program can be found at the following website:

http://www.cwconline.org/programs/wastewater/wastewater.html

Case Study 3 - Town of Paradise, California, USA, Onsite Wastewater Management Zone

Paradise is a community of roughly 27,000 people located in the northern California foothills of the Sierra Nevada Mountains. The incorporated town covers 18 square miles of southward sloping terrace topography bounded on the east and west by rugged canyons.
For this reason, the local residents refer to Paradise as "the Ridge." The population is dispersed and the residential properties are served by onsite septic systems.

Most of Paradise lies on soils that are suitable for wastewater soil absorption systems. The northern end of town lies at roughly 2,700 feet and receives more than 100 inches of rain per year. The north and central areas are characterized by ponderosa pine forests on deep, well-drained clay loam soils. Some areas have shallow, rocky, or poorly drained soils. The southern edge of town lies at 1,000 feet and receives about 30 inches of rain per year. This area is more sparsely populated; it has relatively shallow soils, rock outcrops, and volcanic debris as a result of ancient eruptions of nearby Mount Lassen.

Aerial Photo of the Town of Paradise

Development through the 1970s was easily accommodated by conventional septic systems for both residential and commercial needs. But problems with relying on septic systems became apparent during this period as well. Many system failures were noted, and water sampling conducted in the late 1970s through 1982 found high bacteria levels in surface waters and some private drinking wells around the commercial district.

In response to these findings, the town council in 1983 enacted Ordinance 103 to establish its own wastewater regulations for septic systems. Up to this point, Paradise was subject to the County of Regional Department of Environmental Health septic regulations. The county's authority remained in place after 1983, but now it enforced the city's stronger rules within Paradise. Town officials felt more stringent requirements might help alleviate the need for sewers and also help control growth. Among its many provisions, the ordinance established permit fees, dual-compartment septic tank construction specifications, and defined the usable area necessary for leach fields as a function of slope, depth to groundwater, and percolation. The regulations required that each soil absorption system greater than 400 gallons-per-day (GPD) capacity have a 100 percent reserve leach field located upon the subject property, and

established a maximum wastewater loading rate of 900 GPD per acre. This requirement was placed upon new construction and existing development.

In 1992 the Town implemented an Onsite Wastewater Management Zone to implement its own management and enforcement program, thus assuming responsibility and accountability for the effective operation and maintenance of onsite systems within its jurisdiction.

When the town council established establishing the Zone it also adopted new onsite system regulations. Notably, the new regulations allowed the use of communal leach fields and cluster systems. Through the zone, Paradise established a program for initial and periodic operational evaluation of all onsite systems by private evaluators. The town required operating permits for all new and existing systems; adopted design criteria, including special regulations for large systems and innovative systems; set up variance and enforcement procedures; and established a monitoring program.

The formation of the Zone became the means for Paradise to manage wastewater town-wide. Since inception, Paradise has occasionally revised the policies and operation of the zone. Most notably, the town:

Aerobic Treatment Unit for a Multi-Residential

a. Developed a certification and training programs for private evaluators and operators.
b. Revised regulations and specifications for residential and community or large systems
c. Established an annual operating permit fee of $14.40 per residential customer (more for commercial customers), maintained since formation of the zone. Over time the town revised the fee structure for other permits and activities so that the zone budget went from being subsidized by the town to being self-supporting. Additional fees range from $15.40 for a minor building clearance to $970.00 for an onsite rule variance application. In the 2002 fiscal year (ending June 30, 2002), zone expenses totaled $284,968. Revenues, derived from $199,880 in annual permit fees and $164,472 in other permit fees, totaled $364,352
d. The zone has three full-time and one part-time staff members that are responsible for the following activities:

    i. Review, prepare, and implement procedures for numerous types of permits, reviews, and notices;
    ii. Evaluate and approve or disapprove applications for wastewater systems;
    iii. Perform inspections of onsite systems as required to enforce town and state sanitation laws;
    iv. Perform annual inspections of certain advanced systems;

v. Attend meetings with applicants and the general public;
vi. Respond to, and answer complaints from the public regarding onsite systems;
vii. Perform sampling and analysis of ground and surface water stations twice a year;
viii. Prepare Review quarterly and semi-annual monitoring reports required of certain systems; and
ix. Operate and maintain any town-owned wastewater systems.

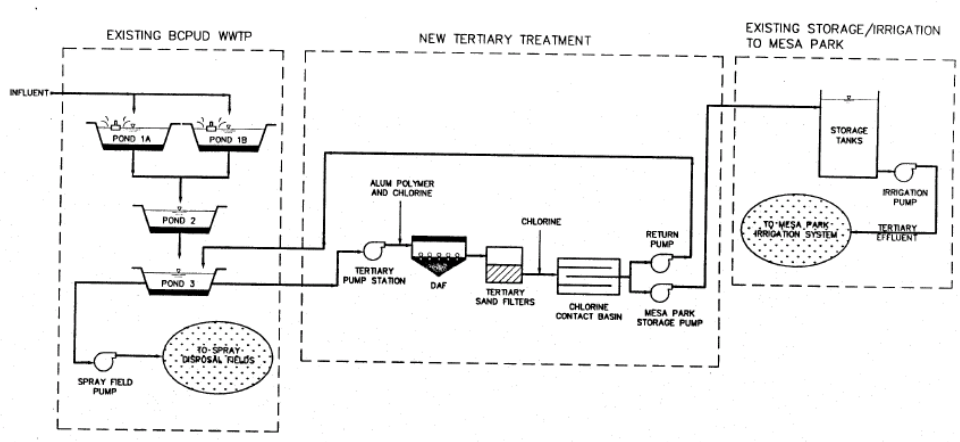
D3. ALTERNATIVE SANITATION TECHNOLOGIES

Case Study 4 - Integrated Wastewater Pond System – Bolinas, California, USA

The Bolinas Community Public Utility District (BCPUD) is a public utility district located in an unincorporated area of West Marin County, California and provides water, wastewater and solid waste services to its customers. The BCPUD owns and operates a sanitary sewer system that collects, treats and disposes of approximately 30,000 gallons per day (GPD) of wastewater (with a maximum flow of 65,000 GPD) from 162 business and residential connections in the downtown area and 1 connection on the Bolinas Mesa.

In the BCPUD sewer system, wastewater is collected from the downtown sewered area and pumped up to the treatment facility on the Big Mesa, which consists of a series of four oxidation ponds for stabilization and storage, with ultimate disposal through pond evaporation and spray disposal on 45 acres of grasslands and a recently constructed water recycling system to reuse treated effluent for irrigation of ball fields and parklands in the community. The treatment system is required to meet the following treatment standards:

Biochemical Oxygen Demand (BOD)	≤ 10 mg/L
Total Suspended Solids (TSS)	≤ 10 mg/L
Oil and Grease	≤ 5 mg/L
Nitrate as Nitrogen	≤ 5 mg/L
Turbidity	≤ 2 NTU



The BCPUD's entire sewer service area encompasses approximately 3 square miles; the collection system consists of pipelines ranging in size from 2-inches to 6-inches, spanning approximately three linear miles. The sewer rates in 2010-11 is an annual charge of $850 for residential service and $896.00 to $1256.00 for commercial service.

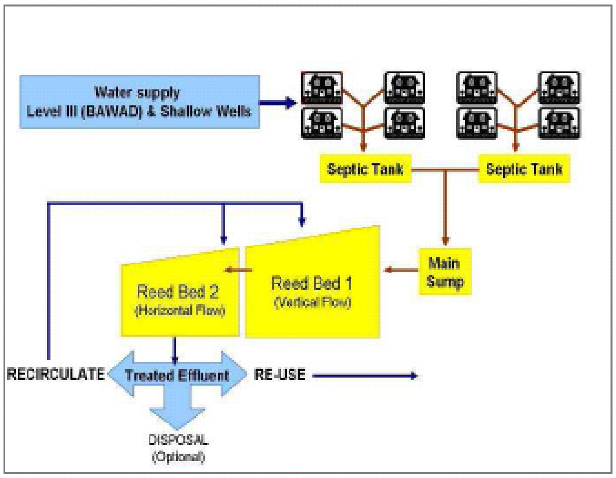
Case Study 5 – Vegetated Gravel Bed System for a Peri-Urban Housing Area Bayawan City, Philippines

Bayawan City is located in the south-west of Negros Island in the Philippines. The project is located in a peri-urban area of Bayawan, which has been used to resettle families that lived along the coast in informal settlements that had no access to safe water supply and sanitation facilities. The project serves approximately 676 households with an estimated population of 3380 people. The community is located on 7.4 hectares of land.

The planning of the project started in February 2005 and constructed was initiated in June 2005 and completed in August 2006. The System started operation in September 2006. The construction of the project was financed by Bayawan City and the costs for engineering, workshops, community participation and social preparation sessions were financed by the DILG-GTZ Water and Sanitation Program. The total costs for the project (including engineering, outreach and construction) was approximately $200,000 at that time.

The houses in the settlement have pourflush toilets. The wastewater from the toilets, bathrooms and kitchen sinks is pretreated in septic tanks where solids are settled and the organic load is reduced. There are a total of 67 septic tanks, each receiving wastewater from 6

to 10 houses. The liquid portion of the wastewater is conveyed by gravity through small bore sewers 250 mm in diameter with slopes 0f 0.2% towards a main septic tank for additional solids removal. From the main sump, the wastewater is pumped into four header tanks and then flows by gravity into the first cell of the vegetated gravel bed, which is a vertical flow bed. From the first cell the effluent flows to the second cell which is designed as a horizontal soil filter.



The treatment system was designed for a flow rate of 50 liters per person per day for a total population of 3,000 people. As of 2008 the system was serving 55 houses with a daily flow or 140 cubic meters per day (m^3/day) and a biochemical oxygen demand (BOD) load of 42 kg/day.

Monthly influent and effluent testing indicates that the treatment system is providing very good treatment with 97% removal of BOD.

Treated wastewater is being reused for a variety of purposes. During construction of the overall project, treated effluent was being reused for concrete production and dust control. Subsequently it is being used for production of organic cut flowers and vegetable farming. Because the wastewater is not disinfected it still contains pathogens, so farmers using the water for food crops have been asked to apply certain safety measures for the safe use of wastewater (i.e. wearing gloves, water soil and not leaves, to stop irrigating with treated wastewater four weeks before harvesting, etc.).

Since coming into operation, the system has been continuously improved. The header tanks ad sumps between the vegetated gravel beds where covered to reduce odors and algae growth. Additionally, a large storage tank was installed to store treated wastewater prior to use.

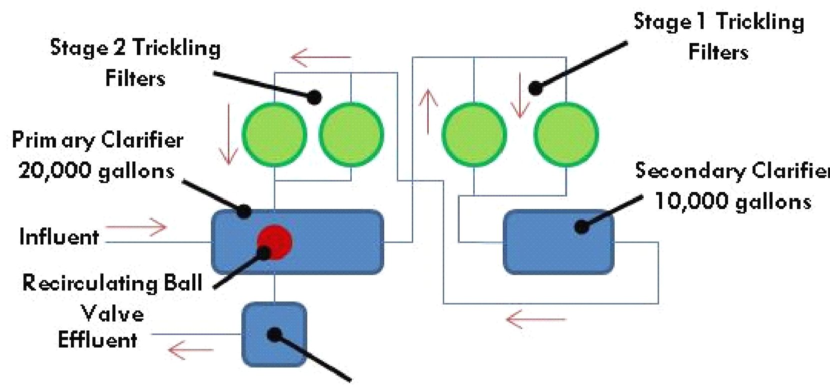
The operation and maintenance of the system is carried out by staff from the City and community. The field operation of the system involves manually turning on and off pumps, management of the treated effluent, management of plants in the vegetation (cutting of the

emergent vegetation once a year), and maintaining site securing and record keeping of daily activities. The City Engineering Department conducts regular inspections of the collection system and treatment plant. As previously mentioned influent and effluent samples are collected monthly and tested for total dissolved solids (TDS), pH, BOD, Ammonia, nitrate, phosphate and E. *coli* bacteria. Annual operation and maintenance costs are estimated to be approximately $5,000 to $6,000 and are paid for by the City.

Case Study 6 – Two-Stage Trickling Filter, Redwood Glen Camp and Conference Center Scotts Valley, California, USA

The Salvation Army owns and operates a year round camp and conference center in the Santa Cruz Mountains in the community of Scotts Valley in Central California. In 1998 the Camp installed new gravity sewer collection system, central wastewater treatment system, water reuse system and subsurface disposal system. The project cost approximately $750,000 including the costs for the gravity sewer system, the wastewater treatment system and new subsurface disposal system and water recycling system.

The Camp is located on 200 acres of land and accommodates 300 people a day. Daily wastewater flows average 15,000 gallons per day (gpd) with peak flows of 30,000 gpd. The wastewater treatment consists of a two-stage trickling filter design with two filters beds at each stage.



The wastewater treatment system has performed very well with BOD and TSS concentrations routinely below 10 mg/L and total nitrogen reductions over 50%.

Yr-Qtr	Total Nitrogen (mg/L)			BOD (mg/L)		TSS (mg/L)	
	Influent	Effluent	% Removal	Influent	Effluent	Influent	Effluent
2003-2	44.5	47.5	0	275	6	89	46
2003-4	46.0	15.8	66	--	<5	--	8
2005-2	--	10.0		--	9.5	--	--
2005-4	74.8	20.6	72	--		--	--
2009-1	--	4.6		--	<5	--	<1
2009-2	--	17.8		--	4.5	--	5
2009-3	85.0	10.7	87	247	3	323	<1
2009-4	--	17.0		--	5	88	6
2010-1	34.7	20.7	40	267	8	444	11
2010-4	--	7.1		--	3	--	17

Operation and maintenance (O&M) activities are carried out by a private service company that conducts weekly maintenance of the system by cleaning pumps, biotube filters and disc filters. The system requires approximately 2 hours of maintenance per week. Monthly O&M cost range from $800 to $1,200 per month with average annual costs equal to $9,200.

Treated effluent is reused to irrigate a baseball field and/or landscape irrigation on the property using a subsurface drip dispersal system. Excess effluent is discharged to a pressure dosed subsurface disposal system.

Case Study 7 – Ecosan Programme – Urine Diversion Dehydration Toilet (UDDTs) Shaanxi Province, China

The Water and Environmental Sanitation (WES) programme of Plan China started in 2005 to cover 500 communities and 200 schools in Shaanxi Province with a grant from Plan Netherland. The WES programme is an integrated water, sanitation and hygiene promotion and education program.

The first urine diverting dehydration toilets (UDDTs) of the project were piloted and demonstrated in Sanyong village in Pucheng County during May/June 2005 and later it ws piloted in other programme counties. After the successful pilot of UDDTs in all counties, the construction of these systems in larger numbers began in July 2005. The number of toilets constructed in 2006 reached 8,457 and by June 2008 over 18,000 UDDTs were installed.

The main reasons of the acceptance of this technology by the communities were:

- Effective promotion by the WES Plan Program;
- Low price in comparison to other toilests;
- Simplicity of usage and maintenance; and

- The individual household subsidy provided by Plan China.

The UDDTs are sized for a household of 5 persons and are expected to produce 400 to 500 liters of urine per year and 50 kg of wet faeces per year.

In the UDDTs promoted by Plan China the urine is collected in a separate container which is often placed under the stairs for safety and efficient space utilization. The toilet is constructed entirely above ground. The UDDT toilet has two outlets and two collection systems. One is used for urine and one for the faeces, in order to keep these fractions separate. There is a cover for the faeces compartments to keep flies and other insects from interacting with the faeces and to reduce potentially bad odors. A urine hole is in the front of the squatting pan is used to collect urine and a flexible hose on the bottom of the urine hole conveys the urine to a small urine storage tank/bottle.

Due to the separation of urine and solids the volume of the units are relatively small. For a household or 5 persons the unit should consist of two processing chambers, each of a volume of 0.25 m^3 per year times 5 people times once a year = 250 kg or 0.25 m^3. The size of the vault is commonly 0.9 m x 0.7 m x 0.6 m (depth) with 0.2 m of free space. Two openings of 0.25 m x 0.25 m are provided in each vault for the removal of dried faeces. One vent pipe (10 to 15 cm in diameter) extends from the vault through the roof of the house or penetrates the wall if there is a second story above the toilet. The vent pipe should be installed in the middle to vent both vaults.

When the first vault is full, the squatting pan is turned 180^0 and the other vault comes into use. The full vault is sealed for a minimum of 6 to 8 months for drying and hygienisation. The retention time and the elevated pH level results in die-off of pathogens and allows safe handling for use as fertilizer. When the second vault is full, the first vault is emptied from the opening provided in the structure, and it then comes into use.

Urine is applied by the households once or twice a week to nearby fields or gardens. Often the urine is diluted with water at a ratio of 2:1 before it is applied to plants. The dried faeces are removed from the vault once or twice a year and also applied directly to fields as a fertilizer.The standard urine diverting toilet in 2007 cost 750 RMB or Approximately $100.

Resources: Sustainable Sanitation Alliance (www.susana.org); IWA Eco-San (www.ecosan.org)

Case Study 8 – Recirculating Packed Bed Textile Filter
Currumbin Ecovillage, Queensland, Australia

The Currumbin Ecovillage is located 7 km from Currumbin Beach on Queensland's Gold Coast on 110 ha of land that adjoins Currumbin Creek. The village eventually will contain a total of 144 houses, a village center with commercial and community facilities, and a school. It was estimated that the Ecovillage at Currumbin would generate approximately 60 000 L/d of wastewater, or approximately 22 ML of wastewater per year. The treatment plant has been designed to produce Class A+ water quality. The mandatory requirements for Class A+ recycle water are as follows (Queensland Environmental Protection Agency, 2005):

- Suspended solids and dissolved organic pollutants to be removed from the wastewater to levels that are acceptable to users,
- Pathogens in the water must be reduced (E. coli concentrations of <10 cfu/100 mL),
- A 5 log (99.999%) removal of viruses and protozoa, and
- Turbidity levels of less than 2 NTU (indicative of the clarity of the water).

Class A+ water allows for toilet flushing, garden watering, car washing, and landscape Irrigation reuses, as well as laundry use.

The treatment system includes primary, secondary and tertiary treatment to met the Class A+ requirements. The treatment system includes primary settling and limited anaerobic digestion using large septic tanks, followed by secondary treatment using a recirculating textile filter packed-bed reactor for carbon removal and nitrification followed by denitrification in a blend tank using nitrified water and primary treated anaerobic effluent. Secondary treated effluent is treated to a class A+ standard using a continuous microfiltration unit (CMF) followed by UV

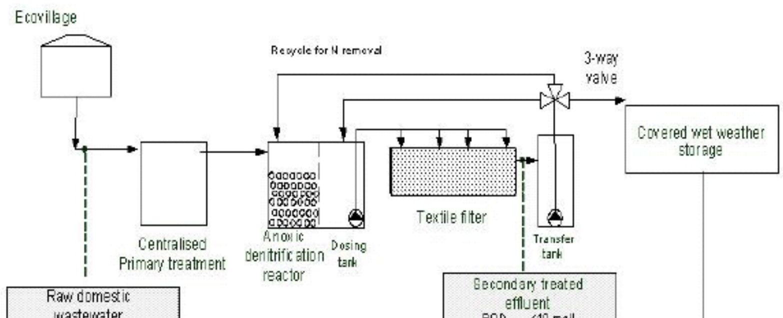
irradiation for primary disinfection and chlorination for residual. The tertiary treatment plant was designed to receive secondary treated effluent and groundwater for treatment to Class A+ reuse standards.

The system is owned by Currumbin Ecovillage body corporate, whice is also responsible for day-to-day operation and maintenance, and management with engineering support from a private engineering company. The plant is operated onsite by a site maintenance manager with remote monitoring and maintenance engineering assistance from the engineering company, which also oversees the plant, manages the assets, and coordinates maintenance works required by using local maintenance plumbers and contractors. The private company also acts as the asset management and maintenance engineers for the plant. Checking and replacing pumps and other equipment and pumping out tanks are conducted by local contractors based on the engineering company's direction and supervision.

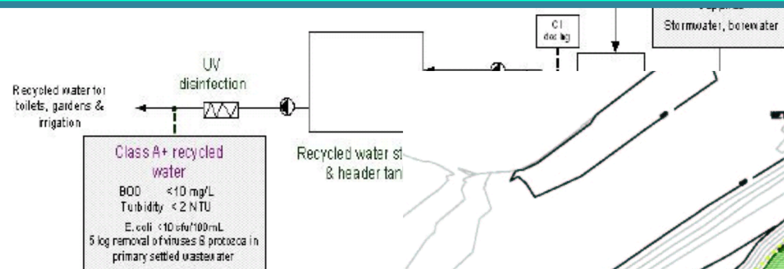
Planning took two years; design, eight weeks; construction, one year (because of significant rain delays); and plant commissioning, six weeks. The plant has been in operation since 2007.

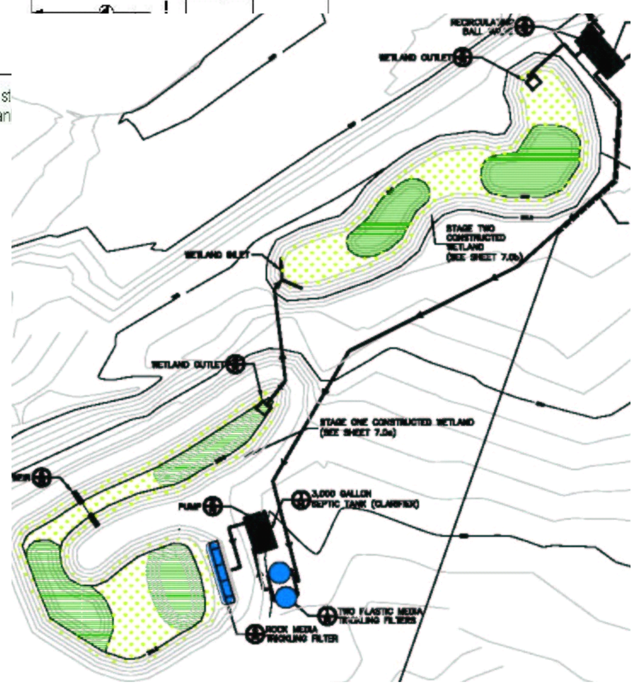
$550,000 was budgeted and the actual cost was $600,000, which includes primary treatment; secondary packed bed reactor; the tertiary micro-filtration plan; UV disinfection; residual chlorine disinfection plant and associated monitoring and control systems such as pH, free chlorine, turbidity, UV transmission monitoring; and inlet and outlet flow monitoring.

Annual user costs are approximately $14,100 ($15,170 AUD) for plant monitoring, maintenance management and engineering support, which amounts to approximately $125 per year per home ($136 AUD/year per home).



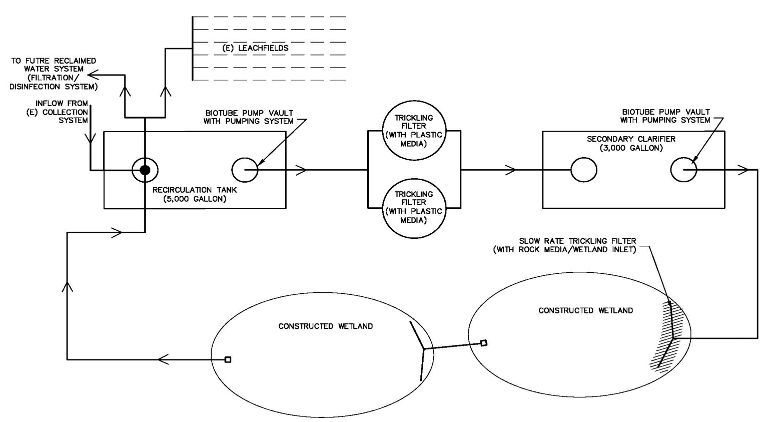
Case Study 9 – Recirculating Free Surface Water Wetland
San Lorenzo Valley School Complex, Felton, California, USA





The San Lorenzo Valley Unified School District (District) operates a multi-school cmplex in Felton, California, USA. The complex includes a preschool, an primary, middle and secondary school. The daily population on the campus is approximately 2,500 students, teachers and administrative staff. The facility is located in the San Lorenzo River Watershed, which has been impacted by excessive nitrogen in the groundwater in the basin. In the 1980's the local and state water authorities adopted regulations requiring all large onsite systems to install treatment systems that reduce the total nitrogen (TN) by 50%.

In 1997, the District installed a fixed activated sludge treatment system; however, the treatment system did not meet the TN standards.



In 1999 the District installed a new wastewater treatment system that included a single stage trickling filter and a free surface water wetland system. The trickling filter is used

primarily for nitrification of the wastewater. A two-pond FWS wetland was designed to reduce total nitrogen using a combination of deep and shallow zones that supports emergent , submerged and floating vegetation. The trickling filter is a

The preconstruction estimate for the project was $210,000; however, due to complex site conditions, high groundwater and marginal soil conditions, the final cost of the project was approximately $270,000. Monthly operation and maintenance costs are approximately $500 per month including labor and electricity.

The system has performed very well and routinely met and exceeded the TN regulations as shown in the table below. The FWS wetland is also used by the School's science department as a living laboratory and is used in the school's environmental education program. The wetland system also supports wildlife in the area.

Yr -Qtr	Total Nitrogen			BOD			TSS		
	Influent (mg/L)	Effluent (mg/L)	Precent Removal	Influent (mg/L)	Effluent (mg/L)	Precent Removal	Influent (mg/L)	Effluent (mg/L)	Precent Removal
2009-1	32.4	13.5	58	16.0	2.7	83	12	3.0	75
2009-2	115.0	58.0	50	85.0	3.0	96	48	<1	99
2009-3	125.1	49.3	61	71.0	2.0	97	168	5.7	97
2009-4	141.0	11.3	92	50.0	4.0	92	140	<1	99
2010-1	67.4	31.0	54	99.0	8.0	92	34	<1	99
2010-2	112.0	61.0	46						
2010-3	121.0	40.6	66	62.0	2.0	97	46	<1	99
2010-4	--	10.9	--	9.0	2.0	78	32	<1	99

Case Study 10 – Anaerobic Baffled Reactor and Anaerobic Filter, Manjuyod Public Market Negros Oriental, Philippines

Manjuyod is a low income district in Negros Oriental in the Phillippines. Wastewater from public markets is considered to be one of the major sources of domestic wastewater in the central part of the community. Domestic wastewater from public markets generally include wastewater from the toilets, sinks, tubs, showers and kitchens. It may also include wastewater from small cottage industries located in the markets. The market serves 60 to 70 stall owners, 200 vendors and several hundred shoppers.

Figure 1: View of the anaerobic treatment modules: settling tank (ST), anaerobic baffled reactor (ABR) and anaerobic filter

The wastewater from the Manjuyod's public market is treated using a simple five stage gravity treatment system consisting of a settling tank, an anaerobic baffled reactor, anaerobic filter and a vegetated gravel bed and storage pond.

The system has been sized to treat 40 m^3 of wastewater per day. The total area of treatment plant is 400 m^2 with a total volume of 374 m^3. The average organic pollution load (measured as biochemical oxygen demand (BOD)) is 600 mg/L and the system effluent quality is less than 30 mg/L BOD. Treated effluent is discharged to the sea.

The wastewater treatment system is a passive design that only requires regular inspections of the settling tank, anaerobic baffled reactor and anaerobic filter and periodic pumping of the tanks. Sludge removal from the tanks s done every 18 to 24 months. The vegetated gravel filter is cleaned as need by removing rubbish and plastic debris. Scum is removed as required from the baffled reactor once it starts to form a thick layer on the upper portion of the water surface.

Figure 2: View of the aerobic treatment modules: planted gravel filter (PGF), indicator / polishing pond (IP).

The system is maintained by Basic-Needs Services Phillippines, Inc. and Bremen Overseas Research and Development Association (BORDA).

The treatment system cost $32,400 US in 2007. Operation and maintenance costs are not reported, but are expected to be low due to the simple design. The highest costs are attributed to periodic pumping of sludge from the tanks.

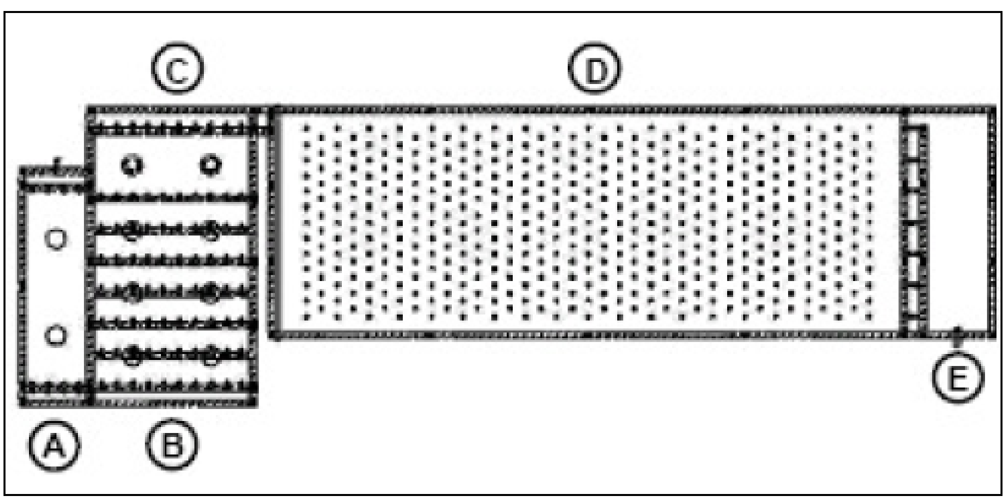
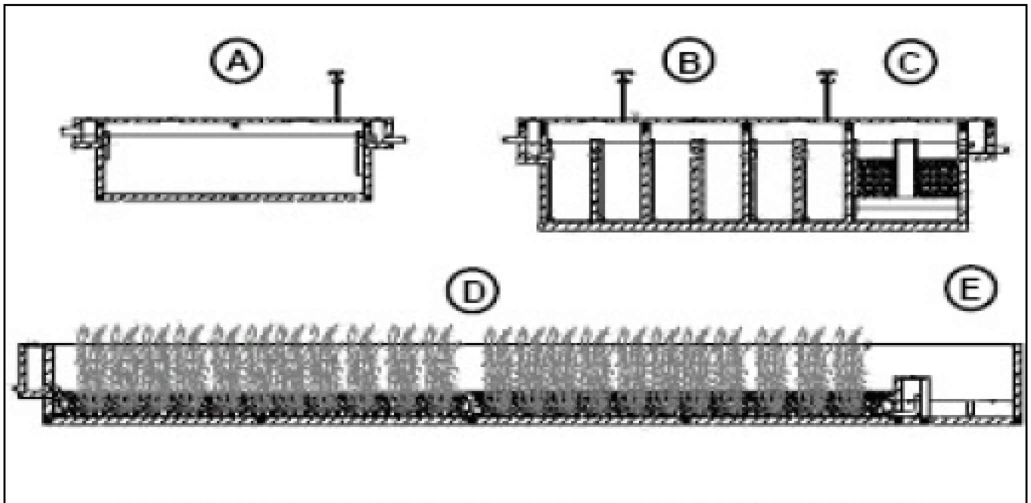


Figure 3: Treatment Plant layout. *A*–Settling Tank; *B*–Anaerobic Baffled Reactor; *C*–Anaerobic Filter; *D*–Planted Gravel Filter; *E*–Indicator Pond. (Source: BORDA)



A—Settling Tank; B—Anaerobic Baffled Reactor; C—Anaerobic Filter;
D—Planted Gravel Filter; E—Indicator Pond

Case Study 11 – Two Stage Trickling Filter and Free Surface Water Wetland
Jean Michel Cousteau Fiji Island Resort, Savu Savu, Vanua Levu, Fiji

The Jean Michel Cousteau Fiji Island Resort is a five star destination resort located outside of the small town of Savu Savu on the island of Vanua Levu in Fiji. The destination resort includes 30 bungalos, a commercial kitchen and restaurant, an organic vegetable garden, fruit tree orchard and swimming pools, public restrooms and spa/gym complex.

The property is located on Savu Savu Bay a designated protected marine reserve in Fiji. In 2000 the resort installed an enhanced wastewater treatment system to remove carbon and nitrogen from the wastewater to protect the fragile coral reefs

surrounding the resort. The system is designed to treat all of the black and graywater on the property and treats over 38 m3 per day of wastewater.

The wastewater system improvements included installing a two-stage trickling filter and two-pond free surface water wetland system. The two-stage trickling filters were constructed using locally available roto-molded plastic tanks filled with crushed plastic water bottles as a biological media. The constructed wetland were excavated on the property and sealed using a locally sourced clay.

The treatment system produces effluent that has a biochemical oxygen demand (BOD) and total suspended solids less than 10 mg/L and the total nitrogen concentration in the wetland is less than 20 mg/L. A subsurface drip irrigation system was installed to reuse the treated effluent for landscape irrigation and irrigation of the fruit trees on the property.

The treatment system was designed by a foreign company; however, it was constructed and is operated by the hotel employees. The overall costs for the treatment and subsurface drip irrigation system was approximately $80,000 US in 2000.

Appendix E

Contract and BID Procedures

E1. General Conditions of Contract (GCC)

The GCC in the bidding documents establish an accepted basis for similar procurement contracts under the project. The GCC will typically outline the operational, protective, variations and remedy clauses that are established between the purchaser and the supplier/contractor.

Operational Clauses. These establish the relationship between the purchaser and the suppliers/contractors they contain information regarding:

- Definitions;
- Rights and obligations of both parties;
- Procedures for shipment and documentation;
- Delivery and transfer of risk;
- Terms and currencies of payment;
- Mode and form dispute settlement;
- Governing language; and
- Applicable law.

Protective Clauses. They establish protection against various risks and allocate them between the parties. They include instructions on:

- Performance security;
- Retention of payments;
- Insurance;
- Inspection and tests;
- Warranty;
- Protection against third party infringement suits; and
- Force Majeure.

Variations. Unforeseen or planned changes during the life of the contract are identified and provided for under these parts of the GCC. They cover the following:

- Quantity changes;
- Adverse physical conditions;
- Price adjustments; and
- Changes in delivery requirements.

Remedies. These deal with the breach of contract by one of the parties. They include provisions on:

- Forfeiture of performance security;
- Procedure for damages, penalties for delay;
- Procedure for suspension and termination; and
- Nonpayment or failure to provide required approvals and information.

E2. Contract Securities

Contract securities are used to ensure that suppliers/contractors will perform their contractual obligations when an award is made after the procurement process is carried out. Securities include: bid and performance securities, retention money and advance payment securities. These may be provided in the form of a bank guarantee or irrevocable Letter of Credit, cash, cashier's check or certified check or an insurance certificate. Retention money on the other hand is a portion of the payments due under the contract, which is retained to ensure performance by the supplier/contractor. When used as a guarantee, it should typically not exceed 5% of the contract value. Instead of the Borrower retaining part of the due payments, the supplier/contractor may also provide a money retention bond in form of a bank guarantee or irrevocable Letter of Credit.

Bid Securities. Bid securities are required as a condition of contract for the bid. It assures compensation to the Contracting Agency for the time and money lost if the successful bidder fails to honor their bid and enter the contract. Bid securities may not be required in small contracts and should not be too high. About 2% of the contract price is acceptable.

Performance Securities. Performance securities are required as a condition of contract validity. They guarantee the contractor's obligations under the contract and should always be required where the contract value is large. However, the amount of the security should not generally exceed 10% of the contract price. Where a performance security is required in addition to retention money, the amount should be reduced to less than 10%. The contract should define clearly the kind of defaults that would lead to the surrender of the performance security e.g. the contract may provide that the performance security be payable only once default has been established by an arbitral award. Where there is no default, the performance security must be discharged after completion of the contract and expiration of the warranty period.

Advance Payment Security. Another form of security is the advance payment security which guarantees advance payment made by the contracting agency against the contractor's default. They are in the form of a bank guarantee or irrevocable letter of credit for an amount equal to the advance payment and are normally callable on demand. Securities must be denominated in the currency of the bid or another freely convertible currency

E3. Advertising and Notification of the Procurement Opportunity

Timely notification of procurement opportunities for goods, works and consulting services is essential for economic and efficient project execution, and is the basis for eliciting maximum competition with fair opportunities for all eligible potential bidders. The notifications

requirements may be established by the project funding agency, such as the Ministry of Finance or World Bank. The local project sponsor will need to determine the notification requirements promulgated by the funding agency.

Pre-Project Procurement Notice. The Pre-Project Procurement Notice (PPN) contains advance information on the major procurement packages being considered for execution and is intended to alert suppliers and contractors of the procurement opportunities under the project. This notification may be sent out once the project has been approved by the funding agency and the initial project(s) has been identified.

Specific Procurement Notice. A Specific Procurement Notice (SPN), for each of the major procurement packages in the project should also be issued. SPNs are issued either as a public Invitation for Prequalification, or in the absence of pre-qualification, as an Invitation for Bids. It is recommended in practice that the invitation also be incorporated in the front of the prequalification or bid documents as appropriate for reference purposes. SPNs should provide adequate notification of specific contract opportunities or Invitation for Bids (IFB) under the project regardless of what procurement method is used.
The SPN should be issued in the following way:

- As an advertisement in at least one newspaper of general circulation;
- By an announcement in the official gazette (if any); and
- By direct notification of all firms which have expressed an interest in the procurement in response to the PPN (See Clause 2.8 Procurement Guidelines).

E4. Qualifications of Bidders

The Purchaser of services or goods should put in place procedures to evaluate the qualifications of the vendors or contractors. There are generally two different approaches taken by public agencies to evaluate a firm or contractors qualifications by either screening the firm through a prequalification process before the procurement documents are distributed or as part of the procurement process commonly referred to as a post qualification process.

During the prequalification process a Request for Qualification (RFQ) is sent out to interested firms soliciting specific information about the firm's qualifications usually presented in a Statement of Qualifications (SOQ) and usually containing a questionnaire, requiring applicants to respond to direct questions as well as to complete a series of forms. The information solicited and the number of forms to be filled should be the minimum essential required to make an objective decision as to the bidder's capabilities. Properly designed and completed, the RFQ should provide the purchaser with a good framework for evaluation, while encouraging applicants to provide full pertinent details on their capabilities.

Prequalification is common for large works, civil works, and turnkey plants. However, prequalification is not generally needed for smaller projects or equipment. In initiating the

procurement process, whether or not there is prequalification of bidders Purchasers need to carry out the following processes, to initiate and manage the bidding process:

- Distribute the Invitation for Prequalification to potential suppliers/contractors;
- Distribute all amendments to the prequalification documents to all firms which have expressed interest in the prequalification process after receiving the RFQ or Invitation for Prequalification;
- Organize and prepare the prequalification evaluation team and facilities; and
- Properly manage and evaluate submitted prequalification documents.

The time allowed for these activities should be reasonable to allow time for potential firms to prepare responsive prequalification applications for the specific procurement.

E5. Use of the Prequalification Process

Using the a prequalification process is aimed at ensuring that only firms who have the required experience, technical and financial resources bid for a contract. Prequalification screens potential bidders and is designed to provide the following benefits:

- Unqualified bidders save the cost of bid preparation, which results in lower overhead costs to them and, therefore presumably lower bid prices in the long run, to the benefit of the Purchaser.
- Leading firms are more likely to bid, knowing that competition is confined to only those qualified.
- The scale of interest by potential bidders can be measured, affording the opportunity to revise bidding conditions as necessary to develop adequate competition.
- The evaluation of only bids from qualified bidders may result in time and cost savings to the Purchaser, as well as a reduction (or elimination) of the threat of pressure being applied by marginally or unqualified bidders for their low prices to be considered.
- An early indication of the Purchaser’s procurement capability is provided, allowing necessary improvements to be made at the initial stages of procurement.

However, prequalification has some potential disadvantages:

- It may increase procurement lead time, although this can be minimized by good procurement scheduling, e.g. undertaking the process while bid documents are in preparation.
- The Purchaser is required to review all prequalification applications whereas with post qualification, the Purchaser would only review qualifications of one or a limited number of bidders.
- Names of all prequalified bidders are known in advance of bid submission, making it easier for bidder collusion and price fixing to occur.

Where government agencies or civil works contractors are likely bidders, prequalification may be used to determine that they are not only capable of supplying the items to be procured, but also that they are commercially-oriented and do not enjoy direct or hidden subsidies from the government.

After prequalification, prequalified bidders are invited to submit bids which are eventually evaluated. The Purchaser is required to award the contract to the bidder offering the lowest evaluated responsive bid. The Purchaser should ask bidders to confirm and update essential prequalification information at the time of bid submission. The lowest apparent evaluated responsive bidder may be denied the contract if evaluation of the updated information indicates that the bidder, no longer possesses the necessary capabilities. This could occur because of changed financial situation, loss of equipment or key personnel, or lack of capacity because of new contract commitments on the bidder’s part.

Prequalification can also be used for a package of contracts essentially similar in type and size. Under these circumstances, applicants can be prequalified for a specific or single contract, combinations of contracts or the entire package. The prequalification document should thus describe the package and the slices, and the criteria required for bidders to meet the qualification requirements for slices, groups of slices or the whole package. The applicant should be asked in the prequalification documents to indicate the contracts for which it wishes to be considered.

Pre- and post qualifications should be based entirely upon the technical, managerial and financial capabilities of bidders to perform the particular contract satisfactorily, and their past performance. The Purchaser should evaluate bids from firms in a manner that takes into consideration the period over which the contract will be executed and known commitments of the bidder over that period.

Where the prime contractor proposes to use the services of major specialist subcontractors, their names and experience should also be solicited. However, the Purchaser should not require applicants to furnish particulars of suppliers of minor sub-contractors, particularly if their incorporation in the procurement of, for example, a works or industrial plant will take place many months into the contract.

The RFQ or Bid documents should avoid rigid statements to the effect that applicants who do not answer all questions or submit all required information “shall be disqualified”. The expression “may be disqualified” is preferable, as it provides flexibility. It is also not in the Purchaser’s interest to reject applications of qualified applicants on the basis of trivial or narrow interpretations of prequalification submissions. However, the Borrower should reject incomplete applications.

Special conditions may apply when the applicant for pre- or post qualifications is a joint venture formed by two or more firms. It is essential that the qualification documents state clearly the

conditions applying to joint ventures, and to any change in its membership after prequalification and to subsequent bidding by the joint venture.

Procedures for Qualification Applications. The pre- or post qualification documents should specify the submissions required, such as completed questionnaire forms and supporting documents and their number and the deadline for their submission. They should also contain a clear statement on the criteria for evaluation of prequalification applications. The anticipated period for evaluation, usually 30 to 60, days and the method of notification to all applicants of the results should be indicated in the documents. As a rule the Purchaser should not consider qualification applications received after the time stipulated. The Purchaser should also make a formal acknowledgment of receipt of the qualification proposals.

Evaluation of Qualification Applications. The Purchaser should establish procedures to evaluate qualification applicants that are based on compliance with quantifiable clearly identified minimum thresholds, which establish the capability of an applicant to carry out the contract satisfactorily. Applicants are than deemed qualified if they meet all the required criteria on a pass/fail basis.

The criteria should also be objective; ambiguous requirements such as “general reputation”, or “cooperativeness” or irrelevant ones are generally not acceptable and thus should not be used by the Purchaser. Likewise the criteria should not be unfairly discriminatory. Examples of the type of essential criteria for prequalification of civil works contractors that Purchaser’s may require include:

Experience. The firm should be able to demonstrate that they have relevant experience in the field and Have carried out a specific volume of work, comparable to that required for the critical items of the contract, measured annually, in at least two of the last five years.

Financial Resources. The firm should demonstrate that they have the financial means to fully finance the estimated contract cash flow for a specified period of months, accounting for the net of requirements for other known commitments over the period of construction.

Personnel Resources. The firm should demonstrate that they have a pool of experienced staffs capable of performing the key functions required for the project, from which contract personnel will be drawn. The qualification document should list the essential functions, and the number of years of relevant experience of the personnel to be detailed in the submission.

Equipment Resources. The firm should demonstrate that they have available specialized equipment essential for the execution of the contract. The list should be limited to highly specialized or heavy equipment, which would be critical to the execution of the contract, and cannot easily be purchased, hired or leased in the market, or readily manufactured for the task. Normal construction equipment (scrapers, bulldozers, loaders, tip trucks and pavers), which can normally be bought leased or hired “off-the-shelf” should not be listed, unless there are particular circumstances which would make access to them difficult.

Conditional qualifications are also appropriate where a potential increase in the work-load of the applicant could significantly alter its ability to undertake the prospective contract.

If the Purchaser doubts the accuracy or completeness of a prequalification application, the applicant should be requested to provide verification or supplement earlier provided information. The Purchaser may also contact references cited in the applications for information required.

E6. Evaluation and Comparison of Bids for Goods and Services

Regardless of how well the other steps in the procurement process are conducted, if bids are not evaluated correctly and fairly, the process has failed. Unfortunately, bid evaluation is the step that is most easily manipulated if one wants to favor a particular bidder. Even though Purchaser have the responsibility to make the evaluation, the local agency managing the pre-qualification and bid process may need assistance from the central government or financial institutions to obtain training and to understand how to review and what to look for in the results.

The basic sequence for bid evaluation is the same for all projects, and consists of the following steps:

1. Preliminary examination to determined in the bids are complete;
2. Determination of bid responsiveness;
3. Correction of arithmetic errors;
4. Conversion to common currency, if required;
5. Identifying omissions and deviations;
6. Application of evaluation criteria;
7. Comparison of bids; and
8. Preparation of evaluation report.

In order to examine and evaluate bids, the Purchaser should form or appoint a Bid Evaluation Committee, that should be composed of at least three qualified members preferably persons who participated in the preparation of bidding documents. The committee should include persons who are qualified and familiar with the technical requirements of the project. The Bid Evaluation Committee is usually responsible for the evaluation and comparison of the bids received and for the preparation of a Bid Evaluation Report, which is typically provided to the project funding agency and the local and central governing agency.

Preliminary Examination. The bid examination phase begins during the public bid opening with a preliminary examination of the bids. Except for decisions about rejecting bids received after the closing time, which is mandatory for all late bids, other decisions about whether a bid is compliant with bid document requirements should not be made during the bid opening. Errors may be made based on an incomplete reading or wrong interpretation of a bid, and a mistaken

decision taken hastily in the presence of the bidders is awkward to correct later. Instead, after the bid opening has been completed, as its first step in the evaluation, the committee should make a thorough examination of all bids received before the deadline for submission.

The preliminary examination of bids determines whether the bids meet the general procedural requirements of the bidding documents. In particular, the Committee should examine bids for compliance with the following requirements, using the bidding documents as the reference point:

- The Bid should be signed properly by an authorized party, including the Power of Attorney if stipulated and are generally in order;
- Bid securities should be in acceptable format, for suitable amount and duration;
- Bid packages should contain all required documents including supporting evidence of bidder eligibility and qualifications;
- Changes should be initialed;
- The mathematical calculations should be properly computed - if not, corrections should be made; and
- Bids should be complete and quote prices for all items in the lot or package if so stipulated in the bidding document.

The purpose of this examination is to eliminate any bids from further and more complicated consideration, if they do not meet the minimum standards of acceptability as set out in the bidding documents and are therefore not substantially responsive.

Correction of Arithmetic Errors. Bids should be checked carefully by the evaluation committee for arithmetic errors in the bid form to ensure that stated quantities and prices are consistent. The quantities should be the same as stated in the bidding document. The total bid price for each item should be the product of the quantity and the quoted unit price. If there is a discrepancy, the quoted unit price shall govern in the recalculation. Prices spelled out in words generally take precedence over numeric quotations in case of differences. The Bid reviewer should correct all arithmetic errors and notify each bidder of the detailed changes. The Bidder must accept such arithmetic corrections or its bid should likely be rejected.

The preliminary examination stage of bid evaluation described above is aimed at making sure that the bids received are substantially responsive. A substantially responsive bid is one that conforms to all the terms, conditions and specifications in the bidding documents without material deviations, reservation or omission. After the preliminary bid evaluation stage, the bids are taken through a detailed evaluation in order to select the bidder whose bid not only complies with the technical requirements in bidding documents, but also offers the Borrower the lowest price for the goods, works and/or services to be procured. During the bid evaluation the Purchaser should adhere to the following principles:

- Ensure that the bid evaluation process is strictly confidential;

- Reject any attempts or pressure to distort the outcome of the evaluation;
- Reject any proposed action likely to lead to fraud and corruption;
- Comply with the Bank's prior review requirements; and
- Strictly apply only the evaluation and qualification criteria specified in the bidding documents.

Evaluation Using a Merit Point System

In cases where evaluation and selection merely on initial purchase price is deemed inadequate and evaluation using the full life cycle is either too time consuming or unwarranted compared to the cost of procurement itself, evaluation may be carried out by assigning merit points or weight ages for price and other relevant aspects. Evaluation using this system is done, for example, for retaining a firm for project planning and engineering services. This system is usually applied by allocating points to a number of factors as illustrated below:

Item	Range of Points
Cost estimate for services	0 – 40
Relevant experience	0 – 20
Technical proposal	0 – 20
Team experience	0 – 20
Total	**100**

In this case the bid scoring the highest number of points will be deemed to be most qualified and responsive firm.

The presumed advantage of using a Merit Point System is its simplicity and ease of application for considering factors that may not easily be convertible to monetary terms. However, the disadvantage is that the weight ages for different factors and the points within each factor must be properly allocated or the outcome will be distorted. Assigning points for some factors could be very subjective and thus open to manipulation.

Deviations from the Requirements of Bidding Documents

Bidding documents generally outline numerous procedures, conditions and requirements some of which are mandatory, and some, which are not. In some instances, bidders submit bids that deviate from the specifications required by the Borrower. Deviations include exceptions, exclusions, qualifications, conditions, stated assumptions, alternative proposals and changes to stated requirements. Deviations may either be material or non-material. Material deviations are:

- Those which affect the scope and quality or performance of a contract;
- Limits the purchaser's/employer's rights or bidders obligations; and
- Affects unfairly the competitive position of other bidders.

A bid which has complied with all the mandatory requirements of the bidding documents, but has minor or insubstantial deviations in respect of terms or conditions on the technical specifications, should be retained for more detailed evaluation and should not be rejected. On the other hand, one which is not substantially responsive because as it contains material deviations or reservations to the terms, conditions and specifications in the bidding documents should not be considered further. In determining whether a bid is substantially responsive the Purchaser, apart from taking into consideration the general procedural issues, also considers the bidder's compliance with the required technical specifications and the commercial aspects of the bid. Deviations may be clarified by bidders but not withdrawn.

Evaluation of Bids for Works Contracts

Evaluation of bids for works contracts is more complex than the evaluation of bids for goods. To make the evaluation process easier and transparent, it is essential for the Purchaser to set out in bidding documents, well defined evaluation criteria and carry out the evaluation process in a transparent manner. If the evaluation criteria are not well defined, Bidders may be reluctant to submit bids. The evaluation of works contracts involves price and non-price factors, depending on the form of works contract being procured. The selection of bids in for a works contract involves two steps after the preliminary examination to determine responsiveness. The first being the selection to determine whether Bidders demonstrate relevant experience in the undertaking the works being procured and the second step is based on price.
As in the case of evaluation of bids for procurement of goods, evaluation of works contracts begins with a determination of the following basic issues:

- Was the bid received by the due date required in the bidding documents;
- Is the bid accompanied by the prescribed fees and bid security;
- Is it submitted in the required form, where necessary; and
- Does it comply with all the specific mandatory requirements of the bidding documents.

Once a bid has been determined as responsive, the Bid Evaluation Committee assesses the technical feasibility of the bids and compliance of such bids with specifications required in bidding documents. Evaluation also involves the examination of the Bidder's key staffs in order to make a determination of whether they possess the qualifications and experience to undertake the works contract. The Purchaser also takes into consideration similar works procurements that the Bidder has engaged in within the last five or so years, and whether they have been successful. Apart from these the Bid Evaluation Committee also evaluates the Bidders financial capabilities using the documentary evidence of the Bidder's financial viability to carry out the contract.

After evaluating the non-price factors, the Bid Evaluation Committee, proceeds to evaluate the prices offered for the contract. Depending on the kind of works contract being procured, the lowest evaluated bidder is determined and awarded the contract. In a contract for the

Confidentiality

After suppliers, contractors and consultants have submitted their bids to the Purchaser by the required deadline, the bid evaluation process outlined above begins on the date indicated in the bidding documents for bid opening. It is important for the Purchaser to note that after the deadline for receipt of bids for goods or works, confidentiality should be imposed and is maintained throughout the evaluation process until announcement of the award of contract.

Rejection of All Bids

In some situations the Purchaser is permitted to reject all bids submitted in response to an invitation for bids if the terms for rejection are provided for in the bidding documents. The Borrower may reject all bids under the following circumstances:

- Where the price in the lowest evaluated bid exceeds the Purchaser's bid cost estimates by a substantial margin;
- When all the bids received are not responsive to the requirements in the bid documents; and
- Where the Borrower after receiving bids reasonably concludes that there is lack of competition.

Where all the bids are rejected, the Purchaser should review the bidding documents and make any appropriate revisions. If substantial changes are made to the bidding documents, the Purchaser should then invite new bids on the basis of the new bidding documents.

The Standard Bid Evaluation Report

After the completion of the evaluation process the Purchaser may be required by the financial lender or decide to prepare a bid evaluation report that describes the process by which the Bid Evaluation Committee evaluated the bids received in response to the procurement process. A Standard Bid Evaluation Report would include the following information:

- Key dates and steps in the bidding process;
- Bid prices, corrections, and discounts;
- Additions, adjustments and price deviations;
- Domestic preference if any;
- technical evaluations if any;
- Post qualification results;
- Names of bidders rejected and reasons for rejection of bids; and
- The proposed contract award.

E7. Award and Signing of the Contract

Once the Purchaser has evaluated the bids and made a determination on the lowest evaluated responsive bid, and a decision has been made about the award, the Purchaser should send notification of the award, a contract form, and a performance security form (indicating the amount of security, if required) to the successful Bidder in a manner and within the time specified in the bidding documents. The Purchaser should request the supplier to return the signed contract together with the required performance security within the time specified in the bidding documents. The Purchaser should also notify unsuccessful Bidders as soon as possible after receiving the signed contract and the performance security.

If the successful Bidder fails to return the signed contract or provide the required performance security, the Purchaser may be required to forfeiture of the Bidder’s Bid Security, and proceed to offer the contract to the second lowest evaluated Bidder, provided that he is capable of performing satisfactorily.

E8. Monitoring, Evaluation and Record Keeping

Monitoring is the continuous assessment of project implementation in relation to agreed schedules and the use of the procured goods, works and services by the project beneficiaries. It is an integral part of good management by the project implementing agency. Its main objectives are to provide continuous feedback on implementation and to identify actual or potential successes and problems as early as possible to facilitate timely adjustments to the project in general and the procurement process.

Continuous monitoring and periodic evaluation of the procurement process can assist the Purchaser to maintain easily retrievable records of procurement implementation which can later be used for evaluation.

Once created the monitoring and evaluation program should be integrated into the management structure of the project, since its purpose is to serve the information needs of the Purchaser’s implementing agency. Its organization is part of the institution-building process and should be treated as such during project appraisal and supervision. The range of the information system and the scale of the monitoring process must be consistent with the staffs and financial resources available and must be sustainable as a feature of management procedures within the Purchaser’s agency.

The cost of providing sound monitoring is not a direct function of the size or cost of the project itself. In innovative pilot projects, the monitoring component may constitute a large part of the total cost, but for follow-up projects run by established agencies, the incremental costs may be negligible.