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PROVISIONS OF INFRASTRUCTURE FOR LOW-COST HOUSING DEVELOPMENTS

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بِسْــــمِ اللَّهِ الرَّحْمَنِ الرَّحِيْمِ

يَقولُ اللهُ تعالى:

(أَفَمَنْ أَسَّسَ بُنْيَانَهُ عَلَى تَقْوَى مِنَ اللَّهِ وَرِضْوَانٍ خَيْرٌ أَمْ مَنْ أَسَّسَ بُنْيَانَهُ عَلَى

شَفَا جُرُفٍ هَارٍ فَانْهَارَ بِهِ فِي نَارِ جَهَنَّمَ وَاللَّهُ لَا يَهْدِي الْقَوْمَ الظَّالِمِينَ)

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ABSTRACT

Infrastructure is an important factor influencing the cost of housing, in addition to being an essential element for healthy living environment. Therefore, it should be provided in adequate manner at low cost for the life basic needs of residents.

The research in this thesis includes the development of an approach for providing low-cost housing (LCH) in Gaza Strip with basic infrastructure at low cost such that not to increase the cost of housing.

The infrastructure for low-cost housing has been classified to include two categories; the basic infrastructure components (BICs) and the supportive infrastructure components (SICs). The BICs have been determined to include seven basic components which are (1) water supply, (2) sewerage system (wastewater collection), (3) wastewater treatment and disposal or reuse, (4) power supply and security lighting, (5) access and paving, (6) stormwater drainage and (7) telephone lines. The SICs involve facilities such as (1) Parks and green spaces, (2) Schools, (3) Health centre, (4) Mosque, (5) Public market and (6) Public services.

An approach has been developed for the provisions of the basic infrastructure components (BICs) for LCH through five phases. The first phase includes designation of the seven components and the main bases of provisions. The second phase proposes an institutional setup. The third phase involves the determination of minimum requirements of provisions of the seven BICs and includes seven parts. Each part is specified for the provision of one component and includes three activities. The fourth phase, introduces management option for operation and maintenance (O&M). Finally, the fifth phase proposes financing and cost recovery arrangements for construction and O&M.

Applicability and practicality of the developed approach in the real life has been examined successfully by applying it to a selected low-cost housing project in Gaza Strip as a case study. The most suitable case study has been selected from five housing developments executed by official housing institutions, using the scoring method as a simple decision making tool.

Specific conclusions have been derived about the main two categories of infrastructure, their components and characteristics. Recommendations have also been suggested for the stakeholders working in the fields of LCH, infrastructure and research.

It is proposed that the developed approach is used as a guiding document by relevant decision makers of planning, design, financing and management of the low-cost housing. It is also recommended that the developed approach be a part of the future Palestinian housing strategy.

ملخص البحث

البنية التحتية هي أحد العوامل المؤثرة في تكلفة المسكن، إضافة إلى أنها عنصر أساسي للبيئة المعيشية الصحية. لذلك يجب تزويدها بأسلوب ملائم وتكلفة منخفضة لتلبية احتياجات الحياة الأساسية للسكان.

يتضمن البحث في هذه الأطروحة تطوير آلية لتزويد التجمعات السكنية منخفضة التكلفة في قطاع غزة بالبنية التحتية الأساسية بتكلفة منخفضة بحيث لا يؤدي تزويدها لزيادة تكلفة المسكن.

تم تصنيف البنية التحتية للسكن منخفض التكلفة (LCH) إلى فئتين، عناصر البنية التحتية الأساسية (BICs)، وعناصر البنية التحتية المساندة (SICs). تم تحديد عناصر البنية التحتية الأساسية (BICs) لتشمل سبعة عناصر أساسية، وهي (1) المياه و(2) الصرف الصحي و(3) معالجة المياه العادمة وتصريفها أو إعادة استخدامها و(4) الكهرباء وإضاءة الشوارع و(5) الطرق والأرصفة و(6) تصريف مياه المطار و (7) خطوط التلفونات. أما عناصر البنية التحتية المساندة (SICs) تتضمن خدمات مثل (1) حدائق عامة ومناطق الخضراء و(2) مدارس و(3) مركز صحي و(4) مسجد و(5) سوق تجاري عام و(6) مباني خدمات عامة.

تم تطوير آلية لتزويد عناصر البنية التحتية الأساسية للتجمعات السكنية منخفضة التكلفة من خلال خمس مراحل. تشتمل المرحلة الأولى على وصف العناصر السبعة والأسس الرئيسية لتزويدها. تقترح المرحلة الثانية بنية مؤسسية. تتضمن المرحلة الثالثة تحديد المتطلبات الدنيا لتزويد عناصر البنية التحتية الأساسية السبعة، وتشتمل على سبعة أجزاء. كل جزء مخصص لتزويد عنصر أساسي واحد ويتضمن ثلاثة فعاليات. تقدم المرحلة الرابعة خياراً لإدارة أعمال التشغيل والصيانة. أخيراً، تقترح المرحلة الخامسة آليات لتمويل واسترداد تكلفة الإنشاء والتشغيل والصيانة.

تم اختبار ملاءمة ومناسبة الآلية المطورة في الحياة الواقعية، عن طريق تطبيقها على مشروع سكني منخفض التكلفة في غزة تم اختياره كحالة دراسية. تم اختيار الحالة الدراسية الأكثر ملاءمة من بين خمس تجمعات سكنية منفذة بواسطة مؤسسات إسكان رسمية باستخدام طريقة النقاط/ Scoring Method كأداة بسيطة لاتخاذ القرار.

تم استخلاص نتائج محددة بما يخص فئات البنية التحتية وعناصرها وصفاتها. تم أيضاً اقتراح توصيات للمسئولين العاملين في مجالات الإسكان منخفض التكلفة والبنى التحتية والبحث العلمي.

ُيقترح أن يتم استخدام الآلية المطورة كوثيقة استرشادية من قبل صناع القــرار ذوي العلاقــة بتخطيط وتصميم وتمويل وإدارة الإسكان منخفض التكلفة. يُوصى أيضاً أن تكون الآلية المطورة جزءاً من استراتيجية الإسكان الفلسطينية في المستقبل.

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First of all, I owe great thanks to Dr. Mohamed Ziara and Dr. Yahya Sarraj to whom I would like to express my gratitude for their invaluable guidance and continuous advice.

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I extend my sincere gratitude and appreciation to my husband, son and daughters for their devotion, trust and tolerance in giving me their time and support to complete this research and bring it into life. Through their trust, devotion, and tolerance, I found the opportunity to solidify my passions in the master study.

I would like to appreciate my mother and the memory of my father whose advice, love and support, shaped my personality and made my passions for education and research. Thanks also for my brothers and sister for their love and assistance.

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I would like to thank all of them.

DEDICATION

This thesis is dedicated to my dear family; husband, son, and daughters and to my mother, who suffer because of my intense passion for highest education and research work and who generously give me the time, love and support that I need to focus my attentions toward study endeavors.

I also dedicate this work to the soul of my dear father; may Allah grant him mercy.

I could never have made this thesis, had all of them not been part of my life and part of my passions.

I love them and thank them.

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ACRONYMS AND ABBREVIATIONS

AHP	Austrian Housing Project
AB	Administration Board
BIC	Basic Infrastructure Component
Bldg.	Building
BMPs	Best Managemnt Practices
BOD	Biological Oxygen Demand
BPs	Best Practices
CMWU	Coastal Municipalities Water Authority
CWT	Centralized Water Treatment
DGL	Department of Governmental Land
DRWH	Domestic RainWater Harvesting
DoED	Department of Engineering and Projects, Ministry of Housing (MoH)
DWT	Decentralized Wastewater Treatment
EA	Environmental Authority
EDC	Electrical Distribution Company
EPR	Effluent Percolation Rate
EQA	Environmental Quality Authority
GDUP	General Directorate of Urban Planning
GDP	General Directorate of Projects, Ministry of Housing (MoH)
GEDCo	Gaza Electrical Distribution Company
Gp	Grinder pump
H.H.	Household
H.T.	High Tension power lines
H.V.	High Voltage
H.U.	Housing Unit
ISF	Intermittent Sand Filter
KNHF	Khanyounis Nablus Housing Fund
KVA	Kilo Volt Ampair
L.M.	Linear Meter
L.T.	Low Tension
LC	Local Committee
LCH	Low-cost Housing
LCHP	Low-Cost Housing Project
LPP	Low Pressure Pipes
L.V.	Low Voltage
LVDB	Low Voltage Distribution Board
MENR	Ministry of Energy and Natural Resources
MLG	Ministry of Local Government
MOH	Ministry Of Health
MoH	Ministry of Housing
MOP	Ministry of Planning
MPWH	Ministry of Public Works and Housing
O&M	Operation & Maintenance
PA	Palestinian Authority
PALTEL	Palestinian Telephone Company
PHC	Palestinian Housing Council
PH	related to soil
PPA	Palestinian Power Authority

PS	Palestinian Standards
PSI	Palestinian Standards Institute
PVC	Polyvinyl Chloride
PWA	Palestinian Water Authority
ROW	Right Of Way
RSF	Recirculating Sand Filter
RRWH	Rooftop Rainwater Harvesting
RWH	Rainwater Harvesting
SAT	Soil Aquifer Treatment
SDGS	Small Diameter Gravity Sewers
SICs	Supportive Infrastructure Components
STEG	Septic Tank Effluent Gravity
STEP	Septic Tank Effluent Pump
SWIS	Subsurface Wastewater Infiltration System
TC	Technical Committee
TSS	Total Suspended Solids
UFW	Unaccounted For Water
UNCHS	United Nations Center for Human Settlements (Habitat)
UNRWA	United Nations for Relief and Work Agency
WHO	World Health Organization
WT-1	Working Team number 1
WWTR	Wastewater Treatment and Reuse
Mcm	Million cubic meter
l/c/d	Liter/capita/day

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Developing countries continually face housing challenges and limitations, especially in dealing with the impoverished segments of society. It is believed that reducing the cost of houses can solve a significant part of the housing problems all over the world. The determination of the exact housing cost is a fiendishly difficult task, as the total cost is the cost of a sum of many smaller elements that change over time (Ziara and Ayyub, 1999; Gichunge, 2001). One of the essential and important elements is the cost of infrastructure.

Infrastructure is widely defined as the system of services and facilities which provides for the basic well- being and quality of life (Ziara and Ayyub, 1996). Infrastructure is also defined as the basic installations and facilities on which the continuance and growth of a community and state depend, as roads, schools, power plants, transportation, communication systems, etc (Ziara and Ayyub, 1996). Urban facilities are the necessary public facilities for maintaining people's lifestyle and city functions and refer to the framework for urban structure which may include transportation facilities such as roads and park lots, public spaces such as parks, green spaces and public squares, supply facilities such as water and electricity, waste disposal facilities such as sewers, waste treatment plants and garbage incinerators, educational and cultural facilities such as schools , libraries and research facilities, and medical and social welfare facilities such as hospitals and child care centers (Japan, 2004). In some communities of the underdeveloped countries, the infrastructure may be limited to unpaved roads only. On the other hand, the infrastructure for some communities for the developed nations may include water, sewer, electricity, telephone, gas, cable television, schools, libraries and playgrounds among other facilities (Awadallah, 1996).

New developments need infrastructure. There is no doubt that the cost of new infrastructure plays a role in the price of housing, as with any development, infrastructure costs associated with affordable housing increase the overall cost of the development, and scant resources are available to assist with this expense (www.floridacommunitydevelopment.org, 2003).

Generally, infrastructure is easier and cheaper to maintain by municipalities if built to a high standard of quality. However, higher standards may require greater up-front expenses for the developer. These costs are passed on to the homebuyer, increasing housing prices (CCRP, 2001). It is important to identify minimum requirements for infrastructure types and levels and permit regulations that allow for minimum standards to make allowance for the production of low-cost housing, while ensuring safety and health of the residents and maintaining good environment for communities (Ziara *et al*., 1997).

The process of providing infrastructure is influenced by a range of factors including technical aspects, regulations, local materials, state and local government budgets, community expectations, private sector involvement in infrastructure investment and the issues of efficiency, equity and access (www.floridacommunitydevelopment.org, 2003).

The scope of infrastructure for which funding is made available should be determined on the basic essential infrastructure that communities would reasonably expect to be available and which is usually supplied by the public sector entities as "monopoly suppliers" (Morris, 2002). The option of introducing realistic pricing mechanisms for infrastructure, applied to houses, will increase the cost of producing new housing and therefore increase housing prices (Hamdi, 1997).

The provision and maintenance of infrastructure with respect to the provision of low-cost housing in Palestine necessitates the establishment of both functional and sensible codes of practice between private and public sector agencies. There is also a need to introduce the private sector in the provision and maintenance of infrastructure with respect to providing low-cost housing in order to achieve sustainable housing development (Ziara and Ayyub, 1999).

1.2 CURRENT SITUATION FOR THE PROVISIONS OF INFRASTRUCTURE FOR LOW-COST HOUSING

1. The provision of proper housing at affordable price is one of the most serious problems facing the Palestinian National Authority (PNA). The housing needs especially those for low-income people in Palestine in general and in Gaza Strip in particular is increasing with increasing demands to the provisions of basic infrastructure under very limited resources.
2. A considerable portion of the housing stock, infrastructure and service facilities in Gaza Strip are problematic and are characterized by inadequacy and substandard.
3. Some of the housing developments which are executed by PNA are not adequately provided by the essential infrastructure components. Many of the new housing developments are implemented and housed without adequate provisions of paved roads, sidewalks, street lightening, and stormwater drainage and sometimes without connecting to potable water supply or sewer network.

4. There is also little consideration for the provision of public services, green areas, open spaces and parks, both in the planning and the implementation stages.
5. Inadequate provisions of infrastructure for Low-Cost Housing (LCH) which are dedicated to low and middle-income people are referred among other reasons to their high costs, nonexistent of funding and the limited budgets allocated to the housing projects, conflict of responsibilities, lack of coordination and cooperation between the relevant national actors and institutions.
6. There is no clear definition of the main categories of urban infrastructure dedicated to LCH, and main components of these categories are not specified clearly. Moreover the provisions of the essential infrastructure components are obligatory in theory, but in practice, they are not.
7. Absence of clear framework for planning and implementation of infrastructure components, and lack of definite assignment of activities to the related actors and stakeholders.
8. There is no identification of proper methodology, alternative techniques, types and levels for provisions of infrastructure components. There is no adoption or adaptation of best low-cost worldwide practices or unconventional technologies in their provisions.
9. There is no clear or unified definition of minimum limits for design criteria, proper standards, norms and specifications for various infrastructure components that are provided to the LCH. There are no incentives or exemptions dedicated to this kind of housing and its related infrastructure with respect to their construction, operation and maintenance.
10. The nonexistence of strict obligations regarding minimization of the negative environmental effects has also contributed to the poor conditions of infrastructure situation.
11. There are no incentives for the local industry or the private sector to propose, develop or produce innovative local products to replace the conventional high-cost ones.

1.3 RESEARCH GOALS AND OBJECTIVES

The overriding goal of the research is to determine the minimum requirements and sound options for the provisions of basic infrastructure facilities/components to the LCH developments. This is in order to maintain healthier and safer communities in sustainable manner without contributing to significant increase of the total costs of housing. The solutions and methods for providing adequate infrastructure for LCH should be creative, simple, economical and sustainable. The research is expected to answer questions related to the problem issues such as who, what, where, why, when and how. The research specific objectives include the followings:

1. *Defining* the essential components of infrastructure facilities for the LCH, their types, levels, and characteristics.
2. *Selecting and refining* proper standards and norms, adequate levels and appropriate low-cost techniques and technologies and sustainable methods for the basic infrastructure facilities/components to serve LCH.
3. *Specifying* infrastructure requirements and regulations which allow more flexibility and provide incentives for infrastructure provisions for LCH.
4. *Determining* possible alternatives of sustainable financing resources and mechanisms for providing the capital and running costs of the infrastructure facilities/components.

1.4 RESEARCH METHODOLOGY

The research methodology is discussed as follows:

1. Literature review regarding types of housing and definition of infrastructure needed to housing to investigate the national and international researches, approaches, techniques, practices, policies and strategies for providing adequate infrastructure components.
2. Identify the main actors and players for the provision of the infrastructure and their corresponding roles.
3. Conduct interviews with decision makers and formal organizations and institutions to discuss issues relevant to the subject.
4. Investigate local practice in housing and infrastructure sectors and identify the suitable possible alternatives for provisions of infrastructure as a basis for developing the proposed approach.
5. Explore the basic infrastructure components, types and levels and standards in the PNA housing projects.
6. Define the funding sources and options for infrastructure and available suitable management options.
7. Development of an approach for provisions of adequate infrastructure for LCH.
8. Select and refine regulations and standards of infrastructure related to LCH

9. Apply the developed approach to a case study to examine its practicability in the real life.
10. Derive conclusions and propose recommendations.

1.5 RESEARCH ORGANIZATION

The thesis is composed of the following five chapters which cover the research subject as illustrated below:

Chapter One: Introduction

This chapter reviews the research problem and the main goal and specific objectives of the research study.

Chapter Two: Infrastructure for Low-Cost Housing (LCH)

This chapter reviews the main features of adequate housing and low-cost housing. It presents the different characteristics of infrastructure for housing developments and classifies the infrastructure which should be provided for LCH into two categories which are the basic infrastructure components (BICs) and supportive infrastructure components (SICs). Then, it reviews and summarizes different low cost alternatives, options and technologies for each basic infrastructure component and the best worldwide used practices and experiences in this context. Approaches for management and operation and maintenance (O&M) are also presented. Costs and cost-recovery is also discussed.

Chapter Three: Developed Approach for Provisions of Basic Infrastructure Components (BICs) for LCH

This chapter describes the developed approach for sustainable and low-cost provisions of basic infrastructure components (BICs) for LCH in Gaza Strip.

Chapter Four: Application of the Developed Approach to a Case Study

In this chapter, the developed approach is applied on low-cost housing project in Gaza Strip as a case study.

Chapter Five: Conclusions and Recommendations

This chapter derives conclusions and suggests recommendations according to the research results.

CHAPTER TWO

INFRASTRUCTURE FOR LOW-COST HOUSING (LCH)

2.1 BACKGROUNDS

2.1.1 Housing Background

1. Housing crisis: Housing has central importance to everyone's quality of life and health with considerable economic, social, cultural and personal significance. However, large segment of the world's population still lacks shelter and sanitation, particularly in developing countries, which continually face housing challenges and limitations, especially in dealing with the impoverished segments of society. The status of low-income housing delivery in the developing countries is far beyond being satisfactory. The extent of such a problem varies with urban centers but the results are the same: high population densities, sanitation problems, unhealthy living conditions and insecurity of tenure. In order to curb this phenomenon, it is important that governments look for resources to increase the output of low-cost housing (Erguden, 2001; UN-HABITAT, 2002; Gichunge, 2001).

2. Adequate housing: roughly about one-half of the world's population does not enjoy the full spectrum of entitlements necessary for housing to be considered adequate. According to international human rights law, adequate housing must provide more than just four walls and a roof over one's head. It means adequate privacy; adequate space; physical accessibility; adequate security; security of tenure; structural stability and durability; adequate lighting, heating and ventilation; adequate basic infrastructure, such as water-supply, sanitation and waste-management facilities; suitable environmental quality and health-related factors; adequate and accessible location with regard to work and basic facilities, sustainability, and affordability (Enck and Tierney, 2002; UN-HABITAT, 2002; www.cohre.org, 2003).

3. Affordable housing: Affordable housing; contrary to popular perception, is not slum housing or subsidized housing, but it is the housing that the average family can afford. In general, it is housing that requires no more than 30 to 35 percent of the household income, regardless of income level, whilst, more than 64 per cent of the World Bank housing projects put the affordability ratio at 20 to 25 per cent of personal income. In Palestine, the affordability ratio has been estimated in 1996 to be 25 percent of the family income. Usually, the difference between the dwelling cost and the ability of the residents to pay for housing may be met by public subsidy, but not all countries, particularly in the third world, are able to provide such a subsidy for a long period of time (Naser *et al.*, 1996; Ziara *et al.*, 1997; CCRP, 2001).

Hence, the low-cost housing can be defined as the affordable housing for low-income bracket of people. However, low-cost housing does not mean low-quality housing, but it does mean cutting down the costs while keeping good quality and maintaining adequacy.

4. Traditional and cluster designs:

a) Traditional design: the traditional design is followed in new developments which are known as "subdivisions" that are located in more suburban or rural areas of towns and cities as shown in Figure 2-1 and Figure 2-3. The residential zoning ordinances usually encourage such a traditional design by requiring minimum lot sizes, uniform road frontage and lot setbacks, specific road standards, and other standard requirements. In general, the only open space within such developments has been yards between adjoining privately owned-housing lots which contribute to increased loss in open space preservation, environmental protection and farmland areas. Hereafter, a rather new concept in development has become predominant in many communities, which is the cluster or conservation design (Church, 2000).

b) Cluster/ Conservation design/ BMPs neighborhood: 'Cluster development' is defined as grouping of all residential structures of a development on a portion of available land, reserving a significant amount of the site as open space as shown in Figure 2-2 and Figure 2-4. It is therefore named as a conservation design. Cluster development differs from traditional development in several ways such as:

1. Cluster development usually site homes in smaller lots and there is less emphasis on minimum lot size. The emphasis on a 'gross density' (i.e., the total number of homes on a given acreage) requirement independent of the lot size, means that the same allowable number of housing units is built in small portion of the total developed area. Even so, some incentive – based ordinances allow for more density in cluster housing.
2. Sitting more housing buildings more closely to each other in smaller areas contributes to reducing the costs of site development by reducing the road widths, water and sewerage network lengths. This also results in narrower lot frontages, shorter street and utility rows plus the preservation of significant blocks of undeveloped open space (Church, 2000; MPCA, 2000).
3. The open space in the remaining land is shared by all residents of the subdivision and can be used for recreational facilities, plantings or agricultural production. Open space have less impervious surface cover and allows for stormwater infiltration; thus, sometimes it is called best management practices (BMPs) neighborhood. It also allows for placing some common infrastructure facilities, such as stormwater detention ponds or decentralized

treatment facilities. It could be used for small-scale agricultural production which benefit from the harvested rainwater or the treated wastewater.

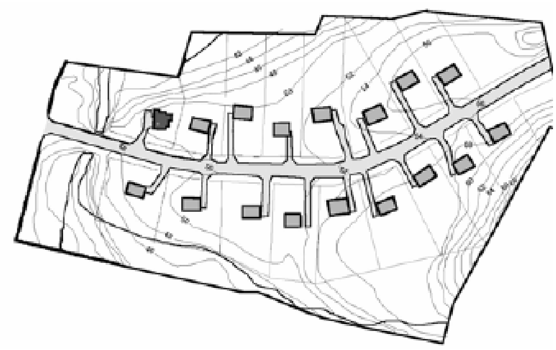


Figure 2-1: Traditional design (Church, 2000).

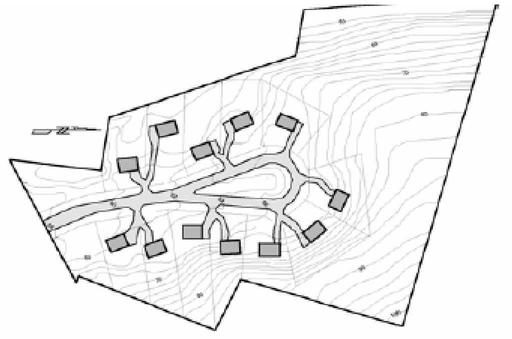


Figure 2-2: Cluster design/BMPs neighborhood (Church, 2000).

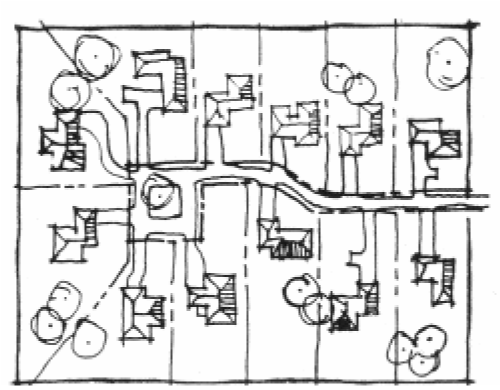


Figure 2-3: Traditional development (MPCA, 2000)

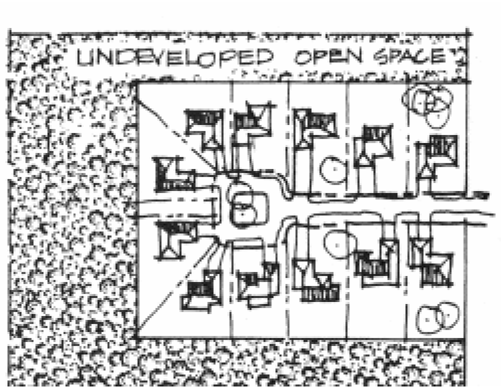


Figure 2-4: Cluster development (MPCA, 2000)

5. Housing current situation: The housing sector in Palestine is among the most vigorous sectors of the economy, and housing investment is the principle choice for most Palestinians who consider that the best investment in their life is paying for home ownership. Yet the housing problem is one of the most important social issues facing Palestinian society, in both its qualitative and quantitative aspects, and the provision of proper housing at affordable price is still the most serious problem (Triulzi, 1996; Ziara *et al*., 1997; Ismail, 1996).

In Palestinian territories, the demand for affordable housing facilities for average and low income groups steadily increasing, taking into account that the house-buyers cannot spend more than 25% of their income on housing, with a high portion of society will not be able to pay this percentage (Ziara *et al*., 1997; Triulzi, 1996). The housing needs in Palestine is challenging and growing up. It has been stated that the total housing needs in Palestine until 2015 would be 385,840 housing units (H.U), from which 86,402 H.Us are accumulated shortage until the end of 2004, and 299,438 H.Us are needed from 2005 until 2015, of which 114,675 in Gaza Strip and 184,763 in West Bank (MPWH, 2005). Tables 1.1, 1.2, 1.3 and 1.4, Appendix 1, present the annual and cumulative needs in West Bank and Gaza Strip.

These figures demonstrates the importance of delivery of low-cost housing, since a large portion of the Palestinian population lives under poverty levels, and hence a high percent of the total housing needs may be low-cost housing for low-income and poor people. The production of low-cost housing definitely necessitates the provision of infrastructure facilities, which should be adequate and of low-cost too.

2.1.2 Infrastructure Background

1. Basic infrastructure defined: UNCHS/Habitat stated that, it is necessary to ensure access to basic infrastructure and services in order to safeguard the health, safety, welfare and improve living environment of all people, and therefore, governments at the appropriate levels, including local authorities should promote the supply of and access to adequate quantities of safe drinking water, adequate sanitation and environmentally sound wastewater management, adequate mobility through access to affordable and physically accessible public transport and other communication facilities, access to markets and retail outlets, the provision of social services, access to community facilities, access to sustainable sources of energy, environmentally sound technologies for the planning and provision and maintenance of infrastructure, including roads, streets, parks and open spaces; a high level of safety and public security; the use of planning mechanisms that reduce negative impacts on biological resources and planning and implementation systems that integrate all the above factors into the design and operation of sustainable human settlements (UN-HABITAT, 2002). Basic infrastructure and services at the community level include the delivery of safe water, sanitation, waste management, transport and communication facilities, energy, green areas and open spaces (Green Infrastructure), health and emergency services, schools, public safety, and social welfare (UN-HABITAT, 2002). Cotton has named the minimum required services for the urban poor to include drainage, water supply, sanitation, access and paving, solid waste management, and power supply and lighting (Cotton and Tayler, 2000).

2. Classification of on-site basic infrastructure: The basic on-site infrastructure components for housing developments are classified to networked and non-networked infrastructure. The networked on-site infrastructure requires supporting infrastructure which is external to the household and neighborhood and classified into "feeder" and "collector" networks. Examples of feeder networks include piped water supply, power supply and telephone lines. Examples of collector networks include sewerage systems. Non-networked infrastructure at the neighborhood and household level can be developed independently of municipal networked services, and include groundwater wells, unsewered sanitation and local drainage to soak pits or ponds (Cotton and Tayler, 2000). There exists a hierarchy in networked infrastructure which consists of primary, secondary, and tertiary infrastructure as illustrated in Figure 2-5**.** The tertiary level of infrastructure depends upon the capacity of secondary and primary networks to feed to and collect from the neighborhood (Cotton and Tayler, 2000).

3. Levels of service: High level of service is unlikely to be sustainable, and success depends upon addressing the key issues of affordability and maintenance. The complex interaction between technical and financial and social factors must be considered. The provisions of high standards of service by implementing agencies are expensive and reflect neither the priorities of the beneficiaries nor their ability to pay. It is more effective to provide only the most basic level of service (primary level infrastructure) at the outset, which can subsequently be upgraded (Cotton and Franceys, 2002).

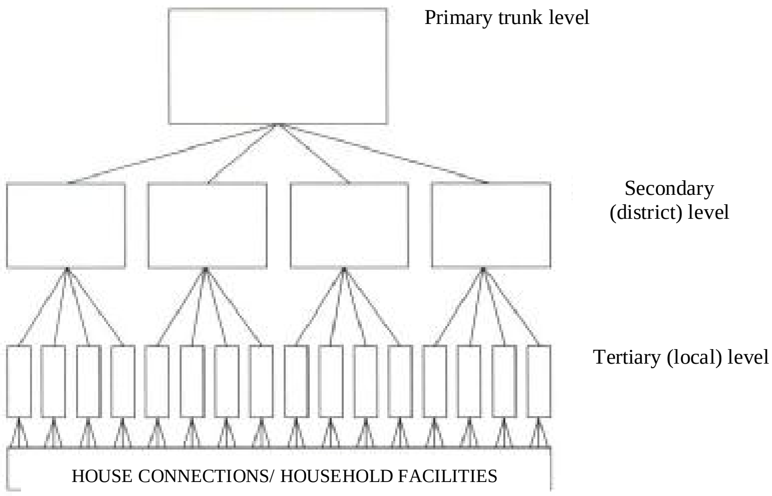


Figure 2-5: Conceptual relationship between primary, secondary and tertiary infrastructure (Cotton and Tayler, 2000)

4. Stakeholders of infrastructure: local and state authorities have the primary responsibility to provide or enable delivery of services, regulated by appropriate legislation and standards. Their capacity to manage, operate and maintain infrastructure and basic services must be supported by central governments (UN-HABITAT, 2002). There are a host of other stakeholders that can participate in service provision and management under the coordination of government at the appropriate levels such as the low-income households, the industrial/commercial/institutional sectors that benefit from public infrastructure, financial institutions, construction firms, the housing development community, the private sector, non-profit organizations, and academia. These stakeholders and their typical roles and responsibilities are summarized in Appendix 2. The governmental Palestinian ministries/authorities that are responsible for the provision of infrastructure may include, but not limited to Palestinian Water Authority (PWA), Environmental Quality Authority (EQA), Ministry of Health (MoH), Ministry of Local Government (MOLG), Ministry of Energy and Natural Resources (MENR), Ministry of Planning (MOP), Ministry of Agriculture (MOA), Gaza Electricity Distribution Company (GEDCo) and Palestinian Telephone Company (PALTEL)

5. Costs of infrastructure: The cost of new infrastructure provisions plays a role in the price of housing and it is one of the cost-influencing factors which typically comprise about 25-30% of the total cost of housing project construction (CCRPC, 2001). However, this percentage is different in governmental housing projects in Palestine. Through an investigation of a number of the executed housing projects by Ministry of Housing (MoH), it has been found that the percentage of infrastructure cost with respect to the total housing development cost is much less and ranges from (4-22%) without considering the land cost; depending on levels, types and number of the provided essential infrastructure components, for multi-story buildings system. This may be referred to that only some of the essential infrastructure components are executed or sometimes partially executed with the highest percentage in case of providing all or most of the essential infrastructure components**.** This percentage has reached about (25%) for some projects which are executed by UNRWA for one and two story buildings only and without considering the land cost. In the other hand, the percentage of infrastructure cost with respect to the total cost of the housing unit has been found in the range (8-9%) for two housing projects of MoH, taking in consideration that the cost of land is included. Finally, it has been concluded that the cost percentage of infrastructure with respect to the cost of the housing unit is not constant and depends on the cost of land (i.e., location) and whether this cost is subsidized (i.e., in case of governmental land) and furthermore, on the level and type of the provided infrastructure.

Financing and facilitating infrastructure to meet basic needs of many urban communities have been difficult for the majority of governments and local authorities, and in general the public authorities have not been able to provide infrastructure to the growing number of urban communities (Erguden, 2001).

There are many factors which could influence the costs of infrastructure and may be considered for lowering their costs. These factors include but not limited to the following:

a) Location: The cost of urban infrastructure depends on location and on the type of land involved. When the costs of infrastructure that are "external" to an affordable housing development such as road construction and bringing in water and sewer lines are added to the cost of housing, they make them unaffordable since large differences in cost per housing unit are usually a result of differences in off-site costs, which are more heavily dependent on location than design (Gichunge, 2001; Naser *et al*., 1996; Knaap *et al*., 2003).

b) Subdivision design: On-site infrastructure costs (e.g., for local streets, sidewalks, sewer, water lines, etc.) vary by subdivision design. Cluster design contributes to reducing the costs of site development by reducing the road widths and lengths, water and sewerage network lengths and linear utility lines (electricity and telephones) lengths (Knaap *et al*., 2003; Church, 2000; MPCA, 2000).

c) Density of housing development: The cost of providing public services such as roads, utilities, schools, emergency services tends to be lower for clustered and denser urban development than for more dispersed, sprawl e.g., the costs of "compact" development as a percent of "sprawl" development is about 75% for roads, 80% for utilities, and 95% for schools. Higher density developments had lower infrastructure costs per housing unit because smaller lots have less total land costs and smaller lot size means more lots and more units per buildable area. Hence, infrastructure charges are spread out over a larger number of units resulting in reduced costs per unit. Furthermore, the adoption of the option of introducing a construction system of one model for multistory buildings will result in the reduction of the cost of the infrastructure that serves several housing buildings (TDM Encyclopedia, 2003; CMHC-SCHL, 2003a; Knaap *et al*., 2003; Ziara, 1999).

d) Type and form of infrastructure provision: The traditional approach of providing infrastructure to new areas through large scale centralized systems is referred to the massive investments in large centralized systems and the lack of appropriate institutional structures for ownership and maintenance for alternative small systems. Recently, there is a great focus on the benefits of adopting on-site infrastructure dealing with energy and water supply, solid and liquid waste management, surface drainage, communication and access. The benefits of clustering on-site systems among small groups of buildings rather than using large centralized municipal systems for both dense urban areas and suburban development has been demonstrated. Cluster and compact designs require small on-site infrastructure systems. The smaller systems are more efficient both operationally and in terms of land use (i.e., consuming small area of land), easier to integrate with complimentary urban systems, responsive to changes in population and more easily upgraded to benefit from improved technologies. On-site infrastructure costs can be off-loaded to developers, reducing municipal expense and creating incentives for more efficient design and load management (Towns, 2000).

e) Standards and Regulations of Infrastructure: the provisions of infrastructure are usually very costly due to the high standards conventional engineering techniques and designs which are copied from the rich, developed western countries such as the American and British standards and codes. Infrastructure standards and regulations associated with the delivery of low-cost housing should be made relevant to the effective demands and incomes of the low income people. This may be done by changing engineering standards relating to road widths, curbs, boulevards, storm drainage systems, sanitary drainage systems, water distribution systems, linear utilities (electric and telephone), above ground utility installations such as electrical transformers and streetlights (The World Bank Group, 2001; CMHC-SCHL, 2003b; CCRPC, 2001; www.floridacommunitydevelopment.org/, 2003). Allowing for the reduction of infrastructure standards to the safe allowable minimums would help offset costs for senior housing projects, and would help offset costs and financial participation in the construction of infrastructure as a method of "additional incentive" (Erguden, 2001; CHULAVISTA, 2003).

2.1.3 Sustainable Development

Traditional indicators of a sustainable community are environmental, social, and economic health. The degree to which community achieves sustainability is directly related to the extent to which the values underlying these indicators are satisfied and overlapped to achieve the goal of sustainable development, which is to maximize the overlap among the environmental, economic and social values, Figure 2-6. The stakeholders should manage to achieve a sustainable future by integrating the concepts and principles of sustainable development, into their decision-making process in order to produce and deliver sustainable communities (FEMA, 2000).

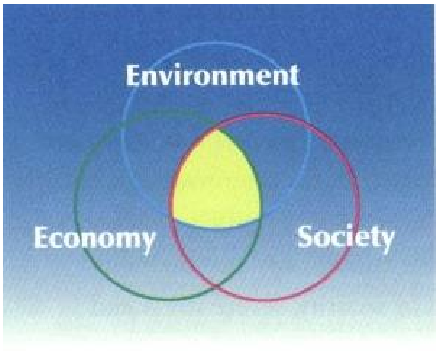


Figure 2-6: Sustainable development goal (FEMA, 2000)

2.1.4 Concluded Remarks

1. Low-cost housing (LCH) is the affordable housing for the low-income people. Low-cost housing is not low-quality housing, but it is housing that have the characteristics of adequate housing while trying cutting down its costs.

2. There is a shortage in the delivery of LCH in Gaza Strip in particular and in Palestine in general which necessitates exploring methods for reducing the final cost of housing to provide incentives for their production and in order to be available for the target population bracket.

3. Lowering the costs of the housing requires among other measures lowering the costs of infrastructure provisions but in such a way which does not compromise or substitute adequacy or quality.

4. It is difficult and unrealistic to define the exact percentage of infrastructure costs with respect to the total costs of housing; as this percentage could differ from one housing development to another according to the levels, types and systems of the provided

infrastructure which differ according to the site specific situation, and according to the cost of land and housing building system. Therefore, it is more realistic to concentrate on how to reduce the costs of the individual infrastructure components in relevant to their real costs using conventional practices of high standards and business-as-usual while keeping the adequate provision of the basic level of service for the health of residents and protection of environment.

5. It is essential to distinguish the infrastructure services for the housing projects into specific categories to distinguish between the basic components for the life being and the other supportive ones.

6. Lowering the costs of infrastructure provisions can be achieved by considering all the cost-influencing factors to minimize their effect in raising the costs.

7. Cluster and compact designs help to reduce the costs of infrastructure provisions.

8. The provisions of infrastructure for the housing projects should be done in a sustainable manner so that meeting the needs of the present population without compromising the ability of future generations to meet their own needs.

2.2 DETERMINATION OF CATEGORIES AND COMPONENTS OF INFRASTRUCTURE FOR LCH

2.2.1 Introduction

Based on the above mentioned review and discussion about the essential infrastructure required for adequate housing and good quality of life for the residents, it is proposed that urban infrastructure for LCH developments to be classified into two main categories, which are:

1. Basic Infrastructure Components (BICs)
2. Supportive Infrastructure Components (SICs)

2.2.1.1 Basic Infrastructure Components (BICs)

The basic infrastructure components (BICs) for are defined as the essential infrastructure components which are considered as a basic requirement for the basic life, health, safety and security of people. Thus, their provisions should be ensured concurrently with construction of the LCH without delay and their costs are usually added to the costs of housing. Their provision is the responsibility of the housing institution (owner/developer) in cooperation and coordination with the relevant national ministries and authorities. The basic infrastructure components (BICs) are determined as follows:

1- Water supply is the vital infrastructure component for LCH, since nobody can live without water for drinking, food preparation and personal and domestic hygiene. The drinking water is considered as the first daily food. Therefore water supply is considered the basic infrastructure component number one **(BIC-1),** and referred to as feeder networked infrastructure.

2- It is essential to promote access to good sanitation facilities in LCH. Underinvestment in sewerage relative to water supply has negative impacts on human health and environment and would lead to harmful contamination of water resources and to exacerbate flooding. Sewerage system is necessary to drain and dispose wastewater (sewage) safely in LCH. Sewerage system is the key element of urban infrastructure, and it is essential for the improvement of the urban environment as well as the preservation of water resources by safe drainage and disposal of wastewater. Therefore, wastewater collection (sewerage system) is an essential component for health of people, protection of environment and prevention of pollution. Hence, it is considered the basic infrastructure component number two **(BIC-2),** and is referred to as collector networked infrastructure.

3- Adequate treatment and safe disposal or reuse of the collected wastewater is very important for the public health, the protection of environment and the receiving waters or soil. This usually done in central municipal treatment plants or in decentralized treatment systems. The treated water should be at specific standards that complies with the disposal place or the specific usage and should be considered as a potential water resource. Thus the treatment of the wastewater is considered the basic component number three **(BIC-3).**

4- Power supply is a basic component nowadays for every household even in LCH, and it is very difficult to live in secure and safe conditions without street and security lighting. There is no house without many kinds of electrical devices which has become an essential requirement for living. The principle benefits of domestic power supply and lighting are largely related to convenience and possibly status. Hence, power supply (electricity) and street lightening is the basic component number four **(BIC-4),** and is referred to as feeder networked infrastructure.

5- Transportation facilities are the basis for smooth movement of people and materials within the urban area including LCH sites, and the roads are the most fundamental of all such facilities. The roads are not merely a means of transportation. They also form a network or a framework for the housing development by securing public space and serving as a conduit for urban infrastructure services. They enable the inhabitants to move freely from their homes to other areas of the site and they allow the movement of people and vehicles from and into the housing location. Access streets and footpaths in LCH are considered as a basic component that takes account of the needs of people, vehicles and services. Their pavement is essential for healthy environment, safety of people and aesthetic appearance of the housing development. Therefore, they are considered as basic infrastructure component number five **(BIC-5),** and is referred to as feeder/collector networked infrastructure.

6- Prevention of stormwater runoff flooding and removal of unwanted water in a controlled and hygiene manner is important to keep the LCH development from flood damages, and to minimize public health hazards, inconvenience to residents and deterioration of other infrastructure such as roads. It is essential to prevent water stagnation in the winter time which would lead to disease-bearing mosquitoes in the standing water; causing negative impacts on environment and residents. Rainwater is becoming a valuable water resource for aquifer recharge and for domestic uses when it is locally harvested. Therefore, stormwater management should be undertaken as a basic infrastructure component number six **(BIC-6)**.

7- Nowadays, telecommunication is becoming necessary with the modernization of the societies. Therefore, telephone lines are important to be provided for LCH for the purpose of telecommunication and information exchange. The free provision of telephone lines by the private telephone companies (i.e. PALTEL Company in Palestine) without any financial burden on the owner/developer facilitates and encourages their provision. Thus, telephone lines are considered as the seventh basic infrastructure component **(BIC-7),** and are referred to as feeder networked infrastructure.

Consequently, it could be stated that BICs for LCH include the following components listed according to their importance for the basic life being of the residents and their necessity to the environmental health of the LCH:

1- BIC-1: Water supply
2- BIC-2: Wastewater collection (sewerage system)
3- BIC-3: Wastewater treatment and reuse or disposal
4- BIC-4: Power supply and security lighting
5- BIC-5: Access and paving
6- BIC-6: Stormwater drainage
7- BIC-7: Telephone lines

2.2.1.2 Supportive Infrastructure Components (SICs)

Supportive infrastructure components (SICs) include all the services which are considered as supportive for the lives of the residents, but not essential for the basic well-being. The existence of supportive infrastructure services within the boundary of the LCH saves the money expended on transportation, facilitates the social life of the residents, and improves the environment of the LCH. Thus, they are considered supplementary public facilities. SICs include one or more of the following service facilities:

1- *Parks and green spaces:* the parks and green spaces are necessary for maintenance and improvement of mental and physical health. Parks are places where residents could relax and gain a sense of refreshment. Green spaces are also important for the maintenance and improvement of urban environment, the prevention of pollution, and the provision of buffer zones between communities.

2- *Schools:* it is important to have schools nearby the LCH. They usually include primary and preparatory schools for boys and girls and sometimes they include secondary schools. This encourages the pupils to reach them on foot, saving money of transportation.

3- *Health centre:* a health centre is necessary to be located within the site of LCH for cases of emergencies

4- *A mosque:* it is important to have one mosque in the LCH development to suit the people Islamic traditions and give the visual impact of Moslems' culture and architecture and encourage the people to reach them on foot.

5- *Public market:* it is much recommended to construct a public market with different shops. This introduces job opportunities for some residents who may rent the shops and makes the household to get their needs from the nearby shops by walking without need to travel which would save money of travel.

6- *Public services building:* it is a building for the local municipality/ municipal council or the local committee (LC) of the LCH. It may include also a police office and emergency office for civil defense, in addition to cultural centre for public uses such as public awareness campaigns and others.

The determination of the need to one or more of SICs is made in the planning phase of the LCH and depends on the each housing project specific conditions.

The location and the required area for SICs are defined, by the owner/developer in coordination with the relevant municipalities and ministries such as Ministry of Education (MOE), Ministry of Health (MoH), Ministry of Religion (MoR) and others. However, their architectural and structural design, funding and construction are the responsibility of the pre-mentioned ministries according to their requirements, standards and guidelines. Their implementations are not necessary done concurrently with the construction of the LCH and could be delayed until the needed funds are available and their costs are not added to costs of the housing units of LCH.

This research would focus on the provisions of BICs only, while the provisions of SICs need another individual research work. The following basic infrastructure components will be discussed in order to specify criteria for lowering their cost while ensuring minimum adequacy and in order to review and select the low-cost systems and techniques of minimum acceptable requirements and design standards which could be proposed for their provisions.

2.2.2 Component 1: Water Supply and Distribution

2.2.2.1 Importance and level of service

Water supply is the vital and basic source of life and no body can live without water. The people need water principally for drinking, cooking, bathing and laundry whereas the quantity of water has the most significant effect on health (Cotton and Tayler, 2000).

The level of service provided to a community is defined in terms of (1) the quantity of water supplied per person per day, (2) the quality of water supplied, (3) the continuity and pressure at which water is delivered in a piped system, and (4) the number and location of water supply points. Therefore, these issues are to be determined from the following sections.

2.2.2.2 Water Quantity

1. Domestic demands:

a) Adequate water provision: Adequate provision of water in urban areas in high-income countries is considered as water that can be safely drunk piped into each home, distributed by internal plumbing to toilets, bathrooms and kitchens, and available 24 hours a day. However, it is unrealistic to set this standard in most low-income nations, since, with limited resources and a limited institutional capacity, getting better provision for everyone is more important than getting very good provision for the minority (UNHBITAT, 2003).

b) Basic water supply: it means the minimum standard of water supply services necessary for the reliable supply of a sufficient quantity and quality of water to households to support life and personal hygiene (WSA, 2003). The availability of sufficient quantity of water for bathing and laundry is of great importance, whereas the quality of this water is not especially important (Cotton and Tayler, 2000). The basic and maximum domestic water quantities according to different standards are summarized in Table 2-1

c) Water demands in Gaza Strip: The average consumption per capita in the Gaza strip was *80 l/c/d* for the year 2003. Other estimates say that municipal and industrial (M&I) consumption rates per capita were *90 l/c/d* in the Gaza governorates for 2002 and 2003 and is planned to be provided at (150 *l/c/d)* on 2020. Each person on an average need (3 l/c/d) of drinking water quality. Per capita water use of households with piped supply is relatively high in Gaza Strip with respect to the intermittent nature of municipal water supply as households routinely store water in tanks (PWA, 2004a; Saghir *et al*., 2000; ES, 2003).

2. Fire protection demands:

The amount of fire fighting water and the number of hydrants increases as the population increases and the rate of fire flow is typically dependent on the land use and varies by community. The needed fire flow of (5m^3/min and 10m^3/min) for (5 and 10 hrs) durations is needed for small areas of less than 2500 population and large areas of larger population respectively (Ziara, 2002). In multifamily residential, the fire flow requirements are in the range (5.7-11.4 m^3/min) (Mays, 2000). In residential districts the required flow ranges from a minimum of (1.9 m^3/min) to a maximum of (9.5 m^3/min) with fire flow duration ranges from (4- 10 hrs) for fire flows from (<3.8 to > 8.5 m^3/min) (McGhee, 1991). However, in most low-income areas, required fire flow of (15 *l/s*=0.9 m^3/min) at a residual pressure head of 4 meters is sufficient where separate allowance for fire fighting demands is not required and any fire hydrants should be on primary and secondary mains ideally of 150mm diameter and over (Cotton and Tayler, 2000).

Table 2-1: Basic and maximum needs of water supply

Standards	Basic/minimum water needs	Maximum water needs
UN-HABITAT standards	50 l/c/d (is adequate for effective control of water-washed diseases)	100 l/c/d (consumption in excess of this value is not necessary for reasons of either health or user-convenience)
WHO standards	100 l/c/d (for small urban communities)	150 l/c/d (for large urban communities)
Cotton, 2000	100 *l/c/d* for house connections for continuous supply and less for limited periods of supply, and 40 *l/c/d* for poor areas	N.A.

Source: UNHABITAT, 1989; Cotton and Tayler, 2000

2.2.2.3 Water Quality

For the past few years, water quality in Gaza Strip has been deteriorating. Groundwater, particularly, the only source of freshwater in Gaza Strip, is being contaminated with Nitrate (NO_3), Chloride (Cl^-). High salinity due to high levels of chloride and high nitrate concentrations in the aquifer makes most of the groundwater wells not suitable for drinking and cause a great threat on the population health (PWA, 1998). As a contingency plan, PWA came up with new relaxed values to compare readings to until reaching the WHO standards in 2015 which are referred to as PWA standards for drinking water quality and they are shown in Table 3.1 in Appendix 3. PWA limits for Cl- and NO_3 are (600 *mg/l*) and (70 *mg/l*) while

WHO and PSI limits are (250 *mg/l*) and (50 *mg/l*) respectively (PWA, 2004a; PWA, 2004c; ES, 2003; Saghir *et al*., 2000; PWA, 2003).

2.2.2.4 Pressure

In the design of the water distribution network, it is necessary to ensure that the water can reach each building with minimum pressure of (2-2.5 bar/20-25m) at house connection during maximum day but not exceed (5.5 bar/55m) and pressure of (1.5 bar/15m) at tap (PWA, 2004). The supply can be assumed adequate if the pressure head in the main is at least (1 bar/10 m) above the highest point in the area to be served and (0.5 bar/5m) at tap (Cotton and Tayler, 2000). Pressures in the range of (1.5-3 bar/15-30m) are adequate for normal use and may be used for fire supply in small towns (McGhee, 1991). The fire flows commonly requires a minimum of (1.4 bar/13.8m) at the connecting fire hydrant (Mays, 2000)

2.2.2.5 Accessibility and Reliability

Accessibility: is the improved access to and reliability of the water supply is of particular benefit in terms of time saved and the potential benefits for the family through improved hygiene.

Reliability: the water rationing by limiting the time for which water is supplied into the water distribution systems is used by the water authorities, hence, the water supply is unreliable, and it is important to investigate the use of multiple sources through combination of many water resources. Most households store water in elevated tanks, both for convenience and in order to maintain the availability of water if the mains supply is unreliable. Storage of water in the municipal water tanks is also another way for ensuring reliable supply (Cotton and Tayler, 2000).

2.2.2.6 Main Sources of Domestic Water Supply in Gaza Strip

At present, the sole drinking water source in Palestine is the groundwater, although, it is reported that 70% of aquifer is brackish or saline and only 20% is fresh with chloride less than 500 mg/l (AL-Saed, 2005; PWA, 2003). It is worth to mention that, in Gaza Strip, there is significant amount of desalinated brackish water from the brackish groundwater wells and brackish beach wells which contribute in water supply and it is produced by some municipal and private desalinated plants.

2.2.2.7 Supplementary Sources of Water Supply

This growing gap between water demand and water supply in Gaza Strip is calling for the utilization of any additional conventional and non-conventional water. There are opportunities at the LCH project level for utilizing additional water sources at low cost and effective manner to save the costs of municipal water supply and reduce the used amounts of fresh water for non-potable uses in addition to recharging the aquifer to improve its quality. These supplementary sources are:

1. Rain water harvesting: Rainwater collection is potential source in Gaza Strip. The quantity of rainwater can be used for irrigation and/or for recharging the aquifer (PWA, 1998). This technique could be used for LCH instead of disposing the rainwater into stormwater sewer lines.

2. Rooftop rain water harvesting* (RRWH)*: Rooftop Rain Water Harvesting is the technique through which rain water is captured from the roof catchments and stored in reservoirs to make water available for future use or recharged into aquifer through recharging wells. Such water generally is of higher quality than most traditional, and many of improved, water sources found in the developing world. The total quantity of collected water is calculated using the following formula, with an average collection efficiency of 80%:

Total quantity of collected water (*l*/ yr) = 80% x Roof Top Area (m^2) x Average Rainfall (mm/yr)

This technique is considered as low-cost technique (i.e., if it is considered in the design stages of the housing buildings) compared to its benefits and can be used for LCH developments to make use of valuable rainwater collected from the rooftops instead of leaving it to flow into sewerage system or into streets causing flooding and pollution and to be polluted by mixing with wastewater and other pollutants in the streets (CGWA, 2000; DTP, 2003; Kumar, 2004; DTU, 2003).

3. Wastewater treatment and reuse: Wastewater in the Middle East region is widely recognized as a significant, growing and reliable water source, since its production is the only potential water source which will increase as the population grows and the demand on fresh water increases. This is referable to possibility of using the treated wastewater in agriculture or recharging it for aquifer recovery, and opportunities are often located within or near the generating community for landscaping and/or agriculture. However, treated wastewater is currently being reused only to a limited extent because of little incentive to use reclaimed wastewater (Bakir, 2001; Saghir *et al.,* 2000; PWA, 1998). The gray water effluent from showers and laundries contain no biological wastes and therefore can be reused for irrigation, fire protection, or even for the flushing of toilets after minimal treatment. The needed separated system for this purpose has a small price compared to the useful generated water in the water-short areas (Rainers, 1990).

4. Water Conservation: In Palestine, the need for water conservation is very great, since it is essentially a means through which efficient use can be made of existing supplies; e.g. doing the same with less, by using water more efficiently or reducing where appropriate. The wide range of water efficiency initiatives currently being undertaken can be grouped under four principal categories which are listed below (UN-HABITAT, 1989; CANADA, 2002; www.local.gov.za/, 2003):

a) Structural methods: water savings resulting from the installation of selected flow-control devices is shown in Table 5.1, Appendix 5, and ranges from (38.3-59) percent with no effect on lifestyle. Metering is used also to conserve water, since it places a financial constraint on consumers to reduce consumption. Outdoors conservation methods include utilizing a low-maintenance landscape which requires very little water such as selection of native grasses, shrubs and trees; reducing evaporative losses; use of treated water or rain water; improvements to soils; and a proper irrigation system such as drip irrigation systems (UNHABITAT, 1989; CANADA, 2002; Solomon, 1998; www.local.gov.za/, 2003; Crites, 1998).

b) Operational methods include unaccounted-for water (UFW); which could be reduced by checking the accuracy of domestic meters, leakage detection and repair and pressure reduction so that line pressures should range between 1.33-4 bars (UN-HABITAT, 1989).

c) Financial methods include water tariff structure with allowing "social tariff' that prices the first block of consumption which corresponds to basic needs, very cheaply; thereafter, each block of consumption should become progressively more expensive (UNHABITAT, 1989).

d) Socio-political methods include legislation such as modification of building (or plumbing) codes, water-use restrictions and public education, availability of water-saving plumbing fixtures, charges, by-laws and regulations (UN-HABITAT, 1989).

2.2.2.8 Water Distribution

1. Methods of water distribution: The water may be distributed by (1) gravity; when the source of water is located in high ground with respect to the buildings where the water flows by gravity, while the water flow in pipes is under pressure and it is the lowest cost distribution system, (2) direct pumping into network, which requires the use of many pumps with different capacities and high qualified staff to control the supply process where the water pressure in pipes is directly influenced with the level of consumption, and (3) pumping with storage; where pumping is selected to supply average demand and in case of low demand the water is pumped into water tanks whereas in case of high demand or in case of fire, pumping is ontinuing in addition to the use of the stored water (Ziara, 2002). The third option, e.g., "pump with storage floating on the system" is the most economical system because smaller and less costly pump is needed, operating cost is less as the pump is always operated at its best efficiency and it is more reliable system in case of power outage.

2. Elements of water distribution works: The physical water distribution components must be provided at the least cost while ensuring efficiency and effectiveness. They consist of off-site and on-site physical infrastructure elements:

a) Off-site physical infrastructure elements: They are located outside the boundary of the housing project and include the water mains that connect the primary water line of the housing development with the nearest municipal water main with the associated valves and manholes and municipal ground or elevated water tanks.

b) On-site physical infrastructure elements: They are the physical elements which lie inside the housing project boundary and may include municipal water wells, public water storage tanks, private/building water storage tanks, pipes, pumps, valves, fire fighting hydrants, landscape irrigation network and rooftop rainwater harvesting system. Polyvinyl chloride (PVC) pipes are the most commonly used plastic pipe for municipal water distribution systems because of its resistance to corrosion, its light weight, its ease of installation and its smoother interior surface (Mays,2000).

2.2.2.9 Suitable requirements of water supply for LCH

1. Suitable domestic water quantity and fire flow for LCH:

- the minimum acceptable water quantity to be provided for LCH is the quantity needed to support life and personal hygiene and necessary for control of water-washed diseases, is proposed to be (100 *l/c/d*). This quantity is not necessary to be of drinking quality as the common case in Gaza Strip but at sufficient quality which is not danger to the residents' health. The quantity of (3 *l/c/d)* with drinking quality could be provided through other sources such as desalinated water.

- the fire flow quantity is proposed to be of the range of (2-5 m^3/min) with flow duration of (2-5 hrs) for small areas of less than 2500 population, and of the range of (9.5-10 m^3/min) with flow duration of (10 hr) for large areas of larger population. The fire hydrants are to be located on the primary or secondary mains without the need for separate allowances.

2. Suitable quality of drinking water for LCH: it is important to ensure at the least the quality of drinking water to save the public health which would cost a lot of money in the future to deal with the resulted diseases. Thus, if the supplied domestic water quality complies with

PWA limits, no separate source for potable water is needed. Otherwise, arrangements between the owner/developer and the PWA should be done to provide desalinated water for (drinking and cooking) through desalinated water shops or by tankers since it is not realistic and very costly to ensure the supply of all domestic water quantities at the drinking quality.

3. Suitable pressures for LCH: minimum pressure head of (1 bar/10m) should be maintained in the water main above the highest point in the area, with an additional (3m) is to be allowed for each floor to which the water has to be supplied. Minimum pressure head of (0.5 bar/5m) should be ensured at tap. These pressures is easier and cheaper to be provided when public water tank is provided at the site, or by using roof water tanks to store water. Pressure head of (1.4/14m) at fire hydrants should be ensured.

4. Suitable water accessibility and reliability for LCH: the water supply should be made accessible for each household through piped system into each housing unit, distributed by internal plumbing to toilets, bathrooms and kitchens, and available 24 hours a day. The reliability of the water supply all the day is to made either by providing ground and roof water tanks for each building if the water is supplied from the municipal water network which is usually unreliable or by providing public water tank for the specific project if the water is supplied from on-site water well/s as for large-scale housing projects with water demands that exceed the capacity of the nearby municipal water main. This would be done in cooperation and coordination with the PWA.

5. Suitable main water source for LCH: the main water supply source for the LCH is connecting to the municipal water main near the specific project as long as it has the adequate capacity for the needed demand. Otherwise, the construction of new ground water well/s may be decided by the PWA/ municipality for the new LCH project to provide the needed demand.

6. Suitable supplementary water sources for LCH: the rainwater collection and rooftop rainwater harvesting (RRWH) are adequate methods which could be implemented at low-cost if considered from the design phase, for augmentation of water supply sources at the vicinity of the LCH project and are to be used instead of using costly stormwater sewers or discharging the stormwater into the sewerage system. Wastewater treatment and reuse is a valuable water supply source in case of using on-site wastewater collection and treatment to replace the valuable fresh water for non-potable outdoor uses such as agricultural and landscape irrigation. Grey water separation and treatment and reuse are also encouraged to be used in special situations of LCH projects where it needs minimal treatment before use in indoor and outdoor uses. Structural water conservation measures should be used for LCH to reduce the needed amounts of water demand.

7. Suitable low-cost water distribution elements for LCH: when the LCH project is connected to municipal water main, it is cheaper to use storage of water for reliable supply in ground and roof water tanks at the building level. If the water supply is to be provided by new groundwater well/s at the site, it is more economical to use the system of pumping with storage in public water tank, either ground or elevated according to the site specific conditions instead of the buildings individual tanks with their individual pumps. Low-cost PVC pipes are to be used for distributions system. Minimal number of valves and fire hydrants are also should be provided to reduce the costs of provisions.

2.2.3 Component 2: Sewerage System

2.2.3.1 Background

Sanitation services mean the collection, removal, disposal or purification of human excreta, domestic wastewater, and sewage. The necessary social, institutional, financial and administrative arrangements must be in place to achieve the principles and practices of adequate sanitation services (WSA, 2003). Good sanitation is aesthetically desirable, and has important health implications. In communities which lack sanitation, most disease transmission occurs in the heavily contaminated neighborhood environment independently of household levels of hygiene (Cotton and Tayler, 2000).

Sewerage system provides a means of removal of both excreta and sullage, which together are referred as sewage. The sewers should deliver the sewage to a sewage treatment facility where suitable treatment processes render it safe for disposal into the sea. Thus, the sewerage system removes the sewage from one place and transfers it to another without safely dispose of or treat the excreta (Cotton and Tayler, 2000).

Wastewater collection and treatment in Gaza Strip is one of extreme fragmentation and about 60% of the urban and rural areas are not connected with sewerage system and on-site treatment systems such as septic tanks and cesspits are used to treat human excreta. As a result, it has been seen that the environmental damage has occurred and even greater damages are forthcoming as a result of the doubling of population in Gaza Strip (Afifi, 2003).

2.2.3.2 Sustainable Sewerage

Planning and designing of wastewater collection and treatment systems has to move beyond a focus on infrastructure provision which considers only high levels of service, and the conventional technological solutions which needs a lot of money must be changed. The full range of technical options which meet the minimum requirements in terms of cost, sturdiness, health benefits and environmental impact should be explored for the provisions of sewerage system (WSA, 2003).

The sewerage system option should be sustainable. Sustainable sewerage is interpreted in two ways. *First* it is taken to mean *'replicable'* in that the scheme can be copied in other surrounding communities; which requires that the approach is technically suitable, socially acceptable, and affordable by the recipient communities in order to be able to continue with the new scheme. *Secondly*, it means *'maintainable'*, e.g., schemes cannot be operated and maintained over an extended period unless the responsible organization is adequately funded, has sufficient numbers of well-trained and well motivated staff, and is supplied with appropriate and well-maintained equipment (IWWT, 2003a).

2.2.3.3 Technologies of Sewerage Systems

A variety of collection system materials and design methodologies are now available to convey the wastewater from the point of production to the point of treatment (IWWT, 2003b). They range from on-plot sanitation systems in which safe disposal of excreta takes place on or near the housing plot such as cesspits and septic tanks to off-site sanitation systems in which excreta are collected from individual houses and carried away to be disposed of through the sewerage system, and from high-cost conventional sewerage to low-cost unconventional sewerage technologies, and from conventional gravity sewers to pressure sewers and vacuum sewers (Mara, 1998). The most common used technologies for the housing developments are classified in Table 2-2.

Table 2-2: Classification of sewerage systems

Conventional sewerage systems		Un-Conventional low-cost sewerage systems	
On-plot sewerage	**Off-plot sewerage *(Centralized)***	**On-site sewerage *(Decentralized)***	**Off-site sewerage *(Centralized)***
1- Individual Cesspits 2- individual Septic tanks with percolation pits	- It is the conventional networked sewerage system which is connected to a centralized off-site treatment plant.	- They include: 1- Settled sewerage/ Small Diameter Gravity Sewers (SDGS) 2- Simplified sewerage - These systems are connected to decentralized on-site treatment facility.	- They include: 1- Simplified sewerage - These systems are connected to centralized off-site treatment plant

Source: developed by the researcher, adapted from (Mara, 1998)

1. Conventional sewerage systems: they include the following types:

a) On-plot sewerage system: They include the septic tanks with percolation pits and cesspits and they rely on the soil characteristics to filter out contaminants from wastewater and treat sludge off-site. If site conditions are less than ideal; groundwater and/or surface water contamination is virtually guaranteed, and treatment of this contamination is non-existent. A large area of land is normally required because septic tank effluent only infiltrates very slowly and thus the land required for soakage pits is greater than for the septic tank and usually there is unlikely sufficient space for a soakaway in congested urban areas (Cotton and Tayler, 2000).

b) Off-plot conventional sewerage systems: Conventional sewerage system is a relatively expensive sanitation option which requires a reliable piped water supply and is concerned with safe disposal of human excreta. The concept of conventional `self cleansing' sewers, were developed more than a century ago and they impetus to the development and implementation of what is called: Centralized Wastewater Treatment infrastructure **(CWT)**. The main type of this system is the "separate system" which is designed to carry foul flows only (i.e. flows from toilet, kitchen and bathroom areas) whereas the "combined systems" which is designed to carry both foul and storm flows has been mostly eliminated (Cotton and Tayler, 2000). Sewage flows by gravity. Pipes of minimum diameter of (200mm) according to American standards, and (150mm) according to France and united kingdom standards are pitched in a downward direction at a rate of (0.5-2%) at minimum depth of (0.5 m), but always steeply enough to maintain a minimum self-cleansing velocity of (0.6 m/s) and a maximum of (3 m/s). The conventional sewerage is composed of branched hierarchy which includes tertiary sewers that discharges to secondary sewers which then discharges to primary or trunk sewers. Costly manholes are usually used and they contribute significantly to the high costs of sewerage system. The conventional sewerage is considered as a highly resource-inefficient technology due to its high capital cost and continuing significant operation and maintenance costs (Brace, 1995; Otis *et al*., 1996; ASCE, 1982; Van Lier *et al.*, 2003; Christ and Huber, 2004; Rainer, 1990; IWWT, 2003b).

Therefore, there was an impressive need to simplified low-cost sewerage systems for the developing countries to substitute the above mentioned expensive systems. This has been actually explored and resulted to what is called low-cost systems.

2. Low-Cost sewerage systems: Attempts at developing lower-cost alternatives usually focus on elements in sewerage systems that most influence costs, such as the average diameter and depth of sewers, average slope relative to ground topography, the number and depths of manholes, and other factors such as total sewer length, population density, set up costs, and excavation in rock. The resulting range of technological options is collectively known as intermediate-cost or low-cost sewerage. The two types are (1) the settled sewerage which arise from changes in technology and (2) the simplified sewerage which is based on changes in design standards and guidelines (Bakalin *et al*., 1994).

a) Settled sewerage (SDGS): In this system, sewage from one or more households is discharged into some form of settling/interceptor tank for removal of floating and suspended solids, which then overflows into shallow, small diameter collector sewers; thus it is known as small-diameter gravity sewers (SDGS). The system is schematically presented in Figure 2-7. Settled sewerage does not need to be designed for the "self-cleansing velocity" since the solids are removed in the interceptor tank which permits flatter gradients and shallower depths for the small-diameter light weight plastic sewer pipes (25-50mm) and the manholes are replaced by clean out ports. The savings in construction costs of settled sewerage compared to the conventional system have been reported to be in the range of 20-50 percent in general and 40 percent in Palestine (Mara, 1996; Bruijne, 2000).

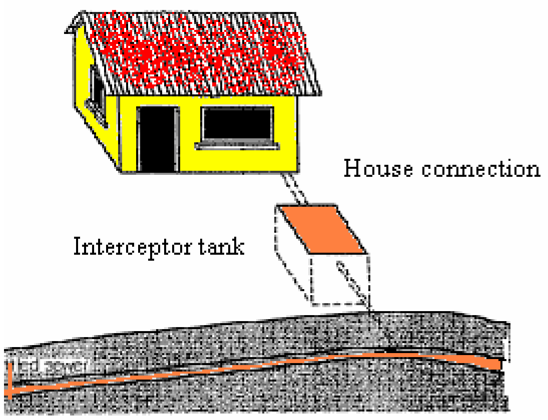


Figure 2-7: SDGS system (Mara, 1998)

b) Simplified sewerage: The most extensive changes in design standards was based on minimum tractive tension, rather than minimum self-cleansing velocity and have resulted in a system called *"simplified sewerage"* which is applicable in the high-density peri-urban tropics and medium and high-density areas in industrialized countries, and they have contributed to cost savings that are achieved from the use of shallower depths, smaller pipe diameters, flatter gradients and fewer appurtenances, etc. without jeopardizing the reliability and safety of the system. It was shown that savings of up to 23% was achievable in Egypt, and up to 50% in Colombia. Summery of characteristics, advantages, and limitations of settled and simplified sewerage is illustrated in Table 6.3, Appendix 6 (Mara and Guimaraes, 1999; Mara, 1996; www.idfc.com, 2003).

c) Grey water separation: grey water separation systems are low cost and sustainable sewerage systems especially in rural and peri-urban areas. Gray water is the collected water from showers, bathrooms and kitchen sinks and contains no pathogens from toilet. The grey water is collected separately through pipelines into septic tank for post treatment where the black water from toilet are allowed to be collected in cesspits.

2.2.3.4 Concluded Remarks

1. Basic sanitation services should be ensured for LCH for safe, hygiene, and adequate collection, removal, disposal or purification of human excreta, domestic wastewater and

sewage. This is to be done by the provision of adequate and sustainable sewerage system.

2. The "self-cleansing" criterion for the conventional centralized sewerage system results in high-cost sewerage systems. On-plot sewerage systems such as septic tank with percolation pits and the cesspits are not sustainable and are not suitable for high density areas due to the large areas of land they require, in addition to their negative impacts on the groundwater especially for nitrate-sensitive areas.
3. The sewerage system that should be provided for LCH should be sustainable, e.g., replicable and maintainable. Selection of the appropriate sewer system depends on many factors such as the existing nearby system, site specific conditions, the environmental considerations, institutional arrangements and socio-cultural and socioeconomic constraints and the economical and financial cost analysis.
4. Low-cost sewerage should be promoted for the low-cost housing with the different available technologies of settled sewerage and grey water separation system which are suitable for rural and low density housing projects and the simplified sewerage which is suitable for urban and high density areas.

2.2.3.5 Suitable requirements of sewerage system for LCH

The low-cost and sustainable sewerage systems which include the simplified sewerage, the settled sewerage and the grey water separation system are to be used for LCH instead of the expensive conventional ones. The selection of the most suitable one depends on the site specific situation of the LCH project.

2.2.4 Component 3: Wastewater Treatment and Disposal or Reuse

2.2.4.1 Background

Wastewater is the used water discharged from houses to the sewerage (or sewer) system. The proportion of a dwellings water consumption that becomes wastewater would typically vary from about 60-80% (e.g., 60-80 *l/c/d*). Wastewater treatment deserves greater emphasis because of current trends of rapidly increasing urban populations, creating an urgent need for adequate disposal of the liquid wastes from domestic populations and industries (ES, 2003).

Wastewater is about 99.9 % water (by mass) and it is the 0.1% solids which necessitates treatment before discharge to the environment due to the existing of contaminants. The typical constituents of typical residential wastewater are shown in Table 7.1, Appendix 7. The most critical ones, for which the wastewater treatment facilities are designed; are the physical constituent; suspended solids (SS/TSS), the organic chemical constituent; biodegradable organics (BOD), and the biological constituent; pathogenic organisms. Other inorganic chemical constituents such as nitrogen (N) and phosphorus (P) are also of concern and the need for their removal must be considered on a case-to-case basis (Crites and Tchobanoglous, 1998).

In Gaza strip, blocked pipes and flooded manholes are daily events and most of the treatment plants are over loaded and becoming inadequate for dealing with the current huge quantities of wastewater (Nashashibi and Duijl, 1995). Statistics of the Palestinian Ministry of Health show that over 60% of the reported disease cases in Gaza generally are water borne (largely diarrhea and bloody diarrhea); about 10% are related to faeces (DEA, 2005). The wastewater in Palestine is highly concentrated because the domestic water consumption is very low due to the scarcity of water, and the ground water resources in Gaza Strip become more polluted with nitrate concentrations exceeding *100 mg/l* NO_3*-N* resulting from seepage from cesspits and effluent discharges into wadis (Nashashibi and Duijl, 1995; Rainer, 1990).

2.2.4.2 Approaches of Wastewater Treatment

1. Centralized treatment approach: The centralized wastewater treatment (CWT) system involves a central treatment plant in which the collected wastewater is treated in large scale using an activated sludge plant. The treated wastewater is for disposal into surface water body rather than reuse (Ho, 1998; EPA, 2004).

2. Decentralized treatment approaches (DWT): Decentralized wastewater treatment (DWT) system is used to serve clusters of homes, where the collected wastewater transport a short distance from the clusters into a local common treatment and disposal system near the site, and it is relatively simple to operate and maintain than centralized systems. DWT are ecological systems that may provide a cost effective and long term option for meeting public health and water quality goals particularly for peri-urban areas and utilizes a closed-loop/cyclical treatment system which uses organic nutrient cycles from point-of-generation to point-of-production and thus, closes the resource loop and provides an approach for the management of valuable wastewater resources. The DWT system contributes to high environmental quality, high yields in food and fiber, low consumption, good quality, high efficiency production and full utilization of wastes. The financial advantages are due to the lower capital investment, and cheaper operation and maintenance costs. The decentralized management systems may achieve a better distribution of benefits and thus have the potential to be more pro-poor than centralized management (Parkinson and Tayler, 2003; Volkman, 2003). The most common DWT methods are (1) biological treatment and nitrogen removal, (2) land treatment application, (3) intermittent and recirculating packed-bed filters, (4) constructed wetlands and (5) lagoons and are summarized in Table 7.5, Appendix 5 for illustration and most of them require a large area of available land except the first method which include different methods that require less area (Crites and Tchobanoglous, 1998).

2.2.4.3 Importance and Benefits of Wastewater Treatment and Reuse (WWTR)

Especially in densely settled areas, Wastewater treatment and reuse (WWTR) is necessary part of civil infrastructure. Hereafter, the main benefits of wastewater treatment:

- Collecting and treating wastewater reduces the spread of diseases and minimizes pollution of the environment and the groundwater resources. The cost of secondary-level treatment for domestic wastewater in the Middle East is cheaper than developing new drinking water supplies.
- It is a valuable resource that, after appropriate treatment, becomes a commercially realistic alternative for groundwater recharge, agriculture, and urban applications, and preserves high quality and expensive fresh water for potable use.
- Treated wastewater can sometimes be a superior and constant source for agriculture with nitrogen and phosphorous that negates the need for additional fertilizer application and result in higher agricultural yields. Treated effluent had superior non-microbiological chemical characteristics than that in groundwater for irrigation and most importantly had lower salinity levels (Volkman, 2003; World Bank, 2000; Faruqui, 2002; EPA, 2004; Faruqui, 2002).

2.2.4.4 Standards of Wastewater Treatment and Reuse (WWTR)

The Palestinian standards of WWTR in irrigation, sea outfall, infiltration to aquifer, landscaping and other uses has been established and shown in Table 4.1 in Appendix 4, and it is more stringent than WHO standards for the microbiological quality guidelines for reuse in irrigation, since producing treated wastewater to a standard for unrestricted irrigation make it possible to be used for any crop and gives great flexibility to its use in farming systems of present and future, and avoids the need for supervised and regulated use of the treated effluent in agriculture (LEKA, 1999).

Although there is a persistent notion within the region that wastewater reuse is against Islam, wastewater reuse is being practiced with the accordance of religious authorities in Oman, UAE and Saudi Arabia; which states that wastewater reuse is permissible for all purposes, including "wudu", provided that the wastewater is treated to the required level of purity for its intended use and does not result in any adverse public health effect (Faruqui, 2002).

2.2.4.5 Levels and methods of Decentralized Wastewater Treatment (DWT)

The different levels of wastewater treatment in decentralized systems, their description and removal efficiencies for critical constituents are illustrated in Table 7.2, Appendix 7 and include preliminary, primary, advanced primary, secondary, secondary with nutrient removal, tertiary, and advanced treatment. The level of treatment provided is closely related to the purpose for use of the treated effluent and to the cost of treatment level. Usually, instead of using expensive tertiary treatment, certain crops can be irrigated by *the secondary treated wastewater* and will benefit from nutrients (e.g., nitrogen, phosphate) still present in the wastewater (Rainer, 1990). Examples of typical treatment methods based on type/level of treatment for small and decentralized systems are shown in Table 7.3, Appendix 7 and commonly used treatment processes and optional treatment methods based on constituent removal for DWT systems are shown in Table 7.4, Appendix 7 (Crites and Tchobanoglous, 1998).

1. **Biological Treatment Processes and Methods in DWT Systems**

The most common treatment method which provides *secondary treatment level* and takes the least area of land is *the biological treatment* which includes aerobic and anaerobic treatment processes. Detailed classification of aerobic and anaerobic treatment processes are illustrated in **Figures 7.1, 7.2** and **7.3** and summarized in **Table 7.5** in **Appendix 7.**

a) Aerobic wastewater treatment; which includes aerobic suspended-growth processes and aerobic attached-growth processes. The following common treatment methods use the aerobic treatment:

(1) Pre-engineered (package) plants; they are used for individuals and small communities. The most common type of biological treatment package plant for flows in the range of (3.8 to 760 m^3/d) is the extended aeration activated-sludge process under the aerobic suspended-growth processes, which is selected due to excellent effluent quality, the ability to remove nitrogen and phosphorus, relatively low sludge yield, relative simplicity, and relative ease of operation. A properly designed and operated extended-aeration facility could produce an effluent with (BOD and SS levels <30 mg/l) (EPA, 1992; EPA, 2000c; Crites and Tchobanoglous, 1998).

(2) Trickling filters; they use the aerobic attached-growth process. The trickling filter-solids contact (TFSC) process is a relatively innovative approach and is capable of consistently meeting secondary and some advanced secondary treatment standards. Main features for its use in small communities include its simplicity, consistently favorable performance, and low O&M requirements compared to other mechanical treatment alternatives. It is capable of

achieving very high-quality effluent (<20 mg/l BOD and SS) and can be designed to provide nitrification (EPA, 1992).

b) Anaerobic wastewater treatment: it requires less land area and produces a well stabilized sludge in lesser quantities than aerobic treatment. The main advantages of anaerobic digestion treatment are: (1) no, or very low energy demand, (2) low space requirement and low investment costs, (3) production of valuable energy in the form of methane, (4) applicable at small as well as large scale, (5) low production of excess sludge, (6) low nitrogen and phosphorus requirements, (7) high loading capacity (5-10 times that of aerobic treatment), (7) high treatment efficiencies, and (8) valuable fertilizers (ammonium salts) in effluents (Parkinson and Tayler, 2003; Volkman, 2003). Such an integrated system, considering the income from the products generated has the potential to be operated as a viable enterprise generating substantial revenues for waste management (Mahmoud, 2005).

(1) UASB technology: The upflow anaerobic sludge blanket (UASB) reactor is the most popular and applied anaerobic sewage treatment technology which is feasible in an urban, developing world context. Since nitrogen and phosphorus are not effectively reduced, it works well with agriculture or aquaculture. Since the pathogens are not completely removed the wastewater needs a post treatment option to meet discharge standards. In Palestine, UASB followed by waste stabilization ponds has been used. A modified version of the UASB reactor which is the UASB-Digester has been developed to cope with the environmental conditions of Palestine has been used (Mahmoud, 2005; Volkman, 2003; Bruijne, 2000).

(2) The septic tank systems for large flow applications: The septic tank is used to receive the wastewater discharged from individual residences and other un-sewered facilities, and serves as an anaerobic digester and as a sludge storage tank. Large septic tanks have been used to serve clusters of homes as well as small communities. Taking into account the accumulation of scum and sludge and an appropriate peaking factor (PF) of 1.5, the equations in Table 2-3 can be used to estimate the required volumetric capacity of large septic tanks based on pump-out frequencies. It has been stated that the tank volume varies from 3.3 to 6.8 times the average flow corresponding to pump out frequencies of 2 to 5 years, respectively. A single-compartment tank is equal to or exceeds the performance of a two-compartment tank and it is more rationale for the dividing baffle to be longitudinally placed rather than placed across tank. Commonly, septic tanks are followed by a subsurface disposal

Table 2-3: Volumetric capacity of large septic tanks

Pump-out interval (yr)	Volume (m^3)
3	2.8 Q_{avg} x PF
4	3.2 Q_{avg} x PF
5	3.65 Q_{avg} x PF
6	4.0 Q_{avg} x PF

Source: Crites and Tchobanoglous , 1998

system, or a single treatment system (Crites and Tchobanoglous, 1998; EPA, 2000b; EPA, 2000d).

c) Nitrification and denitrification; are two suggested processes that significantly reduce nitrogen levels in wastewater, and may be done by trickling filter (TF) plant or recirculating sand filters (EPA, 2000a, EPA, 2004)

d) Disinfection; is used for the inactivation/destruction of pathogenic organisms to prevent the spread of waterborne diseases to downstream users and the environment, considering that the wastewater is adequately treated prior to disinfection. The disinfection technologies are chlorine disinfection, ultraviolet disinfection (UV), and ozone disinfection with chlorine is the most widely used disinfectant for municipal wastewater (EPA, 1999b).

2. **Subsurface Wastewater Infiltration Systems (SWISs)**

They are subgrade land application systems most commonly applied in un-sewered areas. The filter surface varies from (1) long, narrow filter surfaces *(trenches/ soakage trenches)*, (2) wide filter surfaces *(beds/soakage beds)* and (3) deep filter surfaces *(pits and deep trenches/ soakage wells)* which require less area (EPA, 2000b; SAHC, 1995). It is necessary to calculate the required contact area (CA) of the subsurface disposal system in square meters which depends on the soil texture. Values for effluent percolation rates and application rates of wastewater for different soil textures are shown in Table 7.7, Appendix 7. The septic tank and soil absorption could reduce the two pollution parameters; BOD_5 and TSS, but nitrogen is the most significant wastewater parameter not readily removed by the soil (EPA, 2000b; Crites and Tchobanoglous, 1998).

2.2.4.6 Reuse of Treated Wastewater and Gray water in Decentralized Systems

The reuse applications most suited to decentralized systems are shown in Table 7.8, Appendix 7 and includes among others: agricultural irrigation, landscape irrigation, toilet flushing and groundwater recharge. The treated wastewaters provide essential plant nutrients (nitrogen, phosphorous, and potassium) as well as trace nutrients. Landscape irrigation includes urban area for parks, playgrounds, street medians, and residential lawns. Landscape irrigation of areas with public access generally requires disinfected tertiary effluent (Crites and Tchobanoglous, 1998; Volkman, 2003; EPA, 2004). Grey water reuse is much safer than combined wastewater reuse because grey water from showers, bathrooms and kitchen sinks contains no pathogens from the toilet and has a lower oxygen demand than black water. The treated grey water effluent is used to irrigate eggplants, herbs and olives, thus, helping to offset food purchases and generate income by selling surplus production (Faruqui, 2002).

Some of the experimented techniques for treatment and reuse of grey water in west bank is the septic tank-Upflow Gravel Filter (ST-UGF) plant (www.ansad.net, 2005).

Dual water systems are used when the used treatment system in the site would produce permitted quality of treated wastewater and they consist of non-potable, recycled water distribution pipelines that are parallel to the potable domestic water supply pipelines and the installation of this system is cost-effective especially in the new communities (Volkman, 2003).

2.2.4.7 Groundwater Recharge

The reclaimed water could be stored in the aquifer through the infiltration basins and could be reused by agriculture for unrestricted use of crops through recovery wells, by using soil aquifer treatment (SAT) process (PWA, 2004c). SAT systems are inexpensive, efficient for pathogen removal, and operation is not highly technical. The pretreatment requirements for SAT vary depending on the purpose of groundwater recharge, sources of reclaimed water, recharge methods, and location (Volkman, 2003).

2.2.4.8 Septage and Sludge Treatment and Disposal Alternatives

Septage is the semiliquid material that is pumped out of septic(or interceptor) tanks and consists of the sludge that has settled to the bottom of the septic tank over a period of years, and the liquid and surface scum layer. Sludge is the material that settles out of the mechanical treatment of wastewater in DWT systems. Biosolids is the material that remains after sludge stabilization and have characteristics that can provide environmental benefits through reuse, distribution and land application. Despite the differences between septage, sludge and biosolids, the processes used to dewater and reuse or dispose of these materials are similar, and the processes used for sludge processing and disposal are shown in Table 7.9, Appendix 7 (Crites and Tchobanoglous, 1998). However, the issue is out the scope of this research.

2.2.4.9 Concluded Remarks

1. Adequate treatment of sewage to a suitable level will improve the living quality in Gaza Strip. Many infrastructure choices for wastewater treatment are ranging from centralized to decentralized ones and all options between are available to serve the LCH.
2. In CWT systems, wastewater is treated in a central treatment plant to such standards to be discharged to the sea. However, the conventional CWT is not sustainable since the treated wastewater is for disposal than for reuse and the mechanical treatment requires high chemical and energy costs. The septic tank with percolation pits system is not sustainable

for Gaza strip since it does not remove the nitrogen which exists in high concentrations in wastewater and thus contributes to ground water contamination.

3. Well operated, DWT systems may have less risk and less impact on the environment and frequently is more cost-effective than CWT systems for small and peri-urban communities. They offer the opportunity of reuse of the treated effluent for agricultural production and thus have the potential to be more pro-poor.
4. Compact on site treatment plants such as package plants and trickling filters are of acceptable costs and they produce effluent quality which is suitable for reuse in outdoor uses and agricultural activities. UASB plants are low cost and can provide an improved performance and are recommended in cases of limited available area. Septic tank-Upflow Gravel Filter (UGF) plant is suited for Palestine for grey water treatment in urban and peri-urban areas.
5. Grey water reuse is much safer than combined wastewater, and the treated grey water effluent can be used to irrigate eggplants, herbs and olives, and help to offset food purchases and generate income by selling surplus production.

2.2.4.10 Suitable requirements of wastewater treatment systems for LCH

As long as the LCH project lies near municipal sewerage network which is connected to central treatment plant, the lowest cost method for disposal of the collected wastewater is to connect to the municipal sewerage main to discharge the collected sewage to the existing central treatment plant to be treated. Otherwise, the decentralized wastewater treatment approach is to be used and they are suitable for urban, peri urban and rural areas. The suitable low-cost wastewater treatment methods for LCH include package plants and trickling filters which use the aerobic treatment processes, and UASB technology which uses the anaerobic treatment processes. The septic tank-Upflow Gravel Filter (ST-UGF) plant is of low-cost and sustainable technology for grey water treatment and is to be used when the grey water separation is decided to be used for LCH project. These compact plants need small area of land and produce effluent which is suitable for agricultural irrigation and landscaping saving the water amounts of fresh water supply and they also introduce opportunities for the poor and low-income households to find new jobs and increase their income by selling their crop products irrigated by the treated effluent (www.ansad.net. 2005)

Using treated effluent for domestic uses such as toilet flushing, car washing and fire fighting and other non-potable purposes is not yet accepted in Palestine although it has been accepted at the regional level that it is not against Islam. Further research studies and public awareness should be promoted for its use in non-potable purposes since it is low-cost water source which can substitute the valuable fresh water source.

2.2.5 Component 4: Power Supply and Security Lighting

2.2.5.1 Background

1. Power sources: the power sources that are available and suitable for domestic uses and residential areas include:

a) Electrical power/ Electricity: which has come as important to our every day life as it is essential for domestic uses such as lighting and running the household electrical appliances. Electricity cannot be stored in large quantities and, since demand fluctuates, it is necessary to have sufficient installed generating capacity to meet peak demand. Production (generation), transportation (transmission), transforming, and distribution all require facilities that cannot be shared with other industries (Akatsuka and Yoshida, 1999). The production of electricity depends on basic limited resources such as petroleum and natural gas while the demands are increasing especially in the developing countries. Therefore, more efficient use of energy and diversification of energy sources are necessary (Akatsuka and Yoshida, 1999). Electricity needs are sharply decreased by the use of fluorescent light fixtures in most public areas and each suite, as well as the use of photovoltaic lamps for exterior lighting. These energy efficient products sometimes require a higher initial investment than traditional products, but the longevity of the products chosen and the energy efficiency that they provide outweigh the initial expense (www.cmhc-schl.gc.ca/, 2003).

b) Solar power: Solar power is a thermal energy that is collected from the son. It is a clean, environment-friendly, and low-cost energy source. It is collected actively by the common conversion technology of "flat-plate collectors" which are applied in dispersed manner (i.e., on a building by building basis) for domestic hot water heating in order to save costs of consumed electricity for heating the water (Rainer, 1990). 83% of the households in Israel were using solar collectors by 1994, and as of 1992, over 4.5 million buildings in Japan were using solar hot water systems due to their low cost. The solar radiation could be also converted into electricity through photovoltaics (PV) technology which is commonly used in lighting for buildings (www.repp.org, 2005). This technology has been used in lighting some areas in Gaza Strip such as the Bridge of Wadi Gaza.

c) Petroleum fuels: They include gas, kerosene, diesel and other fuels and used as alternative sources of energy diversion and could be used for many domestic purposes such as cooking and heating to substitute the need to electrical power.

3. Transmission, voltage transforming and distribution of power supply: electricity is supplied reliably to consumers using a network of high-voltage transmission lines, substations (to reduce the voltage), and local distribution facilities (Akatsuka and Yoshida, 1999). The cost of conventional power supply is influenced by the proximity of new area to the main transmission lines (Cotton and Tayler, 2000). Although most of larger cities run their electric power lines underground, there are still a large number of communities that transmit power by means of overhead lines, simply because it is less costly method and to avoid the need for excavation every time a buried pipe must be repaired or modified (Rainer, 1990).

4. Power demand: In designing the distribution system, it is necessary to estimate existing demands, the likely growth in that demand and the likely peak-to-average demand (peak factor). The "after diversity" value of 0.75-1.0 kiloWatt per household (kW/H.H) which allows for the typical nature of the demand patterns of the consumers is suitable for urban poor consumers (Cotton and Tayler, 2000). This is consistent with the average local demands which have been calculated by the researcher upon data gained from Gaza electrical distribution company (GEDCo, 2005).

5. Electricity rates (tariff): Electricity rates are determined from the overall cost taking in consideration the fairness to consumers. They are usually consumption-based rates and are determined per kilowatt of supply capacity and per kilowatt-hour of consumption for each consumer according to the type of service in order to maintain the principle of fairness. Time-based rates are introduced to offer incentives to control demand in peak periods and are beneficial to the low-income (Akatsuka and Yoshida, 1999).

6. Electricity conservation: The two basic reasons for electricity conservation are to conserve scarce resources, such as fossil fuels which some day will be used up, and to avoid (or delay) the need for building new expensive power plants. It is said that conservation is the most economical new capacity. The building which has been designed according to the conservation measures recovers the extra costs resulting from those measures within five years only through savings in electricity and fuel consumption. Energy conservation measures in buildings includes (1) the building orientation, e.g., in Palestine, it should be to the south direction or between (5-20) degrees towards south east or south west, (2) the setback distances between buildings should be adequate so that solar energy could reach all the floors of the buildings, (3) adequate landscaping would save energy in summer and winter by using the suitable trees in the right directions to permit sun rays and works as wind preventer in winter and prevent sun in summer, (4) width to length ratio, e.g., the best shape of the building is the rectangular shape which extends east west, since the south side earns in winter twice the solar energy, (5) shading devices; for windows are horizontal for south walls, vertical for east and west walls and combined in east south and south west walls, (6) day lighting and passive solar heating; the area of glass windows of (20-50%) of building plan area can save energy by about (50-80%) in case of good insulation to building. Large windows save energy and money more than savings in energy consumption and natural lighting is better than electrical lighting in enhancing vision by three to four times, (7) adequate insulation of the building shell; while the price of the extra insulation material should not exceed the savings in energy consumption for heating, cooling and lighting (Rainer, 1990; Majd, 2005), (8) using separate electric meters; for each housing unit conserve energy by making each tenant responsible for his own bill and limit his consumption (Akatsuka and Yoshida, 1999).

7. Technical standards for electric installation and maintenance: Electricity is used in every improper use or a defect can be harmful to people and community and can be a fire hazard. For this reason, the regulations covering the installation of electrical facilities are extremely important and the technical standards for electrical installations are usually determined by the governmental body. The construction of these facilities is directly supervised by the national government and once operation begins, all electrical installations must be maintained by the electric utilities. In Gaza Strip, electricity is provided by GEDCo.

8. Security lighting: security lighting includes street lighting and housing site lighting, and its objective is to promote safety at night by providing quick, accurate and comfortable seeing for drivers and pedestrians, to improve traffic flow at night, and to reduce crimes (Homburger, 1997). The floodlights of the housing project site may be a combination of different lighting options such as pole-mounted lights, building-mounted lights, landscape lights, etc. Some of these lighting options are shown in Figure 8.1, Appendix 8 (RA, 2003). In Gaza Strip, the street lighting is the responsibility of the municipalities, whilst the housing sites lighting is the responsibility of the owner/developer. The lighting theory terminology is shown in Table 8.2, Appendix 8.

2.2.5.2 Suitable requirements of power supply and security lighting for LCH

1. The "after diversity" value of 0.75-1.0 kW/H.H which allows for the typical nature of the demand patterns of the consumers and based on the needs of lighting and running typical household electrical appliances is suitable for household demands of LCH.
2. Diversification of energy sources at the home level and using the solar energy are necessary for lowering the costs of electrical power supply for LCH. Solar energy is to be utilized for LCH through direct solar gain by passive solar building design and by using

flat-plate collectors for water heating. Photovoltaic lamps using PV technology could be used for site lighting since it is economical in the long term although may have high initial cost and more research studies are needed for its use.

3. Primary distribution of electricity is done at high voltage using overhead cables; which is reduced by power transformers to lower voltage required for local distribution. Utilization voltage (L.V) can be distributed by overhead lines or buried cables. The underground cables are more economical for LCH in the long-term, safer and avoid the negative visual impact caused by the overhead cables especially for cluster designs. Their costs also can be lowered by decreasing the lengths of needed installed cables which can be achieved by using cluster design where the housing buildings are adjacent to each other.
4. Energy conservation measures in the buildings designs of the LCH are to be considered in the planning and design of the site planning of the LCH and in the buildings designs and orientation in order to reduce electricity demands and costs of their provision.
5. An adequate level of security lighting is to be provided to the LCH while lowering the capital and operating costs by keeping the illuminance level to a minimum, with minimal physical elements, minimum wattage and electrical consumption.
6. Time-based rates are to be introduced, thus, providing price incentives to move demand a way from peak times, and thus lower the costs for the LCH households and enhance the overall supply service.

2.2.6 Component 5: Access, Paving and Landscaping

2.2.6.1 The Street System and Functions

Streets are the most basic facilities among the urban infrastructure to facilitate transportation of people and goods and they provide apace for many other parts of the infrastructure, such as water and sewer lines, electricity and telephone lines in their right-of-way above or below ground (Japan, 2004; Rainer, 1990). Access routs enable the inhabitants of a site to move freely from their homes to other areas of the site and to major adjoining thoroughfares (Cotton and Tayler, 2000). The relationship between the land used for streets and the land they serve depends on the type and density of development. Low-density detached housing on separate lots requires longer streets than do higher-density attached cluster or multistory housing (Rainer, 1990). However, a balance must be struck between the desirable planning standards which may specify large access widths, thereby taking up valuable land, and the need to adopt small lot sizes and high housing density to cope with the demand of shelter (Cotton and Tayler, 2000).

1. Street Classification: the hierarchy of access consists of the following types and shown in Figure 2-8.

a) Trunk roads; form the perimeter of neighboring residential districts and provide networks between districts where traffic is concentrated.

b) Site access roads (Arterial/Main streets); lead off to the trunk road and are designed to be used to access housing sites in neighboring residential and other districts.

c) Site distributer (Collector streets); they expedite traffic movements within neighborhoods and connects all the housing clusters to the site access road.

d) Cluster access (Local streets); they give access to individual household, and known as residential streets.

e) Connecting footpath (special streets); used to interconnect the clusters. They are designed to be used exclusively by pedestrians and bicycles, excluding other vehicles (Cotton and Tayler, 2000; Homburger *et al*., 2001).

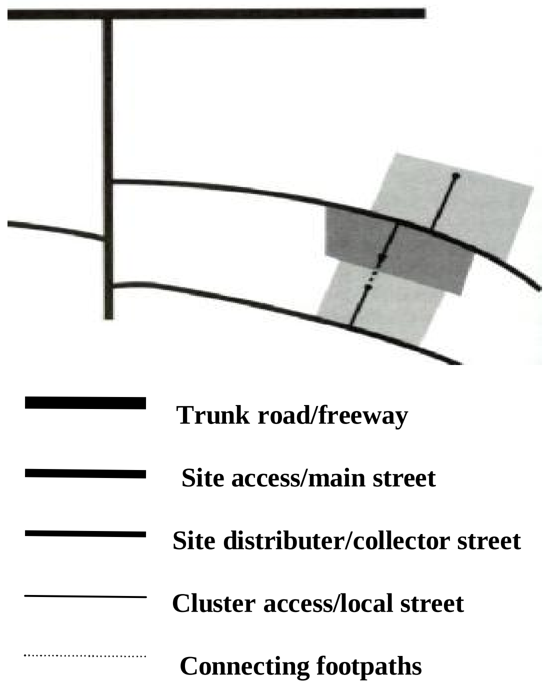


Figure 2-8: Hierarchy of access (Cotton, 2000)

The costs of housing is influenced mainly by the costs of the local streets and footpaths (special streets) since they are considered as on-site infrastructure and their costs are added to the costs of housing. Therefore, lowering their costs is the main part of this section, while lowering the costs of collector and main streets is not the responsibility of the owner/developer but of the municipality. However, some suggestions could be introduced regarding them.

2. Right-of-way (ROW) Width: ROW refers to the land used by transit systems, and its width is a function of the vehicle and pedestrian capacity, travel speed, the function of the particular street in the street network hierarchy, land use, and topography. In the past, ROW widths were selected depending upon the class of highway to be built; widths of (24-39m) for arterials, (18-24m) for collectors and (15-21m) for local streets and those are considered of high standards. Other standards for minimum street widths in the residential areas are (8m) to allow for the movement of vehicles. It is becoming more common to establish ROW requirements based on the final design of the cross-sectional elements which are the traveled portion of the road. A minor roadway design may be adequate for a number of years and economy can be realized through stage construction with the ROW to permit the ultimate development of the roadway procured initially (Carter and Homburger, 1978; Cotton and Tayler, 2000; Rainer, 1990; Abu ELhaija, 1999).

2.2.6.2 Minimum requirements for geometric Design of Streets

The geometric design of streets is a very complex issue, and it uses national and state guidelines to develop the appropriate design for a specific street section. AASHTO's design guidelines recognize the inherent need for flexibility in geometric design and encourage independent designs tailored to particular situations, thus, permitting minimum and maximum values. The six primary factors which influence the geometric design are area (urban or rural), functional classification, (main, collector or local), topography (level, rolling or mountainous), design vehicle (passenger vehicles, trucks), design speed, and design hourly volume (Homburger *et al*., 2001). Reducing the costs of streets and access routes could be done by adopting the minimum allowable cross sections and reducing excavations needed for the needed grades and cross slopes by adopting their allowable minimums or maximums according to the topographic nature of each situation. The following are the main elements of the geometric design with the minimum allowable values:

1) Cross section elements; they include the number and width of moving lanes, turning and parking lanes, shoulders, sidewalks, border areas, medians, etc. Table 9-2a, Appendix 9 lists the AASHTO's minimum guidelines for cross section individual element widths on urban arterial, collector and local streets, and the designer has the flexibility to choose different combinations of the different allowed widths for the final design of the street width. Furthermore, minimum total widths for different types of streets are recommended for low-income area by cotton in Table 9-2b, Appendix 9.

2) Lane and roadway width; lanes of widths (2.7-3.3 m) are usually adequate for local streets in residential areas. Wider lanes, up to 3.6m are needed as speed, volume, and design vehicle size increase.

3) Cross slopes; The typical cross-slope of an urban street is (2 to 4%), sloped toward the sides to allow for drainage. Cross-slopes of (1 to 2%) are adequate for high type pavements such as asphalt.

4) Grades; Minimum grade of (0.5%) to allow for proper drainage and maximum of (3, 4 and 6%) for motorways, dual carriageways and single carriageways, respectively. Other specifications determine the maximum grade for level local urban streets as (8-15%), and for level collector urban streets as (5-9%). Grade of (1:30; 3.3%) is considered suitable for surface drainage.

5) The horizontal curve design; the two components which make up the horizontal curve are the superelevation; of maximum rate of (6%) for urban areas, and minimum radius which is a function of the design speed and superelevation (Rainer, 1990; Cotton and Tayler, 2000, O'Flaherty, 1997; Homburger *et al*., 2001, Carter and Homburger, 1978).

2.2.6.3 Minimum requirements of structural Design/Paving

Paving is provided in order to perform three basic functions; (1) to provide a hard and dry access to residential, commercial and industrial areas, (2) to improve the drainage of built up areas, and (3) to provide a smooth running surface with adequate skid resistance for vehicles. Drainage implications of the street paving may lead to rapid deterioration of the surface if not considered. Paving must have sufficient strength to resist loads which are imposed on it and transmit them to underlying ground (sub-grade) and this strength depends upon the materials used and the pavement thickness. The type of pavement to be used is influenced by location, the expected traffic, the ground conditions, durability of the various options, stormwater runoff, availability of equipment and skill, and accessibility of the area to be paved (Cotton and Tayler, 2000). The structural design of the streets is mainly a function of the Bearing capacity of the sub-grade soil; California bearing ratio (CBR), and the loads imposed on the road surface; expressed in the average daily traffic (ADT). Therefore, lowering the costs of pavement is a function of lowering the loads imposed on them in addition to lowering the widths and lengths of the local streets, sidewalks and footpaths. Furthermore, lowering the costs of pavement could be done by using low-cost materials and adopting the minimum allowable standards and requirements which has been reviewed and listed below:

1) The total pavement depth/thickness; depends on the traffic to be carried and the bearing capacity of the sub-grade. Minimum pavement thickness for different access routes are shown in Table 9-4 and Table 9-8, Appendix 9.

2) Depth/thickness of each layer; depends on the type of material of each layer, and bearing capacity of soil and traffic loading. Minimum construction standards for different pavement materials are shown in Table 9-5 and Table 9-8, Appendix 9.

3) Material of the pavement; depends on the type of the access route/ street, and location. The different types of pavement materials and their characteristics and applicability are illustrated in Table 9.1, Appendix 9, and they include unbound pavement, block pavers, 'Black-top' flexible pavements, and cement concrete pavements. The different materials for pavement of different types of streets are shown in Table 9.8, Appendix 9 (Rainer, 1990; Cotton and Tayler, 2000, Jendiah, 2000).

2.2.6.4 Minimum requirements of landscaping of Streets

The street landscaping or amenities include trees, street furniture, special lighting and street spaces used for pedestrian amenities, and their description are summarized in Table 9.9, Appendix 9. Leftover street space (small sitting areas or parks) are left over from the space needed for the actual roadway or sidewalk, and can be used for public amenities. They provide the opportunity for an improvement in public life, especially in low or middle income neighborhoods where people need to escape their small crowded apartments (Rainer, 1990). Minimum acceptable requirements are to be used according to the site specific situation.

2.2.6.5 Minimum requirements of parking areas

The curb parking is used for the housing developments to facilitate the access of the residents to the housing clusters and for the storage of the vehicles of the residents; where the demand for storage is very high and that for movement is very low. The angle parking is preferred since it provides more spaces than does parallel parking for the same curb length but it uses more street width. The angle of 90 degrees allows larger number of parking spaces than other angles and minimum stall dimensions for 90 degrees parking is 2.6m width by 5.5m length. For new housing developments, off-site parking is recommended in case of lack of space but the site selected should be within an acceptable walking distance of the development, i.e., 90 to 100m (Homburger *et al*., 2001; Carter and Homburge, 1978). However, it is expected that the number of parking areas to be low for LCH, due to the low economical situation of the households. Therefore, it could be assumed that one household of each three households has one car and need one parking area.

2.2.6.6 Current Situation

- For the new planned housing developments, the residential streets are determined and designed by the planners according to the site specific conditions and then approved by the Central organization committee in MLG.

- According to the Decision No. 23_ 18/1997 issued by the MLG in year 1997 regarding the street widths in the new subdivisions; the minimum road width in all new subdivisions is (10m). The regulation issued in 1994 for multistory building (i.e., more than 5 floors including the ground floor) states that the building height should not exceed 1.75 the width of the adjacent street. However, there are no specific standards or guidelines for the minimum limits for street widths, footpaths, sidewalks, etc., for the new housing projects and this are left to the planner of the project site.

-although the MLG adopts the Egyptian law for the percentage of roads and circulation within the development area which ranges from (25-30%) of the total area, it has been seen that this percentage in most LCH projects in Gaza Strip exceeds 35%, especially for those which adopts the conventional subdivision designs (e.g., not clusters) as shown in Table 9.10, Appendix 9, where the minimum widths of local streets ranges from (10-12m), and of collector streets ranges from (16-20m) while in cluster design projects the service roads (local residential streets) ranges from (3-10m) according to the specific design.

- Asphalt pavement is the common used pavement usually used for collector and main streets. The local manufactured interlock pavers with different thicknesses and colors are used for pavement of sidewalks and most of local streets due to their low-cost and durability.

2.2.6.7 Suitable requirements of access and paving for LCH

1. Road sizes, widths, and lengths should be reduced in order to reduce the land devoted to them and to reduce the construction and maintenance costs, and hence reduce the whole cost of the streets and access provisions. This is to be done by adopting and selecting the prescribed minimum allowable standards and guidelines for cross-section elements, grades and cross slopes of the local streets, sidewalks and footpaths.
2. Minimum number of parking areas which is one parking area for each three housing units is to be used. Off-site curb angle parking with the preferred angle of 90 degrees that are located at walkable distances at the perimeter of the housing clusters are to be used for LCH.
3. Since low traffic loads reduces the pavement thicknesses and widths and thus decreasing the total costs of streets; vehicles are to be prevented to move throughout the LCH and this is enhanced by the cluster design and adopting the off-site parking for the household personal cars.
4. Interlock paving is low-cost and practical pavement that enhances rainwater infiltration and is suitable for footpaths, local streets and parking areas of low traffic loads, and thus would be used for LCH pavements. The voided segmental pavements are strongly recommended due to their hard surface and allowing percolation of rainwater and decreasing of the massive appearance of the parking lots through the vegetation in the voids, and their production should be investigated.
5. Streets landscape/amenities are to be considered but at the minimum requirements because

they are of great importance for enhancing the appearance of the LCH and improving the social life of residents.

6. All the above requirements for lowering the streets access and paving can be achieved by using the cluster designs for the LCH project.

2.2.7 Component 6: Stormwater Drainage

2.2.7.1 Systems of stormwater drainage

In urban areas, the tarred pavement roads and the built environment decrease the surface area of stormwater absorption, offer little opportunity for rainwater to soak into ground, speed up the rate of stormwater runoff causing flooding and erosion. Sometimes the domestic wastewater is mixed with rainwater, causing huge flows of pathogen rich wastewater, which cost very much to be treated (BASE, 2003). In Gaza Strip, the common situation during the winter is that the rainwater quickly flows from the streets and roads often mixing with sullage flows or untreated sewage and usually become a nuisance with potential health hazards or a major flooding problem, especially if the soil and gravel are conveyed to the wastewater pump station (RPGG, 1998; PWA, 2004b). Therefore, adequate stormwater drainage is essential and the systems allowable for this purpose are:

1. Traditional Stormwater Sewer Systems: The traditional stormwater sewer systems which have been used as the best protection against flooding in crowded urban developments has proved costly, inefficient and not sustainable in terms of human life and ecological systems (Niemczynowicz, 2003). Therefore, other simple and low-cost systems have been investigated.

2. Surface Drainage/ Roads-as-drains: this is a low-cost system which has been used in many developing countries to save the costs of the stormwater sewer lines and where there is no adequate space to install them. Paved roadways and alleys are used to carry stormwater short distances to drainage channels; that is, water is deliberately allowed to flow along the paved surface and there are no channels alongside. This works where the surfaces are fully paved and well maintained and surfacing materials such as brick and concrete, which are not damaged by stormwater should be used. The most important factor in design is to ensure that the paved areas and roads have positive slope so that the water drains into secondary drains at a known number of outfall points. It is cost effective approach since this reduces both the capital cost of drainage and the need for maintenance (Cotton and Tayler, 2000). However, this system is considered unsustainable especially for countries that suffer from water shortage and aquifer deterioration such as Palestine. Furthermore, this approach may solve the problem in one area while exacerbating it in the other one receiving the drained stormwater. Therefore, new simple and low-cost techniques has been investigated which are known best management practices (BMPs)

3. Best Management Practices (BMPs): Nowadays, concentration on recharging the rainwater into ground and using new approaches which catch the stormwater as near as possible to the points of flooding or direct it to catchment basins are utilized. This approach which is now widely known as best management practices (BMPs) lower the cost of sewer installation, prevent stormwater contamination while running long distances on urban impervious surfaces (i.e., parking lots, roadways, sidewalks, rooftops, etc.). BMPs are simple and cheap processes and practices that resemble what happens in nature and do not rely on using costly physical components and are considered the alternatives to the traditional stormwater sewer system. The principle of using these practices is using the rational method, where the quantity of the storm water is a function of the coefficient of runoff as follows:

$$Q = C\,I\,A \qquad \textbf{Equation 2-1}$$

Where: Q = quantity (m^3/s), C = coefficient of runoff, I = intensity of rainfall (mm/hr) and selected on the basis of design rainfall duration and design frequency of occurrence, and A = area drained (m^2), taking in consideration the conversion of units.

Since the runoff coefficient of paved areas have much larger runoffs than those of grass areas, it is very important to incorporate storm drainage into green space planning (Rainer, 1990; Khalaf, 2005; Quigley and Lawrence, 2002).

BMPs combine a variety of physical, chemical and biological processes to capture runoff and remove pollutants at lot level, reusing some for irrigation and returning the rest to the groundwater. BMPs include flow controls, vegetative stabilization, bioengineering, structural stabilization, riprap stabilization, filtration practices and stormwater detention ponds (EPA, 1999a). Some common low-cost BMPs for the stormwater management are discussed below

1. Detention Ponds and infiltration basins: The detention pond consists of *a permanent pool* of water into which storm water runoff is directed, detained and treated in the pond until it is displaced by runoff from the next storm. Infiltration basin is a stormwater impoundment that does *not contain a permanent pool* of water because it has permeable soils which allows the stormwater to infiltrate through the bottom and sides of the basin to recharge the groundwater. However, both the off-site, rock-edged detention and infiltration ponds are often expensive, require large area of valuable land, unattractive and unsafe (EPA, 1999a; MPCA, 2000; Quigley and Lawrence, 2002). The detailed design criteria, applicability, performance and advantages and disadvantages of these systems are summarized in Table 10.5, Appendix (10).

2. "Bioretention" areas: Bioretention is a best management practice (BMP) developed in the early 1990's and has been used as a stormwater BMP since 1992 (MPCA, 2000). They are engineered system which facilitates depression storage, treatment and infiltration of stormwater which runs over impervious surfaces at residential, commercial and industrial areas while looking like a nicely multifunctional landscaped area; as seen in Figure 2-9 and Figure 2-10. They are relatively low-cost alternative to separately built, highly engineered and questionably effective detention ponds and combined with the environmental benefit. "Bioretention" technology can effectively turn parking lot islands, street medians, tree planter boxes, and landscaped areas near buildings into specialized stormwater drainage and treatment systems. These "biofiltration" landscape islands are recessed, and the pavement is graded so that surface flow is into rather than a way from these areas. With appropriate plant selection, these small-scale plant communities can be almost-self-sustaining and require less upkeep than a typical landscape. The use of surface drains (under-drainage) is optional in order to deliver water in times of drought. Sometimes, the use of "shunt" perforated pipes to discharge the excess stormwater runoff into perimeter swales or the detention pond is necessary to meet the discharge requirements. The construction of bioretention areas is best suited to sites when grading and excavation will occur in any case so that they can be readily incorporated into the site plan without environmental damage (Quigley and Lawrence, 2002; EPA, 1999d).

3. Vegetated swales: "vegetated swales" are usually low depressions in the ground along the contour lines in a slope. The rainwater will not travel in the swales, but will be contained there until it sinks into the ground and replenish the ground water (Gunther, 1998). Swales can easily be included in urban planning as demarcations between roads and footpaths, or between building blocks and can also be used along roads in place of curb and gutter which would reduce the costs of their construction while providing sustainable method of drainage as seen in Figure 2-11 (EPA, 1999c). Trees and shrubs in the depression could be of productive type like fruit trees and will increase the permeability of the soil and thrive from the increased access of water. This will create a shadowy and green impression of the built environment and diminish the traffic noise as shown in Figure 2-12

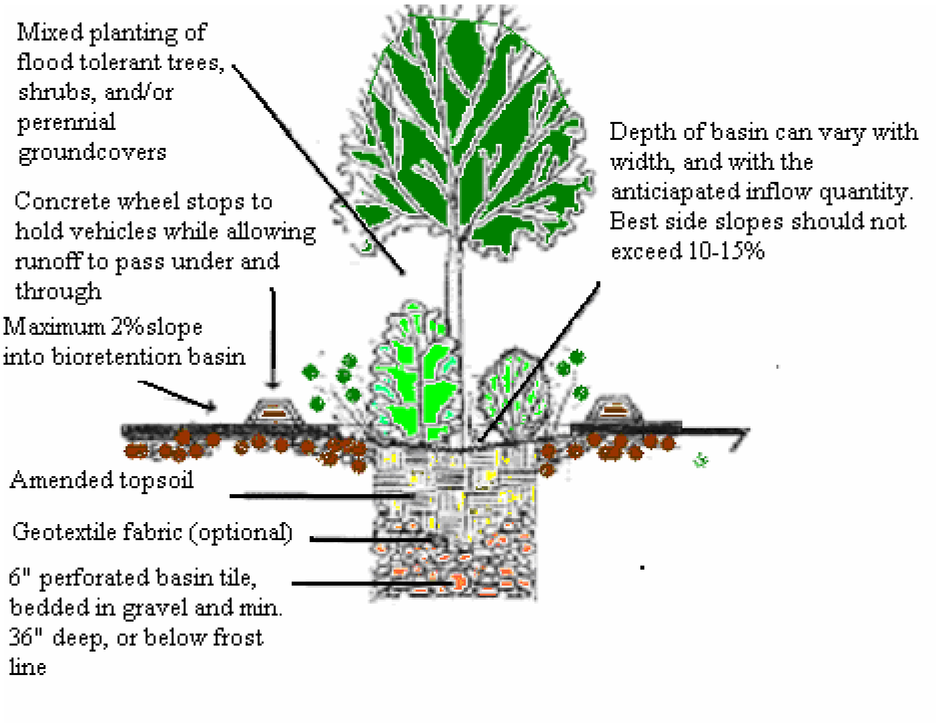


Figure 2-9: Cross section of a parking lot "wetland island" with 2.4m width (Gunther, 1998)

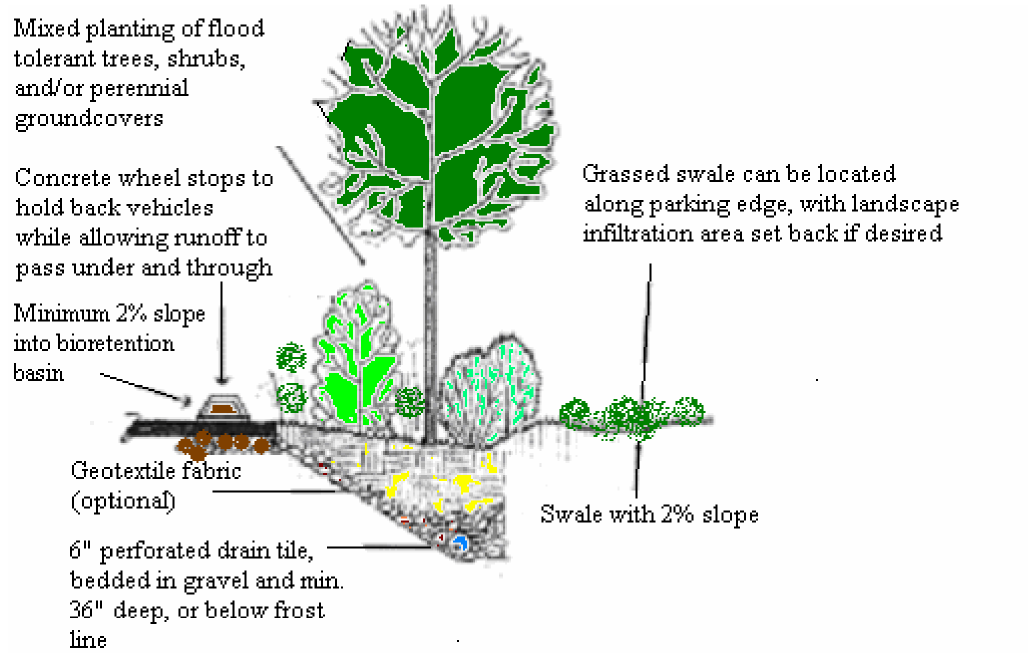


Figure 2-10: Cross section of a parking lot edge with a bioretention strip and optional subsurface collection (Gunther, 1998)

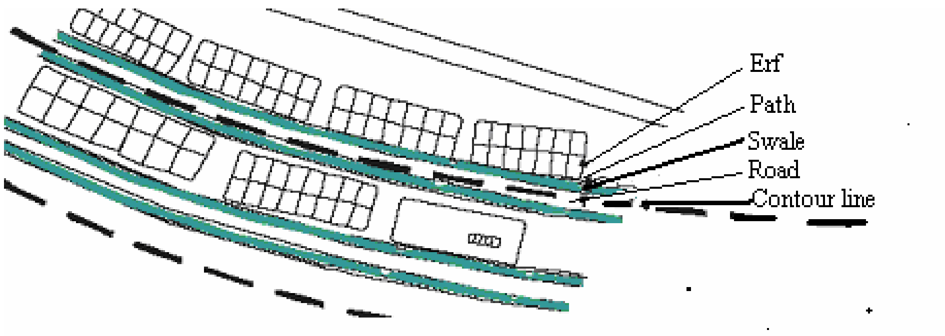


Figure 2-11: An example of urban planning with swales parallel to contour lines (Gunther, 1998)

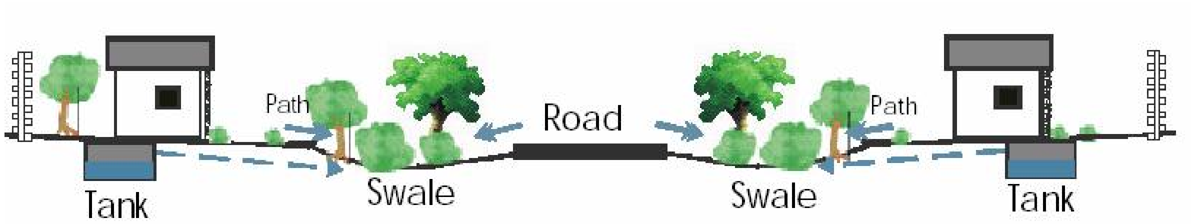


Figure 2-12: Principles of swales; Stormwater is collected in depressions between the houses. Vegetation uses the water for productive growth (Gunther, 1998)

4. Artificial stormwater recharging: When the streets or open areas are paved with impermeable material and where the above surface recharging methods are not possible, (Percolation Pits/recharging wells) could be used to recharge the ground aquifer. They are constructed (1-2m) wide and to (3m) deep and are back filled with boulders, gravels, coarse sand. Percolation Pits with Bores are used whenever the depth of clay soil is deep. The Bores are deep pits to the dimension of about (25cm) diameter and about (3-7.5m) depth depending on the soil condition (DTP, 2003; CMWSSB, 2002).

2.2.7.2 Permeable Eco-Stone Pavements

The Eco-Stone is innovative, environmentally-beneficial pavement of interlocking concrete pavers that offer the structural strength and stability of traditional concrete pavers, and provide a highly durable, yet permeable pavement capable of supporting vehicular loads, combined with benefits of stormwater management. The stones have minimum compressive strength of (49-55N/mm^2/490-550kg/cm^2) with unique patented design that creates drainage openings in the pavement surface which facilitate rainwater infiltration as shown in Figure 2-13, Figure 2-14, and Figure 2-15. The benefits of the Eco-stone pavements are that they facilitate the infiltration of rainwater to reduce or eliminate stormwater runoff, maximize groundwater recharge and/or storage, improve water quality by infiltrating water and mitigate pollution impact. They also decrease project costs by reducing or eliminating drainage and retention systems and permits better land-use planning, allowing more efficient use of available land for greater economic value, and provide a highly durable, yet permeable pavement capable of supporting vehicular loads and suitable for pedestrian, trafficked and heavy duty applications (UNI, 2004).

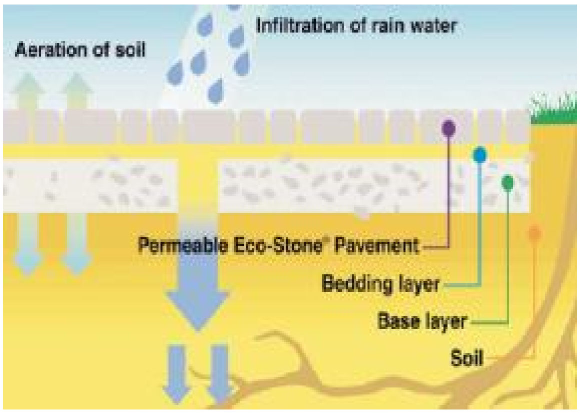


Figure 2-13: Design criteria of Eco-Stone pavers (UNI, 2004)

Figure 2-14: Eco-Stone pavers (UNI, 2004)

Figure 2-15: Eco-Stone permeable pavement driveways (UNI, 2004)

2.2.7.3 Suitable requirements of stormwater drainage for LCH

1. The techniques of low-cost and sustainable best management practices (BMPs) approach are to be used for LCH instead of the curb and sewer system since they are simple and effective, economical, flexible, and add value to landscape without consuming large amounts of valuable land area. "bioretention" areas and islands, are the most low-cost, practical and sustainable regarding controlling and treating stormwater and regarding operation and maintenance requirements. Vegetated swales are another technique which could be incorporated also in the urban planning stage.
2. The permeable voided pavement such as Eco-stone pavers is ideal solution for stormwater drainage in the housing developments, and an individual research study is recommended to examine its applicability in Gaza Strip.

2.2.8 Component 7: Telecommunication (Telephone Network)

2.2.8.1 Background

Until very recently, very little emphasis has been placed on the detailed planning of telecommunication infrastructure, and the planning of telecommunication services are usually left to the local telephone company. However, Telecommunications has developed at a lighting speed and the industry is technologically far a head of other areas of infrastructure. The rapid expansion of computer into all aspects of life, and the inherent need that this equipment has to be communicated, has a tremendous stress on telecommunication (Rainer, 1990; Akatsuka and Yoshida, 1999).

2.2.8.2 Current Situation

Telecommunication industry has been developing recently in Palestine after the establishment of Palestinian Telephone Company PALTEL, which is working under the regulation of the Ministry of Telecommunication and Information Technology (MTIT). PALTEL is responsible for the development, planning, designing, provision, and financing of the telephone network service all over Palestine. Now, most regions and districts of Gaza Strip are provided by the telephone network infrastructure, and it is very easy to provide the new developing areas with telephone lines.

1. Methods of provisions: The two common approaches for on-site telephone lines provision are the aerial (aboveground) distribution and the underground distribution. The main characteristics of the two types are summarized in Table 11.1, Appendix 11.

2. Costs and costs recovery: PALTEL is responsible for all the capital investment costs of the telephone network infrastructure. The capital costs are recovered through the constant one-time paid fees for each new telephone line that is provided to each household. Therefore, for any new housing development, the owner/developer is not required to plan or pay for the provision for this service, but only coordinate with PALTEL for its provision. The operation and maintenance fees are recovered through the bimonthly telephone bills (PALTEL, 2004).

2.2.8.3 Suitable requirements of telecommunication for LCH

1. Telephone network is essential to be provided for the LCH due to its importance for telecommunicating and data processing even for low-income people.
2. Since the planning, design and construction works of telephone network are done by the telephone company according to its standards and specifications in coordination with the owner/developer; nothing can be done for lowering its costs regarding the physical elements.
3. Since all the capital costs of telephone lines provisions are covered by the local telephone company, each household has to pay the connection fee for the company to get a telephone line. Therefore, lowering their costs for the households could be done by encouraging the telephone company to offer subsidies on these fees.
4. Public telephone stations are to be encouraged to be used for LCH to facilitate telecommunication for households who do not have individual telephone line.

2.2.9 Concluded Remarks Regarding BICs for LCH

In the previous sections, the acceptable minimum limits for each BIC has been determined and the suitable low-cost systems and techniques have been summarized for adequate and low-cost provisions of BICs for LCH.

2.3 OPERATION AND MAINTENANCE (O&M) OF INFRASTRUCTURE FOR LCH

2.3.1 Importance of Operation and Maintenance (O&M)

The old adage which is as true as ever before "Do not build what you are capable of building; only build what you are capable of operating and maintaining" is really true (Cotton and Tayler, 2000). The key issue is that O&M is an essential consideration from the very beginning of the planning process; it is not something which comes in at the end. Operation and maintenance (O&M) has been identified by commentators as the key to enhancing the sustainability of infrastructure and assets. The financial consequences of neglecting maintenance are often seen in terms of reduced asset life and premature replacement. Neglecting maintenance also implies increased costs of operating facilities and waste of related natural and financial resources (Sohail *et al*., 2005; UN-HABITAT, 1993).

1. Operation refers to the procedures and activities involved in the actual delivering of services, such as abstraction, treatment, pumping, transmission, and distribution of drinking water which means the use of the infrastructure for its intended purpose (UN-HABITAT, 1993; Cotton and Tayler, 2000). The whole purpose of operation management activity is to provide the maximum productivity within the organization (Hudson *et al.*, 1997).

2. Maintenance refers to activities aimed at keeping existing capital assets in serviceable conditions, such as repair of water distribution pipes, pumps, etc. (Cotton and Tayler, 2000). It is that set of activities, required to keep infrastructure components and facilities functioning as it was originally designed and constructed to function (Hudson *et al.*, 1997). There are many types of maintenance such as preventative maintenance, corrective maintenance, routine maintenance, and periodic maintenance, and their description is shown in Table 11.1, Appendix 11. The two sets of activities relating to operation and maintenance are closely linked, since operations will not continue for long without maintenance, and personnel conducting operations also commonly conduct minor maintenance (UN-HABITAT, 1993).

2.3.2 Lowering the Costs of O&M for BICs

Reducing the costs of O&M would greatly reduce the financial burdens on the municipalities/utilities and on the households and this can be done by the following:

2.3.2.1 Using simplified systems and low-tech techniques for the BICs

As discussed before in the preceding sections, using simplified and low-cost systems and techniques for the provisions of BICs not only lower the capital costs but also would lower the needed works for O&M for mechanical and sophisticated parts of expensive elements. Thus using the simple and low-tech systems and technologies would greatly reduce the costs of O&M.

2.3.2.2 Promoting Community Involvement in O&M of BICs

Traditional centralized systems for O&M, which are the responsibility of municipalities and utilities, are not delivering. Inadequate performance and lack of capacity at the municipal level often dictates that community or user groups need to become involved. Recently there has been a search for alternatives such as community-based approaches (Sohail *et al.*, 2005). There is a whole spectrum of approaches, and the essential differences relate to the degree of involvement of the user community, the role of different public sector institutions and tiers of government, and the involvement of private sector. Each of these systems clearly has different implications for both implementation and management of O&M as shown in Table 2-4.

Table 2-4: Implications of different management systems

Management system	Implications
Centrally managed	Public institutions have statutory responsibility for service delivery and O&M either directly or through their private sector contractors.
User group managed (community)	A group of users is responsible for service delivery and O&M; if there is external support infrastructure, roles and responsibilities for O&M need to be carefully defined between the community and external agencies.
Householder managed	Responsibility for service delivery and O&M of privately owned on-plot facilities rests with the owner/plot holder. Comparatively speaking, this presents few concerns with respect to the management of O&M.

Source: Cotton and Tayler, 2000

Since, it seems service users are being encouraged to ensure the infrastructure in their neighborhood is kept in good condition; it is hoped that getting service users involved will lead to increased efficiency, benchmarking, raise awareness/ debate, contributed to national growth, reduced waste, improved resource allocation, and improved competitiveness. However, it has been recognized that neither community nor government alone can ensure the sustainability of infrastructure; a partnership approach is needed (Sohail *et al.*, 2005).

Therefore, a move towards an O&M management strategy which brings together the most attractive features of municipal management and community management at the ward level into a framework for *municipality-community partnering for* O&M is proposed (Cotton and Tayler, 2000). Any strategy for O&M involving both the municipality and its citizens needs to be built around the following principles; (1) clarity on roles and responsibilities; (2)

accountability of actions; and (3) performance improvement (Cotton and Tayler, 2000). The keys to improving O&M – and sustainability- are the availability of information and attribution of clear roles and responsibilities (Sohail *et al.*, 2005).

1. Management of decentralized wastewater treatment systems: EPA is proposing the voluntary national guidelines in order to raise the quality of management programs, establish minimum levels of activity, and institutionalize the concept of management. The guidelines contain a set of five (5) model programs. Table 11.2, Appendix 11, presents a brief description of each model program, compares the management program objectives, provides a brief description of the types of systems applicable to the program, and lists the major benefits and limitations for each of the five model programs. However, EPA recommends implementation of *Model Program 5, Utility Ownership and Management*, in cases such as when new, high density development is proposed in the vicinity of sensitive receiving waters (EPA, 2000b).

2.3.2.3 Suitable management of O&M of BICs for LCH

The partnership management approach between the municipalities/utilities and the community/households is considered as effective and low-cost management solution which results in best achievements for LCH development if tasks of O&M are carefully distributed among these parties. The used simplified systems and low-tech techniques which need minimal works of O&M encourage this approach. The community involvement in the O&M of some of the on-site BICs encourages self-dependence in performing the assigned tasks of O&M which in turn reduce the monthly fees paid for the municipality or the private sector. However, the utility ownership and management approach is recommended for the centralized networked BICs as well as for the decentralized wastewater collection and treatment and also for decentralized water supply systems where the total responsibility of these systems is given to the municipalities/utilities for adequate management.

2.4 COSTS AND COST-RECOVERY OF PROVISIONS OF BICS FOR LCH

Cost recovery is about how to get contributions in money or in kind from service users to cover the O&M costs and some of the capital costs where appropriate. Recovering some or all of the costs of service provision is necessary if services are to be sustainable in the long term (Cotton and Tayler, 2000). Many maintenance problems can be linked to finance and cost-recovery constraints and insufficient revenues lead to the delay or non-performance of many maintenance tasks. In Gaza strip, for example, there are several distressed municipalities without means to cover routine and basic operating costs of BICs.

A number of funding mechanisms are commonly used for maintenance of different sectors of infrastructure including (1) allocations from local general revenue; (2) grants or transfers from national-level governments based on national general revenue; (3) earmarked levies, special assessments, or dedicated taxes; and (4) direct cost recovery through user charges (UN-HABITAT, 1993; World Bank, 2004).

1. Direct cost-recovery: Direct cost recovery from users has many advantages. Given a fee for service, beneficiaries pay for the services they consume, generally in accordance with the amount they use. Such direct charges tend to minimize wastage and maximize efficiency. This mechanism is most commonly applied to services with an easily measured output such as water and power supply, while sewer service charges are generally 25 to 30% of water supply costs. Drainage and flood protection do not lend themselves to user charges and one common solution is to earmark certain taxes for that purpose. Development of effective direct cost-recovery systems or improvements will involve two basic issues: (1) rate setting, and (2) billing and collection (UN-HABITAT, 1993; Rainer, 1990).

2. Subsidies: Usually, the high level of costs for some of the infrastructure serving the LCH such as water and electricity prohibits the low-income households from paying the full cost-recovery rates for even the minimal monthly amount of these services (Bond, 1998). This results in the need to some kind of subsidy for this target of people. The possible mechanisms for the available subsidies are listed below:

a) Cross-Subsidy: Rates/charges can be established with cross-subsidy blocks which can make the service more affordable to the poor. Cross-subsidization of groups of beneficiaries represents a potentially useful but difficult political tool that must be used on a case-by-case basis. Rate setting and the application of cross-subsidy mechanisms requires the establishment of accurate systems for assessing costs of capital investment and operations and maintenance, as well as updated cadastres of users, and should include data on socio-economic aspects and mechanisms to ensure that the subsidies actually reach the target population (UN-HABITAT, 1993). If subsidies and tariffs are reconstructed to assume entitlement "lifeline" provision to all poor and low-income people, plus rising block tariffs for higher use of resources, it appears possible to significantly augment what the government is presently suggesting as a minimum set of investment and service provision in its municipal investment framework (Bond, 1998).

Therefore, there is a need for infrastructure-related tariff restructuring, cross-subsidies, and "lifeline" services to the poor with respect to water, sanitation, and electricity. The rationale for such a system -based upon national tariff reform emphasizing cross-subsidies and "lifeline" tariffs for low-income consumers- would be not only to meet constitutional responsibility, but also to gain additional public health, environmental and economic benefits to all society (Bond, 1998). A progressive block-tariff and "lifeline" subsidy system assures that a minimum supply of municipal services could be consumed at no charge by poor residents, with rising increase in prices based on increasing consumption levels. By generating surplus through slightly higher marginal costs for corporations, free "lifeline" tariffs can easily be designed for the first block of consumption (Bond, 1998). It would have been relatively easy to cross-subsidies from national-scale industrial, service-sector, and agricultural bulk users of water and electricity, to low-income residential consumers. The vast difference in use patterns, would allow a small marginal increase in tariffs for large users to pay for "lifeline" service at no cost to all other consumers. Such a progressive block tariff system, essentially provide an entitlement to all citizens, would also penalize excessive usage, thereby contributing to conservation goals (Bond, 1998).

b) Direct subsidy: The application of this type of subsidy policy offers the advantage of simplifying rate setting and management requirements by the local authority, as well as the integration of service subsidies within an overall national policy for focusing subsidy resources in low low-income groups (UN-HABITAT, 1993).

c) Subsidy for sanitation: Household subsidies often provided for sanitation because wider public health objectives or environmental concerns mean that the net benefit to society outweighs the benefit perceived by an individual or household. Advocates of sanitation subsidies may also see a social justification to provisions of subsidies, arguing that sanitation is a right and a requirement for a decent quality of life and that the poor households should not be penalized simply because sanitation facilities are costly (www.saniatationconnection.com, 2003).

2.4.1.1 Suitable cost recovery of O&M costs of BICs for LCH

The costs of O&M of BICs for LCH are expected to be lowered due to the reasons mentioned in the previous section. However, the costs of service consumption still expensive and this would result in expensive monthly bills for the LCH households for the some of the BICs such as water, sanitation (sewerage), and electricity. Therefore, cross-subsidy approach is recommended for service consumption for low-income residents of the LCH developments.

Therefore, the "lifeline" tariffs are to be considered as an entitlement. This requires that tariffs should be structured so that all domestic users receive their first monthly units of water and electricity on a fully subsidized basis, provided that subsequent levels consumption are priced at increasing rates so as to cover the initial costs. These cross-subsidies are made to diverge from micro economic orthodoxy; (i.e. national-scale industrial, service sector and agricultural bulk users).

2.5 CONCLUDED REMARKES

1. In this chapter, the problem of housing crisis in Palestine in general and Gaza Strip in particular has been presented, and the impressing problem of shortage in low-cost housing production has been prevailed, concluding the urgent need for finding the ways to lower the costs of housing. The main issues concerning the adequate housing and the low-cost housing have been illustrated concluding the main features of adequate housing and low-cost housing. The provisions of adequate and low-cost infrastructure have been seen as a main feature and basic requirement for low-cost housing to ensure its adequacy.
2. Therefore, the required infrastructure for LCH has been classified into two categories which are the basic infrastructure components (BICs) and the supportive infrastructure components (SICs). Since the BICs are seen to be provided concurrently with the implementation of LCH and their costs greatly affect the cost of housing, it is the main issue to reduce their costs. Hence, the main general factors which influence their costs have been summarized and include the location and subdivision design, the density of the housing development, type and form of infrastructure provisions and the standards and regulation for provisions. The cluster design is preferred on the traditional design in the site planning of the LCH since they could contribute in reducing the costs of infrastructure provisions and in achieving conservation and sustainability goals.
3. Each one of the networked BICs consists of on-site part and off-site part. The cost of off-site part is not to be added to the total cost of housing since it would increase the costs to great extent, especially when the location of the LCH is far from the existing services. The cost of on-site part of each BIC is usually added to the cost of housing and thus has large effect on its costs. Therefore, this research work would emphasize on lowering the costs of on-site BICs.
4. Each basic infrastructure component (BIC) has been discussed to conclude and summarize the suitable minimum limits, simplified systems and low-cost technologies to be used to reduce the costs of the provision for LCH.
5. Since the long-term sustainability for the provisions of BICs is of great importance, many important issues of operation and maintenance works, their management and cost recovery have been introduced.
6. Sustainable cost-recovery mechanisms for O&M costs of BICs are necessary in the most

appropriate manner. It has been concluded that cross-subsidy approach with lifeline entitlement is suitable for LCH.

In the following chapter, an approach for the low-cost and sustainable provisions of BICs for LCH is to be developed based on the aforementioned conclusions and achievements of this chapter.

CHAPTER THREE

DEVELOPED APPROACH FOR PROVISION OF BASIC INFRASTRUCTURE COMPONENTS (BICs) FOR LCH

3.1 FRAMEWORK OF THE DEVELOPED APPROACH

The framework for the developed approach for the provisions of BICs for LCH include all steps of provisions which are the main bases of provisions, minimum requirements for planning, selection, design, physical elements and O&M, management of O&M and capital and running finance and cost recovery. The developed approach involves five phases as shown in Figure 3-1, which are:

Phase 1: Designation of the BICs for LCH and bases of provisions

Phase 2: Institutional setup

Phase 3: Requirements of provisions of BICs

1. Provisions of BIC-1: Water supply
2. Provisions of BIC-2: wastewater collection (sewerage system)
3. Provisions of BIC-3: Wastewater treatment and reuse or disposal
4. Provisions of BIC-4: Power supply and security lighting
5. Provisions of BIC-5: Access and paving
6. Provisions of BIC-6: Stormwater drainage
7. Provisions of BIC-7: Telephone lines

Phase 4: Management of operation and maintenance (O&M) of BICs

Phase 5: Financing capital and O&M costs and cost recovery

Phase 1 designates the seven components of basic infrastructure (BICs) and the main bases for their provisions**. Phase 2** of institutional setup includes the establishment of infrastructure unit (IU) in the housing institution/company for the provisions of BICs. **Phase 3** is for the determination of minimum requirements of provisions of BICs and includes seven parts. Each part is for the provision of one basic infrastructure component (BIC) and includes three activities; ***activity 1*** proposes specific, locally matched and sustainable criteria for the provision of the specific BIC, ***activity 2*** presents the main concept and the selection methodology for the most appropriate low-cost systems and ***activity 3*** summarizes the minimum limits, design parameters and main elements with description of the minimal O&M of the selected systems and technologies. **Phase 4** proposes a management approach for O&M of BICs. **Phase 5** introduces funding and cost recovery arrangements for construction and O&M of BICs through three activities. ***Activity 1*** is for capital finance and cost recovery of

BICs, ***activity 2*** is for cost recovery of basic service consumption costs, and ***activity 3*** is for cost recovery of O&M costs of BICs.

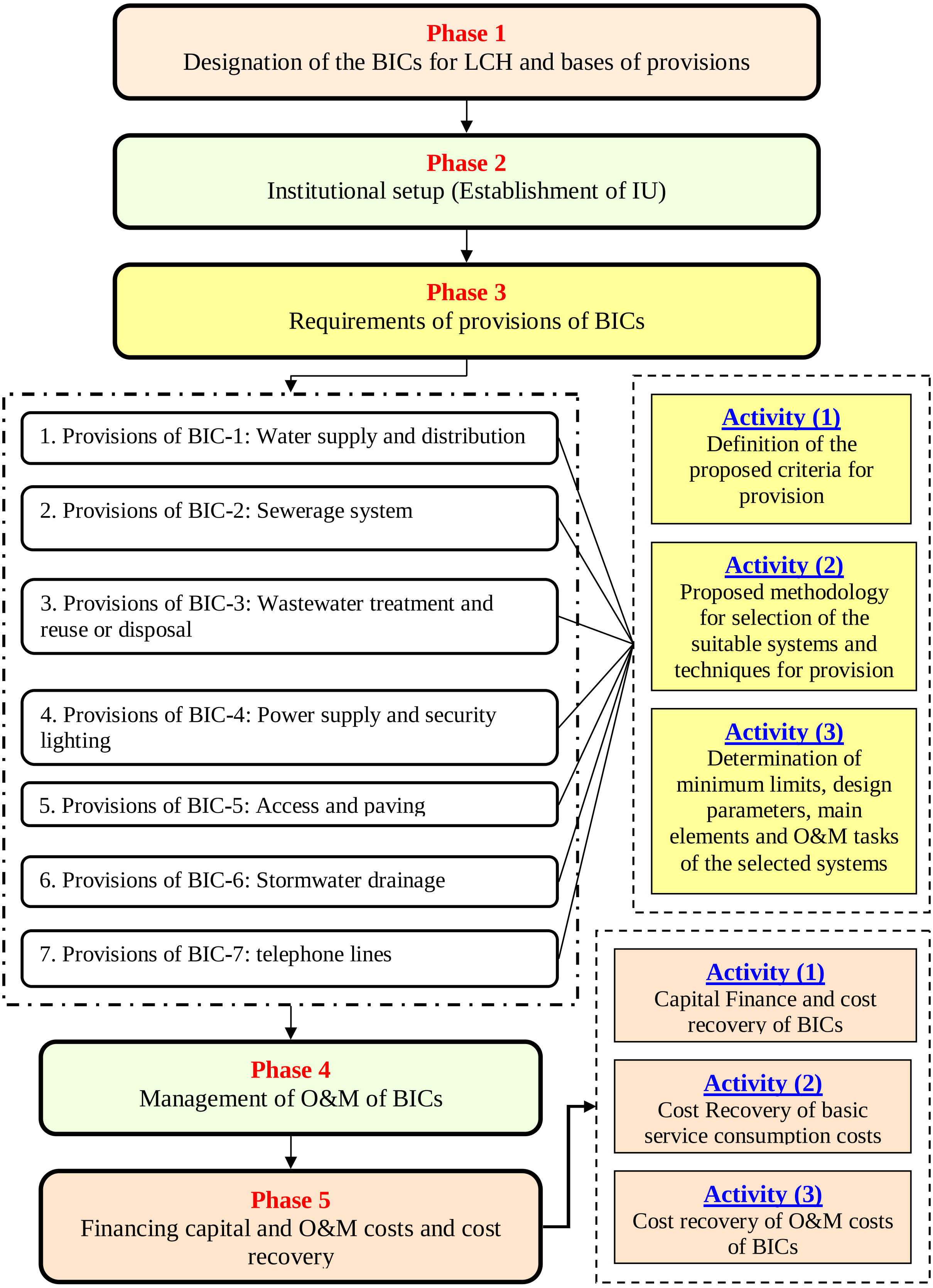


Figure 3-1: The framework of the Developed Approach.

3.2 PHASE 1: DESIGNATION OF BASIC INFRASTRUCTURE COMPONENTS (BICs) FOR LCH AND BASES OF PROVISION

3.2.1 Basic Infrastructure Components (BICs)

The basic infrastructure components (BICs) for LCH include the following components listed according to their importance for the basic life being of the residents and their necessity to the environmental health of the LCH:

1- BIC-1: Water supply
2- BIC-2: Wastewater collection (sewerage system)
3- BIC-3: Wastewater treatment and reuse or disposal
4- BIC-4: Power supply and security lighting
5- BIC-5: Access and paving
6- BIC-6: Stormwater drainage
7- BIC-7: Telephone lines

Since most the aforementioned BICs are considered networked infrastructure which may consist of both on-site part inside the boundary of the LCH and off-site part which lie outside the LCH, The emphasis here is to be focused on the on-site part of each BIC whose costs are added to the cost of the LCH. Therefore, the developed approach is dedicated for lowering the costs of the provisions of the on-site basic infrastructure components while ensuring their adequacy. However, although the costs of provisions of off-site BICs are not added to the total cost of housing, they should be maintained to be at low cost also.

3.2.2 The Bases for the proposed Criteria and the Provisions of BICs

It is necessary to address criteria for the provision of each basic infrastructure component (BIC), so that:

- The criteria for provisions of BICs should be consistent with the sustainability values e.g., the environmental, social and economical for the Palestinians.

- The criteria should take in consideration the local and national technical and institutional factors which are greatly interrelated in the provisions of BICs**.** The technical factors include engineering concerns and environmental concerns, and they are affected by the ownership status but influence on the maintenance requirements. The institutional factors include legislative concerns, economic concerns, administrative concerns and social concerns, and they are affected by the maintenance requirements but influence on the ownership status.

- The criteria should be based on assessment of the local situation, dominant problems and challenges and the current and future basic needs of Gaza people, and would be as a guide for the benefit of the Palestinian people in general, and low-income bracket in particular.

The provisions of BICs for LCH should be based on two important bases; which are (1) sustainable provision and (2) low-cost provision

3.2.2.1 Sustainable provision

The provisions of the BICs should comply with the sustainability dimensions and values, e.g., the provisions should be:

1. **Socially sustainable**

- BICs should be provided in adequate manner for the prevention of spread of diseases, and for enhanced quality of life for citizens in the short and long term, where long term quality of life must take precedence over short term considerations.
- Provisions of BICs should be environment-friendly for the benefit of improving living standards and offering public health protection.
- Safety should be ensured against fire danger and car accidents through ensuring the minimum requirements for fire fighting and access hierarchy design.
- Security should also be ensured through adequate site lighting.

2. **Environmentally sustainable**

- Systems and techniques of BICs for LCH should have the least harmful impact and the most beneficial impact on the environment. The provision of one BIC should not compromise or substitute the provision of another one.
- Development and implementation of new standards and technologies of BICs should be done by partnerships between the relevant governmental institutions and stakeholders to ensure the least environmental impacts.

3. **Economically sustainable**

- Striving to encourage the adoption of low-cost technologies and simple practices for provisions of BICs and to go beyond business-as-usual high cost systems is necessary.
- Shared responsibility between all orders of government is essential to ensure sustainable funding and use of infrastructure, and the residents should pay the full- cost of operation and maintenance (O&M) of infrastructure. However, full-cost pricing should accommodate the need to provide subsidies or lower prices for LCH.

3.2.2.2 Low- cost provision

Lowering the costs of BICs is achieved by reducing the effects of the cost-influencing factors, and this can be done by considering the following guidelines:

1- *Location:* sometimes large differences in cost per housing unit are a result of difference in off-site costs. Hence, the LCH is preferred to be implemented near the municipal services to reduce the costs of long connection to off-site networked municipal services or the costs of construction new decentralized systems.

2- *Subdivision design:* Cluster design which requires clustering more housing buildings closer to each other in small areas of the total land contributes to reducing the costs of site development by reducing the road widths and lengths, water and sewerage network lengths and lengths of electrical and telephone lines. Cluster design results also in Compact and high density design which save valuable land.

3- *The building construction system:* The option of construction system of one model for multistory buildings reduces the costs of BICs per each housing unit.

4- *Type and form of infrastructure provision:* as long as the LCH is located near centralized infrastructure networks, it is simply connected to it with minimal costs. Where the LCH is located far from centralized infrastructure networks, the on-site (decentralized) systems should be of low-cost.

5- *Standards and regulations:* allowing for the reduction of infrastructure standards to the minimum permissible ones which are used and advised in other countries would help offset costs for senior housing projects, and plays as an additional incentive for the owner/developer. The relaxed standards for each specific LCH project should be defined.

6- *Conservation:* conservation is the most economical new capacity. Water and energy conservation is essentially a means through which efficient use can be made of existing supplies (i.e. doing the same with less) by consuming water and energy more efficiently and reducing where appropriate. This does not have to mean severely restricting demand, but reducing excessive consumption through conservation measures, and reducing losses.

7- *Costs:* the costs of external (off-site) infrastructure should not be added to the costs of housing. The costs of internal (on-site) infrastructure are added to the costs of housing, but since their costs are to be lowered significantly, they would be affordable.

3.3 PHASE 2: INSTITUTIONAL SETUP

A responsible unit which is named Infrastructure Unit (IU) is necessary to be established within the public/private housing institution/company which is responsible for the delivery of the LCH. IU would be responsible for the provisions of BICs for the new LCH developments. IU should take in consideration the national objectives and policies, master plans and decisions of the various stakeholders of infrastructure for the benefit of a proper selection, design, financing and management of BICs for LCH.

The IU would coordinate and cooperate as appropriate with other relevant units inside the institution and the relevant governmental and non-governmental institutions for the provisions of BICs. For each specific LCH project, working teams (WTs) for the provision of the different BICs should be assigned by the director of the IU. Each Working team (WT) is responsible for ensuring the adequate provision of one or more of the seven BICs in confirmation with the main bases of provisions and the proposed criteria for each one taking into consideration the assessment of the local conditions and the specific characteristics of each LCH project site. The work methodology for each WT is described in Figure 3-2.

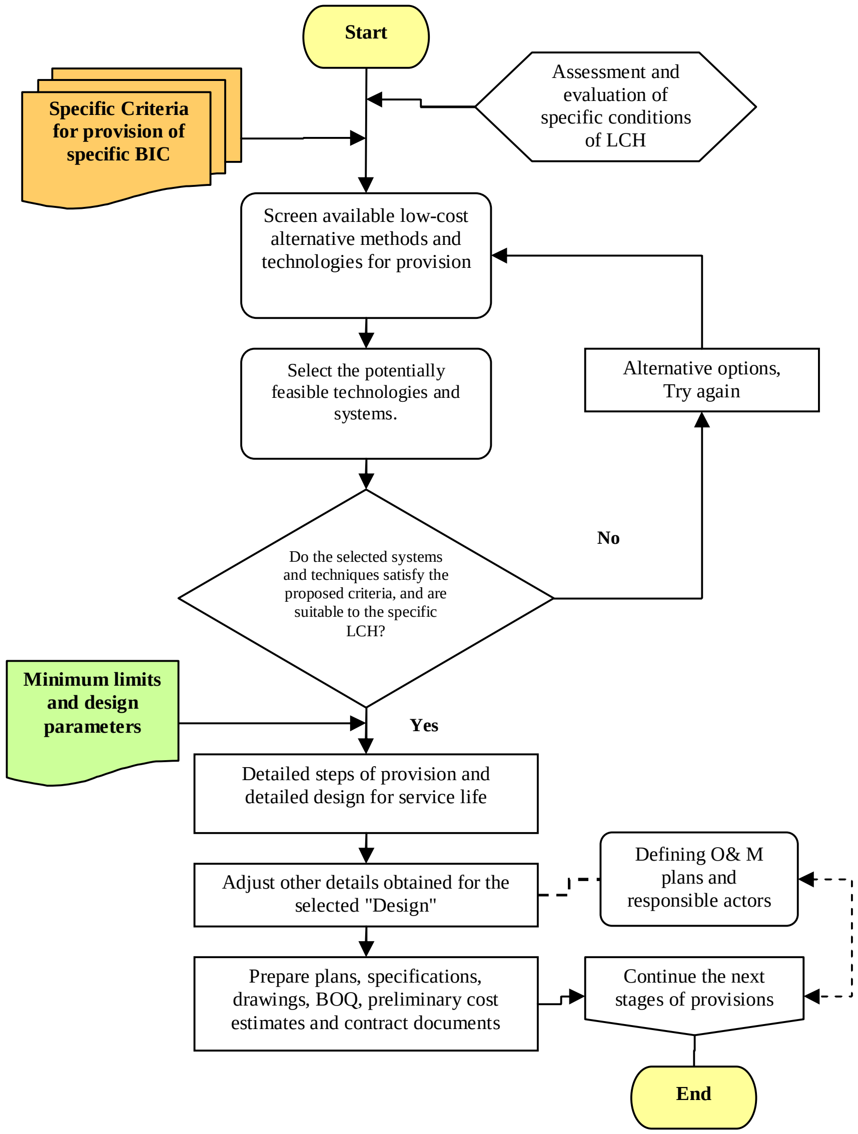


Figure 3-2: Work methodology for each WT to provide each BIC for LCH.

Each WT would follow a specified selection methodology for the best choice of adequate and low-cost systems, techniques and practices for the specified BIC, and then prepares the technical designs in addition to listing the required O&M tasks. Then, final and exact cost estimates for each BIC are done. Finally, the proper arrangements for allocating the needed funds for implementation of BICs are ensured.

3.4 PHASE 3: REQUIREMENTS OF PROVISIONS OF BICs FOR LCH

3.4.1 Provisions of BIC -1: Water Supply for LCH

Objective of provision: The principal objective of the provision of water supply component (BIC-1) is to provide a reliable supply of water in sufficient quantity and of reasonable quality to the LCH. This would be done by the following activities:

3.4.1.1 Activity (1): Definition of the proposed criteria for provision of BIC-1: Water Supply

The provision of water supply for LCH should be sustainable and of low-cost, which requires the consideration of the following proposed criteria which are developed based on Chapter Two, Section 2.2.

1. **Minimum adequate quantity**

Minimum amount of domestic water supply should be provided for LCH for the basic life being, the health and convenience of the user. Minimum amounts of potable water supply (i.e., water for drinking and cooking) should be provided separately if the domestic water quality is not safe for public health. Minimum commercial water demands should be ensured also for shops, schools and clinics. Minimum permissible fire fighting demands should be supplied also for safety reasons.

2. **Minimum allowable quality**

Whereas the availability of sufficient *quantity* of water for bathing and laundry is of great importance, the *quality* of this water is not especially important to be at potable quality, but at the minimum permissible standards allowed by the PWA. Potable water for drinking and cooking should be of adequate salinity levels and nitrate concentrations so that not causing related diseases such as Blue baby disease. The quality of potable water for drinking and cooking should comply with PWA and PSI standards.

3. **Sustainable cheap sources of water**

The carrying capacity of the existing nearby water network (if exists) should be able to supply the total needed demand. Otherwise, new groundwater well with the appropriate treatment may be constructed for LCH in coordination and cooperation with PWA. Supplementary water resources such as stormwater should be considered as an additional source for raw water. It should be harvested from rooftops and paved areas to prevent flooding for one reason and the other reason to use it for outdoor uses or catching it locally for aquifer recharging. In case of adopting decentralized wastewater treatment system (DWT), the treated effluent should substitute potable water for landscape irrigation and/or agricultural activities for food production. Water conservation measures which include indoor water-conservation such as water-saving plumbing fixtures and metering for each housing unit, and outdoor water-conservation such as drought-tolerant plants for landscaping, drip irrigation system and replacing potable water with rainwater or treated wastewater for irrigation must be enforced.

4. **Adequate accessibility and reliability of water supply**

The water supply should be made accessible for each household through piped system into each housing unit, distributed by internal plumbing to toilets, bathrooms and kitchens, and available 24 hours a day. The reliability of the water supply all the day is made either by providing storage water tanks for each building if the water is supplied from the unreliable municipal water network or by providing public water tank for the specific project if the water is supplied from on-site water well/s.

5. **Low cost and durable materials and equipments**

Durable and low-cost local materials and products should be used such as PVC pipes. Minimum number of equipments and pumps is important to save money and energy costs with minimal lengths and diameters of pipes.

3.4.1.2 Activity (2): Proposed methodology for selection of the suitable systems and techniques for provision of BIC-1

- the provision of water supply should be in conformation with the framework of the assignments of tasks and responsibilities among the different actors along the lifeline of this component and which is illustrated in Figure 3-3, and in confirmation with the proposed criteria and general approach of water resource cycle which is developed in Figure 3-4.

- The selection methodology is illustrated in Figure 3-5 for selecting and deciding the suitable sources of water supply according to exact evaluation of the LCH site conditions.

- the adequacy of the nearby municipal water supply is assessed by establishing whether they have the sufficient capacity to serve the LCH, based on approximate supply estimates at the point at which the water enters the zone of LCH. If water demand is found to exceed water supply; this means that there is a need to increase the level of service by increasing periods of supply or choose combined supply sources or find new alternative water resources.

- The complete design calculations is done using the minimum limits and design parameters which are illustrated in Table 3-1 and has been concluded in Activity (3).

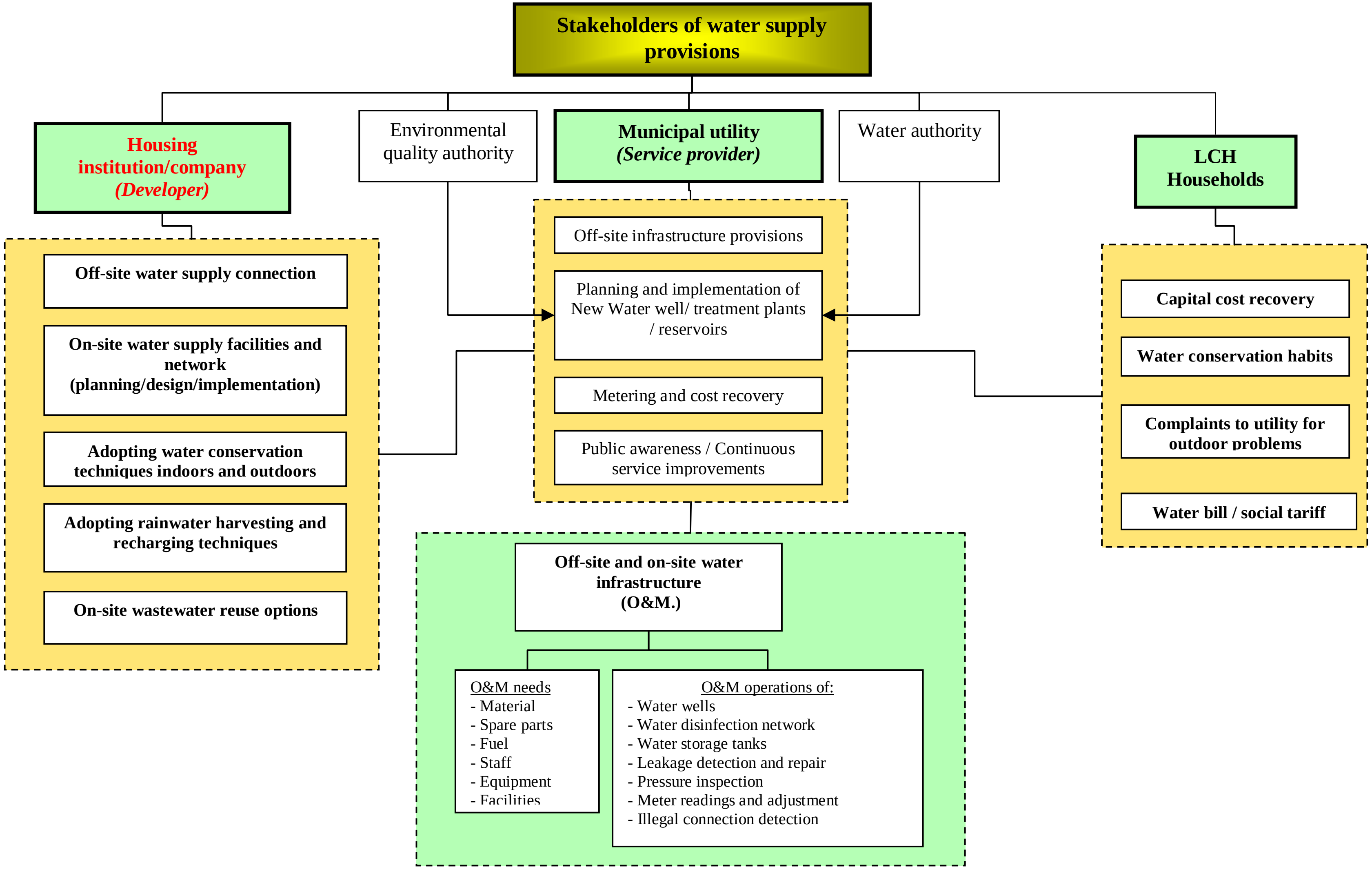


Figure 3-3: Assignment of tasks and responsibilities for provisions of water supply.

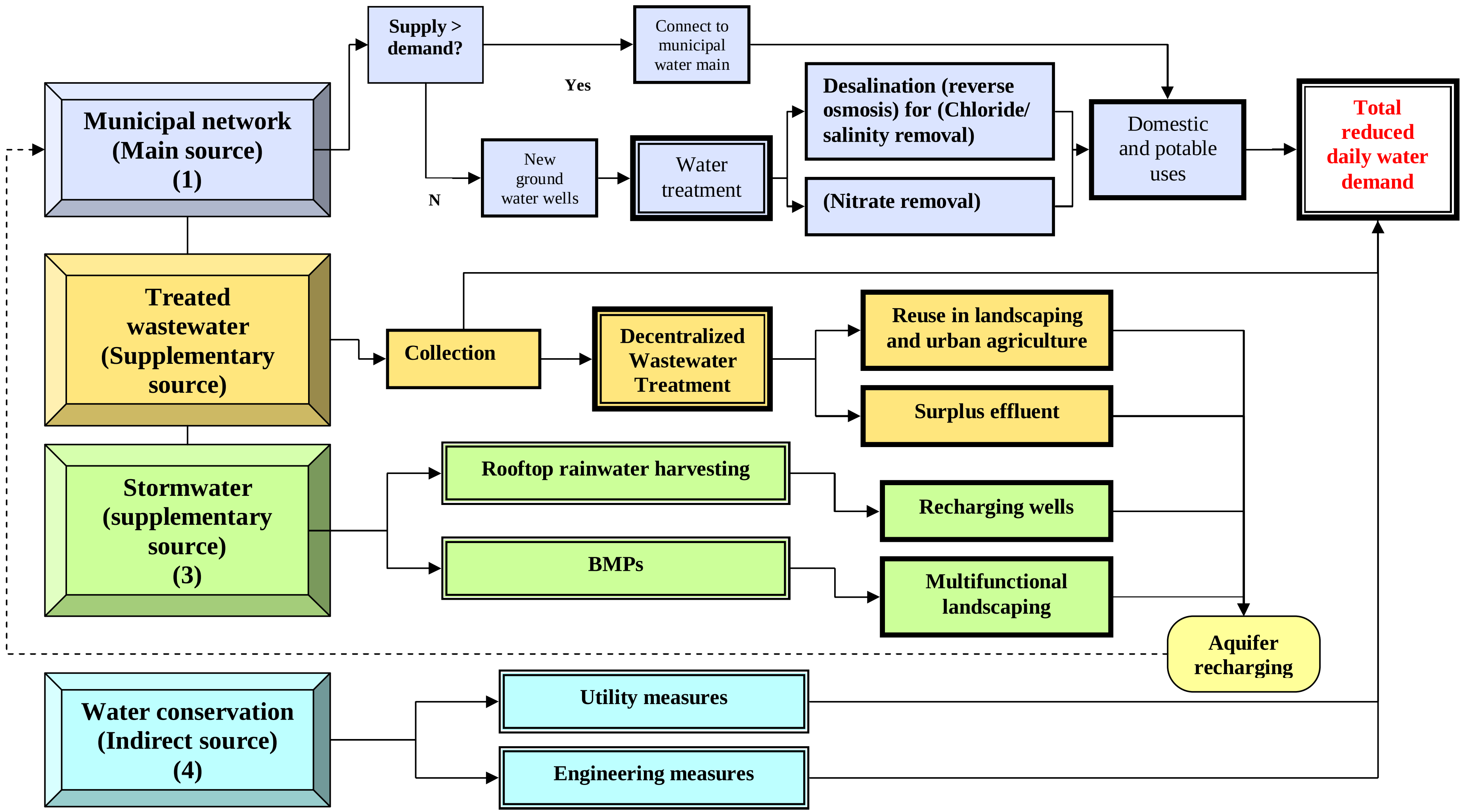


Figure 3-4 : General approach for the resources of water supply to be used for LCH.

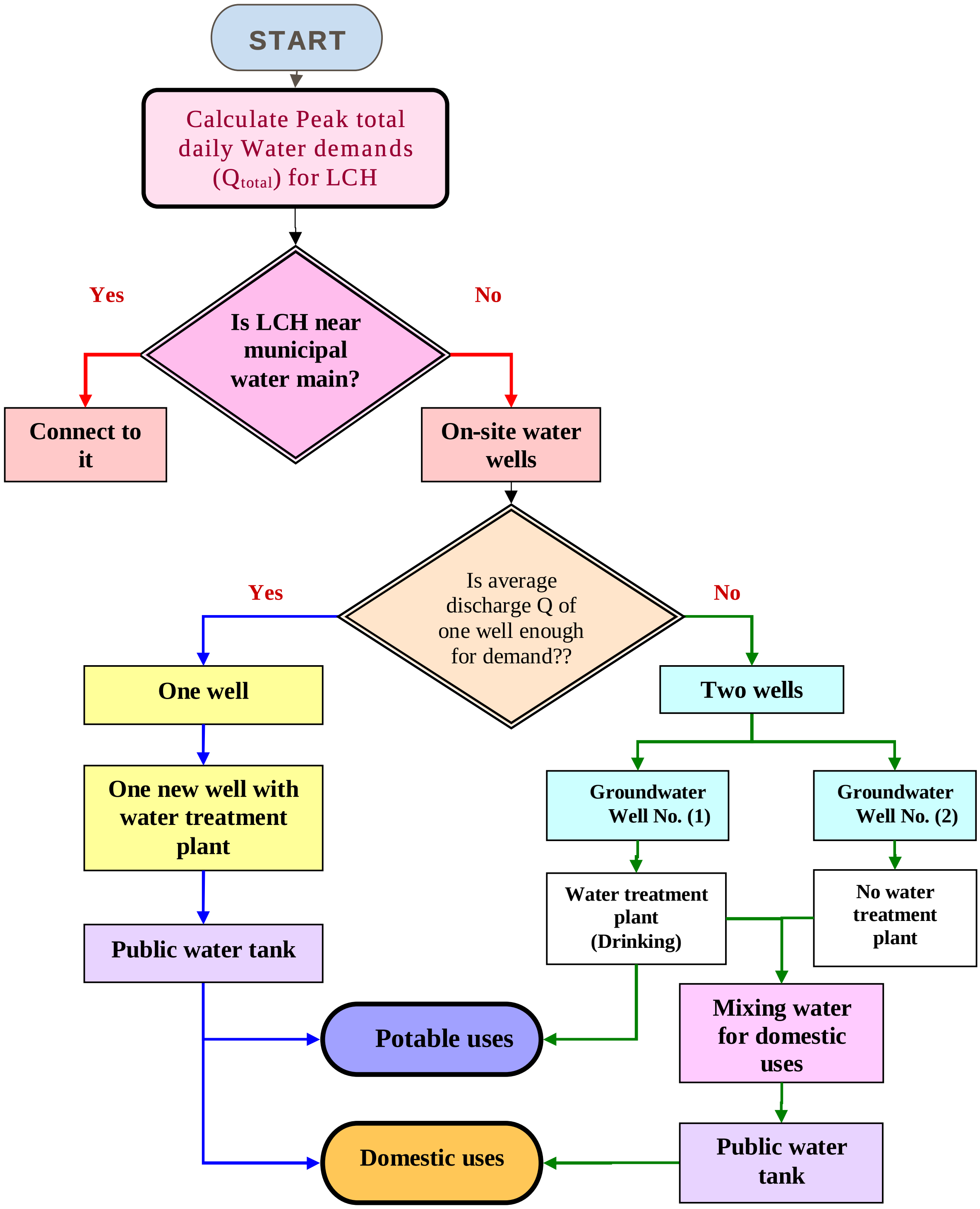


Figure 3-5: Methodology of selection of water supply resources.

3.4.1.3 Activity (3):Determination of minimum limits, design parameters, main elements and O&M

Table 3-1 below illustrates the inventory of main items and minimum requirements for provisions of water supply (BIC-1)

Table 3-1: Inventory for provisions of BIC-1: Water supply for LCH

No.	Item	Minimum acceptable requirement
(1)	**Minimum limits and Design parameters required for planning and design of BIC-1: Water supply**	
1.	**Population**	(1) When the LCH is located in developed area, the population is obtained by multiplying the planned number of housing units in the project by the average household size, e.g., in Gaza Strip (6.8 capita per household). (2) When the LCH is located in new undeveloped area, the best procedure will be to calculate population densities in representative fully developed areas and apply the figures thus obtained to all similar areas within the supply area.
2.	**Minimum adequate Quantity**	
2.1	*water demands*	
a-	Average per capita domestic water demand	It is the (*costumer demand*) of 100 *l/c/d*
b-	Baseline demands (average daily demand)	It equals (average per capita/day x population)
c-	Potable water demands	it is considered in design when separate potable water supply (desalinated water) is provided and has an average of 3 *l/c/d*.
d-	Industrial, commercial and institutional demands	Normally, it is not necessary to make specific allowance for the demand from shops or local primary schools. (1) Industrial demand (if exists) is considered individually. (2) Commercial shops and small workshops are treated as standard housing units. (3) Institutional demands: (a) schools; (4-5 *l/c/d*), (b) - clinics; (300-500 *l per bed per day*)
e-	Fire fighting demands	The needed fire flow is (2-5m^3/min) for 2-5 hrs duration for population less than 2500, and (9.5-10m^3/min) for 10 hrs duration for larger population. It should not be included in the total demand.
f-	Leakage and wastage(*w*)	It is the unaccounted-for water (UFW) which is 25% of the average daily demand.
f-	Average total daily demand	It is the sum of the domestic, commercial and institutional demands
2.2	*Peak factors*	
a-	Peak day factor (PF_d)	- It is to be used in the design of production and storage facilities and bulk supply mains. It is suitable to be taken as 1.2 for LCH
b-	Peak hour factor (PF_h)	- It is to be used in the design of primary and secondary distribution mains. It is suitable to be taken as 2.5 for LCH - Where water is supplied for less than 12 hours per day, peak hour factor may be taken as (30/N) where N is the number of hours supply during the day and ranges between (3-6) hrs.
2.3	*Peak total daily demand*	- The peak daily domestic demand: $Q = P_n(f \times q + w)/100 \quad = P_n(f \times q + 0.25q)/1000$ Where: Q: peak daily demand (m3/day), P: design population, f: peak day factor, q: per-capita average daily water consumption (*l/c/d*), w: per-capita allowance for leakage (*l/c/d*)
3.	**Minimum adequate quality**	
3.1	*Potable water*	The quality of potable water for drinking and cooking should comply with PWA standards. (TDS<1000- 1500 mg/l and Nitrate (NO_3) < 50 – 70

No.	Item	Minimum acceptable requirement
		mg/l), or (Cl< 250 - 600 mg/l and Nitrate (NO_3)< 50 - 70 mg/l), whichever is easy to examine. Further, fecal coliforms should not be found at all. This quality is difficult to be provided in all areas of Gaza Strip for the domestic water supply. In these cases, the drinking water is to be provided by other methods as stated below.
4.	**Low-cost sustainable water sources**	The selection methodology for the main water resource which is illustrated in Figure 3-5 is followed to determine the main water resource for domestic and potable uses.
4.1	*Domestic water (cleaning &sanitation)*	The available resources of water supply for different uses are illustrated in Figure 3-4, and may be anyone of the following: (1) off-site sources: the municipal water network (water from groundwater/desalinated water) (2) on-site ground water wells (pumping with storage floating on the system)
4.2	*Potable water (drinking & cooking)*	Desalinated water from water shops/ water vendors or on-site groundwater wells desalination
4.3	*Fire fighting demands*	Separate allowance for fire fighting demands is not required. Any fire hydrants should be on primary and secondary municipal water mains.
4.4	*Outdoor uses (Landscaping/ car washing/ agricultural activities)*	The fresh water supply is substituted by one or both of the following: (1) rainwater harvesting (2) treated wastewater
5. *5.1*	**Min. pressures** *Minimum pressure head*	- The pressure head in the water main should be at least (10m) above the highest point in the LCH. - An additional (3m) should be allowed for each floor to which water has to be supplied, e.g., for five-story building, an addition 15 m should be allowed, e.g., minimum head allowed in house connection for 5 story building is (25m; 2.5 bar). - Minimum pressure of (0.5 bar/5m) is required at tap. These figures are in relation to the highest ground levels in the area served by the mains and not to the ground levels along the mains themselves - Minimum pressure at fire hydrant is (1.4 bar/14m)
(2)	**Main physical elements**	
1.	**Groundwater wells**	The main elements are (1) Well submersible pump, (2) treatment water facility (Saline removal/ reverse osmosis, nitrate removal) and chloride disinfection unit, (3) water tank (reservoir), (4) booster pump
2. *2.1*	**Pumps** *Well submersible pumps*	- One or two operating pumps and one standby pump for each on-site groundwater well are required. They are chosen knowing the peak discharge Q_{peak} and needed pump head H_P.
2.2 a-	*Booster pumps* Large booster pumps	- Required for (1) pumping water from municipal water mains to the LCH water network or to the public water storage tanks, whereas the second option is preferred due to cost and efficiency reasons, or (2) pumping water from water wells to the public storage tanks. - For each on-site groundwater well, two running pumps and one standby, or one running pump and one standby
3.	**Public water tanks**	- They are used when the supply capacity from municipal water mains is equal or greater than the peak daily demand or when water wells are constructed in the site of LCH, and they eliminates the need for the

No.	Item	Minimum acceptable requirement
		buildings' ground and roof storage tanks and booster pumps and save money. - A combined supply/distribution (pump with storage tank) system is the most economical solution where the water is delivered to the storage tanks through mains that form part of the distribution system. - For economical and technical reasons, a storage capacity of (20-35%) of the maximum daily consumption is recommended in order to offset the shortage in water during peak periods. - ground water tanks are preferred on the elevated ones as long as the site topography permits, since they are cheaper in construction and larger in capacity.
3.1	*The ground water tanks*	Are used in case of existence of high location near the supply area, with storage capacity of (1000-5000m3)
3.2	*The elevated tank*	Are used to provide the required head in case of flat topography of the site and usually have storage capacity of (200-300m3).
4.	**Pipes**	- The water mains should be located above the sewer lines, and should not pass through sources of contaminated water. - PVC pipes are to be used for the water distribution system.
4.1	*Primary and secondary mains*	- Primary and secondary distribution systems should be loops because they allow water to take alternative routes through the system to keep operating pressures at constant level through the system and maintain at least partial supply in event of pipe failure. - All mains of PVC pipes of minimum diameter of (150mm) and greater. In smaller systems, (100mm) may be included in the secondary network. - primary/secondary systems should be a looped grid with mains spaced at average of (500m) intervals
4.2	*Tertiary mains (mains supplying house connections)*	- the normal minimum standard size for tertiary mains is (75 mm) - The required minimum diameter of tertiary mains are related to the number of houses served; (a) for (12 houses), the diameter is (38mm), (b) for (20 houses), the diameter is (50mm), (c) for (40 houses), the diameter is (75mm), (d) for (100 houses), the diameter is (100mm) and (e) for (200 houses), the diameter is (150mm) - an allowance head-loss of (3m) in tertiary mains is assumed - the tertiary mains should be branches to reduce the number of sluice valves and their routes are predetermined by existing rights of way and the location of the nearest secondary mains
4.3	*House connections*	-50mm PVC pipes of length 10m are suitable for a connection that serving 20 houses. -20mm PVC pipes are adequate for connections up to 100m in length. - an allowance head-loss of (2m) in the connection is assumed
4.4	*Pipes depth*	- Minimum cover in lanes less than 3m wide is (60cm). - The cover is at least (90m) in streets subject to traffic loads, - All pipes are bedded in sand or gravel. Concrete thrust blocks are provided at all bends and tees to resist force produced.
5.	**Building water supply elements**	
5.1	*Ground domestic water tanks(Concrete/ plastic)*	- They are used when the supply capacity from municipal water mains is less than the peak daily demand in case of unreliable municipal water supply and non-existence of public water tanks to ensure continuity of water supply. - One concrete tank or plastic tanks to store the water from the municipal network and pump it to the roof tanks.

No.	Item	Minimum acceptable requirement
5.2	*Roof domestic water tanks(plastic)*	1 plastic tank for each H.U. should has a capacity in the range of 500- 1000 liters based on consumption of (100 l/c/d), or one concrete tank for all H.Us. in the building.
5.3	*Small booster pumps*	One pump for each building to pump domestic water from ground to roof tanks, or directly from the municipal main to the roof tanks
5.4	*Meters*	One meter for each H.U.
5.5	*Water-Conservation fixtures*	As shown in Table 5.1, Appendix 5
5.6	*Rooftop rainwater harvesting (RRWH)*	The rooftop rainwater is harvested to flow into the recharging wells and/or the green areas in the central courtyards (bioretention areas) instead of discharging into the streets or the sewerage system. The main elements are (1) catchment area and (2) inflow structure: gutter, inflow pipe and filter.
6.	**Valves**	The water supply network should be design to include minimum number of valves which include the following types:
6.1	*Sluice/shut v/Stop valves*	- They are used to subdivide the distribution system to allocate water between areas and shut down sections of the system for maintenance and their number is reduced if tertiary mains are branches. - Sluice valves should not be provided if they could not be maintained, e.g., it should be possible to isolate areas of (50-100) dunums rather than every branch main.
6.2	*Washing valves*	Washouts should be provided at low points in the distribution system to enable mains to be drained for maintenance and repair.
6.3	*Air release valves*	At least one valve to release the trapped air upon operation.
6.4	*Check valves*	They are only provided to pipes connected to water tanks.
7. 7.1	**Fire fighting hydrants** *Conventional practice*	- Any fire hydrants should be on primary and secondary mains, ideally of (150mm) diameter and over which is capable of carrying the required flow at any fire hydrant at a minimum pressure of 1.4 bar/14m, without the need for separate allowances - the minimum area served by a single hydrant is commonly taken as (3,720 m^2); minimum spacing is 60m, but should not be more than 150m), or at intervals determined by the longest hose that is available on the fire appliances used in the area. - Hydrants should be located at street intersections so that hoses may run in any direction.
7.2	*Special cases*	When either adequate maintenance cannot be guaranteed or water supply is intermittent, stand pipes of (75mm) are provided at intervals of (1-2 km) through the area, with a height enough to discharge into fire tenders and browsers. A tank of (10m^3) capacity that is kept full at all times should be provided adjacent to the standpipe.
8.	**Water conservation measures**	
8.1	*Engineering measures*	Low flush toilets (6 l/flush) or Toilet dams for conventional toilets, Low-flow showerheads, Faucets aerators (6.4-9.5 l/min), Landscaping (drip irrigation/ native drought tolerant plants/ mulching)
9.	**Landscape irrigation system**	Drip irrigation system is used for landscaping, Water source for irrigation is the rainwater or the treated water
(3)	**Minimal operation and maintenance (O&M)**	

No.	Item	Minimum acceptable requirement
1.	**Operation and maintenance**	All off-site and on-site water supply network operation and maintenance works are the responsibility of the relevant municipality, and include the following tasks: (1) Making sure that "as-built" drawings and records are kept including all pipe sizes, locations of sluice valve and other fittings, (2) Skilled leak detection teams need to be trained and resourced to cope both with emergency repairs and persistent leakages and (3) Regular mentoring of water supply and water pressure needs to be developed as part of the operational support program.

Developed based on **Section 2.2.2, Chapter 2 and Appendices 3,4 and 5**

3.4.2 Provisions of BIC -2: Wastewater Collection (Sewerage System) for LCH

Objective of provision: The main objective of the provision of sewerage system is to collect the generated wastewater through safe and adequate collection system into the point of treatment and disposal. This would be done by the following activities:

3.4.2.1 Activity (1): Definition of the proposed criteria for provision of BIC-2: sewerage system

The provision of the sewerage system for LCH should be at low-cost and environmentally, socially and fiscally sustainable by considering the following criteria which are developed based on Chapter Two, Section 2.3:

1. **Protection of public health, environment and pollution prevention**

The amounts of generated wastewater should be collected through safe and adequate collection system into the point of treatment and disposal, while preventing leakage or overflow from manholes, pipes or septic tanks in order to prevent spread of diseases and environmental pollution by pathogenic bacteria and harmful chemicals in the wastewater.

2. **Minimum amounts of generated wastewater**

Minimizing the amounts of generated wastewater by enforcing the use of water saving plumbing fixtures and preventing the stormwater to enter the sewerage system by adopting the "separate system", e.g., not mixed with stormwater in order to reduce the size of the physical components of the collection and the treatment systems and to extend their life span and conserve valuable water resources.

3. **Low-cost sewerage system**

The used sewerage system should be the low-cost *"simplified sewerage"* other than the expensive conventional one; which is based on the minimum tractive force, not on the minimum cleansing velocity (as the conventional designs) to contribute to smaller pipe diameters, lengths, simpler apparatus, less number of manholes with reduced depths, less excavation works because of flatter sewer gradients and minimal or no use of pumping stations in order to lower the capital and running costs.

3.4.2.2 Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-2

The selection of the adequate suitable sewerage system lies within two possibilities which are summarized in Table 3-2**.** It is important to note that due to scarcity of lands and their high costs in the developed urban areas in Gaza Strip, the new planned LCH is expected to be constructed in peri-urban areas which are usually adjacent to agricultural lands. Since the

Table 3-2: Options of wastewater collection (sewerage system)

Option	**Option (1)** **Centralized sewerage system**	**Option (2)** **Decentralized sewerage system**	
Location	LCH is located in an urban area provided by municipal sewerage network.	LCH is located in an un-serviced peri-urban or rural area that is not connected to the municipal sewerage system	
		Possibility (1)	**Possibility (2)**
		No potential agricultural activities.	There are potential agricultural activities.
Type of sewage	Combined grey and black sewage	Combined grey and black sewage	1- Combined grey and black sewage, or 2- Separation of grey water and black water
Low-cost sewerage system	Simplified sewerage	Simplified sewerage, with decentralized treatment plant	1- Simplified sewerage, with decentralized treatment plant. Or 2- Grey water collection and treatment, and use of modified cesspits (septic tanks) for the black effluent.

LCH is planned to serve the low-income families, it is necessary to think how to increase their income by using the allowable natural resources through introducing the dangerous wastewater to be a good water resource for agricultural activities to produce crops to be used personally and selling the extra production to earn money. The treated grey water effluent which meets standards for restricted irrigation can be used to irrigate eggplants, herbs and olives.

The selection methodology for the suitable sewerage system according to the site specific situation is illustrated in Figure 3-6.

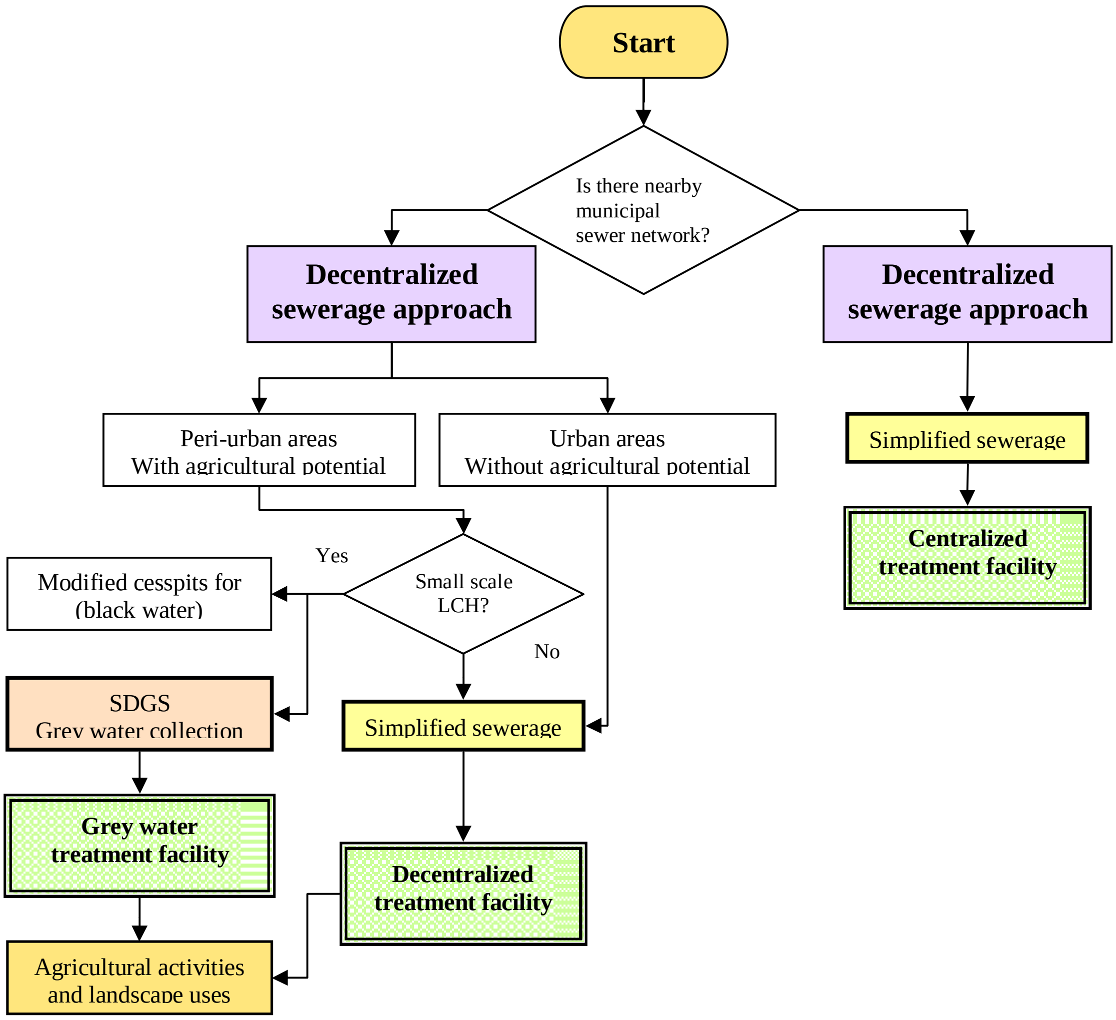


Figure 3-6: Selection methodology for low-cost sewerage system for LCH.

3.4.2.3 Activity (3):Determination of minimum limits, design parameters, main elements and O&M

Table 3-3 below illustrates the inventory of main items and minimum requirements for provisions of BIC-2.

Table 3-3: Inventory for provisions of BIC-2: sewerage system for LCH

No.	**Item**	**Minimum acceptable requirement**
(1)	**Minimum limits and Design parameters required for planning and design of BIC-2: Wastewater collection (sewerage system)**	
1.	**Low-cost Type of the sewer system**	It is the "separate system" which is designed to carry foul flows only; flows from toilet, kitchen, and bathroom areas, with some allowance for stormwater flows.
2.	**Low-cost System layout**	- Layouts should aim to minimize sewer lengths, while this not resulting into increased depths - The sewers are composed of tertiary sewers which discharging into primary/trunk sewers, eliminating the need to the secondary sewers.
3.	**System technology**	

No.	Item	Minimum acceptable requirement
3.1 a.	*Simplified sewerage* Design concept	It is composed of Small-diameter sewers laid at shallow depths with flatter gradients and with fewer and simpler manholes to convey the sewage. The design is based on Minimum tractive tension of 1 Pa rather than minimum cleansing velocity of (0.6m/s).
4.	**System hydraulics**	
4.1	*Design period*	- simplified sewerage employs design periods of 20 years or less, while USEPA limits the design period to (10-15 years), since short design periods minimize the effects of errors in forecasting population growth and their water consumption.
4.2	*Design flow*	1) The calculation of the peak foul flows in tertiary sewers is related to the number of housing units served or to the population, whereas the allowance for groundwater infiltration is usually discounted because tertiary mains are laid above water table, and allowance for stormwater in separate sewers can be taken to be equal to the peak foul flow, i.e., the sewers should not run more than half at the peak foul flow. 2) The average foul flow is calculated as a fraction of the water consumption; it equals 80 *l/c/d.* 3) a peak factor of (1.8) has been used in the simplified sewerage against peak factor of (2-3.3) for conventional systems $Q_{peak}(l/d) = 1.8 \times 80(l/c/d) \times population$
4.3	*Ensuring self-cleansing*	No minimum self-cleansing velocity is required. Instead, simplified sewerage is based on minimum tractive tension of 1 Pa, (i.e., maintaining a boundary shear stress of (0.1 kg/m^2) which is sufficient to resuspend a 1-mm particle of sand) for determining the minimum slope.
4.4	*Minimum slope of sewers*	- Flatter slopes are achieved by small diameter sewers. - the minimum slope of the sewer is determined by: $I_{min} = 0.0055\ Q_i^{-0.47}$, where Q_i *(l/s)* is the initial flow (Bakalian *et al*, 1994)
4.5	*Minimum diameter*	Smaller minimum sizes of sewers (100mm) than specified for conventional sewers (200mm) are used. The use of smaller-diameter sewers results in greater depths of flow and higher velocities, and improves cleansing.
(2)	**Main physical elements**	
1.	**Sewer pipes**	
1.1	*Diameter*	- For tertiary sewers, the size of the sewer is governed by the minimum allowable diameter rather than the capacity required to carry the peak flow. - Minimum diameter of laterals and branches is 100 mm for maximum lengths of 400m, serving up to 1200 people. Other minimum diameters that are based on water consumption of (100 *l/c/d)* and the number of households are illustrated in **Table 6.1, Appendix 6.** Exact method for calculating exact diameters is illustrated in pages 27-28 in (Bakalian *et al*, 1994)
1.2	*Material*	UPVC pipes are used.
1.3	*Depth*	- Typical minimum sewer depth is (0.6-0.65m) below sidewalks, (0.95-1.5m) below residential streets depending on the distance from the street centerline and amount of traffic) and 2.5 m below heavily traveled streets.
1.4	*Gradient*	1 in 270 to 1 in 255 (0.0037 – 0.004m/m) for a100-mm sewer pipe, while the house connection gradients are (2%= 0.02 m/m)
2.	**Service connection**	It is 60-cm square or circular connection (or inspection) box place between the building and the service line under the sidewalk connected to the sewer with a curve of 45 degrees curve and a "Y" branch. A simpler cleanout could

No.	Item	Minimum acceptable requirement
		be substituted. Refer to (Bakalian *et al*, 1994) for technical details.
3. 3.1	**Simplified alternatives to conventional manholes** *"simplified" manholes* a) Spacing	- Conventional manholes are replaced by "simplified" manholes, cleanouts or buried boxes, and manholes are used only at major junctions. -Manholes are placed at all junctions and changes in direction, gradient and size and at inverts that allow the sewers to be cleaned. They are similar to conventional manholes, but they are reduced in size from 1.5m to 0.6-0.9m. Situations where manholes should not be eliminated: 1) very deep sewers (more than 3m) 2) slopes smaller than required 3) sewers with drops, and 4) points of connection from certain commercial and industrial establishments - Spacing should not exceed about 90-100 meters for primary/secondary sewers up to 600mm diameter and 50 meters for tertiary sewers
3.2	*Other simplified alternatives*	1) *inspection and cleaning terminal (terminal cleanout);* used at starting point of sewer 2) *intermediate inspection tube;* used at long straight sewer 3) *two separate 45-degree curves);* used at horizontal curve of 90 degrees 4) *Y branch and one 45-degree curve);* used at service (house) connection 5) *underground concrete box);* used at change of diameter 6) *underground concrete box);* used at change of slope Refer to (Bakalian *et al*., 1994) for technical details.
4.	**Valves**	Not required
5.	**Lift stations**	Not required
(3)	**Minimal operation and maintenance (O&M)**	
1.	**Preventative maintenance**	They are similar to those of a conventional system; Minimum maintenance includes cleaning, flushing, repairs, and supervision of connections and disconnections. The maintenance program should at the very least include: 1) Determination of the types of problems and trouble areas, 2) prompt removal of any accumulation of foreign material, 3) occasional flushing of the sewer lines for cleaning

Developed based on **Section 2.2.3, Chapter 2 and Appendix 6; Bakalian *et al*., 1994**

3.4.3 Provisions of BIC -3: Wastewater Treatment and Disposal or Reuse for LCH

Objective of provision: The main objective of the provision of wastewater treatment and disposal or reuse for LCH is to get rid of the generated wastewater in a sustainable way which protect the LCH from pollution and prevent the spread of diseases, while maximizing reuse opportunities where seen appropriate. This would be done by the following activities:

3.4.3.1 Activity (1): Definition of the proposed criteria for provision of BIC-3: Wastewater treatment and disposal or reuse

Wastewater treatment is either done in central treatment plant for final disposal or done in decentralized facility for reuse should be environmentally sound and socially accepted while not causing unaffordable fiscal burdens on the government or the households, by ensuring the following:

1. Protection of health, environment and catchment areas

The collected wastewater from LCH should not be allowed to be discharged untreated into nearby wadis or into the sea. Pollution control requirements should be incorporated into design and those measures to mitigate negative environmental impacts on ground water resources and water bodies should be undertaken.

2. Adequate effluent standards

The wastewater treatment systems, weather the (CWT) or the (DWT) facilities must produce an effluent with the minimum allowable standards that confirm with the minimum or maximum Palestinian standards for wastewater treatment with respect to the reuse, recharge or disposal options. The most important constituents to be considered and checked are TSS and BOD, fecal coliform and Nutrients as N.

3. Adequate loading capacity of central treatment plants

Preference is given for connecting the LCH to the nearest municipal central treatment plant as long as its available loading capacity is adequate to treat extra load without negative impacts on the public health, the environment or the quality of treated sewage.

4. Utilization of Decentralized Wastewater Treatment (DWT) systems where seen appropriate

When the LCH is located in un-sewered area, the decentralized system DWT approach which is based on the concept of "cyclical treatment" rather than the "traditional linear treatment" should be adopted for the promotion of the conservation of water and nutrient resources. The treatment train (i.e., the sequential attached unit operations/processes of treatment) should be planned and implemented to be socially acceptable and environmentally benign at the lowest costs. Therefore, the following sub-criteria for planning and design of the DWT facility are proposed:

4.1 ***Sustainability:*** the wastewater treatment train (plant) should incorporate the suitable individual unit operations/processes which contribute to the removal of specified physical, chemical and biological constituents of which of major importance are (TSS), (BOD), pathogenic organisms, and sometimes N and/or P, before disposal to sea, infiltration to groundwater, or reuse in landscape/agricultural irrigation according to the site specific situation, so that not harming the environment or public health.

4.1.1 Reuse potential; the treatment train should result treated effluent suitable for urban selective reuse (e.g., contribute to recovery of nutrient and water resources for reuse in agricultural production and landscape irrigation); with standards that conform with the Palestinian Standards shown in Table 4.1, Appendix 4 and satisfies the quality criteria of the

Palestinian Ministry of Agriculture shown in Table 4.2, Appendix 4, and both adopts the limits of WHO standards shown in Table 4.3, Appendix 4 for the unrestricted irrigation for all reuse options; as stringent standards for public safety.

4.1.2 Recharge potential; due sensitivity of Gaza aquifer to nutrients and salinity, the extra effluent should be used to recharge the aquifer but should neither cause contamination of the ground water with nutrients nor cause more chloride concentrations.

4.1.3 Minimal costs; the capital costs of the unit processes/operations of the treatment train should be minimal and cost recovery for O&M should be ensured for sustainable functioning of the system.

4.2 ***Applicability:*** the unit operation/process for removing the specified constituents should be applicable to the local conditions and population of the LCH such as Climate, topography and socioeconomic factors and should also be matched to the expected range of flow rates.

4.3 Performance: the combination of the selected unit operations/processes should produce effluent quality which must be consistent with the minimum reuse, discharge or recharge requirements.

4.4 Reliability: the selected treatment train should be reliable on the long term, e.g., the operations/processes should stand periodic shock loadings and keep the effluent quality as like as it is designed to achieve it.

4.5 Aesthetic: the visual appearance of the DWT facility should not contribute to negative visual impacts on the LCH or odors or noise to the residents by integrating it with the surrounding environment and locating it at adequate distance from the LCH.

4.6 Land availability: the land area assigned for the DWT facility should be adequate to accommodate the current facilities and the future expansion with adequate buffer zones to provide the landscaping and minimize the visual impacts.

4.7 Low energy requirements: the DWT facility should be located geographically at the lowest point in the area of the LCH to minimize the need for pumping costs. The used processes/operations are preferred to be less mechanized as far as possible by promoting the use of non-mechanical units.

4.8 Using grey water system where suitable: the use of gray water separation and treatment is recommended for small, rural projects since they prove to be sustainable in urban and peri-urban agriculture (UPA) for jobs' generations and food production.

4.9 Minimal operation and maintenance (O&M) requirements: the unit operations/processes of the treatment train should require the least O&M. The spare parts should be available at any time with low cost and the skilled personnel requirements for O&M should be minimal.

3.4.3.2 Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-3

There are two possibilities for the provisions of wastewater treatment component for the LCH, which depend on the location and the site specific conditions of the LCH. The two possible situations are:

1. If the LCH is located in sewered area, the sewerage system of the LCH is simply connected to the main municipal sewer line which discharges into a central treatment plant. It is Option (1) in Table 3-4.
2. If the LCH is located in unsewered area, the DWT approach is to be used. In this case the selection of the most suitable decentralized wastewater treatment plant is to be done based on the cyclical treatment concept shown in Figure 3-7 taking into consideration the proposed criteria for provision and the different site specific conditions.

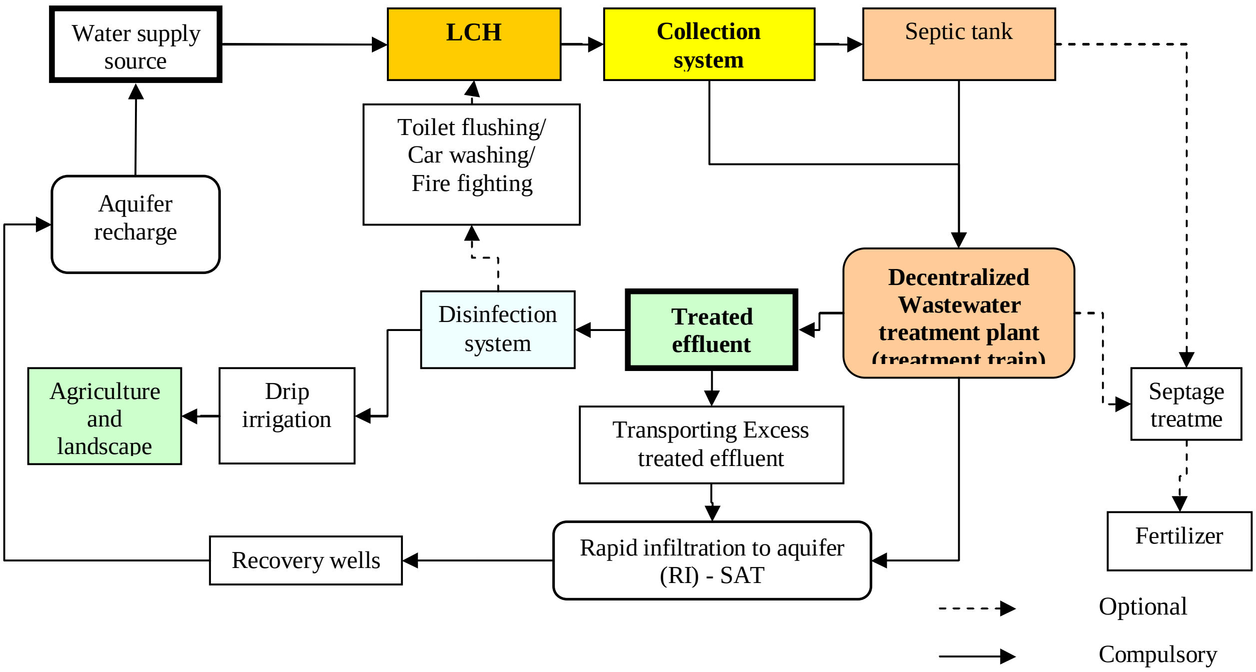


Figure 3-7: Cyclical treatment concept for the DWT approach for LCH.

The proposed framework for the responsible working team (WT) assigned in the IU for the provision of the DWT facility in a systematic manner is shown in Figure 3-8, and summarized as follows:

1. Data collection; of the current and future projections of the generated wastewater, the critical pollutants, the aesthetic and location requirements, cost requirements, treated effluent requirements, design and construction requirements. This is done in cooperation with the water/environmental authority.

2. Site evaluation; regarding reuse options, groundwater recharge or sea discharge should be accomplished, according to (1) information from previous research and (2) information from field study. The different possible conditions for LCH are summarized in Table 3-4.

3. Screening the treatment options/ technologies; is to be done for the LCH according to its specific site conditions as shown in the following steps:

a) Define the reuse application in the LCH; from the reuse options illustrated in Table 7.8, Appendix 7, if it is for landscaping or anticipated agricultural uses or both, and also define the disposal option for the surplus treated wastewater.

b) Define the reuse and disposal requirements; which should be consistent with the specified quality criteria that conform to the Palestinian standards.

c) Define the level/type of the treatment; the most suitable level of treatment for reuse option is *the secondary treatment* which results in removal efficiencies as (*e.g.*, BOD_5 = 25-30 *mg/l*, and TSS = 20-30 *mg/l*), and usually includes disinfection or stabilization ponds for the removal of pathogens.

d) *Review and assess alternative unit operations/ processes and treatment method*s; which are listed in Table 7.3 according to the type of treatment and in Table 7.4, Appendix 7 according to the treatment objective, and those results in the required secondary treatment, taking in consideration the land area limitations constraints.

e) Identify the unit process; where the different unit processes for the removal of the constituents of concern are illustrated in Figure 7.1, 7.2 and 7.3 and summarized in Table 7.5, Appendix 7.

4. Methodology of selection of the suitable DWT plant (train)

The responsible WT is advised to follow the selection methodology described in Figure 3-9 and considering the essential factors listed in Table 7-10, Appendix 7 for the selection of the unit operations/processes for the needed treatment methods. The process applicability is the most important factor in the selection of the unit operation/process and depends on the experience of the assigned engineer/s. The different DWT systems/trains alternatives which have been assessed and selected as the best suitable alternatives for the different site specific conditions of the LCH are summarized under Option (2) in Table 3-4 and discussed as follows:

(1) Option (2)-Condition (1); when the LCH project is of small scale and the reuse option for landscape and agricultural irrigation is not feasible, the first alternative is the *subsurface wastewater infiltration systems* (SWISs) if the required contact area of the subsurface system and the available land area are adequate and depends on effluent percolation rate (EPR) of the soil. Otherwise, the use of *the trickling filter* is used.

(2) Option (2)-Condition (2); where two alternative treatment trains are proposed. *The first alternative* is using the package plants (pre-engineered plants) which use the extended aeration activated sludge plant as shown in Figure 3-10. *The second alternative* is using the trickling filter; that uses either the high rate plastic medium trickling filter, the activated biofilter, trickling filter solids contact or roughing filter/activated-sludge as shown in Figure 3-11. These processes are types of aerobic attached-growth processes.

(3) Option (2)-Condition (3); which uses the two alternatives of Condition (2).

(4) Option (2)-Condition (4-a); where the *UASB/ USBFB* is used. It uses the upflow attached-growth process which is one type of the hybrid attached- growth process that relates to the anaerobic treatment processes as shown in Figure 3-12.

(5) Option (2)-Condition (4-b); the used alternative in this situation is the separation of grey water and using *Septic tank-Upflow Gravel Filter (UfGF).* This method used the attached-growth process of anaerobic treatment as shown in Figure 3-13.

The surplus treated effluent which may exceeds the needs of the LCH could be arranged to be transported to specified locations outside the LCH which may use the SAT method that depends on rapid infiltration process for recharging or for other agricultural activities.

5. Development of treatment process flow diagram (treatment train); the flow diagram (e.g., the grouping together of a number of unit operations and processes to achieve a specific treatment objective) for the suitable selected treatment train is then prepared. The prepared flow diagrams for the different aforementioned situations of LCH illustrated before are illustrated in Figure 3-10, Figure 3-11, Figure 3-12, and Figure 3-13.

6. Preliminary conceptual design; After the treatment train has been selected and the flow diagram has been defined, the conceptual design is to be made according to the following steps:

a) Selection of design criteria; which depends on the critical design factors and sizing criteria of the different unit operations and processes and are selected from Table 7.6, Appendix 7, and on the knowledge and experience of the team members in coordination with the relevant authorities.

b) Development of the plant layout of the treatment train for the physical site; where each of the unit operations and processes is placed on a plan of the site and connected with the required piping.

c) Preparing the hydraulic profiles for average and peak flows; in order to determine if the hydraulic gradient is adequate for the wastewater to flow through the treatment facilities, establish the head requirements for the pumps, where needed, and allow optimization of the location of the treatment units on the site.

d) Solids balance; should be conducted to estimate the amount of sludge that will be produced to aid in planning of sludge processing and storage facilities

7. Final designs; The final designs include the preparations of the Plan layout of treatment facilities, the determination of the hydraulic profile and all details of the treatment units. The main elements of the different proposed trains are summarized in brief in Table 3-5.

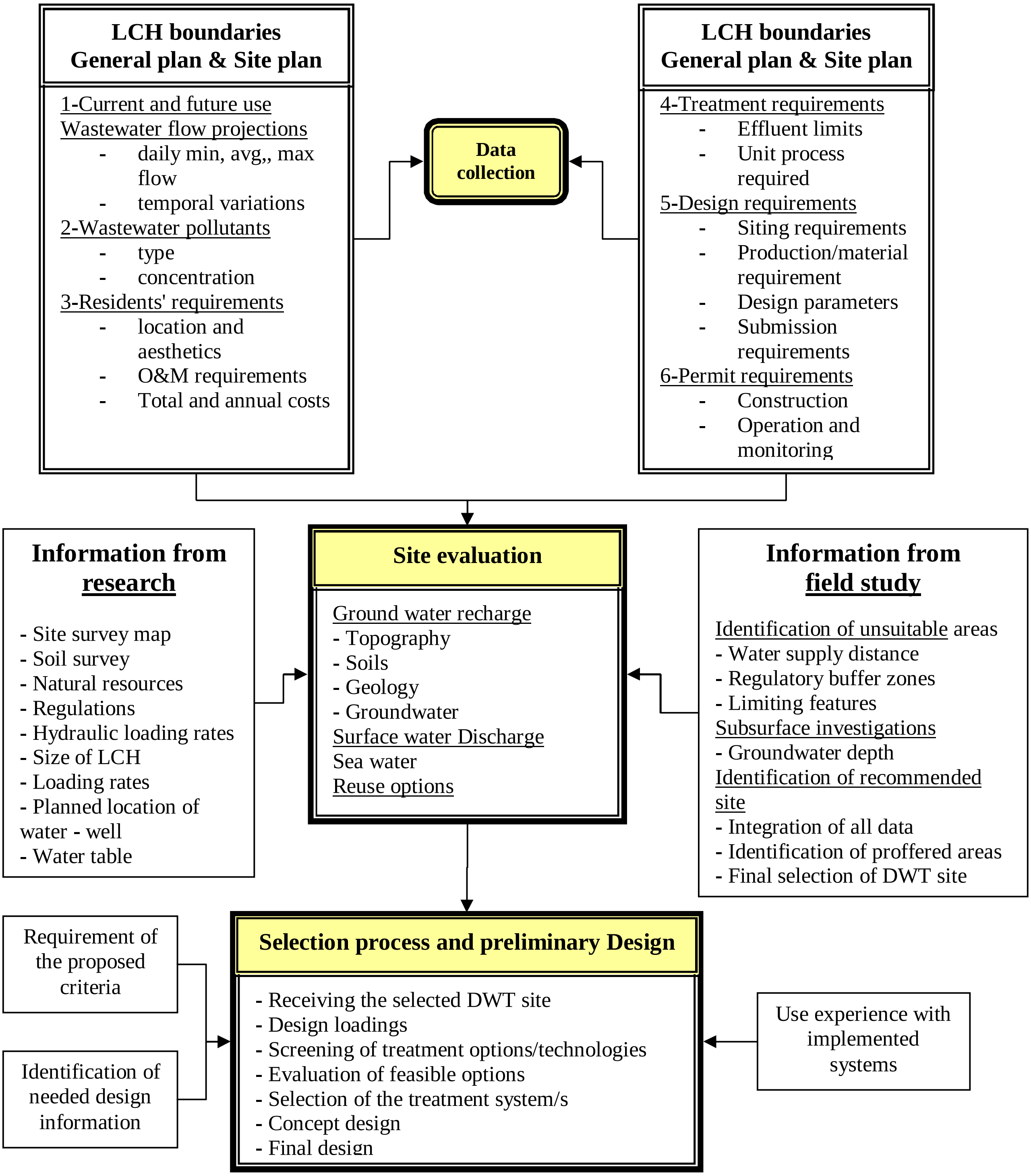


Figure 3-8: Framework for provisions of BIC-3 for LCH.

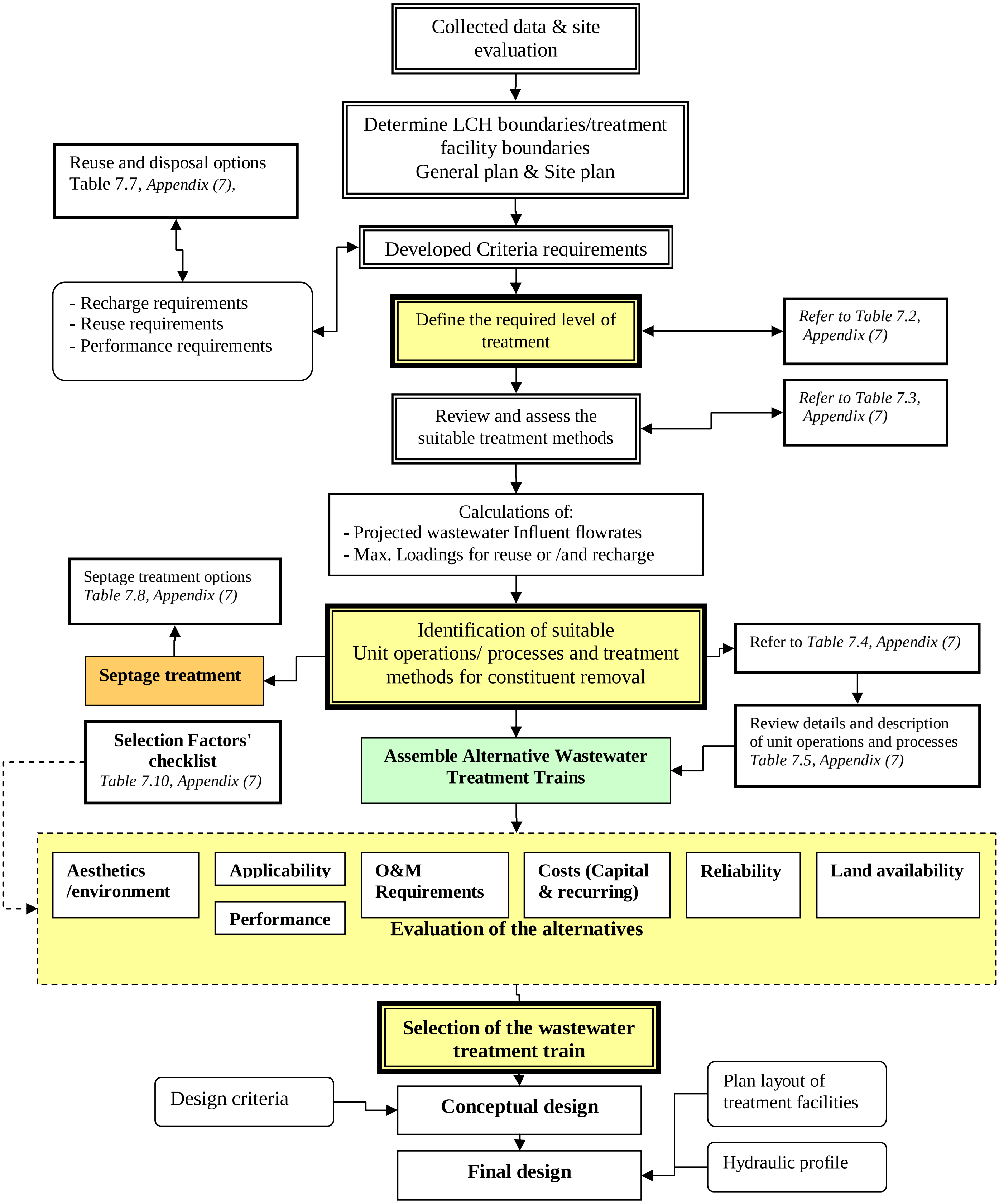


Figure 3-9: Methodology for the selection and design process of the DWT train for LCH.

Table 3-4: Options of wastewater treatment plants (trains)

Item	Option (1) CWT system	Option (2) DWT systems				
		Condition (1)	Condition (2)	Condition (3)	Condition (4-a)	Condition (4-b)
The selected treatment train **(Unit operations and processes of the treatment)**	Central treatment plant	1- On-site subsurface effluent disposal system (SWISs) *(septic tanks, followed by percolation pits/ soakage wells)* 2- Trickling filter **Figure 3-11**	1- Package plant **Figure 3-10** **Or** 2- Trickling filter **Figure 3-11**	1- Package plant **Figure 3-10** **Or** 2- Trickling filter **Figure 3-11**	- Septic tank. - UASB or USBFB or baffled reactor - Stabilization ponds or/ subsurface constructed wetlands. **Figure 3-12**	Septic tank-Upflow Gravel Filter (UfGF) **Figure 3-13** And **Figure 3-14**
Type of sewage	Combined grey and black sewage	Combined grey and black sewage	Combined grey and black sewage	Combined grey and black sewage	Combined grey and black sewage	Separation of grey water and black water
Design concept		Primary treatment	Secondary treatment	Secondary treatment	Secondary treatment	Grey water treatment
Description of LCH site conditions 1) Existence of central sewer system	Existence of centralized sewer	No centralized sewer or one without adequate carrying capacity.	Existence of centralized sewer	No centralized sewer or one without adequate carrying capacity.	No centralized sewer	No centralized sewer
Location	Urban area	rural/peri-urban areas	Urban/ peri-urban areas	Urban area/ peri-urban areas	Urban/rural/peri-urban areas	rural/peri-urban areas
2) existence of potential reuse activities	Nil	Nil	Reuse in landscape and agriculture	Reuse in landscape only	Reuse in landscape and agriculture	Reuse in landscape and agriculture
3) scale of the	Small or large scale	small-scale with	Large scale LCH	Dense development	Small scale LCH	Small scale LCH

Item	Option (1) CWT system	Option (2) DWT systems				
		Condition (1)	**Condition (2)**	**Condition (3)**	**Condition (4-a)**	**Condition (4-b)**
LCH development		available land area.	development	and limited land area.	development.	development.
Septage treatment/ digested sludge	Central treatment (central treatment plant/incineration/	- Anaerobic digestion in the septic tank - De-sludging the septic tank and haulage outside the site	- Aerobic digestion - storage - Reuse as fertilizer	- Aerobic digestion - storage - Reuse as fertilizer	- Reed beds (reuse as fertilizer) - Haulage to Central treatment plant	- Reed beds (reuse as fertilizer) - Haulage to Central treatment plant

Developed by the researcher, based on **Section 2.4.6, Chapter 2**

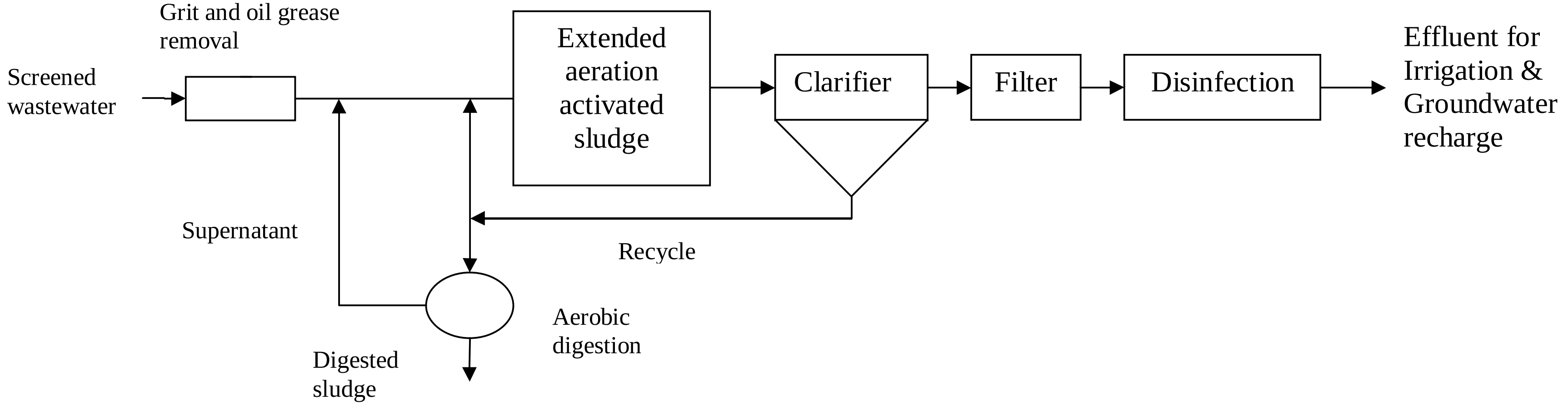
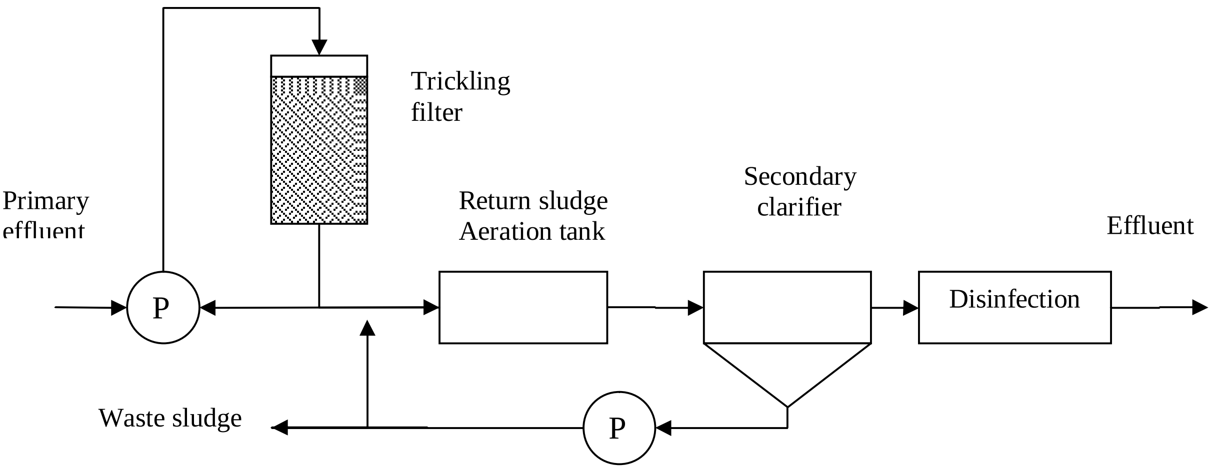
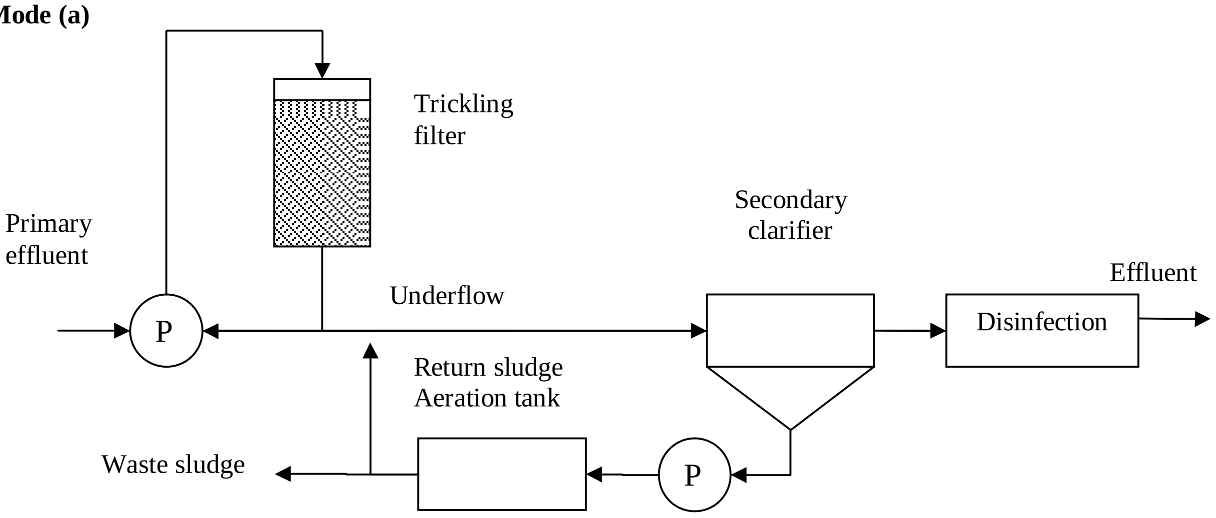


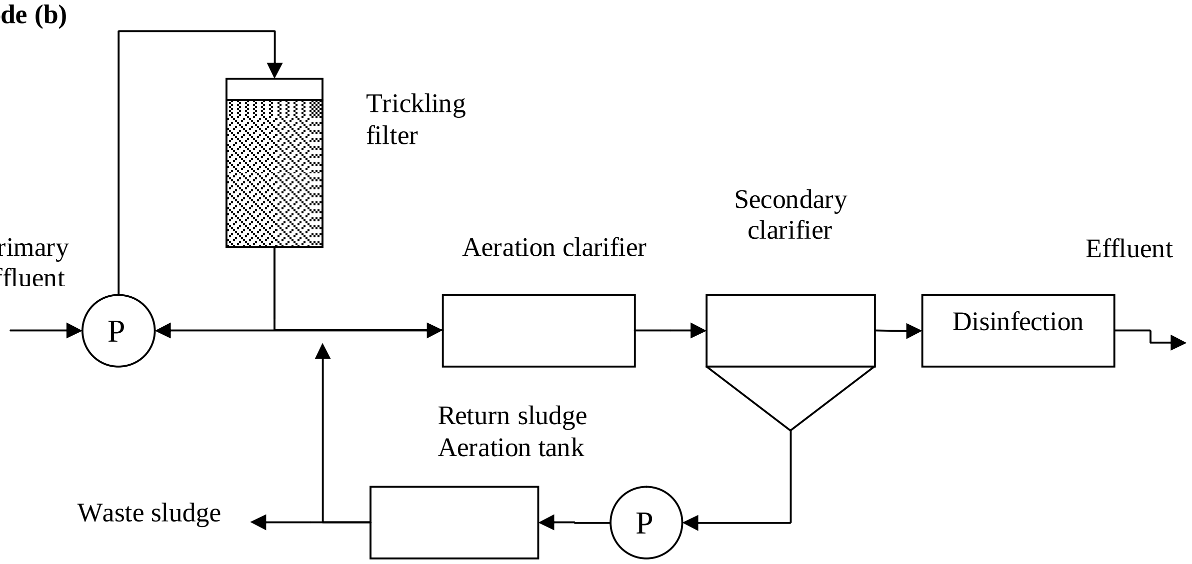
Figure 3-10: Package plant using extended aeration activated sludge process. Adapted from (Crites, 1998; EPA, 2000c)



Mode (a)



Mode (b)



Mode (c)

Figure 3-11: schemes of trickling filter-solids contact (TFSC) processes. Adapted from (Crites, 1998; EPA, 1992)

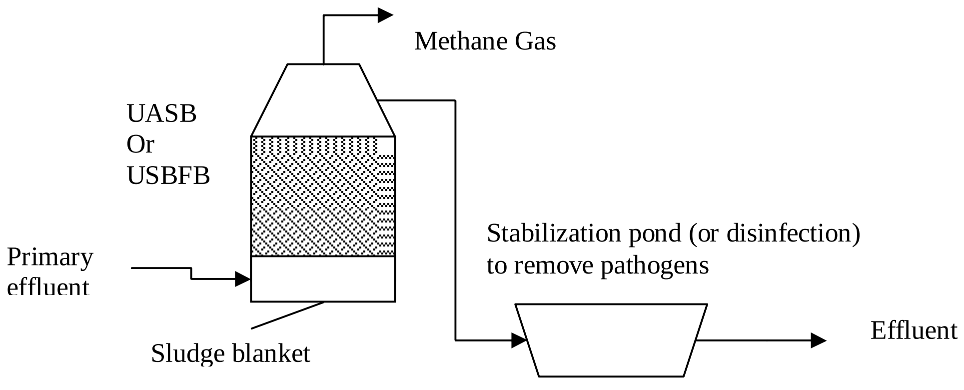


Figure 3-12: Treatment train using UASB. Adapted from (Crites, 1998; Volkman, 2003)

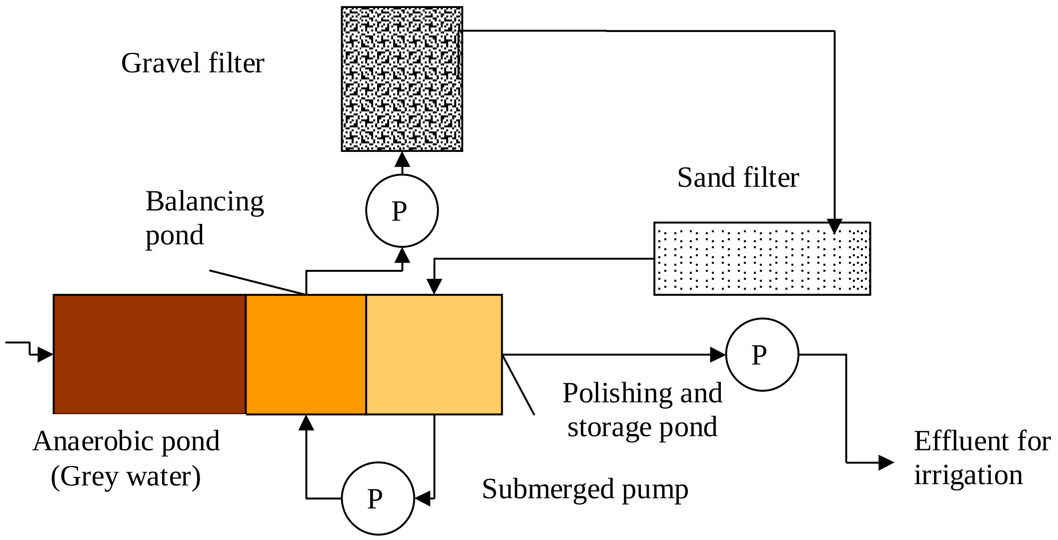


Figure 3-13: Septic Tank – Upflow Gravel Filter (ST-UfGF), Grey water treatment. Adapted from (Crites, 1998; www.ansad.net , 2005)

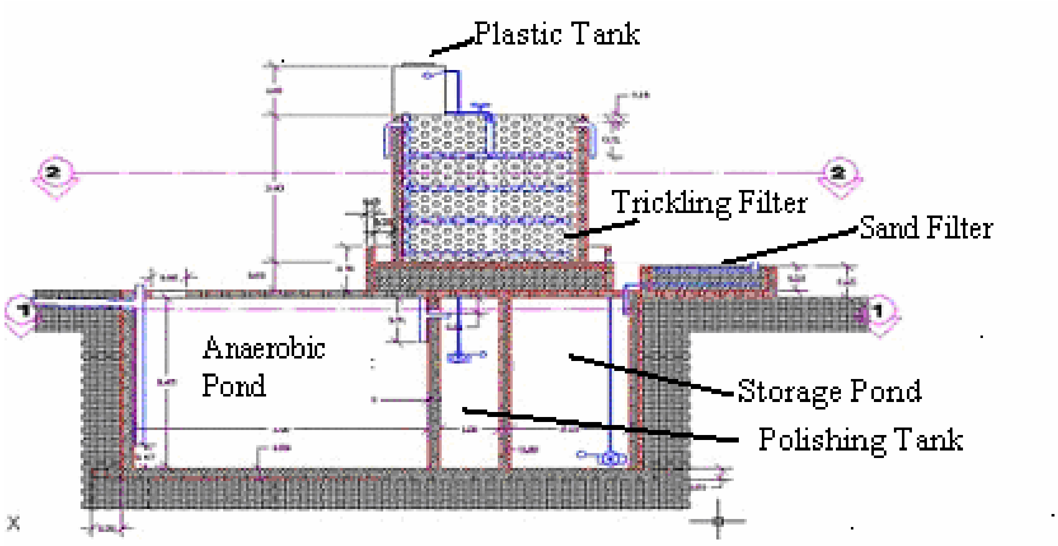


Figure 3-14: Sketch of (ST-UfGF), Grey water treatment. Adapted from (www.ansad.net , 2005)

3.4.3.3 Activity (3):Determination of minimum limits, design parameters, main elements and O&M

Table 3-5 below illustrates the inventory of minimum requirements and main items for the different low-cost alternatives of the wastewater treatment trains which suit different LCH site specific situations that have been selected and discussed before. The conceptual design requirements and parameters which are discussed below, as the detailed designs are to be done in coordination and cooperation with the responsible water and environmental utilities.

Table 3-5: Inventory for provisions of BIC-3: Decentralized Wastewater treatment system for LCH

N.	Item	Minimum acceptable requirement
1-	**Minimum limits and Design parameters required for planning and design of BIC-3: Wastewater treatment**	
1.	**Critical design factors (flowrates)** *(l/c/d)* **and/or** *(m^3/d)*	They are based on the minimum wastewater flowrate of 80 *l/c/d* which equals 80% of the assume water supply of 100 *l/c/d.* - They are the average, peak, minimum and sustained hourly/ daily/ weekly/ monthly flowrates. - The rationale for selecting the design flowrates is based on hydraulic and process considerations and shown in **Table 7.6, Appendix 7**, and may include maximum hour flowrate, minimum hour flowrate, maximum organic load, and maximum day or week flowrate. - Peak hourly factor is taken as (4). Peak daily factor is taken (2.5).
2.	**Sizing criteria**	The sizing criteria for some unit operations and processes are shown Table **7.6, Appendix 7**, and may include flowrate, overflow rate, detention time, mean cell residence time, food/microorganism ration, hydraulic and organic loading, mass loading/medium volume, detention time or dose.
2-	**Main physical elements**	
A.	**Option (1): Centralized wastewater treatment system (CWT)**	
	The main elements of this system are out the scope of this research since the central treatment plant is assumed to be already exists.	
B.	**Option (2):Low-cost Decentralized wastewater treatment system (DWT)**	
1.	**Condition 1: On-site subsurface effluent disposal system (SWISs).**	1. *Septic tank ;* Peak daily flowrate, pump-out interval is the sizing criteria. The volume of the septic tank is calculated using the equations in **Table 2.3**, **Section 2.2.3.5, Chapter 2.** 2. *Percolation pits (soakage wells)*; hydraulic loading rate *(cm/d) is* the sizing criteria
2.	**Condition 2, 3 - alternative 1: Package plant.** Refer to Table 3. 4, Figure 3.11 and Table 7.6, Appendix 7.	1. *Screening* ; peak hour flowrate; as critical design factor, and minimum hour flowrate; for Channel approach velocity 2. *Grit and oil removal;* peak hour flowrate; as critical design criteria, and over flowrate; as Sizing criteria 3. *Raw sewage pumping (m^3/s)*; maximum hour flowrate, as critical design factor 4. *Aeration basin volume (m^3)*; average flowrate and detention time of one day; as sizing criteria, and maximum organic load; peak BOD mass loading to calculate amount of required oxygen and air requirement for aeration. The volume is in the range of (35, 180, 361 m^3) for average design flow of (38,

N.	Item	Minimum acceptable requirement
		190, 380 m^3/d) respectively 5. *Secondary clarifier area(settling tank)- (m^2)*; average flow rate, overflow rate, and peak hour factor of (4); as sizing criteria. The area is in the range of (4, 19, 37 m^2) for average design flow of (38, 190, 380 m^3/d) respectively 6. *Chlorinator capacity (kg/d);* It is in the range of (4.5, 11.5, 23 kg/d) for average design flow of (38, 190, 380 m^3/d) respectively 7. *Chlorine contact chamber volume (m^3);* peak hour flowrate and detention time; as Sizing criteria. It is in the range of (3.4, 16, 34 m^3) for average design flow of (38, 190, 380 m^3/d) respectively 8. *Drying bed area (m^2);* it is in the range of (37, 93, 186 m^2) for average design flow of (38, 190, 380 m^3/d) respectively 9. *Site area (m^2);* it is in the range of (2, 2.8, 4 dunums) for average design flow of (38, 190, 380 m^3/d) respectively *10. Wastewater piping;* peak hour flowrate; as Sizing criteria 11. *Sludge storage facility* ; peak month mass loading; as Sizing criteria
3.	**Condition 2, 3 - alternative 2: trickling filter.** Refer to Table 3. 4, Figure 3.12 and Table 7.6, Appendix 7.	1. *Septic tank volume (m^3) - (primary effluent);* peak hour flowrate and minimum hour flowrate as Critical design factor. Overflow rate and detention time as Sizing criteria 2. *Primary clarifier area (m^2);* It is in the range of (16, 79, 158 m^2) for average design flow of (378.5, 1,893.0, 3,785.0 m^3/d) respectively 3. *Primary effluent pumping (m^3/s)*; peak hour flowrate; as Critical design factor, minimum hour flowrate; as Sizing turndown of pumping facilities It is in the range of (0.0175, 0.088, 0.175) for average design flow of (378.5, 1,893.0, 3,785.0 m^3/d) respectively 4. *Trickling filter volume (m^3)*; peak hour flowrate and maximum organic load; as Critical design factor. Hydraulic loading rate, hydraulic and organic loading rate, mass loading/ medium volume, peak day mass loading ; as Sizing criteria The volume is in the range of (202.5, 1,012.0, 2,024.0 m^3) for average design flow of (378.5, 1,893.0, 3,785.0 m^3/d) respectively. 5. *Recirculation pumping (m^3/s);* It is in the range of (0.0131, 0.066, 0.131) for average design flow of (378.5, 1,893.0, 3,785.0 m^3/d) respectively 6. *Solids contact basin volume (m^3);* Detention time and solids retention time; as Sizing criteria The volume is in the range of (11, 53, 105) for average design flow of (378.5, 1,893.0, 3,785.0 m^3/d) respectively. 7. *Secondary clarifier area (m^2);* overflow rate ($m^3/d/m^2$); as Sizing criteria The area is in the range of (31, 163, 325) for average design flow of (378.5, 1,893.0, 3,785.0 m^3/d) respectively. 8. *Chlorinator capacity (kg/d);* It is in the range of (23, 114, 227) for average design flow of (378.5, 1,893.0, 3,785.0 m^3/d) respectively 9. *Chlorine contact chamber volume (m^3);* peak hour flowrate and detention time; as Sizing criteria. It is in the range of (34, 159, 315) for average design flow of (378.5, 1,893.0, 3,785.0 m^3/d) respectively 10. *Site area (m^2);* It is in the range of (6,071.0, 12,141.0, 20,235.0) for average design flow of (378.5, 1,893.0, 3,785.0 m^3/d) respectively 11. *Wastewater piping;* peak hour flowrate; as Sizing criteria 12. *Sludge storage facilities* ; peak month mass loading; as Sizing criteria
4.	**Condition 4-a: UASB or**	1. *Septic tank (primary effluent) volume* ; peak hour flowrate and minimum hour flowrate as Critical design factor. Overflow rate and detention time as

N.	Item	Minimum acceptable requirement
	USBFB. Refer to Table 3. 4, Figure 3.13 and Table 7.6, Appendix 7.	Sizing criteria. The volume of the septic tank is calculated using the equations in Table 2.6, Section 2.11.8.3. 2. *UASB reactor* ; Volumetric and volatile solids loading rates (Lorg, LVSS) (kg COD/m3.d); as sizing criteria 3. *Stabilization pond area (m^2);* mass loading and hydraulic retention time; as Sizing criteria
5.	**Condition 4-b: Septic Tank-Upflow Gravel Filter (ST-UfGF), *Grey water treatment.*** Refer to Table 3. 4, Figure 3.14	1. *screening* ; the wastewater from the sewer should flow by gravity into screen bars which are manually cleaned. 2. *Anaerobic pond for grey water(m^3);* retention time of 2 days is used for sizing. The water flow to a balancing pond. The settled solids are designed to be removed every two years. 3. *Balancing pond(m^3)*; designed to receive the settled gray water from the anaerobic pond and is provided by submerged pump. 4. *Gravel filter* ; designed to receive the pumped water from the balancing pond, and it acts as upflow anaerobic filter. 5. *Sand filter* ; designed as an intermittent sand filter, receiving the water from the gravel filter and removing the suspended solid and usually divided into four compartments. 6. *Polishing and storage pond (m^3);* Three days storage capacity is used as sizing criteria. A recirculation submerged pump is installed to keep certain level of water in the balancing pond to provide a minimum organic load for the bacteria in the gravel filter. Another pump is installed for irrigation. 7. *Pumps* ; all pumps are submerged pumps 8. *Modified cesspits* ; designed to receive the black water for safe and cheap disposal
6.	**Low-cost Rapid infiltration (RI)/ (SAT)**	The design of this system is out of the scope of this research since it would be located off-site far from LCH in the suitable site for the extra treated effluent. The primary design consideration for this system is site selection, soil depth, soil permeability, and depth to groundwater are the most important factors in site evaluation.
3-	**Minimal operation and maintenance (O&M)**	
1.	**Option (2), Condition 1: (SWISs).**	The primary O&M include infiltration surface maintenance, winter operations, nitrogen management and monitoring. It also includes desludging of the septic tank at the specified desludging periods in the design stage.
2.	**Option (2), Condition 2,3-alternative 1: Package plant.**	*Operation* ; Effluent quality monitoring, regular cleaning of screens; wears and other components, regular adjustment of sludge return rate and air injection rate, regular wasting of solids, sludge dewatering and disposal, control of disinfectant dosage and administration and record keeping. *Maintenance* ; Blowers or mechanical aerators, influent and return sludge pumps, electrical equipment and instrumentation, mechanical dewatering equipment, laboratory equipment and disinfection system.
3.	**Option (2), Condition 2,3 - alternative 2: trickling filter**	*Operation* ; Effluent quality monitoring, regular cleaning of screens; wears and other components, regular adjustment of trickling filter recirculation rate and air injection rate, regular wasting of solids, sludge dewatering and disposal, control of disinfectant dosage and administration and record keeping. *Maintenance* ; Blowers, primary effluent and return sludge pumps, electrical equipment and instrumentation, mechanical dewatering equipment, laboratory equipment and disinfection system.

N.	Item	Minimum acceptable requirement
4.	**Option (2), Condition 4-a: UASB or USBFB.**	*Operation* ; Effluent quality monitoring, regular wasting of solids, sludge dewatering and disposal, monitoring of the produced gas, administration and record keeping. *Maintenance* ; Primary effluent and return sludge pumps, electrical equipment and instrumentation, laboratory equipment.
5.	**Option (2), Condition 4-b: Septic Tank-Upflow Gravel Filter (ST-UfGF),**	*Operation*; Effluent quality monitoring, regular adjustment of effluent return rate, administration and record keeping. *Maintenance*; Primary effluent pumps, gravel media of the filter and the sand media of sand filters, electrical equipment and instrumentation, laboratory equipment.
6.	**Rapid infiltration (RI)/ (SAT)**	The primary O&M include basin cycling, infiltration surface maintenance, winter operations, nitrogen management and monitoring.
Developed by the researcher based on **Section 2.2.4, Chapter 2 and Appendices 4 and 7; EPA, 1992; Crites** and Tchobanoglous**, 1998; www.ansad.net, 2005**		

3.4.4 Provisions of BIC -4: Power Supply and Security Lighting for LCH

Objective of provision: The objective of the provision of *the Power supply* to the LCH is to provide sufficient, stable and reliable power supply for lighting and running simple household electrical appliances, for the convenience and possibly status of the residents. Whereas, the objective of the provision of *the security lighting* is the promotion of safety at night by providing quick, accurate, and comfortable seeing for drivers and pedestrians, facilitating pedestrian movements and recognition of obstacles and other pedestrians to provide a degree of security by reduction of street crimes after dark and to deter theft and vandalism. The principle of street and site lighting is to make objectives appear dark against a brighter road surface. This would be done by the following activities:

3.4.4.1 Activity (1): Definition of the proposed criteria for provision of BIC-4: Power supply and security lighting

The provision of power supply and security lighting for LCH should be at low-cost and sustainable manner. Thus, the following criteria are proposed.

1. **Minimum electrical demands**

The base domestic demands for LCH should be the minimum electrical load for security lighting and running the simple household electrical appliances (TV, refrigerator, computer, radio, washing machine, etc) for the convenience and possibly status of the residents. The "after diversity" value of (0.75-1.0 kW per household) is suitable for the common needs of LCH residents. Furthermore, the needed base demands for commercial and public facilities, and for operating other infrastructure plants and pumps should be considered.

2. **Diversification of energy sources**

It is essential to focus on other available low-cost energy sources such as solar energy for heating and lighting, and gas for cooking and gas or kerosene for winter heating to substitute the expensive electric power.

3. **Conservation of energy**

Measures for reducing electrical consumptions should be considered and they include good orientation of buildings, good insulation, good ventilation, large windows, energy saving equipment, low voltage lamps, minimal number of electric fixtures and lighting poles, electric meter installation, and solar energy utilization for heating and lighting.

4. **Sufficient, stable and reliable power supply**

The primary voltage (H.V) is to be provided through primary feeders, and the capacity of transformers and the utilization voltage (L.V) should have the ability to meet demand, appropriates for expected demand (i.e., no over capacity) and financially sound.

5. **Protection of environment and human being**

Every effort must be made for minimizing the effect of electric installations on environment and protecting local ecology. They should neither be harmful to human health nor damaging to any object, e.g., should all live power lines be insulated or inaccessible for reasons of public safety. Air pollution, water contamination or noise/vibration should be minimized by reducing power generation, e.g., reducing consumption.

6. **Financially sound power supply**

The primary H.V power is to be transmitted by overhead lines through long distances because they are less costly. The utilization L.V power is distributed by underground cables rather than overhead lines because they are less costly in the long run, more safe and aesthetic. Time-based demand charges should be introduced in addition to rated consumption-based charges for power conservation and for the benefit of poor and low-income brackets.

7. **Effective and low-cost security lighting**

The minimum lighting levels to ensure safety and security should be provided with the lowest consumption of energy by the use of low-voltage lamps and minimum number and types of poles and fixtures.

8. **Consistency of security lighting fixtures**

The cluster standards for light fixtures should be strictly controlled for a more consistent appearance, by designation of little specific fixtures design and manufacturer e.g. limited colors, few model types, and little variety in detailing.

3.4.4.2 Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-4

The selection methodology for the most suitable systems and techniques for suitable and reliable power supply provision at the lowest possible costs would be in accordance to the main concept of power supply which has been developed in compliance with the developed criteria is illustrated in Figure 3-15. The provision of electricity is to be done through complete coordination and cooperation with the local electricity distribution company.

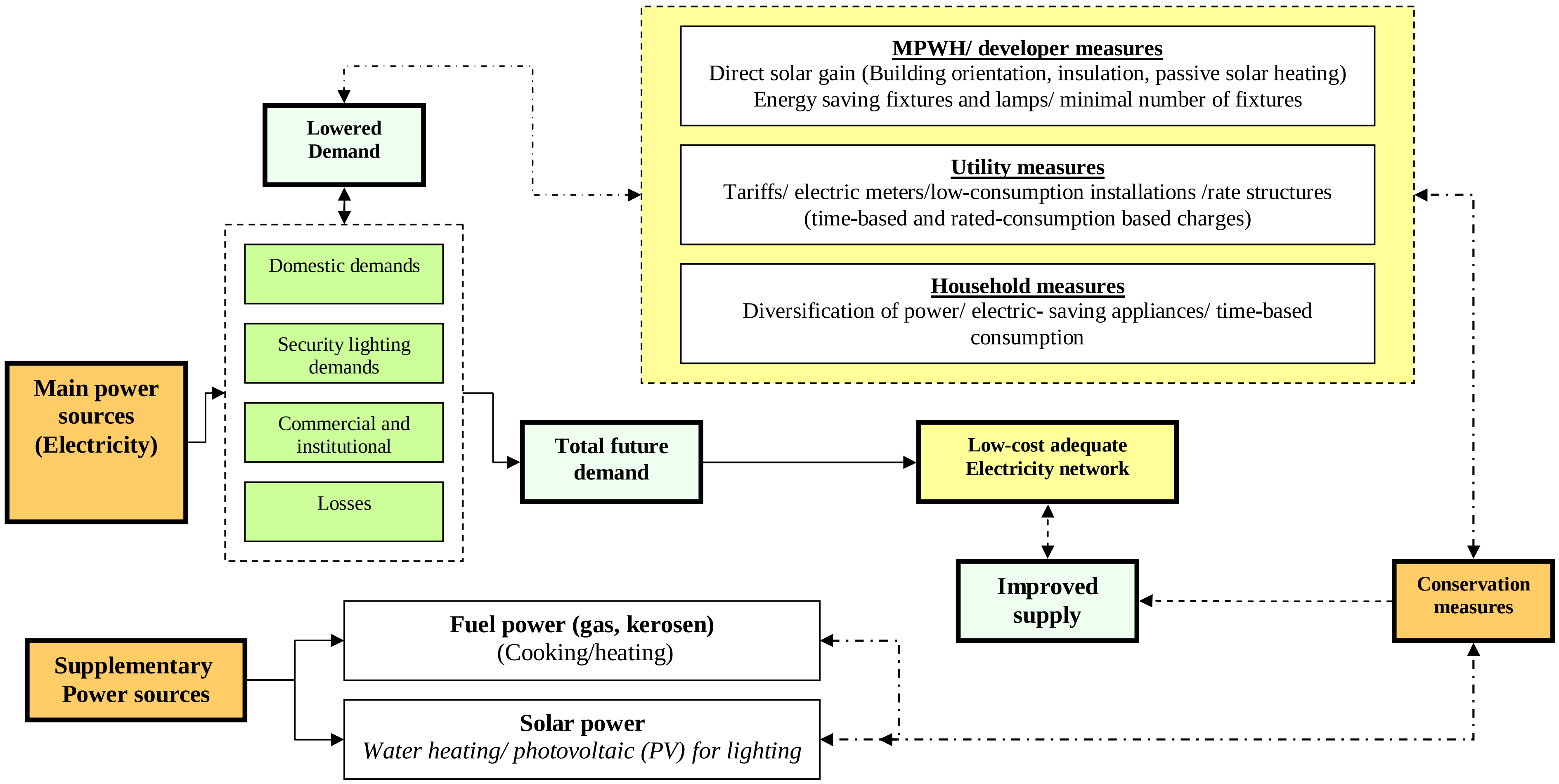


Figure 3-15: The main concept for provision of power supply and lighting with conservation measures for LCH.

3.4.4.3 Activity (3):Determination of minimum limits, design parameters, main elements and O&M

Table 3-6 below illustrates the inventory of main items and minimum requirements for provisions of BIC-4: power supply and security lighting

Table 3-6: Inventory for provisions of BIC-4: Power supply and security lighting for LCH

No.	Item	Minimum acceptable requirement
(A)	***Power supply and distribution***	
(1)	**Minimum limits and Design parameters required for planning and design of power supply**	
1.	**Minimal base load demand for power supply**	- 1 kW/ H.H (i.e., "after diversity" value), for basic domestic uses; (TV, refrigerator, computer, radio, washing machine, and air fans, etc). No heating, conditioning or cooking using electricity. - Demand calculations should include the base total demands, the future anticipated demand, losses and the lighting demands.
2.	**Low-cost sources of power supply**	
2.1	*Electrical power*	It is the main power source and should be provided to satisfy the needed demands
2.2	*Solar power*	It is a low-cost supplementary source to conserve electricity consumption and the monthly bills, and should be provided through:
a-	Direct solar gain	***(1) passive solar heating systems; which include the following:*** *1.Orientation*; The building orientation in Palestine (Gaza Strip) should be to the south direction or between (5-20) degrees towards south east or south west, with large south-facing windows *2.Setback*; The setback distances between buildings should be adequate so that solar energy could reach all the floors of the buildings. *3.Landscaping*; Using the suitable trees in the right directions to permit sun rays and works as wind preventer in winter and prevent sin in summer. *4.Width to length ratio*; The best shape of the building is the rectangular shape which extends east west, since the south side earns in winter twice the solar energy. *5.shading devices*; for windows are horizontal for south walls, vertical for east and west walls and combined in east south and south west walls, *6.day lighting and passive solar heating*; the area of glass windows should be (20-50%) of building plan area and are south-facing *7.Adequate insulation of the building shell* ; The price of the extra insulation material should not exceed the savings in energy consumption for heating, cooling and lighting. ***(2) solar hot water systems*** Such as flat-plate solar collectors; To provide hot water to households
b-	Photovoltaic (PV)	Photovoltaic technology may be used for lighting of local streets and/or clusters
(2)	**Main physical elements**	
1.	**Low-cost distribution networks**	
1.1	*Primary feeder (H.V)*	The primary feeder (H.V) cables delivers power from the power source to a district-sub-station; (local distribution transformers) which in turn feed the

No.	Item	Minimum acceptable requirement
	lines	secondary power lines at utilization voltage. They may be installed underground through residential areas or attached to steel towers of 12 m height in case of long distances to lower costs
1.2	*Secondary distribution (L.V) lines*	They are L.V distributers which may be overhead lines or underground cables. From it, the individual services to households and street lighting are taken. Underground cables are preferred for new developments with continued building and upgrading. The secondary system is designed so that losses of one transformer will not cause low voltage or service interruption.
2.	**Low-cost supporting power poles**	
	(in case of overhead lines networks)	Design involves the consideration of structural stability of the poles, and ensuring horizontal and vertical clearances through appropriate spacing of the poles.
2.1	*Material*	1) The H.V overhead poles are made of steel. 2) The L.V overhead poles are usually made of timber. They are made of steel for distribution points, and corners or turns.
2.2	*Height*	1) The H.V overhead poles are of height (12m). 2) The L.V overhead poles are of height (9 m).
2.3	*Buried depth*	Usually, one sixth of the pole height is buried in the ground; for example (1.5m) for poles of (9m) height.
2.4	*Spacing*	1) The spacing of L.V overhead poles is (25-50 m) until maximum of 50m. 2) Maximum length of a service connection is (25-35 m) and it should be considered in spacing of the power poles
2.5	*Vertical drop*	The vertical drop of the distribution lines should never lower than 3m. For 9m pole, the drop is (5.8m).
2.6	*Minimum impact*	The catenaries of power lines are located at suitable locations so that they have the minimum visual impact on areas through which they run. Buffer areas between high voltage power lines and residential areas are preferably maintained as long as possible.
3.	**Low-cost transformers**	The costs of the transformers are to be reduced by using ones of adequate rated power which suits the required demands and not much more. They should be placed in such a way which does not increase their costs, e.g., the transformers up to 200 KVA may be mounted on poles to minimize land-take. Otherwise, they are placed in sub-station room.
4.	**Adequate locations and areas for substations**	At substation, the loads to individual consumers are estimated and balanced. The sub-stations are situated at the centre or the entrance of the site to limit the low-voltage lines to max. 200m to decrease losses. Substation room requires a plot size of (5.5m^2) to house (1.2 m2) concrete base bad for the transformer.
5.	**Low-cost solar energy systems**	Flat-plate collectors' technology for water heating should be ensured for each building using the new developed technologies for multistory buildings, which utilizes either water circulation through solar-heated oil or filtered water, or by circulating solar-heated water using a motor operated by diesel.
(B)	***Security lighting***	
(1)	**Minimum limits and Design parameters required for planning and design of security lighting**	
1.	**Minimal lighting**	The lighting demand for the LCH project is calculated as (5%) of the total future demand

No.	Item	Minimum acceptable requirement
	demands	
2.	**Adequate source of power supply for lighting**	
2.1	*Electrical power*	It is the main power source for lighting. The live power lines should be insulated if they are easily accessible. Other metal parts of the lanterns such as lamp housing and other fixtures should be earthed. Fuses or circuit breakers are installed so that the power supply is automatically disconnected in the event of power surging or overloading.
2.2	*Solar power*	Photovoltaic (PV) lamps for cluster lighting may be introduced. Although they have initial high cost, the longevity and energy efficiency outweigh the initial expense.
3.	**Minimal lighting level**	A minimum illuminance of (0.5 lux) at any point is needed for areas principally used for pedestrians and a limited amount of very slow traffic, e.g., the "average" illuminance form lanterns is in excess of (1 lux) which is adequate for satisfactory recognition of obstacles and irregularities.
(2)	**Main physical elements**	
1.	**Low-cost lighting poles**	
1.1	*Mounting height (MH)s*	
a-	main and collector streets	They are poles of (8-10m) height
b-	local streets	*They are pedestrian and low trafficked areas*: a) For streets of (4-7m) width; they are wall- mounted lanterns at (3 m) height, or pole –mounted (5m) height. b) For streets less than (4m) width: They are wall-mounted at (3 m) height.
c-	cluster footpaths	*They are pedestrian only areas*: They may be one type or a combination of wall-mounted (3m) and pole-mounted (3-5m)
1.2	*Light source (Lanterns)*	"Lanterns" are those luminaires specifically designed for streets. The lamps of lanterns should be compatible in type/size/color/material, of low glare, low voltage, shielded and directable downward.
a-	main and collector streets	High pressure sodium lamps of (1-4) tubes according to the location of the lighting pole. Lamps are used in accordance with the municipality lighting guidelines.
b-	local streets	Fluorescent lamps are the most appropriate for residential streets less than 7m wide. a- For street width of (4-7m); The light source could be: Two No. 40 Watt fluorescent tubes with I= 500 candles, according to the manufacturer. b- For street width of less than 4m; The light source could be: Two No. 20 Watt fluorescent tubes with I = 200 -240 candles according to the manufacturer.
c-	cluster footpaths	One type or a combination of Two No.20 Watt and/or Two No. 40 Watt fluorescent tubes may be used in different arrangements.
1.3	*Spacing of lanterns*	As a general rule, lighting columns/poles are sites first at difficult locations such as intersections and bends, and the pattern necessary for uninterrupted sections of road is then added.
a-	main and collector	They should be located at maximum spacing of (40m) which equals (4 MH= 4x10). For peri-urban areas, the spacing could range from (6-8 MH). Exact

No.	Item	Minimum acceptable requirement
	streets	calculations are according to the municipality lighting guidelines.
b-	local streets	- For local streets up to (7m) width; the lantern spacing are estimated assuming that the minimum lighting level of (0.5 Lux) occurs at the mid point between two consecutive lanterns. Calculate distance factor (DF) = 25/I, where I is intensity of fluorescent tubes (candelas/cd) of each lantern, by reading down the mounting height column in **Table 8.1, Appendix 8,** until the value of calculated DF, to find the lantern spacing. - For local streets greater than (7m) width; maximum spacing is 4 MH
c-	cluster footpaths and courtyards	For footpaths; calculate distance factor (DF) = 25/I, where I is intensity of fluorescent tubes (candelas/cd) of each lantern, by reading down the mounting height column in **Table 8.1, Appendix 8,** until the value of calculated DF, to find the lantern spacing. The luminance of the courtyards of clusters is calculated by the same concept using the radial distance from the center lantern in the courtyards to the far point to be illuminated.
1.4	*Lighting arrangement*	The lighting arrangements used on local and collector streets with single carriageways are *single sided or staggered***.** *Central arrangements* are used with collector/main streets with dual carriageways with median.
1.5	*Time of lighting (hours of operation)*	- The time of lighting should be decided so that minimum power consumption is resulted. Hours of operation are preferred to be from about 30 minutes after sunset to about 30 minutes before sunrise. - All streets should be lit during the hours of darkness, independently of traffic flow, since the lighting serves the needs of pedestrians, cyclists, emergency services and public security, and these interests would be determinately affected if lights were extinguished during darkness.
1.6	*Switching*	
a-	Manual operation	It is turned off and on at specific time. A main switch is placed at suitable location on a power pole and is connected between supply lines and turned on and off at the appropriate time. Up to 100 lanterns can be operated from a single switching point.
b-	Time switching	They are electrically operated switches, but should be fitted with either a reserve spring-wound time switch or a battery back-up to operate the switch in the event of power failure.
1.7	*Fixtures*	They include the backing plates for the wall fixing, control gears and wiring. - The backing plates for fixing should be strong enough to spread the load. - The control should be water proof and difficult to tamper with and secured. - The wiring should be protected by galvanized steel conduit according the requirements of the power utility.
(3)	**Minimal operation and maintenance (O&M)**	
1.	**Power supply network**	The overhead lines require regular maintenance since subjected to faults from stormwater, lightning and birds. It needs skilled manpower. Negligible maintenance is required for underground cables
2.	**Security lighting**	- community groups can replace simple bulbs or fluorescent tubes but not sodium or mercury vapor lamps - lamps need regular cleaning; dirt on the surface significantly reduces the illuminance - problems with power lines need to be corrected by a qualified electrician

Developed based on **Section 2.2.5, Chapter 2 and Appendix 8**; Cotton and Tayler, 2000; Homburger *et al.*, 2001; O'Flaherty, 1997

3.4.5 Provisions of BIC -5: Access, Paving and Landscape for LCH

Objective of provision: The main objectives of provisions of access routes and paving within and to the LCH are: (1) to provide hard and dry access routes for transportation of people and goods from and to the housing clusters, (2) to provide access for pedestrians to residential and commercial areas and to the parking areas through adequate sidewalks and footpaths, (3) to promote safe conditions by discouraging through traffic within the housing developments, (4) to improve the drainage of built up areas, (5) to provide apace for other parts of the infrastructure, such as water and sewer lines, electricity and telephone lines, traffic lights, signs and other facilities above or below ground in their right-of-way, and (6) to maintain the living environment as open spaces in LCH site; whereas the objective of landscaping is to provide the lasting impact on the appearance and use of the LCH site and streets to enhance the social life of the residents. This would be done by the following activities:

3.4.5.1 Activity (1): Definition of the proposed criteria for provision of BIC-5: Access and Paving

The provisions of access and paving should satisfy the objectives of safety, economy, environmental friendliness and public acceptance. The following criteria for sustainable and low-cost provision of access routs, paving and landscaping are proposed:

1. **Accounting for different needs and promoting pedestrian access**

The provisions of streets and access roads for LCH should take account for the needs of people, vehicles and services according to specific hierarchy of access. The walking distances to the public services (e.g., markets, schools, mosque, etc.) should be minimized. Safe walking for the pedestrians should be enhanced by preventing vehicular movement through LCH clusters while maximizing the pedestrian access through generous footpaths and sidewalks.

2. **Adequate integration and alignment**

The access routs and streets through LCH should also be highly connected together, but carefully and gradually connected to the nearby major streets. They are preferred to be placed parallel to contour lines to lower the costs of excavation with adequate vertical grades and cross slopes that facilitates the stormwater drainage.

3. **Minimum land take**

The access routes and streets should be narrow with the minimum widths and lengths so that taking the least area of valuable land, reducing the impervious cover to enhance stormwater drainage and reduce construction and O&M costs. This could be done by adopting cluster designs and compact and high density approach. The right-of-way (ROW) widths should reflect minimum width to accommodate traffic and sidewalk.

4. **Minimum pavement costs with adequate pavement bearing capacity**

The pavements' thicknesses and hence costs of streets and access ways in the LCH should be minimized through preventing vehicular movement throughout the LCH, and restricting the vehicular access to only Passenger cars (PC) around the LCH. The streets, sidewalks, footpaths and parking areas should be of sufficient bearing capacity to resist loads that are imposed to it, and using suitable pavement material which doesn't deteriorate by stormwater.

5. **Appropriate parking places**

Using the minimum number of parking places in the appropriate layout designs to reserve the land and relegating them to the perimeters of the clusters to reduce the noise and accidents and encourage safe walking.

6. **Ecological landscaping**

The landscape should utilize the techniques of best management practices (BMPs) to enhance stormwater drainage as long as possible by replacing curbstones with bioretention areas and islands.

3.4.5.2 Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-5

The hierarchy of access routes and streets should be planned and determined in integration with the subdivision design, the housing buildings' configuration and the stormwater drainage management, with guidance of the proposed criteria.

The main concept for the provision of access and paving for LCH is to reduce the requirements for design and adopt the minimums of the available standards for both geometric and structural designs in order to reduce the final costs for construction and also the running costs. As illustrated in Figure 3-16, the methodology for provision involves three steps. *The first step* includes some surveys for the expected traffic and for soil bearing capacity. *The second step* is implementing the geometric design of the access routes and streets and includes determination of the types and classes of the different routes, the minimum vertical and horizontal alignments, minimum/maximum suitable grades and cross slopes to reduce excavations and minimum cross-sections for footpaths, sidewalks and ROW for streets to reduce the costs of their construction and pavements. Since the ROW widths of the main and collector streets are usually determined by the relevant municipality according to the roads hierarchy of the town and the local regulations and guidelines, the main emphasis is to reduce the costs of access which directly affect the cost of housing which are the local streets, sidewalks, parking lots and footpaths. However, some minimums for collector and major streets would be presented as a guide for planners to use them as appropriate. The locations, layouts, widths and lengths of local streets and footpaths are determined in the site planning stage according to the selected total site plan and the clusters' configuration. *The third step* of structural design (e.g., pavement design) includes the selection of low-cost pavement material and minimum pavement depth which contributes to lowering the cost of construction.

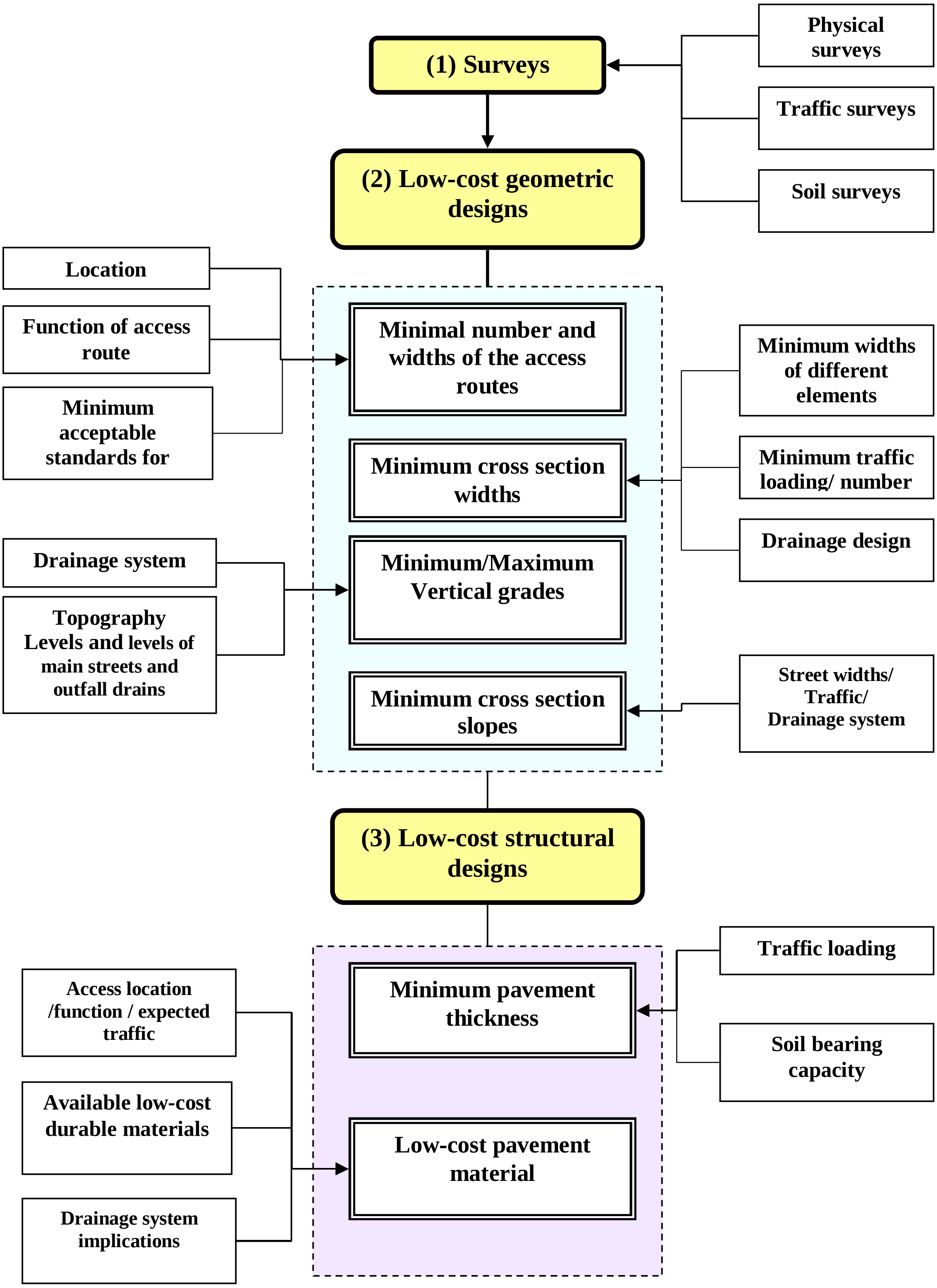


Figure 3-16: The main concept and design criteria for provision of access and paving for LCH.

3.4.5.3 Activity (3):Determination of minimum limits, design parameters, main elements and O&M

Table 3-7 below illustrates the inventory of main items and minimum requirements for provisions of BIC-5.

Table 3-7: Inventory for provisions of BIC-5: Access, paving and landscaping for LCH

No.	Item	Minimum acceptable requirement
(1)	**Minimum limits and Design parameters required for planning and design of BIC-5: Access, paving and landscaping**	
1.	**Low-cost geometric design**	- The minimal acceptable standards and guidelines for different elements of the cross section of the different types of access in the street hierarchy are to be used. These standards and guidelines are summarized in **Table 9-2a, Table 9-2b, Appendix 9.** - The main concerned types of access in the street hierarchy for the LCH project are the *local streets*, *sidewalks*, *footpaths* and *parking areas*. The geometric design of the collector and main streets is the responsibility of the municipality and little opportunity to lower their costs. However, the minimum acceptable standards for their widths and cross section elements are introduced for illustration.
2.	**Low-cost structural design**	- The most permissible relaxed standards for pavement thicknesses are to be used using the most appropriate low-cost available pavement materials. - The minimums of pavement thicknesses and construction standards are summarized in **Table 9.4, Table 9.5 and Table 9.8 in Appendix 9.** - The pavement design is done using the direct design guidelines of Cotton, 2000 or using the exact design methods which are the RStO 86 method, or the developed method of American Asphalt Institute
2.1	*Guidelines of Cotton, 2000*	They are illustrated in **Appendix 9, Table 9.1, Table 9.4 and Table 9.5**
2.2	*RStO 86 method (German method)*	It is easy to be used for design all types of pavements, especially for design of interlock pavement. It depends on determining the traffic load number (TL), which depends on the type of street and its use. The minimums of traffic load numbers are to be used for local streets, footpaths and parking lots. Minimum standards for this method for both interlock and asphalt paving are illustrated in **Appendix 9**, **Table 9.6, Table 9.7 and Table 9.8**
2.3	*Simplified AASHTO method (developed method by the American Asphalt Institute)*	This method is developed by the American Asphalt Institute. It has the advantage that it makes allowance for a range of design axle loads. It is based on the design load and CBR value. It is mainly applicable to asphalt paving and may be used also for block or concrete pavements.
a-	Minimum design loading	- the conventional design methods specify the design loading in terms of the number of standard 8200kg (18,0001b) axle loads relates to heavy commercial vehicles. It would not be used for local streets, since the largest vehicles regularly passing is small private cars (PCs) with laden weight of less than 2000kg, and instead the following design axle loadings are suggested: 1- for lanes less than 3.5m in width; *1500kg* 2- for access lanes and streets (3.5m-6m) in width; *3000kg*

No.	**Item**	**Minimum acceptable requirement**
b-	Subgrade bearing capacity	3- for minor through routes, up to 7.2m road width;*5000kg* The CBR test is used for measuring subgrade bearing capacity, which is required to determine the minimum thickness of pavemnt. Typical CBR values for a range of soil types are given in **Table 9.4, Appendix 9**. In absence of reliable field data, CBR is assumed (3) for natural material and (1.5) for fill material, since it is not practical and should not be necessary to carry CBR tests for every scheme.
(2)	**Main physical elements**	
(A)	**Hierarchy of the streets for LCH with minimal geometric and structural design requirements**	
1.	**Low-cost footpaths and walkways throughout clusters**	They are used to interconnect clusters together and to the parking places around the LCH.
1.1	*Minimum paved width standards*	All the areas connecting the housing buildings together and connecting them to the parking lots should be paved with minimum width of ***(1.2-2.4m);*** **Table 9-2b, Appendix 9**
1.2	*Minimum pavement thickness and low-cost materials*	Referring to **Appendix 9, Table 9.3, Table 9.4, Table 9.5, Table 9.6, and Table 9.8**. Assuming CBR = 3 for natural material*;* ***Minimum thickness is (100 mm)*** and consists of: 80 (60)mm (interlock) on 30 (50)mm (sand) on sub-grade formation of 120MN/m^2
1.3	*Minimum/ maximum grade*	Determined in relation with contour lines and nearby local streets so that contributing to minimum excavations. Minimum/ maximum grades could be accepted according to natural existing levels.
1.4	*Minimum cross slopes*	It is (2-4%) towards the sides of footpaths, and toward the perimeter which is adjacent to the bioretention and grassed areas in courtyards (houshes).
2.	**Low-cost local streets/ cluster access**	They give access to individual clusters within the LCH.
2.1	*Minimum lane number and width*	***2 lanes*** street; each lane of width (2.7-3.3 m), or ***One lane*** of width (3.6m). **Table 9-2a, Appendix 9.**
2.2	*Minimum ROW width*	***6m*** width consisting of (one lane of width 3.6m, 2 sidewalks of 1.2m each), OR ***8m*** width consisting of (two lanes of 2.7m each and two sidewalks of 1.3m each), or (3.6m one lane and two sidewalks of 2.2m width each one)
2.3	*Minimum traffic loads (ADT)and light design axle Loading*	The minimum traffic loads are considered as up to 100 vehicles/day The design loading is considered as only 1500 kg for lanes less than 3.5m in width, and 3000 kg for access lanes and streets, 3.5m – 6m in width, and 5000 kg for minor through routes, up to 7.2m width.
2.4	*Minimum pavement thickness and low-cost*	***Minimum thickness is (110- 130 mm),*** and preferred to be paved with interlock pavement other than the asphalt option, and consisting of either: 1- 80mm (interlock) on 30 mm (sand) on sub-grade formation of

No.	Item	Minimum acceptable requirement
	materials	$120 MN/m^2$, or 2- 60/80mm (interlock) on 50mm (sand) **<u>Note:</u>** The minimum pavement thickness and construction details have been determined as follows: <u>1. Using Cotton, 2000 guidelines</u> in **Appendix 9, Table 9.4, Table 9.5**, or <u>2. Using German RStO 86 method</u>; referring to **Appendix 9**, **Table 9.6, Table 9.8**
2.5	*Minimum/ maximum vertical grade*	Determined in relation with contour lines and nearby collector streets to which they are connected so that contributing to minimum excavations. Minimum/ maximum grades could be accepted according to natural existing levels, e.g., minimum of (0.5%) to allow for drainage, and maximum of (8-15%). These values should be integrated with levels of adjacent streets.
2.6	*Minimum cross slopes*	(2-4%) towards the sides
3.	**Low-cost Site distributer/ collector streets**	They connect all the housing clusters to the site access route. Their design and implementation is the responsibility of the municipality and their costs are not added to costs of housing. However, minimal requirements for design are to be introduced for guidance of the relevant stakeholders.
3.1	*Minimum Lane number and width*	***2 lanes*** of 3m width for each one; **Table 9-2a, Appendix 9.**
3.2	*Minimum ROW widths*	***10m width***; consisting of (two lanes of 3m width for each and two sidewalks of 2m each) OR ***12m width***; consisting of (two lanes of 3.6m width for each and two sidewalks of 2.4m each)
3.3	*Minimum traffic loads (ADT)and light design axle Loading*	The minimum traffic loads are considered as up to 500 vehicles/day The design loading is considered as 8200 kg for through routes carrying buses and trucks daily.
3.4	*Minimum pavement thickness and low-cost materials*	***Minimum thickness is (230 mm),*** and consists of anyone of the following pavement options, taking in consideration that the bituminous surfacing is suitable where there are more than 100 vehicles per day. <u>a) asphalt pavement; anyone of the following:</u> 1- A pavement of thickness ***(340 mm)****;* consisting of (40mm) wearing course, (140mm) asphalt course, (160mm) kurkar sub-base. 2- A pavement of thickness ***(330 mm)*** consisting of double-surface treatment consists of 2 layers of surface treatment, each one of (15mm), (100mm) base-course on 200mm kurkar sub-base (MPWH, 2004). 3- (50mm) dense bitumen macadam on (100mm) rolled stone base on (100mm) rolled stone or broken brick sub-base; with total of *(250mm)*. 4- Pavement thickness of ***(225mm)*** consisting of double surface treatment of two layers with total thickness of (25mm) on (200mm) rolled stone base. 5- Asphalt concrete of (50mm) on (200mm) base course. <u>b) interlock pavement; anyone of the following:</u> 1- 80mm (interlock) on 30mm (sand) on subgrade formation of $150 MN/m^2$

No.	Item	Minimum acceptable requirement
		or 300mm (subbase) 2- 80mm (interlock) on 50mm (sand) on270mm (subbase). c) gravel pavement; (stones of size 6-20mm with about 10% of fine material as binder) Unbound pavement made of Gravel locally available material of compacted thickness of ***(150mm)*** for *lightly trafficked roads* with up to about 100 vehicle movements per day, and thickness of ***(300mm)*** for *heavily trafficked* roads *with more vehicles for partially developed new streets*. Refer to **Table 9.1, Appendix 9**. **Note:** The minimum pavement thicknesses and construction standards are determined directly by Cotton, 2000 guidelines and checked by the exact calculation methods which are the *German RStO 86 method* or *the American Asphalt method*, as follows: 1. Using Cotton, 2000 simple guidelines for asphalt or interlock pavement Referring to **Appendix 9, Table 9.4and Table 9.5** for determination of minimum thicknesses and construction standards. 2. Using *German RStO 86 method* for asphalt or interlock pavement Referring to **Appendix 9, Table 9.4, Table 9.5, Table 9.6, and Table 9.8**. The minimum thicknesses and the different options of pavement could be obtained. 3. Using the *American Asphalt method* for asphalt paving: - The required data for design are: (1) The design load, (2) traffic intensity (ADT) and (3) the sub-grade strength as measured by the CBR value shown in **Table 9.3.** - The pavement depth is obtained from **Figure 9-1, Appendix 9,** using the CBR value for the sub-grade, and the traffic volume (ADT).
3.5	*Minimum/ maximum vertical grade*	Determined in relation with contour lines and nearby local and main streets so that contributing to minimum excavations. Minimum/ maximum grades could be accepted according to natural existing levels, e.g., it ranges from minimum of (0.5%) to allow for drainage, and maximum of (5 to 11%), depending on topography and design speed. - Good drainage is essential and the base must not become saturated by water, since the life of the road depends on the strength of the base.
3.6	*Minimum cross slopes*	(1-2%) towards the sides for asphalt pavement
4.	**Low-cost site access/ main streets**	One or more site access routes leading to a trunk road are planned. Their design is out of the scope of this research, since they are considered as the responsibility of the municipality according to the master plans. However, minimal requirements for design are to be introduced for guidance of the relevant stakeholders.
4.1	*Minimum Lane number and width*	***4 lanes*** of width (3-3.6m) for each one; **Table 9-2a, Appendix 9.**
4.2	*Minimum ROW width*	***18 m*** width consisting of (two lanes of 3m width each, median of 1.2m, 2 sidewalks of 2.4m each, and 2 parallel parking lanes of 3m each. OR ***24m*** width consisting of (two lanes of 3m width each, median of 5.4m to accommodate left turn lane at intersections, two sidewalks of 2.7m each,

No.	Item	Minimum acceptable requirement
		and two parking lanes of 3m width each)
4.3	*Minimum traffic loads (ADT)and light design axle Loading*	The minimum traffic loads are considered as up to 2000 vehicles/day The design loading is considered as the standard of 8200 kg
4.4	*Minimum pavement thickness and low-cost materials*	- The pavement material is asphalt. - The required data for design are (1) The design load (ADT) and typical traffic load numbers for roads and parking areas are shown in **Table 9.6, Appendix 9**, (2) The sub-grade strength as measured by the CBR value and typical CBR values are shown in **Table 9.3, Appendix 9**, where (In the absence of reliable field data, assume CBR = 3 for natural material). - for new developed areas, the main street could be partially developed using gravel material. ***Minimum thickness is (425 mm),*** and consists of anyone of the following: *1. Using German RStO 86 method for structural paving;* Referring to **Appendix 9**, **Table 9.8**, for asphalt paving: ***1- Total thickness of (500 mm)***, consisting of (40mm) wearing course, (40mm) binder course, (100mm) asphalt course on subgrade formation of 150MN/m^2 (i.e., 320mm kurkar sub-base). ***2- Total thickness of (440 mm),*** consisting of (40mm) wearing course, (40mm) binder course, (140mm) asphalt course on subgrade formation of 120MN/m2 (i.e., 220mm kurkar sub-base.) 2. Using *American Asphalt method*; The pavement construction is dependent on the amount of traffic carried and follows the local standards for highway design. For partially paved main streets, the partial acceptable pavement is as follows: Using Cotoon, 2000 guidleines: Unbound pavement made of Gravel locally available material of ***compacted thickness of (150mm)*** for *lightly trafficked roads* with up to about 100 vehicle movements per day, and ***thickness of (300mm)*** for *heavily trafficked* roads *with more vehicles for partially developed new streets*, as shown in **Table 9.1, Appendix 9.**
4.5	*Minimum/ maximum vertical grade*	Determined in relation with contour lines and nearby streets so that contributing to minimum excavations. Minimum/ maximum grades could be accepted according to natural existing levels. It ranges from minimum of (0.5%) to allow for drainage and maximum of (5 to 11%), depending on topography and design speed.
4.6	*Minimum cross slopes*	(1-2%) for asphalt pavement, (2-4%) for partially paved access towards the sides
(B)	**Low-cost parking places**	
1.	**Proper type of parking**	Site-off parking at the perimeters of the clusters is used.
2.	**Adequate parking space layouts and minimum stall dimensions**	Angle parking is used with 90 degrees option, since it provides more spaces per curb length. For 90 degrees parking, width is 2.6m and length is 5.5m.

No.	Item	Minimum acceptable requirement
3.	**Minimum number of parking places**	Minimum number of parking places is used. One parking place per three housing units is considered suitable.
4.	**Low traffic load number (TL)**	The parking places are considered parking with frequent uses with private cars (PC) only; TL is less than 10, according to **Table 9.7**, **Appendix 9**
5.	**Light design axle Loading**	Only light traffic is allowed which include small private vehicles (less than 2000 kg), in addition to allowance of emergency and service vehicles.
6.	**Minimum cross slopes**	(2-4%) towards the perimeter of the parking areas or islands which is to be bioretention areas.
7.	**Minimum pavement thickness**	Referring to **Appendix 9, Table 9.7, and 9.8** ***Minimum thickness is (400 mm) consisting of:*** 80mm (interlock) on 30mm (sand) on subgrade formation of 120MN/m^2(i.e., 290mm sub-base)
(C)	**Low-cost street and site landscaping**	
1.	**Adequate trees and other plantings**	Planting trees are used to improve the appearance of a street and enhance drainage. They should be planted in the ground and not in planters, and only varieties that have been proven to survive on streets, "street trees" should be used. They should be chosen and located so that they are incorporated with the stormwater drainage facilities (BMPs).
2.	**Low-cost street furniture**	This includes benches and seats, tables and wastepaper baskets which make the landscape area more attractive and invite people to use public areas. Using standards designs is economical and allows for easy replacement of damaged pieces.
3.	**Minimal special lighting**	Streetlights should be positioned to illuminate the roadway and not the sidewalk. Pedestrian areas not reached by regular street lights, and walkways and footpaths need special pedestrian lighting which are usually mounted (3 to 4.5 m) height and create an atmosphere of comfort and safety for pedestrians. Details have been discussed in BIC-4.
4.	**Proper leftover street space used for pedestrian amenities / courtyards "houshes"**	- They are areas which are used for public amenities are distributed through clusters of houses. The cluster design of the LCH facilitates the provision of these areas - These small sitting areas or parks provide the opportunity for an improvement in public life, especially in low or middle income neighborhoods where people need to escape their small crowded apartments. - Some short service roads are not required; and substituted by central courtyards inside clusters.
(3)	**Minimal operation and maintenance (O&M)**	
1.	**Interlock paving**	- Periodic maintenance is necessary and the LCH community can manage total maintenance requiring minimum tools. - Some blocks should be kept locally in store to replace as and when necessary for refixing for broken and settled ones. - After excavations for service lines, only those blocks on the trench line need to be re-fixed.
2.	**Flexible pavement (Bitumen surfaced streets)**	In general, they have a 15 year life for up to 3000 vehicles per day. Annual maintenance costs are about 2% of the capital costs with a new seal coat required after no more than five years costing 25% and renewal of the road after 15 years costing about 85% of the original capital cost. a trained labor gang is required to undertake regular maintenance, which

No.	Item	Minimum acceptable requirement
		include: - regular sweeping and removal of accumulated earth - regular patching for the repair of pore-holes and spots which has settled - adequate supplies of aggregate and bitumen need to be available - trench excavations for services must be rapidly reinstated to the necessary pavement standards - resurfacing may raise the road level; manhole covers and frames should be raised too

Developed based on **Section 2.2.6, Chapter 2 and Appendix 9**; Jendia, 2000; Cotton and Tayler, 2000; Homburger *et al.*, 2001

3.4.6 Provisions of BIC -6: Stormwater Drainage for LCH

Objective of provision: The principal objective of the provision of the stormwater drainage is to remove unwanted water from the LCH in a controlled and hygienic manner in order to minimize public health hazards, inconvenience to residents and deterioration of other infrastructure at the lowest costs. This would be done by the following activities:

3.4.6.1 Activity (1): Definition of the proposed criteria for provision of BIC-6: Stormwater drainage

The provision of stormwater drainage for LCH should be done at low-cost and sustainable manner. This requires the consideration of the following proposed criteria:

1. **Economically sustainable drainage system**

1- Eliminating costly sewers by promoting surface drainage.

2- Emphasizing simple, non-structural, low-tech, and low cost methods by allowing natural drainage along natural contours or streets artificial slopes into low-cost, small-scale, lot-level and small-take of land techniques which allow stormwater to be catched locally.

2. **Environmentally sustainable drainage system**

1- Integrating stormwater management early in the site planning activities of LCH, Using natural hydrological functions as the integrating framework.

2- Focusing on prevention rather mitigation, and preventing runoff flooding and damage to the site, by encouraging water to soak into ground instead of discharging to sewers.

3- Considering stormwater as an important, low-cost natural and fresh water resource that should be catched at source with minimal exposure to pollution.

4- Reducing the area of the impervious surfaces while increasing the permeable and pervious areas as much as possible for enhancing rainwater infiltration and aquifer recharching.

5- Relying on natural features and processes for the treatment and infiltration of the stormwater by routing runoff into small-scale practices through a multifunctional landscape.

3. Socially sustainable drainage system

Promoting and enhancing environmentally and economically sustainable drainage practices contributes to public health by prevention of flooding and pollution, contributes to reduction of running costs by minimizing O&M tasks and contributes to social life enhancement of residents by improving the landscape at the lowest costs.

3.4.6.2 Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-6

The developed approach uses the surface drainage system which uses a system approach that emulates natural landscape functions and known as the best management practices (BMPs) or site foot-printing technique which is applied on the micro-scale and distributed through the site near the source of the runoff and integrates a series of linked strategically placed and designed elements, that each contributes to the management of the stormwater; and include a combination of (bioretention areas/ raingardens, vegetated swales, recharging wells, voided pavements), as shown in Figure 3-17 and discussed as follows:

1. The bioretention areas (raingardens) are to be placed in the parking areas as islands, or around the parking perimeter, at the edge of paved areas, at the base of buildings in the central courtyards, and in the open space areas of the LCH, where the runoff is directed to these low-tech treatment systems. Installation of tree-box filters; which are mini-bioretention areas beneath trees and distributing them throughout the site is recommended. The soil should be amended with sandy loam to increase infiltration in these areas.
2. The use of permeable pavement; the interlock pavers or the voided pavers in the footpaths, parking areas, open areas and low-traffic areas such as local streets and grading the paved areas so they drain into the bioretention areas.
3. The use of recharging wells for recharging the harvested rainwater from the rooftops of housing buildings and other public spaces instead of discharging it into sewers or into streets, especially that their area is large with respect to the site area.
4. Reducing the impervious foot-print of the site and saving money is done also in the planning and design of the streets and roads by converting the "urban road" section into "rural road" section; by replacing curbs and gutters in the collector and main streets with vegetated swales and reducing paving widths of the streets, with strategic grading to direct the runoff through the swales along the edges.

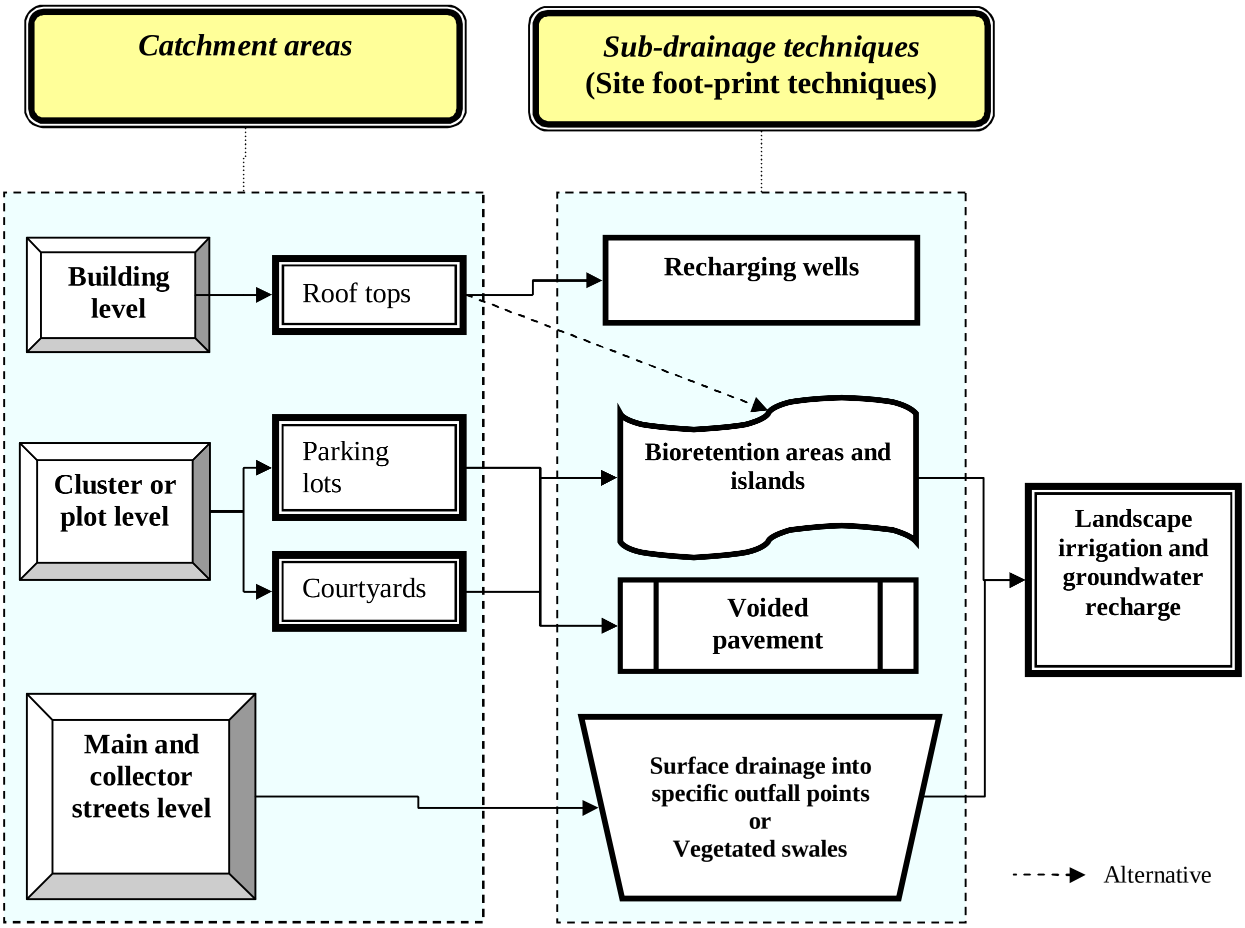


Figure 3-17: Stormwater sub-drainage management practices for LCH.

3.4.6.3 Activity (3):Determination of minimum limits, design parameters, main elements and O&M

Table 3-8 below illustrates the inventory of main items and minimum requirements for provisions of BIC-6.

Table 3-8: Inventory for provisions of BIC-6: Stormwater drainage for LCH

	Item	**Minimum acceptable requirement**
(1)	**Minimum limits and Design parameters required for planning and design of BIC-6: Stormwater drainage**	
1.	**Minimal requirement of surface drainage systems**	- The run-off from areas up to about 5 hectares in area can be carried on the street surface where the annual rainfall is in the range 500-1000 mm/yr. - Where streets are designed as drains, surfacing material such as brick and concrete (interlock pavers), which are not damaged by stormwater should be used.
2.	**Estimation of surface water runoff**	The simplest way of calculating the runoff volume from a given catchment is by the "rational method" which states that: $Q = C\,I\,A$; Where: Q = quantity (m^3/d), C = coefficient of runoff, I = intensity of rainfall (m/d), and A = area drained in m^2. *Notes:* 1- The values of C for different surfaces in Gaza Strip are shown in **Table 10.1 in Appendix 10.** A reduction of (20%) can be applied to the value of C if the

	Item	Minimum acceptable requirement
		road surfaces are semi-permeable (such as interlock and unbound ground) 2- The average rainfall (mm) in Governorates of Gaza Strip is shown in **Table 10.2 in Appendix 10.** 3- The average rainfall intensity; I (mm/hr) is selected on the basis of design rainfall duration and design frequency of occurrence. Intensity duration relationship for different return periods in Gaza Strip is shown in **Table 10.3 in Appendix 10.** 4 - Infiltration rate; *f* (mm/min) of various soil types in Gaza Strip are shown in **Table 10.4 in Appendix 10.** This exact method is to be used for design when different practices of stormwater drainage are to be used in order to calculate the volume runoff for each one separately.
2.1	*Simplified method of estimation of runoff volume in Gaza Strip*	The simple fast way to calculate the runoff volume for LCH project is to use the above mentioned rationale method, taking the total area of the LCH site, and the adopting *the average runoff coefficient (C) for urban areas in Gaza Strip* to equal **0.67** (Khalaf, 2005) in the equation.
(2)	**Main physical elements**	
1.	**Stormwater drainage at main and collector streets level**	
		The stormwater drainage could be done by either one of the following methods according to the site specific situation. If the surface drainage into specific municipal outfalls has been investigated to be impossible, the second option of vegetated swales can be used in the urban planning phase of the LCH development.
1.1	***Surface drainage into municipal outfalls***	- the vertical grades of the main and collector streets allow for surface drainage to specified existing municipal point for rainwater drainage(i.e., existing detention/retention pond or waterway).
1.2	***Vegetated bio-swales***	They should be planned in the urban planning phase of the site of LCH to be integrated as demarcations between roads and footpaths, or between building blocks or along roads in place of curb and gutter, and should be placed along the contour lines in a slope.
a-	Channel Configuration	A parabolic or trapezoidal cross-section with side slopes no steeper than 1:3 is recommended.
b-	Channel slopes.	2-4 %
c-	Sizing Procedures	Rule of thumb: the total surface area of the swale should be one percent (1%) of the area that drains to the swale. A typical design storm used for sizing swales is a six-month frequency, 24-hour storm event. Swales are generally not used where the maximum flow rate exceeds 140 liters/second.
d-	Check Dams	Installed every 17 meters if the longitudinal slope exceeds 4 percent.
e-	Vegetation	Trees and shrubs in the depression could be productive type like fruit trees.
2.	**Stormwater drainage at cluster level**	
2.1	***Bio-retention***	Incorporating bioretention in Parking lots and courtyards areas "Houshes",

	Item	Minimum acceptable requirement
	areas/islands	
a-	Area of bio-retention	- The maximum drainage area for one bio-retention area is determined by the amount of sheet flow generated by a 10-year storm. Flows greater than ***(141 liters per second** = **0.141 m3/s)*** may potentially erode stabilized areas, e.g., the maximum drainage area for one bio-retention in Gaza Strip is (13 dunums= 1.3 hectare). - The sizing specification are based on rainfall over a 6-hour period; For Gaza strip the rainfall over 6- hour for a return period of 10-years is: ***I = 32mm/hr*** from **Table 10.3 in Appendix 10.** - The area of the bio-retention is calculated as follows: 1) Find the rainwater runoff using rational method $Q = C \times I \times A$ with runoff coefficient for urban areas is (0.67) 2) Find the area of the bioretention by the following equation, finding (*f*) from **Table 10.4 in Appendix 10**, then $A_{bio} = Q/f$ 3) Choose the dimensions to be so that the length is twice than the width. 4) Check percentage of the bio-retention area with respect the total drainage area. - As a rule of thumb; the size of the bio-retention area is at least **5%** (with sand/gravel bed) to **7%** (without sand/gravel bed) of the drainage area multiplied by the rational method runoff coefficient (C) determined for the site.
b.	Recommended dimensions of the bio-retention area	- (4.6 meters) wide by (12.2 meters) in length. - The preferred width is (7.6 meters), with a length of twice the width. - *The minimum width allows enough space for a dense, randomly-distributed area of trees and shrubs.* - *The length requirement promotes the distribution of flow and decreases the chances of concentrated flow.*
c.	recommended ponding depth	Maximum of (15) centimeters *The maximum depth to provide adequate storage and prevents water from standing for excessive period of time.*
d.	Slopes of pavement	The slopes of paved areas around the bioretention should be a minimum of (2%) into bioretention area.
e.	Planting soil	- Soil amendments are required for the topsoil in bioretention areas and under pavements for more rainwater absorption - The soil should have infiltration rates greater than (1.25 cm/hr), which are typical of sandy loam, loamy sand, or loam texture with clay content ranging from 10 to 25 percent. - The amended topsoil is laden on a gravel layer to enhance infiltration. - Planting soil should be 10.1 centimeters deeper than the bottom of the largest root ball and 1.2 meters altogether. - Planting soil should be placed in 45 cm or greater lifts and lightly compacted until the desired depth is reached.
f.	Vegetation of the bio-retention	- Three species each of both trees and shrubs are recommended to be planted at a rate of 2500 trees and shrubs per hectare (250 tree &shrub/ dunum = 0.25 / m2); For example, a 4.6 meter by 12.2 meter bioretention area (55.75 square meters) would require (14 trees and shrubs). Proper plant choices are essential to long-term success of landscape islands; - Trees must be able to withstand both drought and periodic flooding of their

	Item	Minimum acceptable requirement
		roots and they should be deep-rooted. Trees of small leaves are preferred. - All shrubs and herbaceous perennials used under trees under trees should be shade tolerant, attractive at close range and evergreen leaves. The specification of flood-tolerant plants will ensure that any intermittent flooding is a benefit rather than a threat to plant health.
g.	Subsurface drains/ "shunt" pipes	They may be required to bypass the biofiltration system and discharge the excess stormwater runoff into swales or conventional conveyance systems. They consist of perforated pipes of (150mm) diameter, bedded in gravel layer at minimum depth of (90cm).
2.2	***Eco-stone permeable pavers***	All the central courtyards, footpaths and parking areas within the clusters should be paved by the permeable voided pavers to allow for infiltration of part of the stormwater.
a-	Dimensions	Length of (230 mm) and width of (140mm)
b-	Thickness	8 mm
c-	Bedding and base layers	The bedding layer and drainage opening fill material should meet the sieve specification of (0.625cm)-(100%) passing; # 4- (0-20%) passing; and #10 – (0-5%) passing. Angular gravel base of (30cm) thickness composed of (3.75 cm) gravel with less than (5%) passing the #100 and #200 sieves is laid on
2.3	***Traditional interlock***	They are used in case of not existence of voided permeable pavers.
a-	Dimensions	Square of (100x100mm), rectangular of (100x200mm) and multi-sided of different lengths and widths.
b-	Thickness	6, 8 or 10 mm
c-	Bedding layer	3-5 cm sand layer. More details in BIC-5: access and paving component, Section 3.4.5
3.	**Stormwater drainage at building level**	
3.1	***Rooftop rainwater harvesting (RRWH)into recharging wells***	- It should be designed as an integrated component of a new construction project to lower the initial construction costs. - Disconnection of the Roofleader (downspout) of the buildings to sewer system should be ensured.
a-	Catchment area (rooftop)	It is the rooftop of each housing building. The roof should not be covered with asphalt or lead based paints as lead contamination may occur in the collected water. The roofs should be covered with tiles and slates - A loss of up to 20% may take place due to evaporation and inefficiencies in collection processes. Thus only 80% of rainfall can be harnessed through rooftop
b-	Inflow structure	It includes the gutter, inflow pipe and the filter
c-	Recharging wells (Storage groundwater reservoirs)	- The collected rainwater is recharged into ground aquifer through one or more recharge wells with pits. They are constructed (1-2m) wide and to (3m) deep and are back filled with boulders, gravels, coarse sand. The Bores are used according to the soil conditions and they are deep pits to the dimension of about (25cm) diameter and about (3-7.5m) depth depending on the soil condition
(3)	**Minimal operation and maintenance (O&M)**	
1.	**Main and collector streets level**	
1.1	*Surface drainage into municipal outfalls*	Regular inspection of the interlock pavers and keep the pavement clean.

	Item	Minimum acceptable requirement
1.2	*Vegetated bio-swales*	(1) Periodic mowing, weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. (2) Cuttings should be removed from the channel and disposed in a local composting facility. (3) Accumulated sediment should also be removed manually. (4) The application of fertilizers and pesticides should be minimal. (5) Repairing damaged areas.
2.	**Cluster level**	
2.1	*Bio-retention areas and islands*	(1) Inspection and repair or replacement of the treatment area components. (2) Trees and shrubs should be inspected twice per year. (3) Diseased vegetation should be treated as necessary. (4) Pruning and weeding to maintain the treatment area's appearance. (5) Mulch replacement when erosion is evident. (6) The application of an alkaline product, such as limestone, one to two times per year to counteract soil acidity resulting from slightly acidic precipitation and runoff.
2.2	*Eco-stone permeable pavers/ Traditional interlock*	Regular sweeping from dust and dirt to allow good infiltration of rainwater, replacing of the damaged pavers and cleaning the voids from dirt.
2.3	*Recharging wells*	Regular inspection of the wells and their filling.
3.	**Building level**	
3.1	*(RRWH) system into recharging wells*	(1) Roof catchments should be cleaned regularly to remove dust, leaves and bird droppings to maintain the quality of the product water (2) The inflow structure elements should be inspected and repaired. (3)

Developed based on **Section 2.2.7, Chapter 2 and Appendix 10**

3.4.7 Provisions of BIC -7: Telephone Lines for LCH

Objective of provision: The principal objective of the provision of the telephone lines to the LCH is to provide the minimum requirement of telecommunication services; which is to make available one telephone line to be connected to each housing unit as needed and to provide the minimum number of public telephone stations within the LCH. This would be done by the following activities:

3.4.7.1 Activity (1): Definition of the proposed criteria for provision of BIC-7: Telephone network

The provision of telephone lines is usually the responsibility of the local telephone company and its costs are covered by the company, and the only financial requirement from the household is to pay the connection fee for having a telephone line. Therefore, there is little to be done for lowering the costs of its provision for benefit of the owner/developer or the household. However, a set of proposed criteria should be ensured to achieve adequate provision and they are:

1. **Provision of minimum needs**

The minimum requirement of telecommunication services is at least one available phone line for each housing unit to serve (dial-tone phone and computer internet) for communication and data exchange. The commercial and supportive facilities within the LCH should be also provided by the minimum number of telephone lines.

2. **Easy access**

The provision of telephone network is compulsory, while the household connection is optional, e.g., every household could have his own phone line whenever he could afford paying the connection fee. Minimum number of public phone stations at suitable walking distances should be provided within the LCH, for residents who do not have the telephone service.

3. **Low-cost telephone connection**

While the provision of the telephone lines does not constitute a financial burden on the owner/developer or the household and the one-time paid connection fee is the only financial burden on the household, the telephone company is commanded to provide incentives for connection for the low-income households of the LCH through reduced connection fees and relaxed payment system.

3.4.7.2 Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-7

The planning, designing, procurement and implementation of the telephone cabling plant are the complete responsibility of the telephone company according its standards and regulations in cooperation and coordination with owner/developer. The implementation phase should be concurrently done with the other underground infrastructure networks provided to the LCH in order to avoid further excavation works. When the method of provision is decided to be over ground, the installation of the needed poles is also required to be done with the other components such as the electrical lighting poles. The selection of the suitable systems and techniques lies on the local telephone company without any contribution from the owner/developer. However, the telephone company is to be encouraged to provide the minimal number of public telephone stations for the LCH project to serve households who cannot afford the individual telephone lines.

3.4.7.3 Activity (3):Determination of minimum limits, design parameters, main elements and O&M

The minimum requirements and design parameters of the telephone lines are to be determined according to the specific LCH project by the telephone company. The underground basic physical elements are usually executed concurrently with the other underground infrastructure and they are listed below in Table 3-9 just for indication and illustration.

Table 3-9: Inventory for provisions of BIC-7: Telephone lines for LCH

No.	Item	Minimum acceptable requirement
(1)	**Minimum limits and Design parameters required for planning and design of BIC-7: Telephone lines**	
1	**Minimal number of telephone lines**	One telephone line connection for each housing unit should be provided. Minimum telephone lines number for the public facilities should also be determined according to the guidelines of the telephone company.
2	**Minimal number of public Telephone stations**	Public telephone stations should be provided for the LCH and they could be located near the parking areas and main public facilities. Their number and standards are determined by the telephone company.
(2)	**Main physical elements**	
1.	**Manholes / Pipe conduits for cables/ Cables/ Building connection**	They are designed and constructed as specified in the drawings prepared by the telephone company and supervised by the engineer.
2.	**Public telephone stations**	Their number and locations are to be determined by the telephone company
(3)	**Minimal operation and maintenance (O&M)**	
1.	**Underground telephone cables**	The maintenance works of underground cables are negligible, since all installations are underground and not subjected to external effects, and they are the responsibility of the telephone company.

Developed by the researcher based on **Section 2.2.8, Chapter 2 and Appendix 11**

3.5 PHASE 4: MANAGEMENT OF OPERATION AND MAINTENANCE (O&M) OF BICs

The minimum O&M tasks have been defined briefly for each basic infrastructure component (BIC) in the **Phase 3** of this approach and they depend on the used system and techniques and the type of each BIC; whether, it is centralized or decentralized. Detailed plans for all types of maintenance which are mentioned in Table 12.1, Appendix 12 should be prepared and assigned for each one of the on-site BICs by IU during the design phase. The as-built drawings are very important to keep for this phase of life-cycle of the project. Management of the O&M tasks for off-site infrastructure component is the responsibility of the relevant municipality, municipal council or national company.

The municipality-community partnership approach for managing O&M of on-site BICs is proposed. The partnership approach is summarized in Table 3-10, described in Figure 3-19 and illustrated as follows:

(a) Utility Ownership and Management; is proposed to be used for BIC-1: water supply and distribution, BIC-2: sewerage system, BIC-3: wastewater treatment, BIC-4: power supply and street lighting and BIC-7: telephone lines.

(b) Community level management; a Local Committee (LC), which consists of representatives from the administration board (AB) of each housing building, is responsible for managing the daily and routine O&M works of the other on-site infrastructure which are BIC-5: access, paving and landscaping, e.g., footpaths, local streets, parking areas, central courtyards (Houshes), interlock (voided) pavement and landscape elements and BIC-6: stormwater drainage practices, e.g., the bioretention areas and/or the vegetated swales, and recharging wells. The LC may also be responsible for O&M works of the special lighting poles inside the clusters such as changing the defect lamps. The LC contracts a private firm or assigns some specialized workers and/or technicians from the households of the LCH for execution of the specific O&M tasks. There is an opportunity to consider self-dependence in performing these tasks to reduce the money paid to the private firm.

Table 3-10: Assignment of tasks of O&M of BICs in the partnership management approach

On-site BICs	Assigned O&M tasks for partners in management
Water supply (BIC-1)	-Municipality/Utility level for (all O&M tasks) - Community level (LC) for (rainwater harvesting systems)
Wastewater collection and treatment (BIC-2, BIC-3)	-Municipality/Utility level for both (centralized/decentralized systems)
Power supply and security lighting (BIC-4)	- Electrical company for (all O&M tasks for electricity network) - Municipality for O&M tasks of street lighting - Community level (LC) for (special pole lighting inside clusters)
Telephone lines (BIC-7)	- Telephone company for (all O&M tasks)
Access and paving (BIC-5)	- Community level (LC)
Stormwater drainage (BIC-6)	- Community level (LC) for (all O&M tasks)

3.6 PHASE 5: FINANCING CAPITAL AND O&M COSTS AND COST RECOVERY

For sustainable provisions of BICs for LCH, it is important to ensure sustainable and available financial source for capital finance of their construction while assuming the minimum cost recovery of these costs from the households included in the cost recovery of the total costs of the housing units through the available repayment system. Furthermore, it is also important to ensure sustainable cost recovery for the costs of O&M works for all the

BICs. This is to be done in the following activities:

3.6.1 Activity (1): Capital Finance and Cost recovery of BICs for LCH

1. Capital finance for provisions of BICs

Currently, the main important source for the capital finance in Palestine in general and Gaza Strip in particular is the donations from Arabic and Foreign donors which are specified for the construction of low-cost housing with the required infrastructure. However, these funds should be kept sustainable for the long run. This could be done by establishing a national governmental revolving fund (RF) in the central government for the benefit of the housing institution for sustainable financing of the LCH projects. The RF could also support the private sector investment in LCH by providing loans with decreased commercial interest. The main financial sources of the RF come from donations and contributions, NGOs, governmental fund transfers and the repayments from the households of the LCH. Moreover, other international financial mechanisms for the provisions of some infrastructure facilities such as private sector partnership (PSP) should be explored. These sources of capital finance are summarized in Figure 3-18 However, the detailed discussion of the fund issue is out of the scope of this research, and may be discussed in more detail in separate research work. It has been mentioned here as an integral part of the provision process of the BICs.

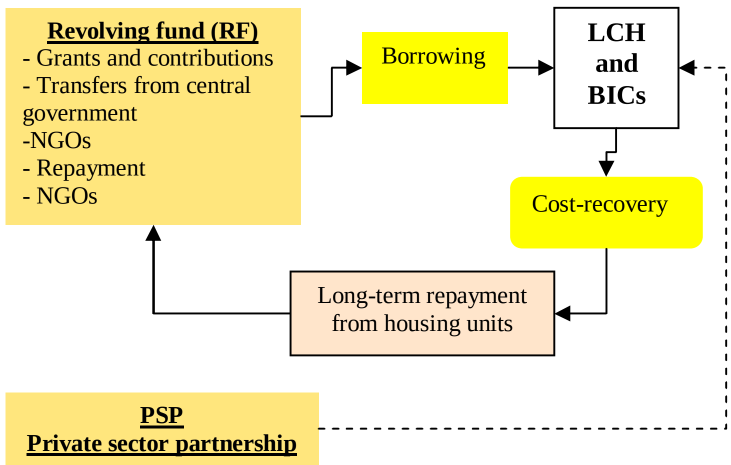


Figure 3-18: Capital Finance of BICs and cost recovery.

2. Capital Cost Recovery

The capital costs recovery for the provisions of BICs is essential to maintain the sustainability of the expended funds to implement other housing projects. This is to be done through long-term repayment of the housing unit costs since these costs are added to the costs of the housing units. Long-term repayment for the housing units has been experienced in many housing projects in Palestine and has proven to be suitable for the local conditions.

3.6.2 Activity (2): Cost Recovery of Basic Service Consumption Costs for LCH

"Lifeline" entitlement (cross- subsidy) is recommended to define cross-subsidy to the poor with respect to water, sanitation, and electricity. Subsidies and tariffs are proposed to be reconstructed to assume entitlement "lifeline" provision to all poor and low-income people, to cover water supply (BIC-1), sewerage system (BIC-2), wastewater treatment (BIC-3) and power supply (BIC-4). A progressive block-tariff and lifeline subsidy system assures that a minimum supply of municipal services could be consumed at no charge by poor residents.

Minimum supply of municipal basic services could be (100 *l/c/d* of clean water) and approximately (20 kWh of electricity per person per month); such that low-income households attain relatively decent standard of living regardless of their ability to pay.

The vast difference in use patterns would allow a small marginal increase in tariffs for large users (i.e., corporations, national-scale industrial, service-sector and agricultural bulk users of water and electricity) to pay for "lifeline" service of the first block of consumption at no cost to all poor consumers and would also penalize excessive usage, thereby contributing to conservation goals. Other source for funding such subsidies is revenues from the local government which come from property and investment (business) taxes.

However, rate setting and the application of cross-subsidy mechanisms requires the establishment of accurate systems for assessing costs of capital investment and operations and maintenance, as well as updated cadastres of users, and data on socio-economic aspects and mechanisms to ensure that the subsidies actually reach the target population.

3.6.3 Activity (3): Cost Recovery of O&M Costs of BICs for LCH

1. Low-cost O&M works

As the used systems and techniques of the BICs have been chosen to be simplified and of low-cost, the works of O&M are also little and simple and does not cost a lot of money.

2. Methods of relaxed cost recovery

The cost recovery of the costs of O&M works should be in a relaxed manner to the low-income households of the LCH. This is ensured by the partnership management approach which has been discussed in the previous section which enhances the cost recovery.

There are three types of cost recovery of the seven BICs, which are related to the procedures of management and type of each BIC, e.g., centralized or decentralized. They are summarized in Table 3-10, described in Figure 3-19 and discussed in the following:

a) Cross- subsidy for utility/municipality bills: The costs of O&M works of BICs which are managed by the municipality/ utility and shown in Table 3-10 are recovered through the monthly bills which consider also the lifeline entitlement and thus are considered affordable to the households of the LCH and therefore are ensured to be recovered.

b) Monthly fees/ self-dependence (Community level): The costs of O&M works of BICs which are managed by the community and shown in Table 3-10 are recovered through special monthly fees paid by the households to the local committee (LC) which may assign a private firm to perform them. Otherwise, for saving money the LC may agree with the households to perform these tasks by themselves in the most proper manner.

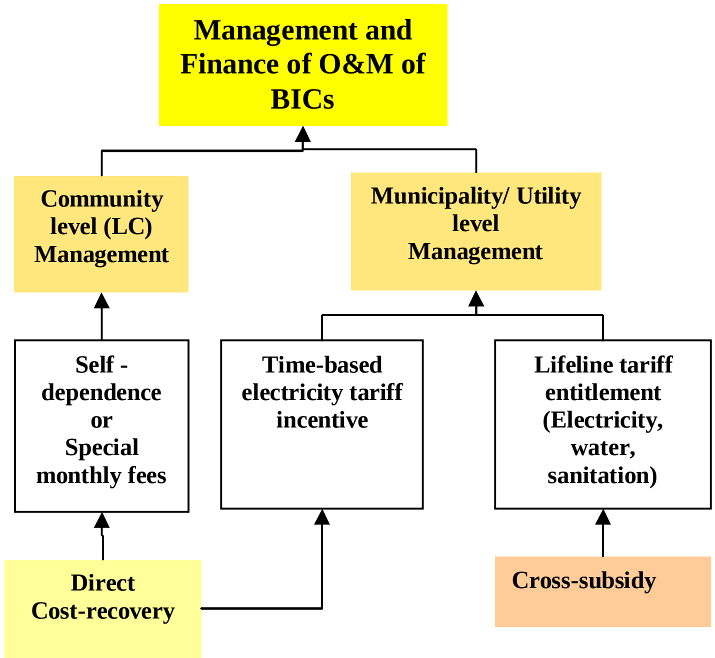


Figure 3-19: Management and Finance of O&M for BICs for LCH.

3.7 CONCLUDED REMARKS

1. This chapter has concluded a sustainable approach for the provisions of the basic infrastructure components (BICs) for the LCH in adequate manner. The BICs for LCH have been determined to include seven basic components which are (1) water supply, (2) sewerage system, (3) wastewater treatment and disposal or reuse, (4) power supply and security lighting, (5) access and paving, (6) stormwater drainage, and (7) telephone lines.
2. The developed approach which has been illustrated in Figure 3.1 involved five phases, which have taken into consideration the shortcomings of the current practices of infrastructure provisions for the LCH projects which usually are considered unsatisfactory, and has been built upon two important bases. The first base is lowering the costs of provisions through considering the general main factors influencing the infrastructure costs, while the second base is promoting sustainable provisions in such a way which maximize the overlapping of environmental, economical and social dimensions of sustainability in all actions of provisions.
3. The developed approach ensures the provisions of the basic infrastructure components in the short and long run, enhances the integration of the provisions of all the BICs, promotes the conservation concepts, satisfies the sustainability values and social concerns and fulfills the Palestinian national goals. Furthermore, the developed

approach introduces sustainable financial mechanisms for the capital funding and covering the running costs of O&M, in addition to suggestions for lifeline tariffs dedicated to poor and low-income people for sustainable cost recovery. Adequate and low-cost management approach for O&M which promotes the community involvement and partnership has been suggested for some of the provided BICs, in addition the traditional centralized management for the other BICs.

4. Empowerment of the developed approach is to be done through applying it to a low-cost housing project in Gaza Strip as a case study in the next chapter.

CHAPTER FOUR

APPLICATION OF THE DEVELOPED APPROACH TO CASE-STUDY

4.1 INTRODUCTION

It is important to examine the practicability and applicability of the developed approach in the real life by applying it to one of the low-cost housing projects in Gaza Strip. There are many agencies which have been working in planning and implementing housing projects in Gaza Strip throughout the public sector and the private sector. When talking about the low-cost housing, or housing that serve the low and middle income people in Gaza Strip, it seems that it is mostly the responsibility of the public sector. The most common ones in this field include the Ministry of Public Works and Housing (MPWH), Palestinian Housing Council (PHC), and UNRWA. Each one of these institutions has its own specific criteria and guidelines for planning and implementing its housing projects. One or two projects which have been planned and implemented by each one of them would be chosen. Then they would be studied and summarized for comparison. Finally, one of them would be selected according to specified criteria as a case study for the application of the developed approach.

4.2 THE OBJECTIVES OF APPLYING THE APPROACH TO A CASE STUDY

The main objectives of applying the developed approach on a case-study are summarized in the following:

1. Examine the Practicability of the developed approach in the real life.
2. Test the **applicability** of the proposed concepts of the approach on Gaza Strip local conditions.
3. Check out how much the developed approach is **practical and friendly used** for the relevant stakeholders and the target population in Gaza Strip.
4. Application of the developed approach to the Case Study will enhance its **empowerment in the real life.**
5. Drawing **conclusions and proposing recommendations** for planning future LCH projects in Gaza Strip in particular and in Palestine in general.

4.3 SELECTION PROCESS OF THE CASE-STUDY

In order to select the optimal housing project to be the case-study for the research work, five housing projects have been chosen. These are two housing projects that are implemented by MoH, one housing project that is implemented by Palestinian Council for Housing (PCH) and one project implemented by UNRWA. They are listed in Table 4-1, and their information is summarized in Table 13.1, Appendix 13. Then, a selection method is chosen and the multiple-criteria are defined for assessment of the different projects. Then each project is studied and evaluated with respect to each criterion in order to choose the most suitable project for the case study.

Table 4-1: Implemented low-cost housing (LCH) projects in Gaza Strip

N.	Housing project name	Implementing institution	Location
1	Al-Zahra Housing City	MoH	Al-Zahra city
2	Austrian Housing Project(AHP) – Al-Shorouq Neighborhood	MoH	Khanyounis city
3	Sheikh Zayed Housing Township	MoH	Beit Lahia city
4	Ein Jalout Housing development	PCH	Nusairat city
5	Khanyounis Re-housing Project	UNRWA	Khanyounis city

4.3.1 Scoring Method

The selection methodology based on decision analysis using a system framework that considers the different criteria for selecting the case study. Almost all methods for solving multiple-criteria problems; multi-attribute, involve two general sub-processes. They are:

1. Articulation of the decision maker's preference structure over the multiple criteria.
2. Optimization of the preference structure.

The various methods can be classified into three classes based on the timing of these sub-processes relative to one another. The prior articulation class is the most widely used. This includes scoring methods, analytical hierarchy process and other techniques.

Scoring method is one of simplest and most popular tools for solving multiple-criteria decision problems. In this method weights are assigned to criteria, and then the alternatives are rated against each criterion (Ziara, 2002). This method would be used for the selection of the case-study, according to the following steps:

1. Definition of multiple-criteria for the final selection of the case-study: The selection of the most suitable housing project from the chosen five LCH projects, for the application of the developed approach would be done according to specified criteria. Ten (10) criteria have been specified in Table 13.2, Appendix 13 according to the following basis:

(a) The researcher's ability to get the needed data and information; which is designated as criterion 1.

(b) The planning, technical design, implementation and management aspects; which are designated as criterion 2, criterion 3, criterion 4, criterion 5, criterion 7, criterion 8, and criterion 9, respectively.

(c) Other factors concerning financing and management; which are designated as criterion 6 and criterion 10.

2. Development of weight factors for the specified criteria: Each criterion is assigned a weight factor relative to its importance, with the least important criterion has the lowest weight factor and the most important criterion has the highest weight factor, noting that the summation of weight factors of the ten criteria is (1.0); see Table 13.2, Appendix 13.

3. Selection of optimal LCH project (i.e., the case study): Each housing project of the five chosen ones is weighted according to each specified criterion, by assigning a score that ranges from one to ten; (1-10) for each criterion according to its consistency with the range of criterion options. For this purpose; Table 13.3, Appendix 13 has been developed. Then, the Tables 13.1, 13.2, and 13.3, Appendix 13 have been distributed to five directors in MPWH who are working in the urban planning, designing and research fields of the housing sector in order to assign weight units for each criterion for each housing project.

Unfortunately, no respond has been received. Therefore, it was compulsory to depend on the researcher's own expertise, knowledge and judgment with the advice and review of the supervisors to assign and calculate the criteria scores and the weight rating for the five housing projects. Finally, the housing project with the highest weight is chosen as the Case-study, as seen in Table 13.4, Appendix 13. It has been concluded that the Austrian Housing Project (AHP) has the highest weighting rate of (8.4), and would be the Case-study.

4.4 THE CASE-STUDY: AUSTRIAN HOUSING PROJECT (AHP)

4.4.1 Background

The idea of the Austrian Housing Project goes back to the preparatory conference for the Oslo Peace Treaty in 1993. Austria promised to make a major contribution, part of which would be devoted to implementing housing measures in the areas of Palestinian autonomy.

The agreement between the Federal Chancellery of the Republic of Austria and the Palestinian National Authority has been signed in January 1997 and stated that two Housing Projects shall be constructed in Palestine, one project in Khan Younis in the Gaza strip and another in Nablus in the West Bank. According to the agreement, the Austrian Chancellery agreed to contribute non-repayable one hundred million shillings (ATS 100 million equal to $10 million US) at the time of agreement, with $5 million US for each subproject. The Austrian non-repayable contribution for Khanyounis Housing Project has been planned to cover the cost of (1) soil investigation, (2) the building construction of about (20,000.0m^2),

(3) the on-site infrastructure, and (4) the Austrian consultant fees.

4.4.2 Institutional Arrangement

The framework for cooperation and coordination between the relevant parties has been set in order to plan, design and implement the AHP in Gaza Strip. The technical committee (TC) consists of the ambassador of Austria, the Deputy Minister of Housing, the project manager (i.e., the Director of Design and Engineering Department) and the Austrian consultant. The main tasks of TC are the approval, updating, amendments of the project documents in addition to the other tasks of tendering and financing.

4.4.3 Project Description

The project is situated in west of Khanyounis town in the southern part of the Gaza Strip as shown in Figure S-1, Appendix 14, in a land area of a bout (20,000.0 m^2). The site plan of the AHP has been designed by an *Austrian architect* and built in collaboration with the Palestinian Ministry of Housing. The architect opted for an enclosed arrangement constructed by 10 blocks (housing buildings) creating 3 protected courtyards which form an interior haven, at night providing a common venue for outdoor amenities and offering a protected playground for kids on the block by day as shown in Figure S-2, Appendix 14. The outcome is clusters of housing at the edge of Khanyounis city and far from existing neighborhoods and their infrastructural network. Another new housing has been planned to be constructed near the AHP in another part of the governmental land which is EL-Farra housing project; Figure S-3, Appendix 14. This project has been also designed by MoH and funded by a private investor in a partnership approach.

The original plan of the project included (10) buildings, 5-stories each one with 4 departments in each floor. Each floor area is (420m^2) with total gross area of (2,100m^2) for each building. An eleventh building was added to the plan in order to comply with site planning requirements of the land area; Figure S-4, Appendix 14. However, due to the declination of the Austrian shilling with respect to the US dollars, the Technical Committee (T.C.) of the project decided in June 1997 to proceed with complete construction of only 8 buildings (Bldg. 1,2,3,4,6,7,9 and 10) and partial construction of other 2 buildings (Bldg. 5 and 8). It has been decided to construct building with a maximum of five stories to eliminate the need for costly elevators. A row of shops have been provided on the ground floor facade of six buildings on the street side to serve the residents of the AHP and the surrounding area in the future; Figure S-5, Appendix 14.

The construction of the buildings was completed in July 1998 and the infrastructure and site works in June 1999. The beneficiaries started to move to their apartments in may 1999, and the official inauguration of the project was made in June 1999. The implementation stage of the project has included one contract for the soil investigation, three contracts for buildings' construction and one contract for the site work and infrastructure. As the beneficiaries started to deposit the down payments in the project account, the board of Khanyounis Nablus Housing Fund (KNHF) agreed in November 1998 to award a contract for the foundations of one building (Bldg. 11) and the completion of buildings (5) and (8); Figure S-6, Appendix 14.

AHP is the first project that has been planned and designed by MoH in cooperation and coordination with the donor consultant; whilst the previous projects have been prepared by the private consultants appointed by the donors.

As EL-Aqsa Intifasda has started on 18 September 2000, the AHP has been exposed to serious attacks from the Israeli army in the adjacent Israeli settlement which caused the residents to leave their apartments to save their lives which has become in great danger. All the buildings have been exposed to great damages and the two buildings (Bldg. 1 and Bldg. 3) which are opposed to the Israeli settlement have been completely demolished, in addition to great damages in the project infrastructure; S-7, Appendix 14. Also, the adjacent EL-Farra project buildings have been exposed to great damages S-8, Appendix 14.

4.5 APPLICATION OF THE DEVELOPED APPROACH TO THE CASE-STUDY

The developed approach of the five phases is to be applied to AHP in the next sections of this chapter. Each phase with the related activities is to be applied to the case study and comments are to be summarized about the consistency of the case study to each phase and activity.

The evaluation of the applicability of the phases/activities of the developed approach on the case-study ranges from Consistent, Partially consistent, Inconsistent and N.A.

"Consistent" means that the case-study completely matches the specified phase of the approach. *"Inconsistent"* means that the case-study contradicts the specified phase of approach completely. *"Partially consistent"* means that the case-study matches the specified phase of the approach in some issues and contradicts with it in other issues. *"N.A."* means that the specified phase of the approach has not been incorporated at all in the case study.

All the data regarding the planning, design, implementation, drawings and photos regarding the AHP have been collected by the researcher from the relevant departments in MPWH (e.g., MoH before year 2002). Then they have been studied and analyzed for the approach application.

4.5.1 Case Study- Phase 1: Designation of the BICs for LCH and bases of provisions

The Case-study (AHP)	Check of consistency with the approach
- According to the Agreement, Article IV (4), the Recipient (MoH) should: a) Elaborate a project documents (PD) for AHP and submit it to the TC for approval. The PD should include (1) a time schedule for construction of housing schemes and the *off-site infrastructure*, (2) the size of the apartment, (3) equipment, (4) target groups, and (5) *a description of the planned necessary infrastructure.* b) provide the necessary development work for the off-site infrastructure (at his own charge), e.g., (1) pedestrian and traffic access, (2) water supply, (3) drainage, and (4) electricity supply - Actually, the basic infrastructure components which have been planned and executed are (1) water supply, (2) sewerage system, (3) wastewater disposal by septic tank system, (4) electricity network, (5) pedestrian and traffic access, and telephone network - The agreement has not mentioned the off-site part of the wastewater collection system (sewerage) since Khan Younis city is not provided by sewerage network. - Although the drainage component has been mentioned in the off-site infrastructure, it has not been included in the BICs provided to the AHP.	**Partially consistent** - The implemented BICs for the AHP has included six out of the seven needed basic components. - The provisions of the BICs have not been done according to specific clear criteria.

1. Conclusion

The case study is considered *partially consistent* with the developed approach with respect to the determination of the BICs and with respect to bases of provisions. The on-site BICs which have been referred by the necessary infrastructure have been determined by the implementing party (MoH). The implemented BICs have been six (6) components out of seven (7) since the stormwater has been planned to be drained from the project site into the nearby sand dunes and empty areas. The planned off-site necessary infrastructure includes 4 networked components since the telephone component is to be provided by the local telephone company at its charge. Furthermore, the provisions of BICs have not considered all dimensions of sustainability values. They also have not considered all the cost-influencing factors. However, the cluster design has been adopted for the subdivision design as one method of lowering the costs.

4.5.2 Case Study- Phase 2: Institutional Setup

The Case-study (AHP)	Check of consistency with the approach
- At the time of agreement and the following stages of planning, design and implementation of the AHP in 1997-1999, the **MoH** was responsible governmental body for the housing sector and it was also responsible for the governmental lands. The housing projects were usually planned, designed and implemented through the following departments and General Directorates: (1) Department of governmental land **(DGL)**: It was responsible for all the	**Partially consistent** - The engineering and design department is responsible for the planning and design of the housing projects

The Case-study (AHP)	Check of consistency with the approach
governmental lands, and could choose and assign the suitable land areas and locations of the housing projects. (2) General directorate of urban planning **(GDUP)**: Among other tasks, it proposes the site plans of subdivision designs of the land that is allocated for the housing projects with the needed circulations within the project. It is also responsible for the sitting and configurations of the housing buildings on the specific land area. (3) General directorate of projects **(GDP)**: It consists of three departments which are: (a) Design and engineering department, (b) Supervision and follow up department, and (c) Maintenance department. The design and engineering department is responsible for the architectural and structural designs of the housing buildings and infrastructure for housing projects.	and their on-site infrastructure. - The institutional arrangement of engineering and design department has not included specialized unit for the planning and design of infrastructure for housing.
- A technical committee (TC) has been established for the AHP to manage all the stages of planning, design and implementation of the project. The project manager was the Director of Design and Engineering Department because this department is responsible for the design of the housing buildings and the infrastructure components and includes the specialized engineers to perform these tasks. - The BICs for the AHP which have been planned and designed by the Department of Design and Engineering are (1) water supply, in coordination with Khanyounis Municipality (2) Sewerage system, which has been designed to include individual septic tank system for each housing building for wastewater treatment and subsurface disposal, which is the common practice in Khanyounis Governorate because it is not connected to central treatment plant. (3) access and paving, which include the geometric and structural design of local streets, footpaths, sidewalks, parking areas and landscaping, while the collector and main streets have been determined by Khanyounis Municipality (4) power supply and lighting, in coordination with GEDCo and Khanyounis Municipality (5) telephone lines, in coordination with PALTEL company - However, the wastewater treatment and disposal system has been changed in the implementation stage by the contractor and the final approval of the project manager to include one communal septic tank for the whole project instead of the individual septic tanks for each housing building.	- This has contributed to some shortcomings in the provisions of the BICs in the adequate manner at the lowest costs. - For example, the first proposal for the decentralized wastewater treatment system was individual septic tanks for each housing building, and the final design of communal septic tank and percolation pits design have been prepared by the contractor.

1. Conclusion

The institutional arrangement in the implementing institution of the AHP (e.g., MoH) has proven to be *inconsistent* with the developed approach. The responsible department for planning and design of the housing projects do not include specific unit for the provision of the infrastructure for the housing project at time of the project execution. This may be referred to that this was the first project which was planned, designed and implemented by MoH and there was no previous need to establish such unit. Furthermore, there has been not integration between the responsible department for the site planning of the project and the responsible department of design and engineering which has caused that some of BICs to be planned in earlier stages in improper manner. There is evidence that there is a need for building capacity in the field of provisions of BICs for the LCH.

4.5.3 Case Study- Phase 3: Requirements of provisions of Basic Infrastructure Components (BICs) for LCH

4.5.3.1 Case Study- Provisions of BIC-1: Water supply

The Case-study (AHP)	Check of consistency with the approach
Activity (1): Definition of the proposed criteria for provision of BIC-1: Water Supply **(Refer to Table 3.1, Chapter 3)**	
1. Minimum adequate quantity The quantity criterion has been considered.	**Consistent**
2. Minimum allowable quality The quality criterion has been considered for domestic water, but not considered for potable uses.	**Partially consistent**
3. Sustainable cheap sources of water The diversification of water sources has not been considered. a) Municipal water supply is considered as the only water supply source. b) No supplementary water resources for outdoor uses to save fresh water such as the harvested water or treated wastewater are considered. c) No operational conservation measures have been used.	**Partially consistent**
4. Adequate accessibility and reliability of water supply Accessibility and reliability criteria of water supply have been considered.	**Consistent**
5. Low cost and durable materials and equipments Durable and low cost materials and equipments are considered**.** PVC pipes have been used.	**Consistent**
Activity (2): Proposed methodology for selection of the suitable systems and techniques for provision of BIC-1 **(Refer to Table 3.1, Chapter 3)**	
- the general approach of water resource cycle which is developed in **Figure 3-4, Chapter 3** for the provision of water supply has not been considered - the selection methodology which is illustrated in **Figure 3-5, Chapter 3** for selecting and deciding the water supply according to exact evaluation of the LCH site conditions has been considered by connecting to the nearest municipal water supply main. - It is assumed that the nearby municipal supply has the sufficient capacity to provide the needed demands. This has been done in cooperation and coordination with Municipality of Khan Younis	**Consistent**
Activity (3): Determination of minimum limits, design parameters and main elements **(Refer to Table 3.1, Chapter 3)**	
(1) Minimum limits and design parameters for planning and design of BIC-1: Water supply	
Minimum adequate Quantity	**Consistent**
- *Peak total demands* a) The total peak daily demand is: $Q = P_n(f \times q + w)/100 \quad = P_n(f \times q + 0.25q)/1000$ - the peak daily domestic demand for **each housing building** is: Q= 20 x 7 (1.1 x 100 + 0.25 x 100)/ 1000 = **18.9 m^3/day** This quantity is ensured by the provision of (4 plastic roof tanks, each one of 5000 L, with total storage capacity of 4x5000*l* = 20,0000*l* =20 m3) for each building.	*Consistent* The total peak daily demand has been provided
b) The total peak hourly demand:	*Consistent*

The Case-study (AHP)	Check of consistency with the approach
- the total peak hourly domestic demand **for all housing buildings** is: Q= 1500 (3x100/24+ 0.25x100/24)/ 1000 = **20.3 m^3/hr** - the total peak hourly domestic demand **for one housing buildings** is **2.3 m^3/hr** - Peak hourly (commercial and institutional demands) = **20.3 m^3/hr** (assumed to be equal to the total domestic demands) - total peak hourly demands for AHP = <u>**40.6 m^3/hr**</u> - total peak hourly demand for EL-Farra project=2x23.5= <u>**47 m^3/hr**</u> - total peak hourly demand for the two projects = 40.6+47= <u>**87.6 m^3/hr**</u> **Check the actual provided water demand:** - Building connections are designed of (2" = 50 mm) diameter pipes which are able to provide water quantity of: $Q = p\ v \frac{D^2}{4}$ = 10.6 m^3/hr > 2.0 m^3/hr (peak hourly domestic demand for one building of 20 H.Us) à OK - tertiary mains are designed of (4" = 100mm) diameter pipes, and are able to provide water quantity of: $Q = p\ v \frac{D^2}{4}$ = **42.4 m^3/hr** > **40.6 m^3/hr** à OK - Secondary water mains are of (6" = 150mm) diameter pipes which are able to provide water quantity of: $Q = p\ v \frac{D^2}{4}$ = **95 m^3/hr** this water quantity is capable of providing both AHP and EL-Farra project of the needed total peak quantity of (<u>**87.6 m^3/hr**</u>) à OK	The total peak hourly demand has been provided
- Minimum adequate quality *3.1 Domestic water;* The quality of domestic water has been considered to match the acceptable municipality water quality as it is supplied by municipal main. *3.2 Potable water;* The quality of the potable water has not been considered, even though the municipal water quality is confirmed in KhanYounis area to be not suitable for potable uses. No specific sources for potable water are considered.	**Partially consistent** *Consistent* *N.A.*
Low-cost sustainable water sources *4.1 Domestic water (cleaning &sanitation)* - The main water supply is only the municipal water network. - The source of the water supply was a new ground water wells that have been executed near the location of EL-Farra housing project. A connection has been made to the new water main near EL-Farra project and then passes through the collector street between it and the AHP; **Figure C1-1, Appendix 14.** - Total length of off-site connection (primary main) is 106.5m. - The stormwater harvesting has not been considered for outdoor uses to replace fresh water. The reuse of the treated wastewater has not been considered because the choice of subsurface effluent disposal systems has been decided.	**Partially consistent** *Partially consistent* Only the supply of municipal water is considered by connection to nearest water main. The other sources have not been considered.

The Case-study (AHP)	Check of consistency with the approach
4.2 Potable water (drinking & cooking); No potable water sources have been looked for. *4.3 Fire fighting demands;* Not all the fire hydrants are located on the secondary or main lines; but on the tertiary mains of (75 mm) diameter.	*N.A.* *Partially consistent.*
Min. pressures; minimum required head at house connection of (25m; 2.5 bar)., and minimum pressure of (0.5 bar/5m) at tap are ensured through the provision of ground storage tanks and roof storage tanks with booster pumps for each housing building.	**Consistent**
***(2) Main physical elements* , Refer to Figures C1-1 – C1-4, Appendix 14**	
Groundwater wells; No on-site groundwater wells are used since all the peak water demand is supplied by the municipal water network.	**Consistent**
Public water tanks*;* Not used, since not new groundwater wells are constructed at site.	**Consistent**
Pipes *4.1 Primary and secondary mains* - they have been laid above the sewer lines - the primary and secondary mains are loops - primary water mains are made of PVC material and of diameters (8" = 200mm) > (150 mm) **à** OK they are able to provide water quantity of 169.56 m^3/hr - Secondary water mains are are made of PVC material and of (6" = 150mm) diameter > (150 mm) **à** OK They are able to provide water quantity of 95 m^3/hr, this water quantity is capable of providing both AHP and EL-Farra project of the needed total peak quantity of (90 m^3/hr), *4.2 Tertiary mains (mains supplying house connections)* tertiary mains are designed of (4" = 100mm) diameter UPVC pipes, which > Min. allowable of (75 mm) **à** OK They are able to provide water quantity of 40.6 m^3/hr *4.3 House connections;* Building connections are designed of (2" = 50 mm) diameter PVC pipes, which serve (20 apartments, and this equals the specified one in the approach. - They are able to provide water quantity of 10.6 m^3/hr > 2.0 m^3/hr (peak hourly domestic demand for one building of 20 H.Us). - 20 mm UPVC pipes are not adequate to be used, since they could provide a quantity of water of 1.7 m^3/hr which is less than the needed 2.0 m^3/hr. *4.4 Pipes depth;* the pipes are designed to be laid at depths which ranges from (80-120cm) according to their depth. **Building-level water supply elements** *5.1 Ground domestic water tanks (Concrete/ plastic);*Ground water tanks; (2 plastic tanks each one of 1500 L), *5.2 Roof domestic water tanks (plastic);* (4 plastic roof tanks, each one of 5000 L, with total storage capacity of (4x5000*l* = 20,0000*l* =20 m3) which greater than the required peak daily demand for each building of 18.9 m^3/day; **Figure C1-3, Appendix 14** *5.3 Small booster pumps*; One booster pump for each building has been use to pump the water from the ground tanks to roof tanks; **Figure C1-3, Appendix 14**	**Consistent** *Consistent* *Consistent* *Consistent* *Consistent* **Partially consistent** *Consistent* *Consistent* *Consistent*

The Case-study (AHP)	Check of consistency with the approach
5.4 Meters; One meter has been used for each H.U. *5.5 Water-Conservation fixtures;* Not used *5.6 Rooftop rainwater harvesting (RRWH);* The collected rooftop rainwater is made to be collected from each building by directing spouts into underground concrete box of dimensions 35x35 cm and depth of 40cm to collect some of the rainwater and overflow excess water to the streets.	*Consistent* *N.A.* *Inconsistent*
Valves*; Refer to* **Figures C1-1, C1-2, Appendix 14:** *6.1 Sluice/shut /Stop valves;*two (2) sluice valves (S.V) of 6" at the secondary main at boundaries of AHP and EL-Farra project. one (1) sluice valve (S.V) of 8" is placed on the primary main at the boundary of EL-Farra project *6.2 Washing valves;* One (1) wash valve (W.V) of 4" is placed on the tertiary main near BLDG 1 *6.3 Air release valves;* One (1) Air Valve (A.V.) of 4" is placed on the tertiary main near BLDG 10. *6.4 Fire hydrant valves;* Three fire hydrant valves of 3" are placed between the water mains and the location of fire hydrants.	**Consistent**
Fire fighting hydrants Refer to **Figures C1-1, C1-2, C-4, Appendix 14;** Refer to **Figure C1-4a, Appendix 14** ***Actual calculations according to the approach:*** - The needed fire flow is ($5m^3$/min) for 5 hrs duration. - No. of required fire hydrants = ($5m^3$/min)/(0.95 m^3/min) = 5.2 à 5 fire hydrants - the minimum area served by a single hydrant is commonly taken as (3,720 m^2) - Check no. of fire hydrants = 20,000 m^2/ 3,720 m^2= 5.3 à 5 fire hydrants (ok) - They should be placed at minimum spacing is 60m, but not more than 150m) - Hydrants should be located at street intersections so that hoses may run in any direction ***Actual situation in AHP:*** - No. of fire hydrants valves in the AHP is 3 fire hydrants. Two of the fire hydrants valves are located on the tertiary mains of (4"= 100 mm) diameter near BLDGs 1,10. One is located on the secondary main of (3" = 150 mm) diameter near BLDG 11 - They are placed at spacing which ranges from (90-145m). One of them is connected to the secondary main near BLDG 11 and two are connected to the tertiary mains near BLDGs 1,10 - They are placed at the three edges of the AHP near street intersections. Therefore, Two additional fire hydrants are required and they should be located on secondary and primary mains of at least (150mm)	**Partially consistent**
Water conservation measures	**Partially consistent**
Landscape irrigation network; *Refer to* **Figure C1-4b, Appendix 14** Landscape irrigation has been provided through special six irrigation points with pipes of (1" = 25mm) diameter connected to the tertiary mains. No utilization of rainwater harvesting or treated wastewater has been done.	**Inconsistent**
(3) Operation and maintenance (O&M)	
Khanyounis municipality is responsible for the O&M works.	**Consistent**

1. Conclusion

The provision of water supply for the AHP is considered *partially consistent* with the developed approach.The provision of water supply has ensured accessibility and reliability of the supply and considered most of the minimum requirements such as minimum quantities and pressure heads for provisions. In the other hand, the provision of water supply has not involved all conservation measures or the diversification of water resources. The provision has not included the rainwater or the treated wastewater as a valuable water resource to be used even outdoor uses instead of being health and environmental hazard. The quality of the provided water has not been examined to be suitable for potable uses.

4.5.3.2 Case Study- Provisions of BIC-2: Sewerage system

The Case-study (AHP)	Check of consistency and final comments
Activity (1): Definition of the proposed criteria for provision of BIC-2: sewerage system **(Refer to Table 3.3, Chapter 3)**	
1. Protection of public health, environment and pollution prevention The sewerage system has been used to collect the wastewater from point of generation to the point of disposal to protect public health and environment.	**Consistent**
2. Minimum amounts of generated wastewater No consideration for reducing the amounts of generated wastewater since water conservation fixtures inside the housing units have not been used adequately.	**Inconsistent**
3. Low-cost sewerage system The conventional sewerage system has been used with some simplifications.	**Partially consistent**
Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-2 **(Refer to Table 3.1, Chapter 3)**	
1- Since Khanyounis governorate is not provided by municipal networked sewerage system, the first proposed system was settled sewerage, e.g. one septic tank with one percolation pit for each housing building which is the common on-site conventional system in Khanyounis governorate. 2- Then, it has been changed into a sewerage system that conveys the foul flows into on-site communal septic tank system outside the boundary of the project. 3- The sewerage system could be considered as "semi-simplified" e.g., it uses the minimum pipe diameters of conventional sewerage and "simplified" manholes instead of traditional ones, but in large number compared to the "simplified" sewerage.	**Partially consistent** The used sewerage system is not considered of low-cost.
Activity (3): Determination of minimum limits, design parameters and main elements **(Refer to Table 3.1, Chapter 3)**	
(1) Minimum limits and design parameters required for planning and design of *BIC-2: wastewater collection (sewerage system)*	
Type of the sewer system; The used sewer system is the "separate system"	**Consistent**
System layout; The layout of the used sewerage system is considered adequate for minimizing lengths and depths of sewers.	**Consistent**
System technology; The used system is the "traditional sewerage" which depends on the "self-cleansing velocity" concept, and minimum American standards for pipe diameters which is 150 mm diameter, instead of using the "simplified system" that depends on the minimum tractive force and minimum	**Inconsistent**

The Case-study (AHP)	Check of consistency and final comments
diameter of 100 mm.	
System hydraulics The system hydraulics for the conventional sewerage system has been used. The actual design flow calculations for the sewerage system are not available. The peak foul flows for the simplified sewerage in this case is related to the population and is calculated as follows: $Q_{Peak} = 1.8 \times (80\ l/c/d) \times (1500\ capita) = 216\ m^3/d = 60\ l/s$	
***(2) Main physical elements*. , Refer to Figures C2-1 – C2-2, Appendix 14**	
Sewer pipes *1.1 Diameter;* The sewerage network had been designed according to the traditional design criteria. As shown in **Figures C2-2, Appendix 14;** - The tertiary pipe network (house connections) consists of UPVC pipes of (6" = 150mm) > 100mm (min. diameter in simplified sewerage) - The secondary pipe network consists of UPVC pipes of (6" = 150mm) > 100mm (min. diameter in simplified sewerage) - The main pipe network consists of UPVC pipes of (8" = 200mm)> 100mm (min. diameter in simplified sewerage) However, using exact method for calculating exact diameters for the simplified sewerage which is illustrated in pages 27-28 in (Bakalian *et al*, 1994), It has been found that pipes of **(100mm)** diameter are adequate for all sewer mains (tertiary, secondary and primary).	**Partially consistent** *Inconsistent* It was enough to use 100mm diameter pipes for tertiary and secondary sewerage mains and 150 mm for primary mains instead of 150 mm and 200mm respectively.
1.2 Material; UPVC pipes have been used of diameters 160mm and 200mm.	*Consistent*
1.3 Depth; The pipe depths range from (1.1- 1.4m) below the footpaths and sidewalks which is larger than (0.6-0.65m) for the simplified sewerage. These deep depths are referred to large gradients of (1%) for all mains for ensuring the minimum cleansing velocity.	*Partially consistent*
1.4 Gradient; Minimum gradient of all sewer mains has been taken (1%= 0.01), although standards for conventional sewers specifies minimum gradients of (0.52%) for 150-200mm pipe diameters. For the simplified sewerage, the gradient would be as follows: Using the equation $I_{min} = 0.0055\ Q_i^{-0.47}$, where $Q_{Peak} = 1.8 \times (80\ l/c/d) \times (1500\ capita) = 216\ m^3/d$, thus; $I_{min} = 0.00351 < 0.0037$, *Take it as 0.0037* m/m , or (0.37%)	*Partially consistent*
Service connection; Each building has 2 service connections, each one for 10 housing units. The service connection consists of a manhole of 80-cm diameter between each building and the service line.	**Partially consistent**
Simplified alternatives to conventional manholes - Manholes of (80 cm) diameter are used for secondary pipe network which consists of UPVC pipes of (150mm). They are used at changes in direction of the secondary lines. - Manholes of (100 cm) diameter are used for primary pipe network which consists of UPVC pipes of (200mm). They are used at junctions between the secondary mains and the primary mains and at changes in pipe direction. - One manhole of (120 cm) is used at the collection point which leads into the septic tank and connected the primary line of (200mm) with the main pipe leading to the septic tank of (250mm). The spacing of the simplified manholes of (80cm) diameter ranges between 8.7m, 9.5m and 11m. The spacing of the large manholes of (100cm) diameter range between (20 to 44.8m).	**Partially consistent** Only some type of simplified manholes are used on the secondary main, but at close spacing and large number. The other simplified low-cost alternatives shown in the approach have not been used instead, at junctions and at

The Case-study (AHP)	Check of consistency and final comments
	change of direction .
Valves ; Not used	**Consistent**
Lift stations; Not used	**Consistent**
(3) Minimal operation and maintenance (O&M)	
1. Preventative maintenance Not specified; it is usually the responsibility of Khanyounis municipality	**N.A.**

1. Conclusion

The case study could be considered *partially consistent* with the developed approach with respect to the sewerage system because it uses the concept of the conventional sewerage system which has resulted into large pipe diameters at considerable pipe gradients laid at deep depths which requires a lot of excavations and large number of manholes with large diameters is also used. Therefore the cost of the implemented sewerage system is considered high with respect of the proposed simplified system. enthusiasm

4.5.3.3 Case Study- Provisions of BIC-3: Wastewater treatment and disposal or reuse

The Case-study (AHP)	Check of consistency and final comments
Activity (1): Definition of the proposed criteria for provision of BIC-3: Wastewater treatment and disposal or reuse, **(Refer to Table 3.5, Chapter 3)**	
1. Protection of health, environment and catchment areas; No consideration for public health or environment was done, since the used treatment system was conflict with the site specific conditions. The used on-site septic system did not depend on sustainability objectives, but just transfers the common problem of septic flooding to far place from the housing buildings.	**Inconsistent**
2. Adequate effluent standards; The percolated wastewater through the percolation pits has not considered the contamination caused to the groundwater.	**Inconsistent**
3. Adequate loading capacity of central treatment plants; there is not central treatment plant in the Khanyounis governorate where the AHP is located. N.A.	**N.A.**
4. Utilization of Decentralized Wastewater Treatment (DWT) systems where seen appropriate; The DWT system has been utilized using the SWIS; (septic tank with percolation pits). This system is considered inadequate with respect to the critical situation of the groundwater resources in Gaza Strip in general and Khanyounis governorate in particular. This system do not comply with any of the proposed sub-criteria for the decentralized wastewater treatment systems.	**Inconsistent**
Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-3 **, (Refer to Table 3.5, Chapter 3)**	
- The first design by MoH which was individual septic tanks per each building of 5.4m x 2.4m x 2.4m and consists of two compartments, and followed by a percolation pit of 2.5m internal diameter and depth of 8m; **Figure C3-1, Appendix 14** - In the implementation stage of this component, the contractor prepared the modified design of this component which consists of one communal septic	**Inconsistent**

The Case-study (AHP)	Check of consistency and final comments
tank with ten (10) percolation pits outside the boundary of the project. This design was reviewed and approved by the DoED. - No specialized engineers in the field of the DWT systems have been assigned or consulted. No coordination or cooperation with the water and environmental authorities has been done also. - The selection of the septic and percolation system did not depend on any accurate data or site evaluation or screening of any of the suitable alternative DWT methods. It directly relies on the local experience and the common practice that used in Khanyounis area which is not connected to any municipal sewer system although it proves its unsuitability and inappropriateness.	
Activity (3): Determination of minimum limits, design parameters and main elements **(Refer to Table 3.5, Chapter 3)**	
(1) Minimum limits and Design parameters required for planning and design of BIC-3: Wastewater treatment	
1. Critical design factors (flowrates) *(l/c/d)* **and/or** *(m^3/d)* *Actual Daily flowrates:* <u>*1. Calculations according to the developed approach:*</u> 1- Average total day (Q_{avg})= (0.8)x(100 *l/c/d)* x (6.8 c/household) x (220 households) = 119,690 *l/d* = <u>***120 m^3/d***</u> peak daily factor is taken (2.5) 2- Peak total day (Q_{Peak}) = 2.5 x 120 = <u>***300 m^3/d***</u> <u>*2. Actual calculations for the AHP:*</u> *for the AHP, (from the calculation sheets of the contractor)* Average total day Q_{avg}= (0.67)x(150 *l/c/d)* x (6 c/household) x (186 households) = 112,185 *l/d* = <u>***120 m^3/d***</u> The maximum day flowrate is used as sizing criteria for the septic tank	**Inconsistent** No consideration has been given to the wastewater amounts of the planned public facilities such as the mosque, the schools, the public market, etc. This may be referred to construction of separate special treatment facility for them or to consider them in the other treatment facility of EL-Farra housing project.
(2) Main physical elements , **Refer to Figures C3-1 – C3-4, Appendix 14**	
A: Option (1): Centralized wastewater treatment system (CWT)	
This option is not applicable for the AHP, since there is no central treatment plant in Khanyounis governorate.	
B: Option (2):Low-cost Decentralized wastewater treatment system (DWT)	
1. Condition 1: On-site subsurface effluent disposal system (SWISs). ***1- Septic tank*** The final design includes one communal large septic tank to receive the sewage from the whole AHP with 10 percolation pits for subsurface infiltration of the effluent; **Figure C2-2, Figure C3-1, Appendix 14** <u>*1. Calculations according to the developed approach:*</u> - from Section 2.2.3.5, Chapter 2, the volumetric capacity of the septic tank for pumping interval of **(3 yrs)** is: V = 2.8 x 1.5 x Q_{avg} = 4.2 x (120m^3/d) <u>**= 504 m^3**</u> OR, as a rule of thumb, V = 5 x Q_{avg} = 5 x (120m^3/d)	**Inconsistent** The actual designed and implemented septic tank is not adequate for the generated amounts of wastewater with regards to its dimensions and

The Case-study (AHP)	Check of consistency and final comments
<u>= **600 m^3**</u> - the septic tank could be sized as: *19m (length) x 9.5m (width) x 3.5m (height)* - there is no need to divide the septic tank into compartments since the performance of one compartment septic tank is better. *<u>2. Actual calculations for the AHP:</u>* - The volumetric capacity of the septic tank has been taken as <u>**300m^3**</u> - it has been sized as: *13m (length) x 6.4m (width) x 3.3m (height)* - The septic tank has been divided into four (4) compartments. **Refer to Figure C3-2, C3-3, Appendix 14**	configuration.
- ***Percolation pits (soakage wells)*** *<u>1. Calculations according to the developed approach:</u>* - the contact area required for the subsurface soakage system is: CA=DF/PR, DF = 120m^{3}per day, Taking the application rate of AR = 33 *lpd/m^2* for the soil type in Khanyounis (Table 7.7 , Appendix 7) è **CA= (120 x 1000 *l/d)*/(33 *l/d/m^2*) = 3636 m^2** - find the contact area for one percolation pit: CA(one percolation pit) = $\pi D^2/4 + \pi Dh$ - Find the No. of percolation pits: assuming that the internal diameter(D) of each percolation pit is **(2.8m);** 1) For depth pf percolation pit (h)=<u>4m</u> and CA(one percolation pit) = 42m^2 è No. of pits = 3636/42 = <u>87 pits</u> 2) For depth pf percolation pit (h) = <u>8m</u> and CA(one percolation pit) = 77m^2 è No. of pits = 3636/77 = <u>47 pits</u> 3) For depth pf percolation pit (h) = <u>10m</u> and CA(one percolation pit) = 94m^2 è No. of pits = 3636/94 = <u>39 pits</u> *<u>2. Actual calculations for the AHP:</u>* Ten (10) percolation pits have been decided to be connected to the septic tank, each one of (2.8m) internal diameter and a depth of (4m). The number and sizes of the percolation pits did not depend on any calculations or justifications. **Refer to Figure C3-2, C3-4, Appendix 14** ***However,*** It would be better if other decentralized treatment and reuse plants have been used such as package plant or a trickling filter to produce good effluent for landscaping and transportation of the surplus to nearby agricultural lands which are dominant in Khanyounis area. These compact treatment plants would not need a lot area of land; instead they need smaller area than needed for the septic tank and percolation pits system.	**Inconsistent** The actual designed and implemented number of percolation pits is (10) pits against (78) percolation pits of the same sized according to actual calculations. The subsurface disposal system does not remove nitrogen which is critical constituent in Gaza strip for causing groundwater contamination. The adjacent new housing project (EL-Farra) project would need similar size of septic tank and same number of percolation pits which need additional area of land and more contamination risks.
(3) Minimal operation and maintenance (O&M)	
Option (2), Condition 1: On-site subsurface effluent disposal system (SWISs). The only specified activity for O&M for the used septic tank system is desludging the septic tank every 2 years. The responsible party for the O&M tasks for this system has not been mentioned or determined.	**Inconsistent**

1. Conclusion

The provision of the wastewater treatment and disposal for the AHP is considered *inconsistent* with the developed approach. There has been no appropriate selection methodology for the best suitable low-cost and adequate DWT system at the planning and design phases and no consideration for the critical implications on the groundwater system in that area have been made. The decentralized communal septic tank with percolation pits has not been designed at the appropriate manner. Anyone of the proposed decentralized treatment facilities in the approach could be used at low-cost and small land-take area to treat the wastewater into effluent quality which would be suitable for landscaping, outdoor uses and agricultural activities in the nearby areas to make use of the nitrogen content in the treated effluent instead of being contamination source for the groundwater. Otherwise, the trickling filter which could remove nitrogen content by nitrification and denitrifaction processes could be used for treating wastewater before recharging it into aquifer safely.

4.5.3.4 Case Study- Provisions of BIC-4: Power supply and street lighting

The Case-study (AHP)	Check of consistency and final comments
Activity (1): Definition of the proposed criteria for provision of BIC-4: Power supply and security lighting **(Refer to Table 3.6, Chapter 3)**	
1. Minimum electrical demands; more than minimum electrical demands are considered. The assumed electrical demand is 5.0 kW per household.	**Inconsistent**
2. Diversification of energy sources; Diversification of energy sources is considered by using flat-plate collectors for water heating.	**Consistent**
3. Conservation of energy; Measures of conservation of energy are considered to good extent, and solar energy has been used to substitute electricity for water heating.	**Consistent**
4. Sufficient, stable and reliable power supply; Sufficient, stable and reliable power supply has been considered	**Consistent**
5. Protection of environment and human being; Protection of environment and human being is considered through good designs and underground installations.	**Consistent**
6. Financially sound power supply; H.V and L.V have been installed underground due to the short distance between the AHP and the nearest H.V tower. However, time-based rates are not introduced locally.	**Partially Consistent**
7. Effective and low-cost security lighting; Effective illuminance is considered in design. However, they are designed according to high standards and considered expensive	**Inconsistent**
8. Consistency of lighting fixtures; Consistency of lighting fixtures is considered to some extent.	**Consistent**
Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-4 **(Refer to Table 3.6, Chapter 3)**	
The most appropriate systems and techniques for power supply have been selected for the AHP. The electricity is considered as the main power supply and many conservation measures have been taken in consideration such as diversification of power sources, utilizing the solar energy system and direct solar gain designs have been adopted at the buildings designs level.	**Consistent**

The Case-study (AHP)	Check of consistency and final comments
Activity (3): Determination of minimum limits, design parameters and main elements **(Refer to Table 3.6, Chapter 3)**	
***(A) Power supply and distribution* (Refer to Table 3.6, Chapter 3)**	
(1) Minimum limits and Design parameters for planning and design of power supply	
1. Minimal base load demand for power supply (a) the minimal base load demands for power supply is to be calculated as follows: - *1 kW/ H.H* for basic domestic uses. No heating, conditioning or cooking using electricity. - Demand calculations should include the base total demands, the future anticipated demand, losses and the lighting demands. - Demand calculations: (1) Calculate the base total demand (TD) for all the housing units; TD (kW) = (1 kW /H.H)*(No. of H.Us)= (1)*(220) =**220** kW (2) Calculate the future *domestic* anticipated demand (FD) domestic FD = 1.8 * TD = 1.8 * 220 = **396** kW assume future demand for *public facilities* to equal domestic demands = **396** kW total FD = 2 x 396 = **792** kW (3) Add the power distribution losses; 10-12% (4) Add the lighting demand; 5% (5) Calculate the total future demand (TFD): TFD (Kw) = (1+0.12+0.05)*FD = 1.17 * 1.8 TD = 2.106 TD TFD = 1.17 * **792** = **926.64** kW (6) Determine the needed number and power of the transformers and substations to supply the total demand, which could be: *Two (2) transformers* of **(630 KVA)** (b) However, for the AHP, the needed number and power of the transformers and substations to supply the calculated total demand are: *Two (2) transformers have been chosen*, each one of **(1250 KVA)**	**Inconsistent** The calculated demands are considered large which have contributed to large power transformers which are expensive.
2. Low-cost sources of power supply	
2.1 Electrical power; The main power source for the needed demands is the electrical power	**Consistent**
2.2 Solar power; **Refer to Figure C-4, Appendix 14;** it is concluded that: a- Direct solar gain ***(1) passive solar heating systems; which are:***	**Consistent**
1. Orientation; The buildings are oriented 40 degrees south east and 50 degrees south west. Half of the buildings are directed 40 degrees south east-north west and the other half are directed 50 degrees south west-north east. The windows are located at all directions and large enough for ventilation.	*Consistent*
2. Setback; The cluster designs provide enough setbacks between buildings.	*Consistent*
3. Landscaping;The trees of the landscaping were provided, but for the benefit of residents outside not for the benefit of buildings.	*Consistent*
4. Width to length ratio; The shape of the buildings is rectangular with length (26m) to width (17m) ratio of 1.5.	*Consistent*
5. Shading devices; Shading for the windows is provided through installation of (32cm) thick side walls consisting of (12cm) block interior layer, (8cm) thick concrete binder and (12cm thick exterior layer, with forming open back (12cm) thick blocks in the area of windows and (24cm thick in the area of	*Consistent* The used walls were according to Austrian experience and

The Case-study (AHP)	Check of consistency and final comments
balconies. Other windows are opened to balconies to prevent direct exposure to the son. **Refer to Figure C4-3a, Appendix 14**	practice.
6.Day lighting and passive solar heating; The area of glass windows is adequate to provide good level of day light, and lies in the range (20-50%) of the plan area of the building. **Refer to Figure C4-3a, C4-3b, Appendix 14**	*Consistent*
7. Adequate insulation of the building shell; Good insulation was provided by installation of the walls; pre-mentioned in shading devices. Good plastering of 3 coats of the external walls is used. Good insulation of the roofs of proofing layers of polybid, cold bitumen paint and 2 layers of fiberglass were used also. **Refer to Figure C4-3a, C4-3b, Appendix 14**	Consistent The insulation of the external walls was according to Austrian experience and practice.
(2) solar hot water systems The solar power also has been used for water heating through using flat-plate solar collectors. **Refer to Figure C4-3b, C4-3c Appendix 14**	*Consistent*
b- Photovoltaic (PV); Photovoltaic (PV) has not used because they are rarely experienced or used locally.	N.A.
(2) Main physical elements, Refer to Figures C4-1 – C4-3, Appendix 14	
1. Low-cost distribution networks *1.1 Primary feeder lines;* The nearest H.V power supply has been determined near to the new planned EL-Farra housing project. Thus the connection of the AHP to the H.V power was easy through passing the H.V cables underground until reaching the locations of transformers (T1) and (T2)in EL-Farra project, then they reach transformers T3 and T4 in AHP. The H.V cables are installed inside (150mm) PVC pipes. **Refer to Figure C4-1, Appendix 14**	**Consistent**
1.2 Secondary distribution lines; All the low voltage lines (distribution lines) have been installed underground inside PVC pipes of (150mm). **Refer to Figure C4-2a, Appendix 14**	**Consistent**
2. Low-cost supporting power poles (in case of overhead lines networks)	Not used because the underground cables have been used.
3. Low-cost transformers - Each of the transformers T3 and T4 are of rated power of **(1250 KVA)** which is more than the required demand and is located inside a substation room. - (T3) has been serving Bldgs (1, 2, 3, 4, 6), the lighting of courtyards, and half of the street lighting and the parking area. The other transformer (T4) has been serving Bldgs (5, 7, 8, 9, 10, 11), the lighting of one courtyard, part of the street lighting and the part of the parking area. **Refer to Figure C4-2a, Appendix 14**	**Inconsistent**
4. Adequate locations and areas for substations Each of the transformers T3 and T4 are located in substation room of (4mx4m) which is incorporated into the green courtyards of the clusters without any negative impact, at suitable and centralized locations in the AHP. The area of each substation room is (16 m^2) **Refer to Figure C4-2a, C4-2b , Appendix 14**	**Consistent**

The Case-study (AHP)	Check of consistency and final comments
5. Low-cost solar energy systems Solar energy technology and energy conservation have been adopted through using the solar heating technology of circulated water through solar-heated filtered water by 20 mirrors for each building to serve 20 H.Us. **Refer to Figure C4-2b, C4-2c , Appendix 14**	**Consistent**
(B) Security lighting **(Refer to Table 3.6, Chapter 3)**	
(1) Minimum limits and Design parameters for planning and design of security lighting	
1. Minimal lighting demands; The lighting demand has been considered in calculating the power demands	**Consistent**
2. Adequate source of power supply for lighting *2.1 Electrical power;* The main source for lighting was the electrical power. *2.2 Solar power;* PV lamps have not been used since they were not common or expertise at that time and has high initial costs.	 **Consistent** N.A.
3. Minimal lighting level; - For the clusters' lighting, no specific design procedure has been mentioned. The lighting poles of clusters are designed according to the Austrian standards which is considered a high standards and expensive. - The lighting pole of the main and collector streets near the project is designed according to the standards of GEDCo which was responsible for lighting at that time.	**Inconsistent**
(2) Main physical elements, Refer to Figures C4-4 – C4-3, Appendix 14	
1. Low-cost lighting poles ***1.1 Mounting height (MH)s*** a- main and collector streets; The mounting height for poles of the main and collector streets is (10m). **Refer to Figures C4-4, C4-5, C4-6, Appendix 14** b- local streets; The mounting height for poles of the local streets has been planned to be (10m). **Refer to Figures C4-5, Appendix 14** c- cluster footpaths; The lighting poles for the clusters have been chosen of (3.6m) height **Refer to Figures C4-6, C4-7, Appendix 14** ***1.2 Light source (Lanterns)*** a- Main and collector streets; They are no. IP65, (250W) high pressure sodium (HPS) lamps and pole mounted. Some poles has one lamp and others has two lamps according to their location. **Refer to Figures C4-6, Appendix 14** b- Local streets; Lamps of no. IP65, (250W) high pressure sodium (HPS) has been planned to be used. c- Cluster footpaths; The lanterns for the clusters are pole mounted at (3.6m) height with (4) no.IP65 BEGA 8406 QT-DE 12 (150W) lamps. **Refer to Figures C4-6, C4-7, Appendix 14** ***1.3 Spacing of lanterns*** a- main and collector streets; The spacing of lighting poles for streets was	 **Partially consistent** *Consistent* According to municipality regulations. *Inconsistent* More than minimum acceptable requirements *Inconsistent* More than minimum acceptable requirements **Inconsistent** *Inconsistent* More than minimum acceptable requirements *Inconsistent* More than minimum acceptable requirements *Not consistent* More than minimum acceptable requirements **Partially Consistent**

The Case-study (AHP)	Check of consistency and final comments
according to GEDCo lighting standards, e.g., the maximum spacing of lighting poles of (10m) height for the adjacent main street of (30m) width with island range from (27, 25, 19, 35 and 40m). The maximum spacing of lighting poles for the adjacent collector street of (24m) width between the AHP and the cemetery range from (22, 34 and 38). The spacing is much less than the maximum permissible one of (40m).	
b- local streets; The spacing of lighting poles for streets is according to GEDCo lighting standards; the maximum spacing of lighting poles of (10m) height for the local street of (10m) width between the AHP and the adjacent EL-Farra project range from (31 and 33). The spacing is much less than the maximum permissible one of (40m).	**Partially Consistent**
c- cluster footpaths and sidewalks; To find the lantern spacing. - Calculate distance factor (DF) = 25/I; 1) Using the light source of (two No. 20 Watt fluorescent tubes, I =240 candles); DF= 25/240= 0.104. From Table 8.1, Appendix (8); For wall-mounted height (3m), the distance is (28m). For pole-mounted of height (5m), the distance is (32m) 2) Using the light source of (two No. 40 Watt fluorescent tubes, I =500 candles); DF= 25/500= 0.05. *From Table 8.1, Appendix (8);* - For poles of height (3m), the distance is (36m). - For poles of height (5m), the distance is (40m) Since the building length is (26m) and width is (17m); The first alternative is to use wall-mounted, two No. 20 Watt fluorescent tubes (3m) height at each corner of each building. The other alternative is to use pole-mounted, two No. 20 Watt fluorescent tubes (3m) height at each corner of each courtyard. However, in the AHP, the actual case is: **Refer to Figures C4-4, C4-5, C4-8 , Appendix 14** The spacing of cluster lighting is according to the Austrian lighting standards; The lanterns of the footpaths inside the clusters are located at the edges of the central courtyards at distances that range from (21-30m), e.g., four lighting poles for each central courtyard and located at the edges of it. Furthermore, one pole is located in the green area at the substations locations and one at the corner garden and another one in the green area near parking No. 5 and 6.	**Inconsistent** The specification of the cluster floodlighting seems to be of high standards which resembles the Austrian standards and of high costs. This may be referred to make the project to have distinguished appearance which reflects the Austrian donation and designs. Some or all of the cluster poles could be wall-mounted to the buildings with fluorescent lamps to save the cost of poles and electricity consumption.
1.4 Lighting arrangement; The lighting arrangements used on local and collector streets with single carriageways are single sided. The lighting arrangement for the adjacent main street is also single sided. However, this may be because they are partially constructed. No information about the final arrangements of the lighting poles for these streets. **Refer to Figures C4-5, C4-6, Appendix 14**	**Partially Consistent**
1.5 Time of lighting(hours of operation); No information are available	**Inconsistent** Not specified
1.6 Switching;	**Inconsistent** Not specified
1.7 Fixtures; All the installations are hard-wired (e.g., not exposed, but installed inside underground pipes)	**Consistent**

The Case-study (AHP)	Check of consistency and final comments
(3) Minimal operation and maintenance (O&M)	
1. Power supply network; The maintenance works has not been specified. It is the responsibility of GEDCo	**Consistent**
2. Security lighting; It is the responsibility of the responsible municipality. Household's responsibility has not been checked due to the political reasons.	N.A.

1. Conclusion

The provisions of power supply and lighting is generally considered *partially consistent* with the developed approach and considered of high cost which consequently contributed to increasing the costs of the housing units. The calculations of power demand are considered very conservative and resemble the demands for any other housing, which contributed to high demand loads and the use of high rated power transformers and electrical installations. However, the solar energy power have been utilized through the direct gain of solar energy by using the flat-plate collectors' technology for heating the water in addition to the use passive solar designs through suitable orientation of the buildings, adequate building insulation measures, and good distribution and areas of windows.

The used electrical distribution system is considered of low-cost in the long run since it has used the underground cables instead of overhead lines which suit the cluster designs. The overhead lines may be considered of low-cost for other traditional designs such as line-oriented designs. The security lighting for the AHP is considered over designed with respect to low-cost housing. The cluster lighting designs were made according to the Austrian standards in order to represent their contribution without consideration to how much this would increase their costs. Other relaxed standards could be used for security lighting without jeopardizing their effectiveness have not been considered and low-electric consumption lamps such as the fluorescent lamps have not been used although they could reduce the capital and running costs.

4.5.3.5 Case Study- Provisions of BIC-5: Access and paving

The Case-study (AHP)	Check of consistency and final comments
Activity (1): Definition of the proposed criteria for provision of BIC-5: Access and Paving **(Refer to Table 3.7, Chapter 3)**	
1. Accounting for different needs and promoting pedestrian access; Accounting for different needs of people, vehicles and pedestrians is considered with promotion with enhancement of pedestrian access to the extent level	**Consistent**
2. Adequate integration and alignment; Integration of the various types of access routes and streets is considered.	**Consistent**

The Case-study (AHP)	Check of consistency and final comments
3. Minimum land take; Minimum Land take for access is not adequately considered	**Inconsistent**
4. Minimum pavement costs with adequate pavement bearing capacity; the costs of pavement of footpaths, local streets and sidewalks are kept to a minimum with adequate strength.	**Consistent**
5. Appropriate parking places; They are considered in the design	**Consistent**
6. Ecological landscaping; No adequate consideration for ecological and multifunctional landscaping	**Inconsistent**
Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-5 **(Refer to Table 3.7, Chapter 3)**	
The planning and design of widths and lengths of the main and collector streets connecting to AHP has been done by municipality of Khanyounis according to the local standards and guidelines to confirm with streets hierarchy of the town. In the other hand, Geometrical design of the layouts of local streets, sidewalks, footpaths and parking places within the AHP site has been done during the site plan design of the AHP by the MoH engineers in cooperation and coordination of the Austrian consultant to conform with the cluster design. Then, the structural designs have been done according to the local common practices and experience. In general there was a considerable emphasis on reducing their cost.	**Consistent** The access hierarchy for the AHP have been planned and designed in an appropriate selection methodology.
Activity (3): Determination of minimum limits, design parameters and main elements **(Refer to Table 3.7, Chapter 3)**	
(1) Minimum limits and Design parameters for planning and design of BIC-5: Access, paving and landscaping	
1. Low-cost geometric design; **Refer to Figure C5-1, Appendix 14**	
The different types of access in the street hierarchy have been considered and planned in the design of access of AHP. They are composed of footpaths (inside the clusters), two local streets (cluster access), one collector streets (site access) and two main streets. All the primary factors influencing the geometric design of urban streets have been considered bearing in mind that the access is pedestrian oriented with minimal traffic which is limited to the personal cars of the households and emergency and service vehicles.	The consistency is to be checked in the following section.
2. Low-cost structural design; The type of pavement and total thickness for the different types of pavement have been determined to lower the costs of construction using low-cost pavement materials . However, the design methods which have been used for different pavements were not available.	The consistency is to be checked in the following section.
(2) Main physical elements , **Refer to Figures C5-1 – C5-14, Appendix 14**	
(A) Hierarchy of the streets for LCH with minimal geometric and structural design requirements , (Refer to Table 3.7, Chapter 3) and **Figures C5-1 – C5-9**	
1. Low-cost footpaths inside clusters and sidewalks of the streets **Refer to Figures C5-2, C5-3, C5-4, C5-5, C5-6, C5-7, C5-8, Appendix 14**; the following types of footpaths and sidewalks are used: 1- Type (1); they are located at the perimeter of AHP around the housing buildings. 2- Type (2); they are located also between the clusters of housing buildings and parking places 3- Type (3); they are located inside the clusters around the central grassed courtyards and around the green areas where the electric transformers are	**Inconsistent** In general, the provision of footpaths and sidewalks is considered expensive because their planning and design exceeds the minimum

The Case-study (AHP)	Check of consistency and final comments
located. 4- Type (4); they are located around the corner garden and around the corner platform.	widths for low-cost provision. However, the pavement thicknesses is considered less than adequate with respect to the thickness of sub grade layer, which contributes to higher cost in the long term.
1.1 Minimum paved width standards **Refer to Figures C5-2, C5-3, C5-4, C5-5, C5-8, C5-9, Appendix 14**; - All non-built and non grassed areas are paved with interlock. - the widths of footpaths and walkways are: 1-Type (1): footpaths are of widths ranges from 5, 6, and 7.8m 2-Type(2) footpaths differ from place to place; the widths in the range of *(1m, 3m, 4.6m)* (between buildings 1, 2 and P.No. 1), in the range of *1.6m, 3.8m* (between the buildings 3, 4, 6 and P.No. 2) and (between buildings 6,7, 9 and P.No. 3), of *3.8m width* (between building 10 and P.No. 4), of *3.6m width* (between building 11 and P.No. 6) and of *4m* width (between building 5 and P.No. 6) 3- Type (3) footpaths are of widths of 4m. 4- Type (4) footpaths; they ranges from 5.5, 7.8, 12.8 and 11.7m around the corner garden and ranges from 3.96, 5.4 and 8m around the corner platform.	*Inconsistent* The widths of the footpaths and sidewalks are much more than the minimums.
1.2 Minimum pavement thickness and low-cost materials **Refer to Figures C5-6, C5-7, Appendix 14**; They are paved with: 60mm (interlock) on 50mm (sand) on compacted base coarse 200mm with compaction ratio of (98%), which are laid on compacted soil.	*Partially Consistent* The used pavement thickness of soil and interlock is OK, but the base coarse layer thickness is not adequate.
1.3 Minimum vertical grade; Has not been mentioned in the design documents or detailed drawings.	Not available
1.4 Minimum cross slopes; Has not been mentioned in the design documents or detailed drawings.	Not available
2. Low-cost local streets/ cluster access **Refer to Figures C5-1, C5-2, Appendix 14**; There are two local streets which lie between the AHP and EL-Farra project adjacent to the parking areas P.NO. 5 and P.NO. 6. as shown in drawing A101. The first one connects the collector street to both AHP and EL-Farra project and the second one provide access mainly to EL-Farra project. They have not been constructed until the completion of the two projects.	**Inconsistent** In general, the provision of local streets is considered expensive because their planning and design exceeds the minimum requirements for low-cost provision.
2.1 Minimum Lane number and width; The first local street adjacent to P.NO.5 and attached to the collector street has 4 lanes, each one of width (2.75m). The second local street is attached to the first local street has 2 lanes, each one of width (3.5m)	*Inconsistent* The lane numbers are much more than the minimum

The Case-study (AHP)	Check of consistency and final comments
2.2 Minimum ROW width; The first local street has carriageway width of **(11m)** consisting of 4 lanes; each of width (2.75m) in addition to the parking places in both sides. The second local street has carriageway width of (7m) consisting of 2 lanes; each of width (3.5m)	*Inconsistent* The lane widths are much more than the minimum
2.3 Minimum traffic loads (ADT) and light design axle Loading; ; Not specified or mentioned.	Not available
2.4 Minimum pavement thickness and low-cost materials; It has been partially paved with Kurkar material of thickness of **(20cm).** This has been done in the expense of MoH to make the project to be accessible as a first stage of development.	*Consistent* As partially developed low traffic streets until the completion of the nearby EL-Farra housing project.
2.5 Minimum vertical grade; Not specified or mentioned	*Inconsistent*
2.6 Minimum cross slopes; Not specified or mentioned	*Inconsistent*
3. Low-cost site distributer/ collector streets	**Inconsistent**
Refer to Figure S-1 and Figures C5-1, C5-2, Appendix 14; There is one adjacent collector street between the AHP and the urban area of the city.	In general, the provision of collector streets is considered expensive because their planning and design exceeds the minimum requirements for low-cost provision.
3.1 Minimum Lane number and width; total carriageway width is (11m) consist of 3 (4) lanes; each lane of 3.6m (2.75m) width and	*Inconsistent* The number of lanes exceeds the minimum suitable ones.
3.2 Minimum ROW widths; It has **(15m)** width, consisting of carriage way width of 11m with 3-4 lanes as above and 2 sidewalks of 2m width each. It has been partially developed with partially paved width of (6m) to make the AHP to be accessible.	*Partially Consistent* The used width exceeds the minimum allowable, but may be referred to its consistency with the urban design of the total adjacent area
3.3 Minimum traffic loads (ADT)and light design axle Loading ; Not specified or mentioned.	Not available
3.4 Minimum pavement thickness and low-cost materials; It has been partially paved with Kurkar material of thickness of **(20cm).** This has been done in the expense of MoH to make the project to be accessible as a first stage of development, although it is the responsibility of Khan Younis municipality due to the lack of needed funds in the municipality to execute this road in that time.	*Consistent* The partial pavement of 20 cm kurkar is larger than the minimum allowed width.
3.5 Minimum vertical grade; Not specified or mentioned	*Inconsistent*
3.6 Minimum cross slopes; Not specified or mentioned	*Inconsistent*
4. Low-cost site access/ main streets/ Major through routes	**Inconsistent**

The Case-study (AHP)	Check of consistency and final comments
Refer to Figure S-1 and Figures C5-1, C5-2, Appendix 14 There are two adjacent main streets near the AHP. One of them has ROW width of (30m) and the other has ROW width of (24m) Although the palnning, design and financing of these streets are usually not the responsibility of the owner/developer and their costs are not added to the costs of housing, the owner/developer is usually implementing them due to lack of funds of municipalities, their costs constitutes burden on the implementing actor and may be indirectly added to cost of housing.	In general, the provision of main streets is considered expensive because their planning and design exceeds the minimum requirements for low-cost provision although their costs are not to be added to the costs of housing.
4.1 Minimum Lane number and width; Each road consists of 6 lanes of width of (3.3m) for each one.	*Inconsistent* The number of lanes exceeds the minimum requirements for low-cost provision.
4.2 Minimum ROW width 1- The first main street has **(30m)** width consisting of (6 lanes of 3.3m width each; 3 lanes in each direction, median of 3m, 2 sidewalks of 3m each) 2- The second main street has **(24m)** width consisting of (6 lanes of 3.3m width each; 3 lanes in each direction, no median and sidewalks of 2m each. However, these streets are planned to be partially developed with partially paved width of (6m) to make the AHP to be accessible.	*Inconsistent* the widths for the main streets adjacent to the project exceeds the minimum requirements for low-cost provisions which ranges from (18-24m)
4.3 Minimum traffic loads (ADT)and light design axle Loading; Not specified or mentioned	Not available
4.4 Minimum pavement thickness and low-cost materials; It has been partially paved with Kurkar material of thickness of (20cm). This has been done in the expense of MoH to make the project to be accessible as a first stage of development, although it is the responsibility of Khan Younis municipality due to the lack of needed funds in the municipality to execute this road in that time. This type of pavement is considered of low-cost with respect to partially developed areas although its costs are not to be added to the cost of housing. However, since the implementing housing institution or company is usually implementing them due to lack of funds of municipalities, their costs constitutes burden on the implementing actor and may be indirectly added to cost of housing.	*Consistent*
*4.5 Minimum vertical grades ;*Not specified or mentioned	*Inconsistent*
4.6 Minimum cross slopes; Not specified or mentioned	*Inconsistent*
(B) Low-cost parking places (Refer to Table 3.7, Chapter 3) and **Figures C5-10 – C5-14**	
1. Proper type of parking; In **Figures C5-10, Appendix 14**, it is seen that Site-off angle and parallel parking at the perimeters of the clusters is used. It consists of six parking areas named as P.NO. 1, P.NO. 2, P.NO. 3, P.NO. 4, P.NO. 5, P.NO. 6	**Consistent**
2. Adequate parking space layouts and minimum stall dimensions; Different layouts are used; the parallel and angled parking has been used.	**Consistent**

The Case-study (AHP)	Check of consistency and final comments
3. Minimum number of parking places; As shown in **Figures C5-10, C5-11, C5-12, C5-13, C5-14, Appendix 14**; there are six (6) parking areas in the AHP; 1- P.NO.1 consists of 16 parking places (90 degrees angle parking). 2- P.NO.2 consists of 13 parking places (combined of parallel and 90 degrees angle parking). 3- P.NO.3 consists of 13 parking places (90 degrees angle parking). 4- P.NO.4 consists of 10 parking places (90 degrees angle parking). 5- P.NO.5 consists of (14+9) parking places (60 degrees angle parking) shared between AHP and EL-Farra project. 6- P.NO.6 consists of 26 parking places (90 degrees angle parking) shared between AHP and the schools; 13 parking places are for AHP. Total number of parking places dedicated to AHP is (79) parking places, which could serve (3x79=237) housing units.	**Consistent** The used standards satisfy the minimum requirements. The 79 parking places which could serve 237 housing units is adequate to serve the AHP which consists of (220) housing units.
4. Low traffic load number (TL); The parking places are considered parking with frequent uses with private cars (PC) only	**Consistent**
5. Light design axle Loading; Only light traffic is allowed which include small private vehicles (less than 2000 kg), emergency and service vehicles.	**Consistent**
6. Minimum cross slopes; Not specified or mentioned, but the stormwater is planned to flow from the parking lots into the adjacent streets.	**Not Consistent** Slopes should be directed to bioretention islands
7. Minimum pavement thickness; The pavement of the parking places have been planned to be made of asphalt material and consists of: 60mm (asphalt) layer 3/4", M.C.O. 1 kg/m^2, compacted base coarse 250mm of compaction ratio of (100%) laid on natural soil 95% compacted. **Refer to Figure C5-12a, C5-13a Appendix 14** However, the pavement has been changed into interlock pavement of thickness of (360mm) which consists of : 60mm (interlock) on 50mm (sand) on compacted base course 250mm with compaction ratio of (100%), which are laid on compacted sub-grade. **Refer to Figure C5-12b, C5-13b, Appendix 14**	**Consistent** With respect to the type of pavement, but non consistent with respect to the pavement thickness
(c) Street and site landscaping (Refer to Table 3.7, Chapter 3) and **Figures C5-5 – C5-8**	
1. Adequate trees and other plantings; Adequate trees have been used within and around the AHP in the footpaths and the courtyards and consist of: 1- 24 trees of Date palm (شجر نخيل) 2- 14 trees of Araucaria (شجر أرز) 3- 22 trees of Ficus (شجر ظل) 4- 20 trees of Citrus lemon (شجر بروش ليمون) in addition to the grassy areas in the courtyards and the corner platform.	**Consistent** The used standards satisfy the minimum requirements.
2. Low-cost street furniture; Refer to Figure C5-5, C5-6, C5-7, C5-8, Appendix 14 Benches made of Hebron marble are constructed in the central courtyards 1,2 and 3 and in the corner garden. Two types of standard designs have used of dimensions of (15x45x225cm) and (15x45x50cm). Furthermore, benches are located in the corner garden with marble floor.	**Inconsistent** The site furniture is considered of high standards which is expensive and not easy to replace the damaged pieces.
3. Minimal special lighting; **Refer to Figures C4-6, C4-7, Appendix 14** Special lighting within the clusters is distributed along the footpaths, the central courtyards and the green areas. They are of height 3.6m and discussed	**Inconsistent** The used standards exceed the minimum requirements for

The Case-study (AHP)	Check of consistency and final comments
in Section 4.5.3.4 **4. Proper leftover street space used for pedestrian amenities/courtyards "houshes";** **Refer to Figure C5-1, C5-3, C5-5, C5-8, Appendix 14** There are three central courtyards inside the clusters, two corner gardens; one of them at the corner between Bldgs. 1 and 3 and the other between Bldgs. 9 and 10. Also, one green area between building 11 and P.NO.5, and two green areas near the electrical transformers.	security lighting. **Consistent** The used standards satisfy the minimum requirements.
(3) *Minimal operation and maintenance (O&M)* **, (Refer to Table 3.7, Chapter 3)**	
1. Interlock paving; No specified operation and maintenance works has been mentioned or assigned for the interlock paving through the community.	**Inconsistent**
2. Flexible pavement/ (Bitumen surfaced streets); No specified operation and maintenance works has been mentioned or assigned for the asphalt paving. These works usually are the responsibility of the municipality.	**Inconsistent**

1. Conclusion

The provision of the access and paving for the AHP is considered *partially consistent* with the developed approach for lowering the costs of provisions. Although the provision of this component has proven to comply with the proposed criteria for adequate provision but has not comply with the criteria for low-cost provision especially with respect to the geometric design which utilizes large widths of footpaths and sidewalks. This may be referred to that the planning of the AHP has been done in coordination with the Austrian consultant who emphasizes in keeping the project at high quality to represent the Austrian contribution at distinguished shape. Furthermore, the widths of collector and main streets which have been planned by Municipality of Khanyounis exceed the minimum allowable standards for such streets. All of these factors contribute to large area of land-take devoted for them and which may be dedicated to housing and this cost a lot of money. However, the pavement standards have proven to be inadequate with respect to minimum pavement thickness which could cause rapid deterioration of the pavement in the long run as their designs have been made as a rule of thumb. The pavement material adopted for the project is considered adequate with respect to lowering the costs since the local interlock pavers have been used for pavement of footpaths, sidewalks and parking areas.

4.5.3.6 Case Study- Provisions of BIC-6: Stormwater drainage

The Case-study (AHP)	Check of consistency and final comments
Activity (1): Definition of the proposed criteria for provision of BIC-6: Stormwater drainage **(Refer to Table 3.8, Chapter 3)**	
1. Economically sustainable drainage system; Stormwater sewers have been eliminated and surface drainage to drain the	**Inconsistent**

The Case-study (AHP)	Check of consistency and final comments
stormwater into the adjacent new main developed streets is used. However, the grassed areas and trees planters have not been designed to allow natural drainage since their perimeters were raised by curbstones and are planned to be irrigated by domestic water supply. The parking areas do not incorporate green islands for stormwater drainage.	
2. Environmentally sustainable drainage system; The stormwater management was not integrated in the site planning. No specified techniques are used for encouraging soakage of water into ground. The area of impervious surfaces has not been reduced adequately to encourage infiltration. Natural features and processes for stormwater infiltration have not been considered. Landscape is not designed to make use of stormwater.	**Inconsistent**
3. Socially sustainable drainage system; The stormwater drainage practices have not been used on contributing to improved landscape in the adequate way that enhances the social life of the residents.	**Inconsistent**
Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-6 , **(Refer to Table 3.8, Chapter 3)**	
There was no specific attention into design of the stormwater component and no technical designs have been made specifically for it. The proposed design concept have not been used; the drainage of building roofs in inadequate manner into concrete boxes in the pavement and then overflow into the footpaths, the green areas was not integrated with the stormwater management of the site.	**Inconsistent**
Activity (3): Determination of minimum limits, design parameters and main elements , **(Refer to Table 3.8, Chapter 3)**	
(1) Minimum limits and Design parameters required for planning and design of BIC-5: Access, paving and landscaping	
1. Minimal requirement of surface drainage systems; surface drainage is suitable for use in the AHP since the site are is 20 dunums= 2 hectares < allowable area of 5 hectares, and the average rainfall in Khanyounis governorate is (306mm) < allowable rainfall (500-1000mm) the area of the project to be drained is planned to be paved with interlock paving which is suitable for drainage since it does not deteriorate by stormwater.	**Consistent**
2. Estimation of surface water runoff; The simplified method is to be used for calculation of the volume of runoff in the AHP, due to its simplicity and since one stormwater management practice is to be used for the project which is the bioretention areas. the following data are determined for calculations: 1) total area of the site (A) = 20,000.0m^2 2) Rainfall intensity (I) In Gaza Strip: I = 18mm/hr for (2 years) return period, I = 26mm/hr for (5 years) return period, I = 32mm/hr for (10 years) return period, I = 37 mm/hr for (20 years) return period, I = 50mm/hr for (100 years) return period 3) The average runoff coefficient for urban areas in Gaza Strip (C)= **0.67** 4) In Khanyounis governorate, where the AHP is located; *f*= 5.96 *mm/min* 5) The average rainfall in Khanyounis is (306mm) Therefore, the quantity of runoff for 10 years return period is: **Q = CIA** **= (0.67) x (32 mm/hr) x (20,000.0 m^2) = 428.8 m^3/hr**	**Inconsistent** No estimation for the runoff quantities has been done since this component has not been involved in the basic infrastructure components for the project.

The Case-study (AHP)	Check of consistency and final comments
***(2) Main physical elements* , Refer to Figures C6-1 – C6-13, Appendix 14**	
1. Low-cost stormwater management at main and collector streets level *1.1 Surface drainage into specified municipal outfalls* this option is suitable for the drainage of main and collector streets since the project is constructed in new developed area characterized with sand dunes so that these streets could be designed to be constructed at adequate grades and cross slopes which facilitates the drainage of stormwater into specific suitable points at low cost.	**Inconsistent** The drainage of the main and collector streets have not been considered or specified in the project documents.
2. Low-cost stormwater management at cluster and lot level In general, the stormwater management at the cluster level is considered inadequate and not of low-cost for the following mentioned reasons.	**Inconsistent**
2.1 Bio-retention areas and islands The best suitable stormwater drainage system to be used at the cluster level is the bioretention areas, since the cluster design facilitates the accommodation of such areas easily. a- Area of bio-retention the area of the bioretention would be calculated as follows: - As a rule of thumb; the size of the bio-retention area is at least **5%** (with sand/gravel bed) to **7%** (without sand/gravel bed) of the drainage area multiplied by the rational method runoff coefficient (C) determined for the site, e.g., 7% x 0.67x 20,000.0m^2= **938m^2.** - The area of the bio-retention is calculated exactly as follows: 1) Find the rainwater runoff using rational method $Q = C \times I \times A$ with runoff coefficient for urban areas is (0.67) and I= 32mm/hr for a return period of 10-years. **Q= 0.67 x (32mm/hr) x 20,000.0m^2 = 428.8 m^3/hr** 2) Find the area of the bioretention by the following equation, finding (*f*) for Khanyounis area, the soil is Sandy Loess over Loess; *f* = 6 *mm/min =360mm/hr (0.36m/hr)*, then $A_{bio} = Q/f$ A_{Bio} = *Q/f* = (**428.8 m^3/hr) / (*0.36m/hr*) = 1,191.1m^2** > **938m^2 à OK** *Therefore, this area can be distributed into more than 7 bioretention areas which could be distributed at the locations determined for the green areas in the site of AHP in addition to other ones in the parking areas.* 3) Choose the dimensions to be so that the length is twice than the width (i.e., see the following item). **This means that the shapes of the bioretention would differ from the existing ones.** 4) Check percentage of the final bio-retention areas with respect the total drainage area so that it is not less than 5-7% according to using sand bed or not. **Refer to Figure C6-1, Appendix 14**, there are 7 green grassed areas distributed throughout the AHP according to the site plan design. The details of these areas are shown in **Figures C6-2, C6-3, C6-4, C6-5, C6-6, Appendix 14** Total green areas in the AHP site = 1,413.0m^2 > 938 m^2 (needed	**Inconsistent** The bioretention concept has not been included in the design. *Inconsistent* Although the AHP include large green area distributed inside the clusters, they do not work as bioretention due to the following reasons: - although the existing green areas are enough to be used as bioretention, they are not sized or designed to work as bioretention areas and they have raised curbstones around them which prevent the stormwater to soak into them from the surrounding areas. **Refer to Figures C6-4, C6-5, C6-6, Appendix 14** - Moreover, these areas are designed to be irrigated by domestic water supply through irrigation points with meters. **Refer to Figure C1-4, Appendix 14**

The Case-study (AHP)	Check of consistency and final comments
bioretention), With percent of (1,413.0/ 20,000.0) = 7% (OK). **Refer to Figures C6-7, C6-8, C6-9, Appendix 14**	- Their locations are not so adequate; no green areas have been made in the parking areas as small islands or at their perimeter, and instead the parking areas have been designed to be drained into nearby streets. **Refer to Figure C6-10, C6-11, Appendix 14**
b- Recommended minimum dimensions of the bio-retention area The proposed minimum dimensions for each bioretention area of the seven areas are (8m) width and (18m) length.	*Inconsistent* The dimensions of the green areas are of squared shape distributed into triangular areas by paved footpaths. **Refer to Figure C6-7 , C6-8, C6-9, Appendix 14**
c- The maximum recommended ponding depth; is not available for the green areas	*Inconsistent*
d- Planting soil; The used soil for the green areas is the clay soil for depth of (30cm). It is not suitable for good infiltration of stormwater due to its low permeability.	*Inconsistent*
e- Vegetation of the bio-retention - the number of the planted trees in the AHP is (80 trees) which is less than the recommended number of (0.25 x 1413m^2 = 353 trees), where (1260 m^2 is the area of the open grassed places)	*Inconsistent*
f- Mulch; Not used	*Inconsistent*
2.2 Eco-stone permeable pavers; These pavers are not available locally yet, and new researches are needed to develop this type of pavement.	**N.A.**
2.3 Traditional interlock; They are used for the pavement of all footpaths and unplanted areas of courtyards. a- Dimensions; Rectangular interlocks of (100x200mm) have been used. b- Thickness; 6mm thickness pavers has been used. c- Bedding layer; Bedding layer of 5 cm sand has been used laid on compacted base coarse of 20cm laid on compacted soil.	**Consistent**
3. Low-cost stormwater management at building level In general, the stormwater management at the buildings level is considered inadequate and not of low-cost for the following mentioned reasons**.**	**Inconsistent**
3.1 Rooftop rainwater harvesting (RRWH)into recharging wells; No recharging wells have been used. Instead, the rooftops have been drained into small concrete boxes of (35x 35cm) and depth of (40cm) has been constructed under the inflow pipe to collect stormwater and they flood into	*Inconsistent* The collected stormwater could be

The Case-study (AHP)	Check of consistency and final comments
the footpaths and nearby areas. **Refer to Figure C6-12, C6-13, Appendix 14**	directed into the close courtyards which should have been designed as bioretention areas, instead of overflowing on footpaths and streets
(3) Minimal operation and maintenance (O&M)	
1. Main and collector streets level; The maintenance works has not been specified **2. Cluster and lot level** ; The maintenance works has not been specified **3. Building level** ; The maintenance works has not been specified	**Inconsistent** **Inconsistent** **Inconsistent**

1. Conclusion

The provision of the stormwater drainage for the AHP *was not considered at all* from the beginning. It seems that the stormwater drainage from the site area is assumed to be drained naturally along the natural slopes into the adjacent unpaved roads to the surrounding sand dunes. However, this assumption would not be sustainable for the long term when the nearby areas have completely developed and would contribute to flooding problems. The drainage of the rooftops of the buildings have been done in inadequate way which has proven to be a cause for environmental pollution and health risk since the drained stormwater is collected in small boxes under the footpaths which flood over the courtyards footpaths and the stagnation of water after the storm event produces insects which is danger to health of people. On the other hand, it has been recognized that the use of BMPs such as the bioretention areas is very easy to be incorporated with the minimal costs since the needed areas for bioretention are provided through the large green areas in the courtyards. As the existing open areas of the courtyards are expected to be lowered as proven in the BIC-5 (access and paving), the available green areas iside the courtyards are to be lowered. Thus the remaining needed bioretention areas could be distributed in the parking areas in the site to provide multifunctional landscaping and enhance stormwater drainage. Some modification in the design, location and configuration of these areas could make them valuable bioretention areas. Moreover, the non provision of this component would contribute to negative environmental and health implications which would cost a lot of money.

4.5.3.7 Case Study- Provisions of BIC-7: Telephone lines

The Case-study (AHP)	Check of consistency and final comments
Activity (1): Definition of the proposed criteria for provision of BIC-7: Telephone network **(Refer to**	

The Case-study (AHP)	Check of consistency and final comments
Table 3.9, Chapter 3)	
1. Provision of minimum needs ; Has been considered	**Consistent**
2. Easy access ; Has been considered	**Consistent**
3. Low-cost telephone connection; The provision of this component has been already ensured since the capital investment costs of are totally covered by the telephone company.	**Consistent**
Activity (2): Proposed methodology for selection of the suitable systems and techniques for the provision of BIC-7 **(Refer to Table 3.9, Chapter 3)**	
An electrical engineer has been assigned to coordinate with an assigned engineer from the telephone company (PALTEL, for example) during all phases of planning and implementation has been assigned. The underground cabling system has been used for the provision of the telephone network. The implementation phase has been done concurrently with the other underground infrastructure networks in order to avoid further excavation works	**Consistent**
Activity (3): Determination of minimum limits, design parameters and main elements **(Refer to Table 3.9, Chapter 3)**	
(1) Minimum limits and Design parameters required for planning and design of BIC-7	
1. Design population; All the design population requirements have been considered by the telephone company PALTEL according to the submitted drawings of AHP from the MoH.	**Consistent**
2. Minimal number of telephone lines; One telephone line connection for each housing unit has been provided. Minimum telephone lines number for the public facilities have been determined according to the guidelines of the telephone company.	**Consistent**
3. Minimal number of public Telephone stations ; No public telephone stations has been implemented	**Inconsistent**
***(2) Main physical elements* , Refer to Figures C7-1, Appendix 14**	
All the minimum required main elements for the telephone lines provisions such as the underground trenches, the manholes, the pipes conduits, the cables and the building connections have been designed and implemented by PALTEL according to its specifications and standards and on its expenses. **Refer to Figure C7-1, Appendix 14** **Public telephone stations** ; no consideration for the planning or implementation for the public phone stations has been considered	**Consistent** **Inconsistent**
(3) Minimal operation and maintenance (O&M)	
The operation and maintenance works has not been specified since it is the responsibility of the telephone company both at on-site and off-site levels	**Consistent**

1. Conclusion

The provision of the telephone line component is considered consistent with the developed approach. It has been planned, designed and implemented by the local telephone company in coordination with the housing institution (MoH) at all stages and done according to the site plan drawings of the project. The minimum requirement of telecommunication for each housing unit has been ensured through the provision of one telephone line for each housing unit. The telephone plant components have been installed underground to keep the running costs at the minimum. However, the option of providing public telephone stations to serve the households who cannot afford the expenses of the telephone connections has not been considered. The provision of the telephone lines component is considered of low-cost since it is the common practice in Palestine to provide this component by the telephone company which provides the capital costs of provision and recover them through the connection fees.

4.5.4 Case Study- Phase 4: Management of Operation and Maintenance (O&M) of BICs

The Case-study (AHP)	Check of consistency and final comments
The municipality-community partnership approach for managing O&M **; Refer to Table 3.10, Figure 3.20, Chapter 3** - According to the signed agreement; Article IV, Item 1.9; "the recipient; MoH shall be responsible for site management. This activity may also be assigned to third parties. The MoH shall in any case be responsible to the Donor for the activities of the site management". - However, the management program for site management which includes both the management of O&M of the housing buildings and the BICs has not been defined and the management activities have not been assigned at the beginning when the households have moved to their apartments. - The responsible parties for management of O&M works for BICs have not been specified.	**Inconsistent** - No official documents or specific guidelines for detailed management of O&M are specified. -The arrangement for managing O&M for BICs at the community level and household level for the AHP has not been specified.
(a) Utility Ownership and Management; - It is the common practice that the municipality is usually responsible for O&M of the off-site and on-site water supply system, sewerage pipelines and street lighting. GEDCo is responsible for O&M of the H.V and L.V power lines which are located on-site and off-site. - The communal septic tanks system has not been practiced before, and its management arrangements have not been specified for the AHP. - the management of O&M works are usually the responsibility of PALTEL company	*Partially Consistent* The management of O&M for the septic tank system has not been assigned.
(b) Community level management;; The community level management has not been specified from the beginning, and not specified later due to the aforementioned political situation which causes the households to leave the project.	*Inconsistent*
(c) Household level management; The household level management has not been specified from the beginning, and not specified later due to the aforementioned political situation which causes the households to leave the project.	*Inconsistent*

1. Conclusion

The management of O&M for the AHP is considered inconsistent with the developed approach with respect to partnership management. Management assignments at the community and household levels have not been specified although this issue has been a requirement in the donation agreement documents. The shortcoming of not programming the O&M management characterizes not only the AHP but most of the low-cost housing projects in Gaza Strip. Furthermore, the political status and the current situation of the project has prevented the researcher to investigate or examine the actual situation of management after the completion of the project since the project has been emptied from the households after a short time of its completion and has been exposed to great damages from the Israeli army.

4.5.5 Case Study- Phase 5: Financing Capital and O&M Costs and Cost Recovery

The Case-study (AHP)	Check of consistency and final comments
Activity (1): Capital Finance and Cost recovery of BICs for LCH **,** (Refer to Figure 3.19, Chapter 3)	
1. Capital finance for provisions of BICs ***(1) Donations from Arabic or foreign governments directly to the responsible institution*** The source of fund for construction of On-site BICs for AHP was The Austrian Government contribution. - As agreed between Austria government and MoH, the Austrian contribution for the Khan Younis Project was (50 million Austrian shillings); corresponding to ($ 5 million US) at the time of the agreement. - This value was planned to finance (1) the construction of ten housing buildings, with total gross area of (2,100m^2) for each one, (2) soil investigation, **(3) the on-site infrastructure**, and (4) the Austrian consultant fees (2% of the total contribution). - The contribution of the MoH will be (1) a suitable piece of land, (2) preparation of the designs with coordination of the austrian consultant, (3) issuing the tenders, supervising the project implementation, payment of the necessary fees, and **(4) provision of the off-site infrastructure.** - Due to the declination of the Austrian shillings with respect to US $, the planned (10) buildings of (5 floors each), it was agreed that only (8 buildings) will be completed, while the other (2 buildings; 5&8) will be constructed up to ground beams, and the completion of them will be made when revenues of selling the apartments and commercial shops are available. ***(2)Transfers form the central government;*** Ministry of Finance (MoF) has to transfer the appropriate funds to the governmental authorities and ministries for implementing some of off-site infrastructure such as: - connecting to the main water supply by the Municipality of Khanyounis - construction of the main and collector streets which connect the project site to the surrounding urban areas and this is the responsibility of Municipality of Khanyounis - connecting to the main electrical supply by the electrical company (GEDCo) However, no connection to centralized sewerage or stormwater sewers due to non-existence of such networks in the jurisdiction of the project. ***(3) The third source is "borrowing" from an established national governmental revolving fund (RF) in the central government*** - As stipulated in the agreement between Austria and MoH (at that time); the MoH establishes the **"Khan younis Nablus Housing Fund (KNHF)"** which serves as the **"Revolving Fund".** The KNHF has a separate accounting system. - The KNHF is endowed with the financial proceeds (e.g., from renting and	**Partially Consistent** In general the case study is considered consistent with the developed approach with respect to the capital of the BICs and with respect to cost recovery except some limitations and remarks, as discussed in the following: - The Austrian contribution is planned to finance the capital costs of the on-site infrastructure components. - However, the government transfers to cover the off-site main and collector streets has not been adequate so that the Municipality of Khanyounis did not have enough financial resources to implement them which enforces the MoH to partially develop some of these streets connecting to the AHP. - the sustainability of the established revolving fund

The Case-study (AHP)	Check of consistency and final comments
selling) generated from the project (Austrian Housing Project) as determined in the agreement to provide Palestinian people with as many as appropriate low-cost housing facilities as possible. - As soon as the housing units have been allocated and the first down payments and monthly repayments have started to be collected and installed with interest rate of (4%); a new contract for completion of Bldgs (5& 8) and the construction of Bldg (11) up to top ground beams. However, as EL-Aqsa Intifada has started on 2002, the monthly repayments have stopped and the scheduled revenues have not been achieved. Thus, the new contract has been handed over and partially completed due to lack of funds. KNHF has been closed (blocked). ***(4) Private sector partnership (PSP) mechanism*** This mechanism could be explored for the decentralized wastewater treatment facility. This approach needs more research investigation and examination at the local level for such decentralized systems. ***2. Capital Cost Recovery*** The Austrian fund would be recovered from the apartments and shops' selling and renting, forming a revolving fund (KNHF) for new projects - KNHF is considered sustainable with regard to the main concept of revolving money to reuse the revenues for new projects, and this requires normal and stable political and economical conditions.	**(KNHF)** is questioned with regard to be restricted to the Austrian donation, because sometimes, it is needed to use a combination of funds to construct new large housing development, with the possibility to referring to the funding parties for the specific project.
Activity (2): Cost Recovery of Basic Service Consumption Costs for LCH	
"Lifeline" entitlement (cross- subsidy) This approach has not been utilized and the tariff costs for the basic services such as water, sanitation and electricity for this project are the same for all other housing projects. The low-income bracket of population has not been offered such lifeline entitlements in Palestine in general. This contributes always to low cost recovery of the service consumption which causes a lot of financial burdens and stress on these service providers.	**Inconsistent**
Activity (3): Cost Recovery of O&M Costs of BICs for LCH	
1. Low-cost O&M works The costs of O&M works have been lowered through using low-cost and simplified systems and techniques for the provided BICs which needs little and simple works for operation and maintenance. Consequently, this lowers the costs to the most extent. ***2. Methods of relaxed cost recovery*** This could be done by distributing the tasks of O&M for the different BICs into different levels as illustrated in the previous phase of management. *a) Cross- subsidy for utility/municipality bills; has not been considered* *b) Monthly fees/ self-dependence (Community level); not available* *c) Self dependence (individual building level); not available*	**Not Available** The political status due to Intifada has made the AHP to be insecure due to its location near the Israeli Settlement. This has caused the residents to leave the project before the completion of one year of their living in the project. Therefore, no information how the O&M works for the different components

The Case-study (AHP)	Check of consistency and final comments
	of BICs have been managed or their costs have been planned to be recovered.

1. Conclusion

The capital finance and cost recovery for the implemented BICs of the AHP complies with the developed approach.

The capital finance for provisions of BICs has been covered by Austrian donation as the costs of the housing buildings and their costs have been added to the costs of housing units. These costs has been planned to be recovered through long-term repayments form the households into a new established revolving fund to implement more new projects for low-income people which are similar to the AHP. Actually, as soon as the down payments of the households began to be installed to this fund, the work in implementation of new buildings at the same site of the project has begun. Nevertheless, the revolving fund has been closed during EL-Aqsa Intifada, because to AHP has been exposed to great Israeli attacks which makes the households to leave their apartments and stop pay the monthly payments. Furthermore, one drawback of the planned revolving fund was that it is restricted to the Austrian contribution repayments, while a central revolving fund which includes different sources of contributions would be better.

Covering the costs of O&M works for the different components have not been specified or documented when the households received their housing units and moved to them at the completion of the project and although many ideas have been proposed regarding the management of the project, no agreement has been reached regarding this issue. Furthermore, it was hardly to examine the actual situation for covering these costs and the mechanism for their recovery at the specified different levels due to the aforementioned political reasons. The cross-subsidy for the basic service consumption has not been introduced.

4.6 CONCLUDED REMARKS

The developed approach has been applied easily and successfully to the case study. The AHP has been easily experimented and effectively evaluated with respect to the provisions of BICs. In general, the AHP is considered *partially consistent* with the developed approach. Some of the provided BICs have been provided at high quality which exceeds that required for LCH and other BICs have not been provided at all. Therefore, although the AHP has been planned and designed to be a low-cost housing project to serve the low-income people, the actual costs of the housing units are considered more than could be paid by the target bracket of people. Moreover, other important aspects such as the management of O&M of the BICs have not given the required attention which makes the provision to be unsustainable. However, the Austrian donor country has proposed some type of sustainable fund which is the revolving fund to ensure the sustainability of the expended money on the project to serve more target bracket of low-income people. unfortunately, many other issues which could be learned and concluded from this project have been lost due to the past and current political situation during EL-Aqsa Intifada which had great effect on this project due its danger location near the boarder adjacent to an Israeli settlement which have given another lesson for choosing safe and secure locations for the future new housing projects in Palestine.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 SIGNIFICANCE OF THE DEVELOPED APPROACH

The housing sector in Palestine is one of the most crucial sectors of the economy and the housing investment is the first priority for most Palestinians even the low-income population. The housing needs has been and still up to now impressive and increasing continuously and exceeding the limited financial resources especially those needs for the low-income segment of population and those who are living under poverty line with a percentage of 80% of the total population. In spite of all the efforts that has been done by the PNA since 1994 in the development of the housing sector and in the production of the low-cost housing, the big shortage in the housing units accompanied with their final high costs and inadequate infrastructure provisions is still considered the main phenomena of the housing sector in Palestine in general and Gaza Strip in particular. Most of the implemented LCH projects fail to reach the target bracket of low-income people due their final high costs which exceeds their financial abilities.

Therefore, the production of low-cost housing which is provided by the necessary infrastructure is essential to solve a significant part of the housing shortage problem in Palestine. However, low-cost housing does not mean low-quality housing but it does mean cutting down the costs while maintaining adequacy that has been internationally believed and documented as a human right which should not be violated.

Therefore, the basic infrastructure components have to be provided at adequate level to maintain the basic level of service but so that be affordable to the implementing stakeholders to provide them and to the low-income households to pay their costs.

The developed approach provides the public and private housing institutions/companies who work in the field of LCH production with a systematic, simple, clear and practical steps and activities for the provisions of the defined seven components of basic infrastructure for the LCH at adequate level without contributing to increasing the housing costs. The developed approach includes all phases and stages of provision process such as planning, selection, conceptual design limits and parameters, finance and management of O&M in a systematic methodology.

The developed approach has fulfilled the main objectives of providing the BICs for LCH and has achieved the benefits of their provision such as improved health, improved living environment, greater convenience, sounder household finances, and opportunities for income generation through agricultural activities and skills development by:

1. Providing a reliable supply of water in sufficient quantity and of adequate quality for the basic life needs and maintaining the health of the residents of LCH.
2. Protecting public health and well-being of the LCH, preventing spread of diseases and environmental pollution by collection of the generated wastewater through safe and adequate collection system into the point of treatment and disposal.
3. Protecting the LCH from pollution by the wastewater, protecting the scarce water resources, and relieving the pressure on the scarce freshwater resources by wastewater treatment and maximizing reuse opportunities.
4. Providing sufficient, stable and reliable power supply for the convenience and possibly status of the residents, and promoting safety and providing a degree of security at night by providing security lighting.
5. Providing access and paving in order to provide hard and dry access routes for transportation of people and goods, to provide safe conditions for movement, to improve the drainage of built up areas, to provide apace for many other parts of the infrastructure in their right-of-way above or below ground, and to maintain the living environment as open spaces.
6. Removing unwanted stormwater water from the LCH in a controlled, hygienic and sustainable manner in order to minimize public health hazards, inconvenience to residents and deterioration of other infrastructure.
7. Providing the minimum requirement of telecommunication services.

5.2 CONCLUSIONS

The main conclusions of this research work are classified in the following headlines with sub-conclusions:

1. The housing needs in Palestinian territories are huge and a significant percent of them are needed for low-income population as it has been reported that 80 percent of the Palestinian people is living under the poverty line.

2. Low-cost housing (LCH) is the affordable housing for the low-income people. It does not mean low-quality housing but mean cutting down the costs while raising the quality and maintain adequacy. This necessitates the provisions of infrastructure at adequate level while keeping the costs of provisions to minimal so that not contributing to increase the cost of LCH.

5.2.1 Categories and Components of Infrastructure for Low-Cost Housing

1. Infrastructure for LCH has been defined and classified into two categories. The first category includes the basic infrastructure components (BICs) and the second category includes the supportive infrastructure components (SICs). The components of each category have been specified.
2. The main components of BICs category are (1) water supply, (2) sewerage system, (3) wastewater treatment, (4) power supply and security lighting, (5) access and paving, (6) stormwater drainage, and (7) telephone lines. The main components of SICs category are (1) Parks and green spaces, (2) Schools, (3) Health centre, (4) A mosque, (5) Public market and (6) Public services building.
3. Provisions of BICs are essential to be provided at a basic level of service for the basic life being, possibly status of living and convenience of residents, while the provisions of SICs are not so essential to basic life being but they supports the social life and save money of transportation to far public facilities.
4. BICs should be provided concurrently with the construction of the LCH project. They may be of networked or non-networked (decentralized) type. Networked BICs consist of on-site part and off-site part. It is the costs of the on-site part which are added to the cost of housing. The needed SICs are not necessary to be provided concurrently with the construction of the LCH projects and their costs are not added to the cost of housing. Thus, they have been not a part of the research work
5. Reducing the impacts of cost-influencing factors of BICs would reduce their costs. These factors include the subdivision design and housing density, type and form of infrastructure system, technology and design concept, and the local standards, codes and regulations.

6. It is unrealistic to define the exact percentage of infrastructure costs with respect to the total costs of housing; as this percentage could differ from one housing development to another according the provided infrastructure which differs according to the site specific situation, and according to the cost of land and housing building system. Therefore, it is more realistic to concentrate on how to reduce the costs of the individual infrastructure components in relevant to their real costs with the use of conventional practices with high standards and business-as-usual, while keeping the provision of basic level of service for the health of residents and protection of environment.

5.2.2 Main principles for Provisions of Low-Cost Adequate BICs

1. *Sustainable provision* of BICs is a key principle and includes sound planning, appropriate

technical options, sustainable financing and cost recovery mechanisms and adequate management of operation and maintenance.

2. *Provisions of basic level of service for BICs rather than physical infrastructure*, so that achieving the benefits of their provision at minimal capital and running costs while reflecting the priorities, needs and demands the low-income households and their ability to pay for them.
3. *Acceptance of minimum permissible limits and reduced design parameters* is a core factor in the provisions of BICs for lowering the costs of provisions while providing the basic level of service. Reductions in infrastructure requirements and limits would offset costs of infrastructure construction and provide incentives for their provisions.

5.2.3 Fundamental Concepts and Approaches for Provisions of BICs

1. Clustered compact designs for LCH developments with enhancement of the mixed design approach which include provisions of SICs in the LCH developments as seen appropriate.
2. Integration and interrelation in BICs provisions together since they are greatly interrelated and dependent on each other.
3. Reducing the requirements and standards for the provision of any BIC would save money to be used in the provision of another component.
4. Decentralization approach and Small decentralized systems in provisions are more efficient, easier to integrate and responsive to expansion, more easily to upgrade, cheaper to plan and finance.
5. DWT approach for wastewater treatment and reuse has potential benefits for UA and income generation.
6. Conservation measures concept is the most low-cost economical new capacity.
7. Simple/low-tech systems /foot-print techniques at micro scale.
8. *Moving a way from the stringent standards* prevalent in industrial countries and looking beyond the traditional, high quality expensive designs into ones which reflect the effective demands and incomes of low-income people.
9. Reducing the requirements and standards for the provision of any basic infrastructure component (BIC) would save money to be used in the provision of another component.

5.2.4 Guidelines for Lowering the Costs of Each BIC

The following guidelines are concluded to ensure the basic adequate level of service while not contributing to increasing the costs of housing:

1. Water Supply (BIC-1): Adopting minimums of quantity and quality, low cost supplementary sources of water supplies such as harvested stormwater and treated wastewater for non-potable uses, water conservation measures and the system of ‘pumping with storage floating in the system’ as appropriate.

2. Sewerage system (BIC-2): using the simplified sewerage system for foul sewage, and SDGS for greaywater separation

3. Wastewater treatment and disposal or reuse (BIC-3): Decentralized wastewater treatment (DWT) systems lead to huge cost reductions in the construction and maintenance, generate jobs for residents, reduce water supply demands, increase wastewater reuse opportunities for the urban agriculture (UA) and irrigation/fertilization of green areas. Anaerobic wastewater treatment is suitable for LCH due to their low-cost, no-energy, small land take, applicability to any scale and production of valuable energy and fertilizers. The grey water separation and treatment is low-cost and sustainable approach for the treatment and safe use of effluent for irrigation, fire fighting, toilet flushing and car washing.

4. Power supply and street lighting (BIC-4): The "after diversity" value of electricity demand has been defined. Solar energy is a “low-cost" intervention through (1) passive solar designs, (2) flat-plate solar collectors for water heating or/and (3) UV technology for external lighting. Passive solar design techniques are “no-cost” intervention which transforms standard low-cost houses into energy efficient houses. Minimum levels of security lighting have been determined.

5. Access and paving (BIC-5): Reducing streets lengths and widths and narrower footpaths and sidewalks has been determined. Minimal pavement thicknesses with low-cost materials have been specified. Minimal off-site curb angle parking places are described. Cluster designs enhance lowering the requirements and costs of access and paving.

6. Stormwater drainage (BIC-6): Cluster conservation design enhances stormwater infiltration with using voided Eco-stone pavements. Recharging wells are suitable for harvesting the rainwater from the buildings rooftops. Bioretention areas or "raingardens" are low-cost and simple BMPs, easy to maintain, and add aesthetic value to the site, without consuming large amounts of valuable land area. Vegetated swales are low-cost BMP instead of curb and gutter system.

7. Telephone lines (BIC-7): One phone line connection for each housing unit with minimum number of public phone stations for residents who do not have the telephone service.

5.2.5 Management of Operation and Maintenance of BICs

1. O&M of BICs is an essential consideration from the outset of the planning and design processes not something which comes later in order to draw on their benefits continuously over their useful life.
2. The partnership management approach between the municipalities/utilities and the community is sustainable and low-cost method for management of O&M of BICs and for recovering their costs.

5.2.6 Capital Financing for Provisions of BICs

1. A special revolving fund is sustainable financial source.
2. Private sector partnership (PSP) should be promoted.
3. "Lifeline" entitlement with respect to water, sanitation, and electricity is essential for residents of LCH to ensure sustainable cost-recovery.

5.2.7 Results of Application of the Developed approach and the Proposed Criteria to the Case Study

1. Scoring method is suitable and successful for solving simple multi-criteria decision problems.
2. The developed approach is applicable and practicable and friendly-used to the local LCH developments.

5.3 RECOMMENDATIONS

All the stakeholders and actors in the field of low-cost housing and residential infrastructure may benefit from the following recommendations:

1. Advising the Developed Approach as a part of the future Palestinian housing policy and incorporating it in the future Palestinian housing law.
2. Enforcement of the Developed Approach in the future Palestinian LCH developments.
3. Enhancing effective coordination and continuous cooperation between the housing institution/company and the relevant municipalities/ authorities/ utilities for achieving good and suitable provisions and management of BICs.
4. Advising good institutional arrangements and capacity building measurements in the housing institution/company for the benefit of adequate provisions BICs.
5. An education effort is necessary to help the local officials, developers to understand the goals and advantages of cluster development.
6. Allowing for modifications and improvements of the local existing laws and regulations, accepting minimum limits and relaxed standards and go beyond business-as-usual.

7. Adopting the main principles of provisions and enhancing the proposed concepts and the new suitable low-cost techniques and technologies in the provisions of BICs.
8. Designing a "Solar Energy Code" to develop and enforce the energy efficient designs and technologies in the LCH developments and applying modifications on the existing building regulations and/or codes of practice for enforcing the use of water-saving plumbing fixtures.
9. Promoting and facilitating the partnership management for O&M of BICs.
10. Establishing special revolving funds and investigating private investments and partnerships in provisions of BICs.

5.4 RECOMMENDED STUDIES

1. Individual study for lowering the costs of the housing units should be done to be integrated with this research study in order to reach an overall reduction of all cost-influencing factors to deliver a low-cost housing in Palestine.
2. An individual research work is recommended for the best provisions of SICs for LCH.
3. An individual study is recommended on the UV technology for its use in site and street lighting of LCH.
4. New research work for development of permeable Eco-stone pavement.
5. Experimental studies on BMPs for stormwater management such as the bioretention areas and vegetated swales.
6. More extensive research studies on low-cost DWT trains/plants on the local level.
7. Pilot demonstration projects and public awareness are recommended for the use of the treated wastewater effluent for non-potable uses such as toilet flushing and car washing.
8. Advising future studies and research investigations to quantify the cost reduction percentage which could be achieved using the developed approach in this research, in the provisions of basic infrastructure components (BICs) for LCH.

5.5 ENCOUNTERED DIFFICULTIES DURING THE RESEARCH WORK

Frankly speaking, there were a lot of difficulties which has been encountered by the researcher during the research work. These difficulties have delayed the finalization of this thesis and its appearance to reality and caused a lot of inconvenience and tired to the researcher. These difficulties deserve to be clarified and they are summarized in the following:

1. The subject of the research work is very wide and includes two distinct difficult subjects, which are (1) low-cost housing (LCH) and (2) infrastructure, which include a wide range of components and facilities relating to basic infrastructure components and supportive

infrastructure facilities. Although the first subject was not a main part of the thesis, but it has been studied widely and comprehensively at first since it is an integral part of the main thesis subject, which is the provision of infrastructure for LCH. This has taken a lot of time to be done.

2. Infrastructure is a wide and unlimited subject, where each individual component and facility of it needs a lot of time for reading to be reviewed and summarized to reach the focal points concerning the research subject. It has a wide range of definitions according to different industrial and rich countries or the poor, underdeveloped and developing countries, and thus, there was a need to compare and analyze all of that deeply.
3. Deep lack in references, text books, papers in the subject of low-cost infrastructure. Little existence of experts in the field of low-cost housing and the field of low-cost infrastructure and very little local experience in these subjects.
4. Difficulty in getting the needed data and information from the relevant institutions and authorities concerning the subject and lack of serious cooperation.
5. The difficult and unmoral political situation during the time period of the research work which prevents the researcher to reach the housing projects that have been chosen for the selection of the case study. Furthermore, the case study, AHP is located in very dangerous area near Israeli settlement and has been exposed to serious attacks and damages from the Israeli army, and this delay the researcher from visiting the project to take the needed real information and pictures. Added to this, some of the necessary issues (e.g., management of O&M and cost recovery) in the developed approach could not be applied to the project, since the residents have left the project since the beginning of EL-Aqsa Intifada in 2000, e.g., after about one year of the project completion.

REFERENCES

Abu ELhaija, Ahemd. H. (1999). **Strategies and Approaches for Developed Urban Planning**. **استراتيجيات وآليات التخطيط الحضرى المطور**

Afifi, Sami. (2003). **Septage treatment in a vertical flow reed bed system**, IUG, Proceedings of the International Conference on Engineering and City Development, Gaza,, Palestine

Akatsuka, Yuzo; Yoshida, Tsuneaki. (1999). **Systems for infrastructure development-Japan's Experience-.** JICA, TOKYO

AL-Saed, Rashed. (2005). **Water rsources in Palestine: are they sustainable enough to provide a safe drinking water?.** Palestinian engineer magazine, No. 50, July, 2005. Special Edition

ASCE**.** (1982). **Gravity sanitary sewer design and construction**. Manuals and reports on engineering practice -No.60, American Society of Civil Engineers, New York

Awadallah, Faisal. (1996). **The infrastructure vis-à-vis low cost housing case study** , Int. Conf. on Affordable Housing, November, 1996, Birzeit, Palestine.

Bakalian, A. A. Wright, R. Otis and J.A. Netto. (1994). **Simplified sewerage: design guidelines.** UNDP-World Bank Water & Sanitation Program, International Bank for Reconstruction and Development, Washington, DC, 20433, USA. First printing, May 1994. Available at: http://www.wsp.org/publications/global_simplified.pdf

Bakir, H. (2001). **Wastewater management services in water stressed countries: guiding principles and options for sustainable development.** In:
The 2nd Asian Conference of Water and Wastewater Management (CEHA), 8 – 9 May, 2001, Tehran, Islamic Republic of Iran, available at:
http://www.emro.who.int/Publications/CEHA-ASIAN%20CONFERENCE.pdf, last visit on July 2003

Bond, Patrick. (1998). **Basic infrastructure for socio-economic development, environmental protection and geographical desegregation: South Africa's unmet challenge.** Department of Geography & Environmental Studies, Graduate School of Public & Development Management, University of the Witwatersrand, PO Box 601, Wits 2050, Johannesburg, South Africa

Brace, C. (1995). **Public works in Canadian cities: The provision of sewers in Toronto (1870- 1913).** Urban History Review 23: 33- 43

Brazilian Association of Sanitation and Environmental Engineers **(BASE)**. (2003). **Stormwater Management and Urban Drainage in Developing Countries**

Bruijne, G. (2000). **A new approach to sanitation in Palestine**. Waterlines, VOL.19, NO.1, JULY 2000, Urban Sanitation, p. 19-23. available at:
http://www.efm.leeds.ac.uk/CIVE/Sewerage/articles/LcSewPalestine.pdf

Carter, E. C., Homburger, W.S. (1978). **Introduction to transportation engineering**.

Institute of transportation engineers, Inc. Arlington, Vergenia 22209

Ministry of Environment – CANADA **(CANADA).** (2002). **Water Conservation – Every Drop Counts.** Available at: http://www.ec.gc.ca/water/en/info/pubs/e_pubs.htm

Central Ground Water Authority, Ministry of Water Resources **(CGWA)**. (2000). **Rooftop rainwater harvesting**. Available at:
Website: www.cgwaindia.com, **and** http://www.rainwaterharvesting.org/Policy/cgwa.htm.
last visit on 2004

Chittenden County Regional Plan Commission **(CCRP)**. (2001). **2001 Chittenden County Regional Plan, Housing.** Vermont, p. 6.1-p. 6.15.
Available at:
http://www.ccrpcvt.org/plan/housing.pdf , and
http://www.ci.burlington.vt.us/planning/mdp/09housing.pdf#search='Chittenden%20County%20Regional%20Plan,%20affordable%20housing' , last visit was on June 23, 2003

Christ, O. & Huber, H. (2004). **The future concept of wastewater treatment**. Decentralized Sanitation and Reuse, HUBER Technology (DeSaR), available at:
http://www.huber.de/ueberuns/symposium/Symposium_Prof_Wilderer_DeSaR_e.pdf

Church, John. (2000). **Cluster/conservation development**. Local Governement Information and Education Network (LGIEN). Fact sheet 2000-010, Local Governement Topics.

CITY OF CHULA VISTA **(CHULAVISTA)**. (2003). **Constraints to housing provision.** HOUSING ELEMENT 1999-2004, Available at:
http://www.chulavistaca.gov/City_Services/Development_Services/Community_Development/PDFs/Housing/HousingElementConstraints.pdf

CMHC-SCHL. (2003a). **Improving quality and affordability: *modifying development standards*.** Available at:
http://www.cmhc-schl.gc.ca/en/imquaf/afho/afadv/pore/modest/index.cfm, last visit on Nov. 2003.

CMHC-SCHL. (2003b). **Increasing density through lot size and design**. Canada, available at http://www.cmhc-schl.gc.ca/en/imquaf/afho/afadv/cohode/indelsde/how.cfm

Chennai Metropolitan Water Supply and Sewerage Board **(CMWSSB)**. (2002). **Rainwater harvesting: simple methods and significant results**.
Available at: http://www.chennaimetrowater.com/home.htm . last visit on Dec, 2003

Cotton, A.P.; Tayler, W.K. (2000). **Services for the urban poor**. Section 4. Technical Guidelines, WEDC, Loughborough University, UK.

Crites, Ronald W., Tchobanoglous, George. (1998). **Small and decentralized wastewater management systems**, WCB/McGraw Hill.

Draft Environmental Assessment **(DEA)**. (2005). **North Gaza sewage treatment plant project**. PWA, the world bank and EMCC, supported by Dorsch Consult., March, 2005

Directorate of town Panchayatas **(DTP).** (2003). **Rain water harvesting.** Availavle at: http://www.tn.gov.in/dsvp/rainwater.htm . Last visit on 2004

Development Technology Unit **(DTU).** (2004). **Rainwater harvesting.** Available at: http://www.eng.warwick.ac.uk/DTU/pubs/rwh.html , last visit on: April, 2003

Enck, Peter, Joy Tierney. (2002). **Affordable housing – Making it a reality**, A Report of the Second Mayors' Regional Housing Task Force.

Erguden, Selman. (2001). **Low-Cost Housing: policies and constraints in developing countries.** International Conference on Spatial Information for Sustainable Development, 2-5 October 2001.

Environmental Protection Agency **(EPA).** (1992). **Manual – wastewater treatment/disposal for small communities**. Office of Water, Washington, D.C. Office of research and development, OH, EPA /625/R-92/005, September, 1992

Environmental Protection Agency **(EPA).** (1999a). stormwater technology fact sheet, **Wet detention ponds**. Office of Water, Washington, D.C. EPA 832-F-99-048, September, 1999

Environmental Protection Agency **(EPA)**. (1999b). wastewater technology fact sheet, **Chlorine disinfection**. Office of Water, Washington, D.C. EPA 832-F-99-062, September, 1999

Environmental Protection Agency **(EPA).** (1999c). wastewater technology fact sheet, **Vegetated swales.** Office of Water, Washington, D.C. EPA 832-F-99-048, September, 1999

Environmental Protection Agency **(EPA)**. (1999d). wastewater technology fact sheet, **Bioretention**. Office of Water, Washington, D.C. EPA 832-F-99-012, September, 1999

Environmental Protection Agency **(EPA).** (2000a). **Wastewater technology fact sheet, trickling filter nitrification.** Office of Water, Washington, D.C. EPA 832-F-00-015, September, 2000

Environmental Protection Agency **(EPA)**. (2000b). **EPA Guidelines for management of onsite/decentralized wastewater systems**. September 26.2000, draft.

Environmental Protection Agency **(EPA)**. (2000c). wastewater technology fact sheet, **Package plants**. Office of Water, Washington, D.C. EPA 832-F-00-016, September, 2000

Environmental Protection Agency **(EPA).** (2000d). **Decentralized systems technology fact sheet, Septic tank system for large flow applications**. Office of Water, Washington, D.C. EPA 832-F-00-079, September, 2000

Environmental Protection Agency **(EPA).** (2002). **Onsite Wastewater Treatment Systems Manual**, EPA -625-R-00-008, Unites States Environmental Protection Agency USEPA

Environmental Protection Agency **(EPA).** (2004). **Appendix A: Definition of terms and descriptions of wastewater systems.** Available at: http://www.epa.gov/owm/mab/smcomm/rtc/mast3.pdf. last visit on: March, 2004

Environmental Science **(ES).** (2003). **Introduction to urban infrastructure**. Available at: http://www.users.bigpond.com/therices/envsci/watersupply.html , Last visit on: Oct. 2003
Faruqui, Naser I. (2002). **Wastewater treatment and reuse for food and water security**, UA- Magazine, pp. 20-23

Federal Emergency Management Agency **(FEMA).** (2000). **A vision of sustainable communities**. Planning for a sustainable future. Publication No. 364

Gaza Electricity Distribution Company **(GEDCo).** (2005). Interview information, EIbaid, Kanan, director of research and studies.

Gichunge, H. (2001). **Factors that contribute to the cost of provisions of low cost housing in Nairobi, Kenya**. International Conference on Spatial Information for Sustainable Development, Nairobi, Kenya, 2–5 October 2001

Gunther, Folke. (1998). **Innovative technology**. Hifab International AB, Swedeplan-Swedesurvey, Inregia, Report, April 6, 1998.

Hamdi, N. (1997). **Housing Alternatives: Lessons from experience**. The reconstruction of Palestine: Urban and Rural Development, A. Zahlan, ed., Kegan Paul, London, 405-420.

Ho, G. (1998). **Principles of wastewater treatment.** Institute for Environmental Science, Murdoch University, Australia, Caribbean Environment Programme Technical Report #43 1998. available at: http://www.cep.unep.org/pubs/Techreports/tr43en/Principles%20of%20wastewater.htm . last visit on: 2004

Homburger, Wolfgang S., Hall, Jermo W., Reilly, William R., Sullivan, Edward C. (2001). **Fundamentals of traffic engineering**. 15th Edition. Course notes, UCB-ITS-CN-01-1, January 2001, ISSN 0192-5911

Ismail, Ghassan. (1996). **Two conceptual approaches for solving the housing problem in Palestine**, Int. Conference on AAFORDABLE HOUSING IN PALESTINE, November, 1996, Birzeit, Palestine. H. Nigim, M. Ziara, W. Hashlamoun (Editors), pp. 2.2.2 – 2.2.8

International Workshop on Wastewater Treatment **(IWWT).** (2003a). **Case studies of DWT or sustainable sewerage**. Decentralized Technologies for Effective Management. 9-10 January, 2003. Available at: http://www.idfc.com/pages/Knowledge/workshop/Case%20Studies.htm

International Workshop on Wastewater Treatment **(IWWT).** (2003b). **Alternative wastewater collection systems**. Decentralized Technologies for Effective Management. 9-10 January, 2003. Available at: http://www.idfc.com/pages/workshop/casestudy02.htm

Japan. (2004). **Seminar on public works administration in regional government II.** City Planning System. October, 2004. JICA, JAPAN

Jendia, Shafik. (2000). **Highway engineering-structural design**. Dar AL-Manara, Gaza (Published in Arabic), Master program course ENGC 6345, Road Design and Maintenance, September, 2002.

Khalaf, Atef. (2005). **Assessment of rainwater losses due to urban expansion of Gaza Strip**. Master Thesis in Water Resource Management. Islamic University

Knaap, Gerrit; Talen, Emily; Olshansky, Robert; Forrest, Clyde. (2003). **Infrastructure and urban development in Illinois**. Department of Urban and Regional Planning, University of Illinois at Urbana-Champaign, available at: http://www.mrsc.org/mli/l3/PL2.aspx , last visit on: June, 2003

LYONNAISE DES EAUX KHATIB AND ALAMI **(LEKA)**. (1999). **Wastewater reuse**, Technical paper No. 30., Service Improvement Project for water and wastewater systems in the Gaza Strip

Mahmoud, Nidal. (2005). **Sustainable sewage management in Palestine: positioning of anaerobic processes within the sanitation landscape**. Palestinian engineer magazine, No. 50, July, 2005. Special Edition

Majd, Majdi. (2005). **أساسيات ترشيد استهلاك الطاقة في تصميم المباني.** No. 50, Palestinian engineer magazine, July, 2005**.** Special Edition

Mara, DD. (1996). **Settled sewerage**. In: Mara DD (ed) Low-cost urban sanitation. Chichester (UK): John Wiley and Sons

Mara D.D., Guimaraes, A.S.P. (1999). **Simplified sewerage: potential applicability in industrialized countries.** Technical note, Urban Water 1 (1999) pp. 257-259, available at: www.elsevier.com/locate/urbwat

Mara, D. (1998). **Low-cost sewerage**. Promotion through Innovation/ Innovative Technologies, pp. 249-262, University of Leeds, UK. Available at: http://www.efm.leeds.ac.uk/CIVE/Sewerage/articles/WHO_EOS_98.5_pp249-262.pdf

Mays, Larry W. (2000). **Water distribution systems handbook**. Arizona State University. Temp, Arizona. McGraw-Hill, Inc.. USA

McGhee, Terence J. (1991). **Water supply and sewerage.** Lafayette College. McGraw-Hill, Inc. USA

Morris, Lia. (2002). **Discussion paper - strategic planning & planning schemes**, Housing Industry Association Limited.

Ministry of Public Works and Housing **(MPWH)**. (2004). General Directorate of Engineering and Design, General Directorate of Monitoring and Follow up

Ministry of Public Works and Housing **(MPWH)**. (2005). General Directorate of studies, researches and development, report, March, 2005

Minnesota Pollution Control Agency **(MPCA).** (2000). **Protecting water quality in urban areas**. Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban and Developing Areas of Minnesota, March 1, 2000

Naser, Kamal, & Mukhtar, Naji & Abdul Hadi Ayman. (1996). **Housing finance policy in Palestinian territories**, The Reconstruction of Palestine: Urban and Rural Development, A

Zahlan, ed., Kegan Paul, London, pp. 556-587

Nashashibi, M., and Duijl, L.A. van. (1995). **Wastewater characteristics in Palestine**. Water Science and Technology, Volume 32, Issue 11, 1995,pages 65-75

Niemczynowicz, Janusz. (2003). **Innovation trends in urban water supply and sanitation.** Department of Water resources Engineering, University of Lund, Box 118, S- 221 00 Lund, Sweden.

O'Flaherty, CA. (1997). **Transport planning and traffic engineering**. John Wily & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012

Otis RJ, Wright A, Bakalian A. (1996). **Guidelines for the design of simplified sewers**. In: Mara DD (ed) Low-cost Sewerage. Chichester (UK): John Wiley and Sons

Palestinian Telecommunication Company **(PALTEL)**. (2004). **Interview** with Eng. Faraj Masri, Director of Gaza city department, PLATEL Company.

Palestinian Standards Institute **(PSI).** (2003). Treated wastewater. PS 742 – 2003

Palestinian Standards Institute **(PSI)**. (2005). Drinking water. PS 41 - 2005

Palestinian Water Authority **(PWA).** (2000). **Standards of drinking water quality in Gaza Strip – "Intermediate/مرحلية"**. July, 2000

Palestinian Water Authority **(PWA).** (2004a). **Water quality assessment of drinking wells in Gaza Governorates**. December, 2004

Palestinian Water Authority **(PWA).** (2004b). **Rainfall and groundwater in the Gaza Strip**. WATER Resources Directorate, July 2004.

Palestinian Water Authority **(PWA).** (2004c). **Palestinian water resources policies towards sustainable development of the water sector.**

Palestinian Water Authority **(PWA).** (2003). **Palestinian Water Authority, National Water Plan (NWP)**

Palestinian Water Authority **(PWA).** (1998). **Water resources management in Gaza Governorate.** Oct. 1998.

Parkinson, Jonathan, Tayler, Kevin. (2003). **Decentralized wastewater management in peri-urban areas in low-income countries.** Environment&Urbanization, Vol. 15 No. 1 April 2003

Quigley, Martin F.; Lawrence, Timothy. (2002). **Multifunctional landscaping: putting your parking lot design requirements to work for water quality**. Local Governement Information and Education Network (LGIEN) Fact sheet 2002-017

Rainer, George. (1990). **Understanding infrastructure: a guide for architects and planners.** John Wiley & Sons, Inc. Printed in the United States of America.

Regional Plan for Gaza Governorate **(RPGG).** (1998). Ministry of Planning and International Cooperation. Palestinian National Authority, May 1998.

Reston Association **(RA).** (2003). **Design guidelines.** Available at: http://www.reston.org/design/d_designguidelines.html , last visit on: April, 2004

South Austrian Health Commission Code **(SAHC).** (1995). *waste control systems*, **standard for the construction, installation and operation of septic tank systems in south Australia** Issued by the Environmental Health Branch of the Public and Environmental Health Service, South Australian Health Commission. 11 - 13 Hindmarsh Square, Adelaide SA. PO Box 6 Rundle Mall SA 5000.

Saghir, J., M. Schiffler and M, Woldu. (2000). **Urban water and sanitation in the Middle East and North Africa region: The way forward,** The World Bank, Middle East and North Africa Region, Infrastructure Development Group, available at: http://lnweb18.worldbank.org/mna/mena.nsf/f34b224d37365b3f852567ee0068bd93/2421f467c2c02626852569510066 60e9/$FILE/way-english.pdf , last visit on Oct. 2003
(Saghir, 2000)

Sohail, M.; Cavill, S.; and Cotton, A.P. (2005). **Sustainable operation and maintenance of urban infrastructure: Myth or Reality**. ASCE, Journal of Urban Planning and Development.

Solomon, Clement, P. Casey, C. Marckne and A. Lake. (1998). **Water efficiency**. Fact sheet. National Small Flows Clearinghouse. ETI.

TDM Encyclopedia. (2003). **Smart growth policy reforms**, Victoria Transport Policy Institute, Updated May 7, 2003, available at: http://www.vtpi.org/tdm/tdm95.htm, last visit on Oct. 2003

Triulzi, Umberto. (1996). **The economics of housing as a vehicle for the peace process**, Int. Conference on AFFORDABLE HOUSING IN PALESTINE, November, 1996, Birzeit, Palestine. H. Nigim, M. Ziara, W. Hashlamoun (Editors)

UNI-GROUP **(UNI).** (2004). **Jordan cove urban watershed project**. Uni eco-stone case study, Green, Glenn Brook Subdivision Waterford, Connecticut. UNI-GROUP USA, Manufactures of UNI paving stones. http://www.uni-groupusa.org/Jordan.pdf

United Nations HABITAT **(UNHABITAT).** (2003). **Water and sanitation in the world's cities: local action for global goals.** Available at: http://www.earthscan.co.uk/samplechapters/1844070042Intro.htm

United Nations HABITAT **(UN-HABITAT).** (2002). **Habitat II conference**. Available at http://www.earthsummit2002.org

United Nations Centre for Human Settlements **(UN-HABITAT)**. (1993). **The maintenance of infrastructure and its financing and cost recovery.**

UN-HABITAT. (1989). **The conservation of drinking-water supplies: techniques for low-income settlements.** Available at: http://hq.unhabitat.org/register/publications_download_statistics.asp

Volkman, Sarah. (2003). **Sustainable wastewater treatment and reuse in urban areas of the developing world**. Department of Civil and Environmental Engineering, Master's International Program, Michigan Technological University.

Water Services Act **(WSA).** (2003). **Interpretative guide for sanitation: discussion document**. Available at: http://www.dwaf.gov.za/Documents/Policies/WSA_Sanitation_Interpretative.pdf . Last visit on June, 2003.

World Bank. (2000). **World bank development indicators 2000**. World Bank, Washington, DC.

The World Bank Group. (2001). **What are the policy issues? land, housing and urban services**, available at: http://www.worldbank.org/urban/poverty/land.html , last visit on June 2003.

Ziara, Mohammed. (2002). **Infrastructure planning in developing countries**. Master coarse, second semester 2001/2002 (ENGC 6353), College of civil engineering, Department of infrastructure Master Program, Islamic university – Gaza Strip

Ziara Mohammed, Naser Kamel, Touqan Shadia. (1997), **Evaluation of housing affordability and conditions in Palestine**, Final Report, Grant by the Swedish Government-Sida, BirZeit University.

Ziara Mohamed, Ayyub Bilal. (1996). **Methodology for construction reduced-cost Housing: system framework with decision analysis**, Conf. on Affordable Housing, Birzeit, Palestine.

Ziara Mohammed, Ayyub Bilal. (1999). **Decision analysis for housing-project development**, Journal of Urban Planning and Development.

Web-site References

www.ansad.net. (2005). Last visit at 25 April 2005

www.cohre.org/hrbody2.htm . (2003). last visit at 30 may 2003

http://www.cmhc-schl.gc.ca/en/imquaf/afho/afadv/cote/buenefho/case1.cfm#related . (2003). Last visit at 2004

www.floridacommunitydevelopment.org, (2003). Last visit on 2003

www.local.gov.za/DCD/policydocs/whitepaper/cl2pat.html . (2003). last visit on Oct, 2003

http://www.idfc.com/pages/Knowledge/workshop/Case%20Studies.htm. (2003)

www.repp.org/articles/static/1/995469913_2.html. (2005). last visit on 25 September 2005

www.saniatationconnection.com/financing and cost recovery.htm . (2003)

LIST OF APPENDICES

APPENDIX (1)

Housing need in Palestine

Table 1.1: Total Housing needs in Palestine

Housing need classification	Housing needs until 2015 In Gaza Strip	Housing needs until 2015 In West Bank	Total Housing needs until 2015 In Palestine
Housing needs relating to accumulated shortage at the end of 2004	39,740	46,662	86,402
Housing needs relating to natural population growth (2005-2015)	114,675	184,763	299,438
Total Housing needs	**154, 415**	**231,425**	**385,840**

Source: MPWH, 2005

Table 1.2: Total housing needs in West Bank

Year	Total projected population	Population in West Bank	Accumulated housing needs in West Bank	Yearly housing needs in West Bank
End of 2004	3,868,721	2,450,414	**46,662**	
2005	4,004,126	2,536,178	60,721	14,059
2006	4,144,270	2,624,944	75,272	14,551
2007	4,289,320	2,716,817	90,332	15,060
2008	4,439,446	2,811,906	105,920	15,588
2009	4,594,826	2,910,323	122,053	16,133
2010	4,755,646	3,012,184	138,751	16,698
2011	4,922,093	3,117,611	156,033	17,282
2012	5,094,366	3,226,727	173,920	17,887
2013	5,272,669	3,334,662	192,433	18,513
2014	5,457,213	3,456,551	211,594	19,161
2015	5,648,215	3,577,530	231,425	19,831
Total housing needs during the period (2005-2015)				**184,763**
Cumulative housing needs				**231,425**

Source: MPWH, 2005

Average family size is 6.1, natural growth rate is 3.5%

Table 1.3: Number of annually needed Housing Units (H.U.s) in Gaza Strip (2004-2015)

According to natural population growth

Year	No. of population	Needed Housing Units (H.U.) per year
2004	1,391,953	8,431
2005	1,440,671	8,726
2006	1,491,095	9,031
2007	1,543,283	9,347
2008	1,597,297	9,675
2009	1,653,203	10,013
2010	1,711,066	10,363
2011	1,770,953	10,726
2012	1,832,936	11,102
2013	1,897,089	11,490
2014	1,963,487	11,892
2015	2,032,209	12,309
Total needs		**123,106**

Source: MPWH, 2005

Average family size is 6.8, natural growth rate is 3.5%

Table 1.4: Number of annually needed Housing Units (H.U.s) in Gaza Strip (2004-2015)
Distributed to governorates According to natural population growth

	2,004	**2,005**	**2,006**	**2,007**	**2,008**	**2,009**	**2,010**	**2,011**	**2,012**	**2,013**	**2,014**	**2,015**	**Total**
North Gaza	1,585	1,640	1,698	1,757	1,819	1,882	1,948	2,016	2,087	2,160	2,235	2,314	23,14
Gaza	2,978	3,083	3,191	3,302	3,418	3,537	3,661	3,789	3,922	4,059	4,201	4,348	43,49
Middle Gaza	1,222	1,264	1,309	1,354	1,402	1,451	1,502	1,554	1,609	1,665	1,723	1,784	17,83
Khanyounis	1,640	1,697	1,757	1,818	1,882	1,947	2,016	2,086	2,159	2,235	2,313	2,394	23,94
Rafah	1,006	1,041	1,078	1,116	1,155	1,195	1,237	1,280	1,325	1,371	1,419	1,469	14,69
Total	**8,431**	**8,726**	**9,031**	**9,347**	**9,675**	**10,013**	**10,364**	**10,726**	**11,102**	**11,490**	**11,892**	**12,309**	**123,10**

Source: MPWH, 2005

Average family size is 6.8, natural growth rate is 3.5%

APPENDIX (2)

Typical stakeholders of infrastructure provisions and their responsibilities

Table 2.1: Typical stakeholder roles and responsibilities

Primary stakeholders	Typical roles and responsibilities
Low-income households	They are the intended users of the infrastructure components within The Low-Cost Housing.

Secondary stakeholder	Typical roles and responsibilities
National Government Governmental ministries	Setting the broad policy framework incorporating: - planning and design standards; cost recovery; subsidy. This has a direct impact on proposed externally funded programmes. - Coordination of policy to avoid ending up with conflicting messages at the municipal level which then creates confusion and difficulty in implementation. - Funding specific programmes in infrastructure, health and ducation.
Local Government (Municipalities/ utilities)	- Statutory responsibility for a wide range of service provision including operation and maintenance. - Specific groups of employees can be affected and may merit separate attention as a distinct stakeholder group e.g. solid waste workers.
Specialist line agencies	-These include agencies with responsibilities for water supply and power supply. - The extent of their jurisdiction over different parts of the networks varies widely from place to place and it is important that this is established during project identification.
Community Based Organisations (CBOs)	- Often engaged in self-help activities, campaigning for better services and in some cases procuring services (see private sector below). It is important to take account of existing CBOs before setting up new structures to deal with externally funded programmes. Inadequate representation of women and disadvantaged groups may be a concern in some CBOs.
Non Government Organisations (NGOs)	- Variety of large and small groups including those associated with churches, religious activities and schools. - Act as intermediaries, negotiating with urban government on behalf of communities. Undertake wider advocacy on more equitable service distribution and poverty reduction. May be involved directly with service delivery, taking on the role of contractors.

Secondary stakeholder	Typical roles and responsibilities
Private Sector	- Households and community groups engage in informal service provision in the absence of the public sector. - Small entrepreneurs operating in the informal economy, such as local solid waste collection. - Formal sector companies providing services such as water supply and solid waste collection to part or the entire town.
External donor/ lending agencies	- Provision of grant-in-aid or loan finance to support programmes specifically targeting the urban poor. - Institutional development and technical support programmes influencing pro-poor policies linked to broader policy reform e.g. for increased cost recovery.
Source: Cotton and Tayler, 2000	

APPENDIX (3)

Palestinian Water Quality Standards

Table 3.1: Palestinian Water Quality Standards

Item	**Maximum Concentration Level**		
	PWA (*mg/1*)	**PSI 41-2005 (*mg/l*)**	**EPA Standards l0/96 (*mg/1*)**
Chemical Standards			
TDS	**1500**	**1000**	**500**
CL	**600**	**250**	**250**
NO3	**70**	**50-70**	**10 as N (45)**
NO2	0.10		1 as N
NH4	0.50		
Total Hardness	600	500	
Alkalinity	400		
SO_4	400	200	
Ca	200-100	100	
Mg	150	100	
Na	200	200	
K	12	10	
F	1.50	1.5	4.00
FRC L	0.8-0.2		
ABS - Industrial detergents	0.50	0.5	
Heavy Metals			
Fe	0.5	0.3	0.3
Al	0.2	0.2	0.05-0.2
Cu	1.0	1.0	1.3
Zn	5.0	5.0	5.0
Mn	0.1	0.1	0.05
Ni	0.05	0.05	0.1
Pb	0.01	0.01	0.015
Sb	0.005	0.005	0.006
Se	0.01	0.01	0.05
As	0.01	0.05	0.05
Cd	0.003		0.005
Cr	0.05	0.05	0.1
Hg	0.001	0.001	0.002
CN	0.05	0.05	0.2
Pesticides and Organic Pollutants			
Alachlor	0.02		0.002
Aldicarb	0.01		0.007

Item	Maximum Concentration Level		
	PWA (*mg/1*)	**PSI 41-2005 (*mg/l*)**	**EPA Standards l0/96 (*mg/1*)**
Aldrin/Dieldrin	0.00003		
Atrazine	0.002		
Chlordane	0.002		0.002
(D.D.T)	0.002		
1,2 Dibromo-3 chloropropane	0.001		
2,4-D	0.03		0.070
Heptachlor, Heptachlore epoxide	0.00003		
Lindane	0.002		0.000200
Methoxychlor	0.02		0.04
Permethrin	0.02		
Simazine	0.002		0.004000
Tri-fluralin	0.02		
2,4,5 T P	0.01		
Endrin	0.002		0.002
Vinyl chloride	0.005		0.002
Monochloramine	3.0		
(T.H.M)	0.1	0.25	0.1
Emitted Materials			
Alpha emitters	0.1		15 Ci/L
Beta emitters	1		4 mrem/ r
Radium 226 and 228			5 Ci/L
Microbiological Standards			
Total Colon Count	1		
Viruses			0
Coliforms			<1/100 mL
Gardia Lamblia			
Hetrotrophic Plate Count			
Legionella			
Pseudomonas Sp.	0.000000		
Pyrogens			
Physical Properties			
Turbidity	4 NTU		0.5-1.0 NTU
PH	6.5-8.5		6.5-8.5
Temperature	25		
Color	15		

Source: DEA, 2005; PSI, 2005; PWA, 2000

APPENDIX (4)

Palestinian Wastewater Standards

Table 4.1: Wastewater Standards (PWA, PSI and EQA)

Quality parameter mg/1 except other wise indicated	Fruit trees			Forest (not used as parks)	Sea outflow (500m)	Infiltration to aquifer	Wheat and industrial crops	Gardens and Parks	Irrigation Fodder	
	Almond	**Olive**	**Citrus**						**Green**	**Dry**
BOD5	45	45	45	60	60	40	60	40	45	60
COD	150	150	150	200	200	150	200	150	150	200
DO	More than 0.5	More than 0.5	More than 0.5	More than 1.0	More than 1.0	More than 0.5	More than 0.5	More than 0.5	More than 0.5	More than 0.5
TDS	1500	1500	1500	1500	-	1500	1500	1200	1500	1500
TSS	**40**	**40**	**40**	**50**	**60**	**50**	**50**	**30**	**50**	**50**
PH	9-6	9-6	9-6	9-6	9.0-6.0	9.0-6.0	9-6	9-6	9-6	9-6
COLOR (PCU)										
FOG	5	5	5	5	10	0.00	5	5	5	S
PHENOL	0.002	0.002	0.002	0.002	1	0.002	0.002	0.002	0.002	0.002
MBAS	15	15	15	15	25	5	15	15	15	15
NO3.N	**50**	**50**	**50**	**50**	**25**	**15**	**50**	**50**	**50**	**50**
NH4.N	**-**	**-**	**-**	**-**	**5**	**10**	**-**	**50**	**-**	**-**
O.Kj.N	50	50	50	50	10	10	50	50	50	50
Po 4.P	30	30	30	30	5	15	30	30	30	30
CI	**500**	**500**	**500**	**500**	**-**	**600**	**500**	**350**	**500**	**500**
So 4	500	500	500	500	1000	1000	500	500	500	500
Na	200	200	200	200	-	230	200	200	200	200
Mg	60	60	60	60	-	150	60	60	60	60
Ca	400	400	400	400	-	400	400	400	400	400
SAR	9	9	9	9	-	9	9	10	9	9
Residual C 12	-	-	-	-	-	-				
A1	5	5	5	5	5	1	5	5	5	5
Ar	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cu	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
F	1	1	1	1	-	1.S	1	1	1	1
FE	5	5	5	5	2	2	5	5	5	5
Mn	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ni	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Pb	1	1	1	1	0.1	0.1	1	0.1	1	1
Se	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cd	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zn	2	2	2	2	5	5	2	2	2	2
CN	0.05	0.05	0.05	0.05	0.10	0.10	0.05	0.05	0.05	0.05
Cr	0.1	0.1	0.1	0.1	0.5	0.5	0.1	0.1	0.1	0.1
Hg	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.05	0.05	0.05	0.05	1	1	0.05	0.05	0.05	0.05
B	0.70	0.70	0.70	0.70	2.00	1.00	0.70	0.70	0.70	0.70
FC (CFU/100ML)	**1000**	**1000**	**1000**	**1000**	**50000**	**1000**	**1000**	**200**	**1000**	**1000**

Quality parameter mg/1 except other wise indicated	Fruit trees			Forest (not used as parks)	Sea outflow (500m)	Infiltration to aquifer	Wheat and industrial crops	Gardens and Parks	Irrigation Fodder	
	Almond	Olive	Citrus						Green	Dry
Pathogens										
Amoeba & Gardia *(Cyst/ l)*	-	-	-	-					-	-
Nematodes *(Eggs/ l)*	Less than 1.0	Less than 1.0	Less than 1.0	Less than 1.0	Less than 1.0	Less than 1.0	Less than 1.0	Less than 1.0	Less than 1.0	Less than 1.0

Source: *DEA, 2005; PSI, 2003*

Table 4.2: Quality criteria of treated wastewater for reuse in agricultural irrigation in Palestine

Parameter	Types of irrigated plants		
	Cotton, Sugar beet, Grains ***mg/l***	**Olives, Peanuts, Banana, Citrus, Almond** ***mg/l***	**Vegetables, Date Palms, Gardens, Playgrounds** ***mg/l***
BOD	60	45	35 -40
Suspended solids (SS)	50	40	30
Oxygen(DO)	0.5	0.5	0.5

Source: LEKA, 1999

Table 4.3: Recommended Microbiological Quality Guidelines for Wastewater Use in Agriculture

category	Reuse Conditions	Exposed group	Intestinal nematodes (Arithmetic mean no. of eggs per liter)	Fecal coliforms (Geometric mean no. per 100 ml.)	Wastewater treatment expected to achieve the required microbiological quality
A	**Unrestricted Irrigation** Irrigation of edible (eaten uncooked) crops, sports fields, and public parks. (a)	Workers, consumers and public	<=1	<= 1000 (b) <= 200 for public lawns such as hotel lawns with which the public may come into direct contact.	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	**Restricted Irrigation** Irrigation of cereal crops, , industrial crops, fodder crops, fruit trees and pasture and trees.	Workers	<=1	No standard recommended.	Retention in stabilization ponds for (8-10 days) or equivalent heminth and faecal coliform removal.
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur.	None	Not applicable	Not applicable (N/A)	Pretreatment is required

Source: WHO (1989), adapted from LEKA, 1999

(a) The unrestricted irrigation is specified in the Palestinian standards for wastewater for all types of agriculture irrigation for (faecal coliform <=1000) except for gardens and parks with (faecal coliform <= 200)
(b) A more stringent guideline **(200 faecal coliform / 100 ml)** is appropriate for public lawns, with which the public may come into direct contact.
(c) In case of fruit trees, irrigation should cease 2 weeks before the fruit is picked and no fruit should be picked of the ground. Sprinkler irrigation should not be used.

APPENDIX (5)

Water saving fixtures

Table 5.1: Potential Water Savings of Low-Flow Fixtures

Fixture (a)	Fixture Capacity (b)	Water Use (*lpd*)		Water Savings (*lpd*)	
		Per Capita	6.8- Person Household	Per Capita	6.8- Person Household
Toilets (c)					
Low-flow	**6.1 *l/flush***	**24.2**	**164.7**	**N/A**	**N/A**
Conventional	13.2 *l/flush*	53.0	360.3	28.77	195.61
Conventional	20.8 *l/flush*	83.3	566.2	59.05	401.51
Conventional	26.5 *l/flush*	106.0	720.7	81.76	555.94
Shower heads (d)					
Low-flow	**9.5 (6.4) *lpm***	**25.7**	**175.0**	**N/A**	**N/A**
Conventional	11.4 to 18.9 (9.8) *lpm*	39.4	267.7	13.63	92.7
Conventional	18.9 to 30.28 (12.9) *lpm*	51.5	350.0	25.74	175.02
Faucets (e)					
Low-flow	**9.5 (6.4) *lpm***	**25.7**	**175.0**	**N/A**	**N/A**
Conventional	11.4 (7.6) *lpm*	30.3	205.9	4.54	30.89
Conventional	11.4 to 26.5 (12.5) *lpm*	50.0	339.7	24.22	164.72
Toilets, Showerheads, and Faucets Combined					
Low-flow	**N/A**	**75.7**	**514.8**	**N/A**	**N/A**
Conventional	N/A	122.6	833.9	46.93	**319.15**
Conventional	N/A	184.7	1256.0	109.01	**741.25**

N/A = not applicable *lpm* = liters per minute lpd = liters per day

(a) Low-flow = post-1994, Conventional = pre-1980 to 1994

(b) For showerheads and faucets: maximum rated fixture capacity (measured fixture capacity).

Measured fixture capacity equals about two-thirds of the maximum.

(c) Assumes four flushes per person per day; does not include losses through leaks.

(d) Assumes 4.8 shower-use minutes per person per day

(e) Assumes 4.0 faucet-use minutes per person per day

Source: Solomon et al., 1998

APPENDIX (6)

Sewerage system

Table 6.1: Number of households served by simplified sewers of 100-300 mm diameter

Sewer diameter (mm)	Maximum number of households served[b]
100	234
150	565
225	1360
300	2536

a. Source: Mara, 1996

b. Assumptions: initial proportional depth, 0.6m; peak flow factor, 1.8; return factor, 0.85; water consumption, 100 *l/ c/d* ; household size, 5; minimum tractive tension, 1 Pa; Manning's n, 0.013; wastewater density, 1000 kg/ m^3; g, 9.81 m /s^2.

Table 6.2: Number of industrialized-country households served by simplified sewers of 100-300 mm diameter

Sewer diameter (mm)	Maximum number of households served[a]
100	56
150	136
225	328
300	612

[a] Assumptions: initial proportional depth, 0.5m; peak flow per household, 4000 *l/d*; minimum tractive tension, 2.5 Pa; Manning's n, 0.013; wastewater density, 1000 kg/ m^3; g, 9.81 m/s^2.

Source: Mara and Guimaraes, 1999

Table 6.3: Comparison between Settled and Simplified Sewerage

Item	Settled sewerage	Simplified sewerage
Terminology	-Septic tank effluent gravity sewers (STEG) -Small diameter gravity sewerage (SDGS) -Small-bore sewerage -Solids-free sewerage	Shallow-sewerage <u>Two versions of it:</u> 1- Condominial variant (backyard/ in-block), which is the cheaper. 2- In-street Sewerage(double sewers). It is installed in each side of the street under each pavement and called "double-in-street simplified sewerage"
Concept	-Wastewater from one or more households is discharged into a single-compartment septic tank (usually called a solids interceptor tank). -The settled (or solids-free) effluent from the septic tank is then discharged into shallow, small-bore gravity sewers.	-This system does not convey presettled sewage. -Household wastewater discharged directly into small-diameter plastic or vitrified clay pipes. -It is essentially conventional sewerage stripped down to its hydraulic basis
Design period		20 years or less
Initial requirements	Adequate water supply	Adequate water supply
Main characteristics	Household wastewater is settled in a solids interceptor tank (single compartment septic tank). Tank effluent discharged into small-diameter plastic pipes laid at shallow depth, at an inflective gradient. Waste water treated in facultative and maturation ponds (or discharged into conventional sewer system)	Household wastewater discharged directly (i.e. without settlement) into small-diameter plastic or verified clay pipes. Wastewater treated in anaerobic, facultative and maturation ponds (or discharged into conventional sewer system).
Applicability	<u>*most suitable in areas:*</u> - New housing developments - With existing septic tanks. - low housing densities such as small rural housing projects - terrain is too flat - soil is rocky or unstable - Groundwater level is high. - densely populated mountain communities - When danger of pollution from cesspits.	<u>*most suitable in:*</u> - High housing density, low-income areas. - It is suitable for new housing estates with a regular layout. - small lot sizes; no space for on-site sanitation pits or for the solids interceptor tanks - For areas of hilly or flat terrain. - poor soil conditions - impermeable soil - high water consumption - unplanned low-income - New housing estates with a more regular layout.
Flexibility		- Flexibility in the use of criteria is unavoidable. -The designer may make professional judgments about specific standards. - Modified standards could be applied in any design.

Item	Settled sewerage	Simplified sewerage
Sustainability	Sustainable, due to its suitability to convey low quantities of wastewater due to water conservation practices	Sustainable, due to its suitability to convey low quantities of wastewater due to water conservation practices
Advantages	*Low cost because:* - Small-diameter (75 mm minimum), plastic pipes laid at shallow depth at an inflective gradient. - Construction is fast and Unskilled personnel for operation and maintenance. - Elimination of manholes ultimately reducing cost. - Reduced excavation costs, and material costs. - Final treatment requirements are scaled down. - Reduced depth of mains.	*Low cost because* it uses: - small-diameter (100 mm minimum) plastic pipes, serving up to 1200 people). - shallow depth and low gradients (i.e. 1 in 270 (0.0037 m/m) - Costly manholes are eliminated or replaced with less expensive cleanouts. - Increasing the spacing between access points. - Design modifications are based on sound engineering principles. - Not create a substandard level of service or lowering the level of service.
Disadvantages	No critical disadvantages if the requirements of their performance are satisfied.	No critical disadvantages if the requirements of their performance are satisfied.
Integration	Can be integrated to the existing conventional sanitation system	Can be integrated to the existing conventional sanitation system
Costs **(These are indicative costs. Local costs must be properly estimated)**	Costs are typically 20–50 percent less of conventional sewerage. Areas with existing septic tanks, cost reduction will be 40–70 percent.	Cost savings of 20 -50 percent. Considered of **first choice** for low-cost urban sanitation.
Requirements for O&M	Sewerage authority: regular inspection of sewers; maintenance of any lift stations; interceptor tank desludging; operation of treatment works.	Community: removal of any sewer blockages within housing block. Sewerage authority: Operation and maintenance are similar to conventional sewers. regular inspection of ex-block sewers; maintenance of any lift stations; operation of treatment works
Treatment	Wastewater could be treated in facultative and maturation ponds, or decentralized facility (or discharged into conventional sewer system)	Wastewater is treated in anaerobic, facultative and maturation ponds or decentralized facility (or discharged into conventional sewer system)
O&M responsibility	Municipality/ utility has to assume responsibility for regular emptying of solids interceptor tank, and ensure that only settled sewage connections are made to the sewers.	Municipality/ utility should be responsible for all tasks of O&M However, Community has to accept responsibility for operation and maintenance for condominial sewers laid within the housing block.
Source: Developed by the researcher, adopted from: (www.efm.leeds.ac.uk/, 2003; www.servicesforall.org/, 2003; www.wsp.org/, 2003; www.epa.gov/, 2003; (www.sanicon.net/, 2003; www.servicesforall.org/ , 2003)		

APPENDIX (7)

Wastewater treatment

Table 7.1: Main constituents in typical residential wastewater

Constituent	Abbreviation
Total solids	(TS)
Volatile solids	
Total suspended solids	(TSS)
Volatile suspended solids	
5-day biochemical oxygen demand	(BOD_5)
Chemical oxygen demand	(COD)
Total nitrogen	
Ammonia	(NH_4)
Nitrites and nitrates	(NO_2-N; NO_3-N)
Total phosphorus	(TP)
Fats, oils, and grease	
Volatile organic compounds	(VOC)
Surfactants	
Total coliform	(TC)
Fecal coliforms	(FC)

Source: EPA, 2002

Table 7.2: Levels of wastewater treatment

Treatment level	Description	Removal efficiencies
Preliminary	Removal of wastewater constituents that may cause maintenance or operational problems with the treatment operations, processes, and ancillary systems.	
Primary	Removal of a portion of the suspended solids (SS)and organic matter from the wastewater.	(50-60%) of SS (30-50%) of BOD
Advanced primary	Enhanced removal of suspended solids (SS)and organic matter from the wastewater. Typically accomplished by chemical addition or filtration.	
Secondary	Removal of biodegradable organics (BOD)and suspended solids (SS). Disinfection is also typically included in the definition of conventional secondary treatment.	(85-95%) of SS (80-95%) of BOD (90-95%) of coliform
Secondary with nutrient removal	Removal of biodegradable organics (BOD), suspended solids (SS), and nutrients (nitrogen (N), phosphorus (P), or both nitrogen and phosphorus).	
Tertiary	Removal of residual suspended solids, usually by granular medium filtration. Disinfection is also typically a part of tertiary treatment. Nutrient removal (N&P) is often included in this definition.	(98-99%) of BOD
Advanced	Removal of dissolved and suspended materials remaining after normal biological treatment when required for water reuse or for the control of eutrophication in receiving waters.	

Source: Adopted from (Crites and Tchobanoglous, 1998; Rainer, 1990)

Table 7.3: Typical wastewater treatment and containment options – based on type of treatment- for small and decentralized systems

Type/level of treatment	Description	Examples of treatment methods	Type of system* S	D
Wastewater collection		Pressure sewers without grinder pumps	√	√
		Pressure sewers with grinder pumps	√	√
		Small diameter variable slope sewers	√	√
		Vacuum sewers	√	√
		Simplified sewers	√	√
Preliminary	Removal of wastewater constituents that may cause maintenance or operational problems with the treatment operations, processes, and ancillary systems.	Coarse screens	√	
		Fine screens	√	
		Grit removal	√	
		Oil and grease removal	√	√
Primary	Removal of a portion of the suspended solids (SS) and organic matter from the wastewater.	Septic tanks	√	√
		Imhoff tanks	√	√
		Rotary disk filter	√	
Advanced primary	Enhanced removal of suspended solids (SS) and organic matter from the wastewater. Typically accomplished by chemical addition or filtration.	Septic tank with effluent filter vault	√	√
		Septic tank with attached growth reactor element (Trickling Filter)		√
Secondary	Removal of biodegradable organics (BOD) and suspended solids (SS). Disinfection is also typically included in the definition of conventional secondary treatment.	Aerobic units	√	√
		Aerobic/anaerobic	√	√
		Intermittent sand filter	√	√
		Recirculating gravel filter	√	√
		Peat filter		√
		Lagoons	√	
		Constructed wetlands	√	√
		Aquatic treatment	√	
Advanced (tertiary)	Removal of residual suspended solids (SS), usually by granular medium filtration. Disinfection is also typically a part of tertiary treatment. Nutrient removal (N)is	Land treatment	√	√
		Intermittent and recirculating packed-bed filters	√	√
		Filtration, rapid	√	
		Constructed wetlands	√	√

Type/level of treatment	Description	Examples of treatment methods	Type of system*	
			S	D
	often included in this definition.	Disinfection, chlorine, UV radiation	√	√
		Repurification (including the use of membranes and carbon adsorption)	√	√
		Recycle treatment systems		
		- *Toilet flushing*		√
		- *Landscape watering and toilet flushing*		√
Containment		Holding tanks		√
		Privy		√

*S = small centralized and D = decentralized

Source: Adapted from: Crites and Tchobanoglous, 1998

Table 7.4: Commonly used treatment processes and optional treatment methods –based on constituent removal- for decentralized treatment system (DWT).

Treatment objective	Treatment process	Treatment methods
Suspended solids removal	Sedimentation	1. Septic tank 2. Free water surface constructed wetland 3. Vegetated submerged bed i`
	Filtration	1. Septic tank effluent screens 2. Packed-bed media filters (incl. dosed systems) - Granular (sand, gravel, glass, bottom ash) - Peat, textile 3. Mechanical disk filters 4. Soil infiltration
Soluble carbonaceous BOD and ammonium removal	Aerobic, suspended-growth reactors	1. Extended aeration 2. Fixed-film activated sludge 3. Sequencing batch reactors (SBRs)
	Fixed-film aerobic bioreactor	1. Soil infiltration 2. Packed-bed media filters (incl. dosed systems) - Granular (sand, gravel, glass) - Peat, textile, foam 3. Trickling filter 4. Fixed-film activated sludge 5. Rotating biological contactors
	Lagoons	1. Facultative and aerobic lagoons 2. Free water surface constructed wetlands
Nitrogen transformation	Biological Nitrification (N) Denitrification (D)	1. Activated sludge (N) - Sequencing batch reactors (N) 2. Fixed film bio-reactor (N) - Recirculating media filter (N, D) - Fixed-film activated sludge (N) - Anaerobic upflow filter (N) - Anaerobic submerged media reactor (D) 3. Submerged vegetated bed (D) 4. Free-water surfacc constructed wetland (N, D)
	Ion exchange	Cation exchange (ammonium removal) Anion exchange (nitrate removal)-
Phosphorus removal	Physical/Chemical	1. Infiltration by soil and other media 2. Chemical flocculation and settling i 3. Iron-rich packed-bed media filter
	Biological	1. Sequencing batch reactors

Treatment objective	Treatment process	Treatment methods
Pathogen removal (bacteria, viruses, parasites)	Filtration/Predation/Inactivation	1. Soil infiltration 2. Packed-bed media filters - Granular (sand, gravel, glass bottom ash) - Peat, textile
	Disinfection	1. Hypochlorite feed 2. Ultraviolet light
Grease removal	Flotation	1. Grease trap 2. Septic tank
	Adsorption	1. Mechanical skimmer
	Aerobic biological treatment (incidental removal will occur; overloading is possible)	1. Aerobic biological systems

Source: EPA, 2002

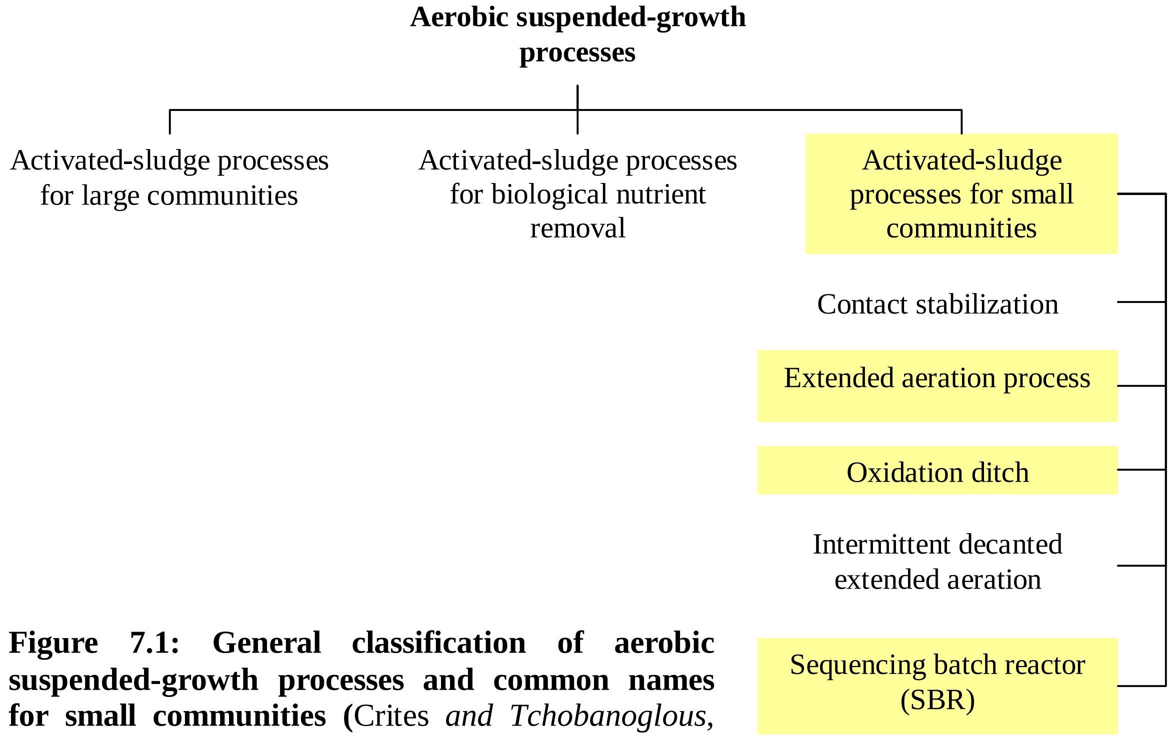


Figure 7.1: General classification of aerobic suspended-growth processes and common names for small communities (Crites *and Tchobanoglous*, 1998)

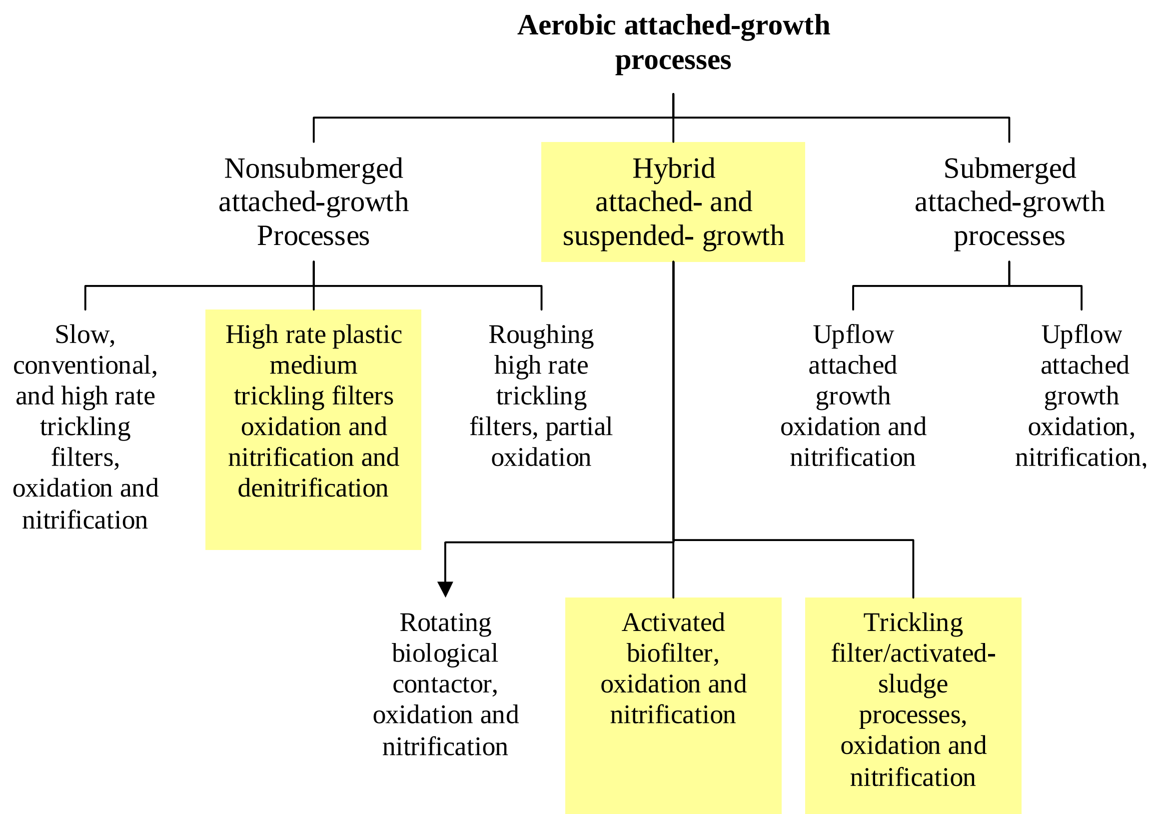


Figure 7.2: General classification of aerobic attached-growth processes and their common names (Crites *and Tchobanoglous*, 1998)

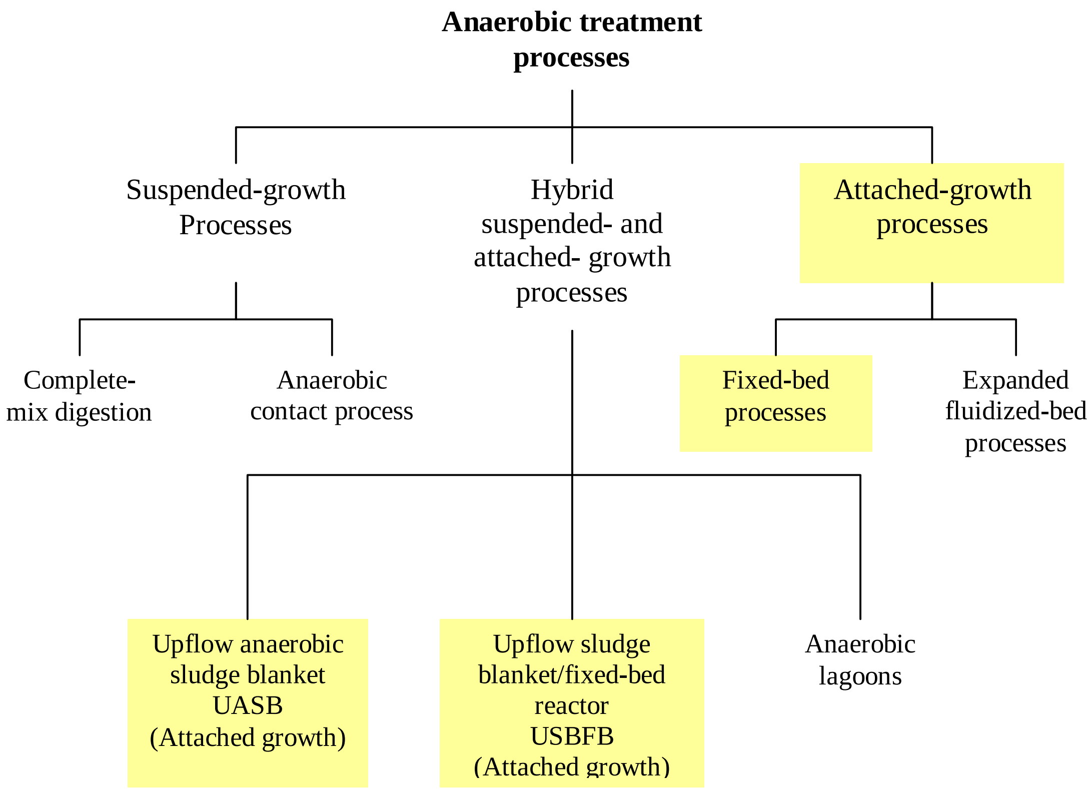


Figure 7.3: General classification of anaerobic treatment processes and their common names (Crites *and Tchobanoglous*, 1998)

Table 7.5: Summary of most used unit processes and operations for decentralized wastewater treatment systems (DWT)

	Unit Process/ Treatment	Classification / Description	Removal efficiency	Process design and operating parameters
		(1) Biological Treatment and Nutrient Removal		
1.	**Aerobic Suspended-Growth Process** The suspended-growth process, activated-sludge is the most commonly used process for the biological treatment of wastewater. The design of activated sludge processes suitable for small communities	**1. Activated-sludge processes for small communities)** 1.1 Contact stabilization process 1.2 Extended aeration process (Package Plants) 1.3 The oxidation ditch process 1.4 Intermittent decanted extended process 1.5 Sequencing batch reactor process	- BOD_5 < 30- 10 *mg/l* - TSS < 30- 10 *mg/l* - Biological removal of nutrients NH_3-N < 2 mg/l Treat flowrates between (7.57-378.5 m^3/d) Treat flowrates between (37.85-1892.5 m^3/d) Treat flowrates between (37.85-757 m^3/d)	Process loading criteria/ food-to-microorganism ration/ mean cell residence time/ volumetric organic loading rate/ reactor sizing and configuration/ sludge production/ oxygen requirements and supply/ energy requirements
2.	**Aerobic Attached-Growth Process** In aerobic attached-growth processes, the microorganisms responsible for treatment are attached to a fixed medium. New hybrid processes have proven to be quite effective, more than the conventional attached-growth process (trickling filter process)	**1. Nonsubmerged Attached-Growth Processes (biological filters/trickling filters)** 1.1 Slow, conventional, and high rate trickling filters, oxidation and nitrification a. Conventional Gravel Filters (Gravel Media) b. Tower Trickling Filters (Plastic Filters) 1.2 High rate plastic medium trickling filters. Oxidation and nitrification 1.3 Roughing high rate trickling filters, partial oxidation **2. Hybrid Attached-and Suspended-Growth processes**	Are suitable for treatment of soluble and other relatively dilute organic wastes - BOD_5 & TSS =< 20 *mg/l* - nitrification (if lightly loaded) - BOD_5 & TSS =< 30 *mg/l* - nitrification (if lightly loaded) - BOD_5 & TSS =< 30 *mg/l* Reducing organic loads and seasonal nitrification applications Are used to treat wastewater with	Hydraulic loading rate/ organic loading rate/ oxygen transfer/ recycle/ dosing rate/ temperature/ operational parameters/ secondary sedimentation facilities

	Unit Process/ Treatment	Classification / Description	Removal efficiency	Process design and operating parameters
		2.1 Rotating Biological Contractor (RBC), oxidation and nitrification 2.2 Activated biofilter (ABF), oxidation and nitrification	both particulate and soluble constituents Significantly higher levels of BOD removal	
		2.3 Trickling filter/ solids contact process (TF/SC)	BOD loading is 4 to 5 times higher than those used in conventional filters	
		2.4 Roughing filter/ activated-sludge process (RF/AS) 2.5 Biofilter/activated- sludge process (BF/AS) 2.6 Series trickling filter/ activated-sludge process **3. Submerged Attached- Growth process** 3.1 Submerged upflow attached growth, 3.2 Submerged upflow fluidized-bed attached growth	Used for treatment of domestic wastewaters including: - carbonaceous oxidation and nitrification - carbonaceous oxidation, nitrification and denitrification	
3	**Anaerobic Suspended- and Attached-growth and Hybrid processes**	**1. Suspended-Growth Anaerobic process (recent development)** 1.1 Anaerobic complete-mix digestion process 1.2 Anaerobic contact process **2. Attached-Growth Anaerobic process** 2.1 Upflow attached- growth process 2.2 Down flow attached- growth process 2.3 Fluidized-bed attached-growth process **3. Hybrid suspended-and –attached-growth Anaerobic process**	Used to treat waste containing particulate biodegradable materials such as sludge form primary and secondary treatment Are suitable for treatmnent of soluble organic wastes such as food processing Used to treat wastes with both particulate and soluble	

	Unit Process/ Treatment	Classification / Description	Removal efficiency	Process design and operating parameters
		3.1 Upflow anaerobic sludge blanket reactor (UASB) 3.2 Upflow sludge blanket/ fixed-bed reactor (USBFB) 3.3 Covered anaerobic lagoon	constituents.	
4.	**Pre-Engineered (package) wastewater treatment plant**	1. Extended aeration activated sludge process 2. Hybrid systems involving both aerobic and anaerobic processes	Biological treatment plant for flow of (3.8 – 760 m^3/d)	
		(2) Land Treatment Systems		
1.	**Slow Rate (SR)**	Is the oldest and most widely used land treatment	Wastewater is treated by physical, chemical, and biological mechanisms as it percolates through the soil	
2.	**Rapid Infiltration (RI) Soil Aquifer Treatment (SAT)**	It is land treatment resembles intermittent sand filtration/ has the highest hydraulic loading rate of any land treatment system/ they help in recovery of water and groundwater recharge and temporary storage renovated water in aquifer	BOD removal is (75-96%), by absorption./ TSS is removed by filtration to (1-2 mg/ l)/ N removal by (38- 71%) by nitrification and denitrification.	
3	**Overload flow (OF)**	It is developed to take advantage of slowely permeable soils such as clays	Phosphorous removal of (40-99%)/ Metal removal of (50-90%)/ Trace organic removal of (10-96%)/ Fecal coliform removal by (2-4) orders of magnitude/ viruses removal by (99.99%)	
		(3) Intermittent and Recirculating Packed-Bed Filters		
1	**Low-rate granular and porous medium filters**	**1. Single-pass (Intermittent) packed-bed filters (IPBF)** modern Intermittent sand filter (ISF) - It treats septic tank effluent - It treats facultative pond effluent - It treats wastewater prior to irrigation without chlorine	Removal of BOD ranges (90-99%) Removal of nitrogen ranges (10-77%) Removal of fecal coliform ranges	

	Unit Process/ Treatment	Classification / Description	Removal efficiency	Process design and operating parameters
		disinfection - Economical for flows up to (11.625 m^3/d) - It is accompanied with drip irrigation for reuse applications **2. Multipass (Recirculating) packed-bed filters (RPBFs)** - It treats septic tank effluent with flows up to (3785 m^3/d) - it nitrify pond effluent prior discharge to constructed wetlands - it treats septic tank effluent prior to UV disinfection and water reuse **3. Other packed-bed filters** 3.1 Absorbent plastic-medium filter (Waterloo biofilter) - It uses absorbent plastic medium for aerobic treatment 3.2 Textile packed-bed filter (textile biofilter) - as alternative to sand and granular filters - utilize no woven textile chips 3.3 Peat filters - peat is a permeable absorbent medium filter	(97.9-99.9%) Typical performance: BOD ranges (4-6 mg/ l) TSS ranges (4-6 mg/ l) Nitrogen removal percent of (44-82%) Removal of BOD 93.5- 98.4 % Removal of TSS 93.9% Removal coliform 99.99% Removal of BOD 96% Removal of TSS 95% NH_3 as N 90% Total N as N 80% Total P as P 58% Total coliform 99.9%	
		(4) Constructed wetlands		
1.	**Subsurface-flow constructed wetlands (SF)** It is constructed wetland with the flow beneath the	It has the advantages of smaller land area requirements and avoidance of odor and mosquito problems as compared to free-water surface (FWS). The disadvantages are the increase costs due to the gravel media and the potential for clogging of the media	Removal of BOD (65%) with the effluent of BOD =< 8-25 *mg/ l* TSS <= *10 mg/ l* N <= 10 *mg/ l* , (20-70%) removal Pathogen removal of 99% (2 log)	

	Unit Process/ Treatment	Classification / Description	Removal efficiency	Process design and operating parameters
	surface of a gravel or sand medium. The vegetation is bulrush, reeds, cattails.		of total coliform	
(5) Lagoons				
	The four major types of lagoons, based on the presence and source of oxygen are:			
1.	**Aerobic lagoons**	Photosynthesis provides oxygen for aerobic conditions throughout the water coloum		
2.	**Facultative lagoons**	Surface zone is aerobic. Subsurface zone may be anoxic or anaerobic		
3.	**Partial-mix aerated lagoons**	Surface aeration produces aerobic zone that ranges from half depth to total depth depending on oxugen input and lagoon depth.		
4.	**Anaerobic lagoons**	Entire depth is anerobic.		

Source: developed by the researcher, based on : Crites and Tchobanoglous, 1998; EPA, 2002

Table 7.6: Critical design factors and sizing criteria of some unit operations and processes

Unit operation or process	Critical design factors	Sizing criteria
Wastewater pumping and piping	Maximum hour flowrate	Flowrate
Screening	Maximum hour flowrate Minimum hour flowrate	Flowrate Channel approach velocity
Grit removal	Maximum hour flowrate	Overflow rate
Primary sedimentation	Maximum hour flowrate Minimum hour flowrate	Overflow rate Detention time
Activated sludge	Maximum hour flowrate Maximum organic load	Mean cell residence time Food/microorganism ratio
Trickling filter	Maximum hour flowrate Maximum hour flowrate Maximum organic load	Hydraulic loading Hydraulic and organic loading Mass loading/medium volume
Secondary sedimentation	Maximum hour flowrate	Overflow rate or detention time
Chlorine contact tank	Maximum hour flowrate	Detention time
UV disinfection	Maximum day or week flowrate	Dose

Source: EPA, 2000-b; Crites and Tchobanoglous, 1998

Table 7.7: Percolation rates and application rates of wastewater for different soil textures

Soil Texture	Percolation Rate (min/cm)	Application Rate (Lpd/m2)
Gravel, coarse Sand	<0.4	not suitable
Coarse to medium sand	0.4 - 2.0	49
Fine to loamy Sand	2.4 - 5.9	33
Sandy loam to Loam	6.3 - 11.8	24
Loam, porous Silt	12.2 - 23.6	18
Silty clay loam, clay loam	24.0 - 47.2	8
Clay, colloidal clay	>47.2	not suitable

Source: EPA, 2000d; Crites and Tchobanoglous, 1998

Table 7.8: Typical wastewater reuse and disposal options for small and decentralized systems

Option	Example
Constructed wetlands	Free water surface Subsurface flow
Discharge to water bodies	Streams, lakes, ponds, reservoirs, bays, ditches, rivers, oceans
Evaporation systems	Evapotranspiration beds Evaporation ponds
Land application	Surface application Spray application Drip application
Reuse applications	Agricultural irrigation Landscape irrigation Groundwater recharge Habitat wetlands Non-potable supply Industrial supply Recreational lakes Water supply augmentation
subsurface soil disposal	Soil absorption systems - *Conventional leachfields* - *Shallow trench pressure dosed leachfields* - *Shallow sand-filled pressure dosed leachfields* - Drip irrigation (integral or external emitters) Seepage beds Mound systems Fill systems At-grade systems

Source: Crites and Tchobanoglous, 1998

Table 7.9: Sludge processing and disposal methods

Processing/ disposal method	**Unit operation, unit process, or treatment method**
	Small systems
Preliminary operations	Sludge pumping Sludge grinding
Thickening	Gravity thickening Gravity belt thickening Lagoons
Stabilization	Aerobic digestion Sludge storage basins Composting
Disinfection	Composting Lime stabilization Long-term storage
Dewatering	Belt filter press Sludge drying beds Lagoons Reed beds
Composting	Aerated static pile Windrow
Ultimate disposal	Land application Landfill

Adapted from: Crites and Tchobanoglous, 1998

Table 7.10: Important factors (checklist) for evaluation and selection of unit operation/unit process

Factor	Comment
1.Process applicability	The applicability of a process is evaluated on the basis of past experience, data from full-scale plants, published data, and pilot plant studies. If new or unusual conditions are encountered, pilot plant studies are essential.
2. Applicable flow range	The process should be matched to the expected range of flowrates. For example, stabilization ponds are not suitable for extremely large flowrates.
3. Applicable flow variation	Most unit operations and processes have to be designed to operate variation over a wide range of flowrates. Most processes work best at a relatively constant flowrate. If the flow variation is too great, flow equalization may be necessary.
4. Influent wastewater characteristics	The characteristics of the influent wastewater affect the types of characteristics processes to be used (e.g., chemical or biological) and the requirements for their proper operation.
5. Inhibiting and unaffected constituents	What constituents are present and may be inhibitory to the treatment constituents processes? What constituents are not affected during treatment?
6. Climatic constraints	Climatic constraints Temperature affects the rate of reaction of most chemical and biological processes. Temperature may also affect the physical operation of the facilities. Warm temperatures may accelerate odor generation and also limit atmospheric dispersion.
7. Reaction kinetics and reactor selection	Reactor sizing is based on the governing reaction kinetics. Data for reactor selection kinetic expressions usually are derived from experience, published literature, and the results of pilot plant studies.
8. Performance	Performance is usually measured in terms of effluent quality, which must be consistent with the effluent discharge requirements.
9. Treatment residuals	The types and amounts of solid, liquid, and gaseous residuals produced must be known or estimated. Often, pilot plant studies are used to identify and quantify residuals.
10. Sludge processing	Are there any constraints that would make sludge processing and disposal infeasible or expensive? How might recycle loads from sludge processing affect the liquid unit operations or processes? The selection of the sludge processing system should go hand-in-hand with the selection of the liquid treatment system.
11. Environmental constraints	Environmental factors, such as prevailing winds and wind directions and proximity to residential areas, may restrict or affect the use of certain processes, especially where odors may be produced. Noise and traffic may affect selection of a plant site. Receiving waters may have special limitations, requiring the removal of specific constituents such as nutrients.

Factor	Comment
12. Chemical requirements	What resources and what amounts must be committed for a long period of time for the successful operation of the unit operation or process? What effects might the addition of chemicals have on the , characteristics of the treatment residuals and the cost of treatment?
13. Energy requirements	The energy requirements, as well as probable future energy cost, must be known if cost-effective treatment systems are to be designed.
14. Other resource requirements	What, if any, additional resources must be committed to the successful implementation of the proposed treatment system using the unit operation or process being considered?
15. Personnel requirements	How many people and what levels of skills are needed to operate the unit operation or process? Are these skills readily available? How much training will be required?
16. Operating and maintenance requirements	What special operating or maintenance requirements will need to be provided? What spare parts will be required and what will be their availability and cost?
17. Ancillary processes	What support processes are required? How do they affect the effluent quality, especially when they become inoperative?
18. Reliability	What is the long-term reliability of the unit operation or process being considered? Is the operation or process easily upset? Can it stand periodic shock loadings? If so, how do such occurrences affect the quality of the effluent?
19. Complexity	How complex is the process to operate under routine or emergency conditions? What levels of training must the operators have to operate the process?
20. Compatibility	Can the unit operation or process be used successfully with existing facilities? Can plant expansion be accomplished easily?
21. Land availability	Is there sufficient space to accommodate not only the facilities currently being considered but possible future expansion? How much of a buffer zone is available to provide landscaping to minimize visual and other impacts?

Source: Crites and Tchobanoglous, 1998

APPENDIX (8)

Security lighting

Table 8.1: Distance Factor (DF)

Mounting Height	3m	5m	8m
Spacing (m)	**Distance Factors**		
10	1.51	1.41	0.95
12	1.00	1.05	0.80
14	0.68	0.79	0.67
16	0.48	0.60	0.55
18	0.35	0.46	0.46
20	0.26	0.36	0.38
22	0.20	0.28	0.32
24	0.16	0.23	0.27
26	0.13	0.19	0.23
28	0.10	0.15	0.19
30	0.08	0.13	0.16
32	0.07	0.11	0.14
34	0.06	0.09	0.12
36	0.05	0.08	0.11
38	0.04	0.07	0.09
40	0.04	0.06	0.08

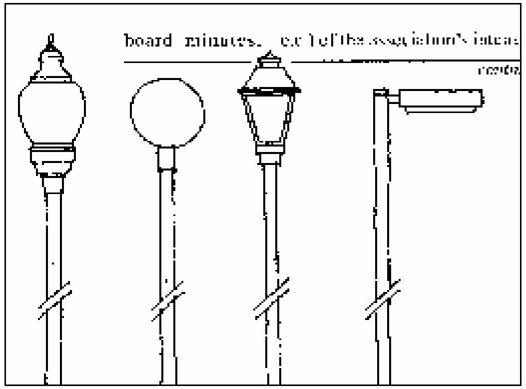
Source: Cotton and Tayler, 2000

Table 8.2: Lighting terminology

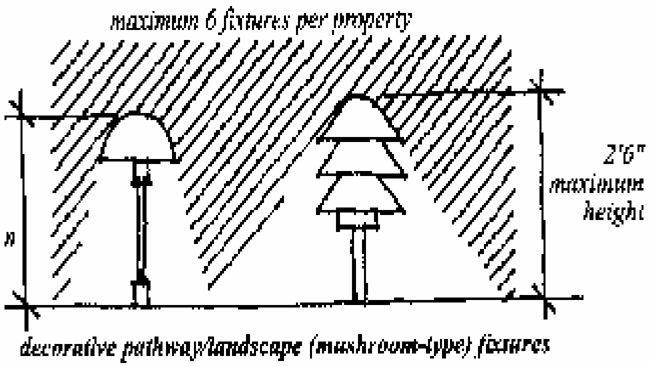
Terminology	Description
1. Photometric terms	
Light	Describe the radiant energy that is capable of being perceived by the eye.
Luminous flux	Is the light given out by a light source in all directions. The unit is lumen *(lm)*
Luminous intensity	It describes the light-giving power (candlepower) of a light source in any direction. The unit is candela *(cd)*
Illuminance (E)	Is the density of luminous flux incident on a surface which is receiving light from a lantern. Its unit is the lux *(lx)* where 1 lux = 1 lumen per square meter (lm/m^2)
Luminance (L) Photometric brightness	It is the luminous intensity reflected from a unit projected area of an illuminated surface in a given direction. The unit is $(L = cd/m^2)$. Average luminance recommended for traffic routes according to british standards are (0.5 L) for local distribution roads and residential area major access roads, (1 L) for important rural and urban traffic routes and district distribution routes, and (1.5 L) for high soeed roads and dual carriageway roads.
2. installation terms	
Lighting installation	Refers to the entire equipment provided for the lighting of a road surface. it comprises the lamp(s), lantern(s), means of support and the electrical and other auxiliaries

Terminology	Description
Lamp	It is the light source or bulb. Their types include incandescent, fluorescent, low and high-pressure sodium and low and high-pressure mercury. -The Cluster lamps should be of white light (fluorescent) lamps, compatible in type/size/color/material, low glare, low voltage, shielded, directable downward.
1-Fluorescent lamps	The most popular for lighting residential areas/ it emits a white light which is the most natural light for the human eye, provides a modern appearance, and it is the most efficient with regard to energy requirements. New models are small and simple because they do not require transformer part.
2-High-pressure sodium (HPS)	Suitable for lighting minor and major streets. The 400-W high pressure sodium vapor lamps have a "creamy" color and provide A "golden-white" light output, and have rated llife of 15-28 x 10^3 years.
3-High-pressure mercury	It has a bluish-white color which adds to its desirability because of its aesthetic value. It is used where white light is required, but requires auxiliary equipment and more complex circuitry for operation.
4-Photovoltaic lamps(PV)	They convert solar radiation into electricity through the photoelectric effect by using photovoltaic. They are economical in the long-term for exterior lighting..
Luminaire (lantern)	Is a complete lighting unit consisting of the lamp together with its housing and other features
Lighting column (lighting standard)	Is the pole that is used to support a luminaire and is made of steel, aluminum, fiberglass or wood. Utility line poles often used to mount luminaires in residential areas, which also could be mounted from walls of buildings.
Mounting height (MH)	Is the nominal distance between the carriageway surface and the photometric centre of the luminaire, i.e. the center of the lamp. Mounting height varies from 5m to more than 30m, but is usually *8m, 10m or 12m. 8m* are used in narrow roads (local distributors and access roads to residential areas). *10m* are commonly used on urban traffic routes. *12m* is used on wide or heavily trafficked routes. In villages and housing developments, they are low as *5.7m* (the minimum permissible clearance). As MH increases the spacing of the poles increases.
Spacing	Is the distance between successive luminairs in an installation, measured parallel to the centre line of the carriageway. Typically, spacing is *3 MH to 5 MH* for most traffic routes, and *6 MH to 8 MH* on more minor routes. On sharp bends and intersections, the spacing have to be closer than on street sections
Lighting arrangement	Is the pattern to which luminaires are sited in plan view. The lighting arrangements used on single carriageways are single sided, staggered and central plus opposite and for narrow streets, they are single sided or staggered with the choice being influenced by the effective carriageway width. Central arrangements are now commonly associated with dual carriageways.

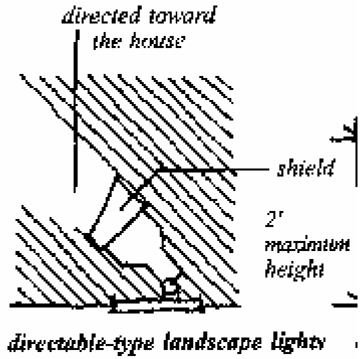
Source: Cotton and Tayler, 2000; Homburger et al., 2001; O'Flaherty, 1997



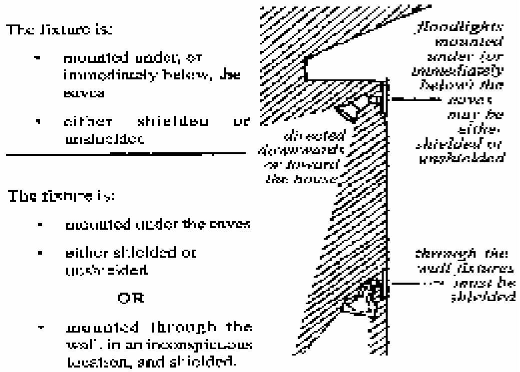
(a) landscape lighting poles



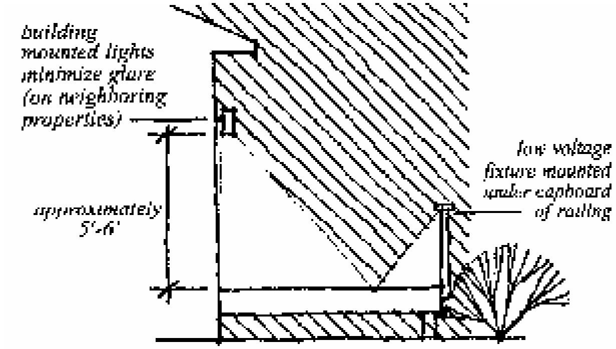
(b) landscape lighting "mashroom"



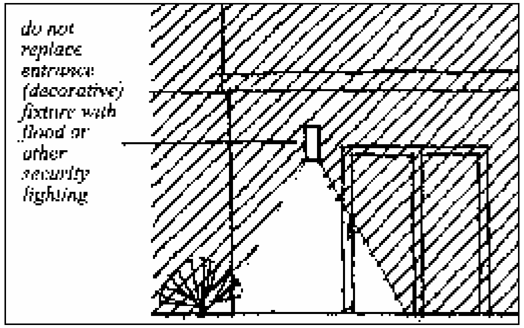
(c)directable-landscape lights



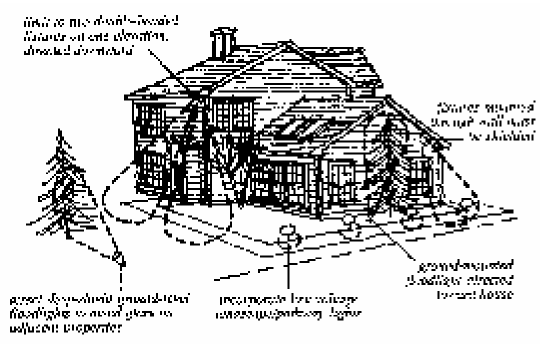
(d) Directed down-shielded security lighting



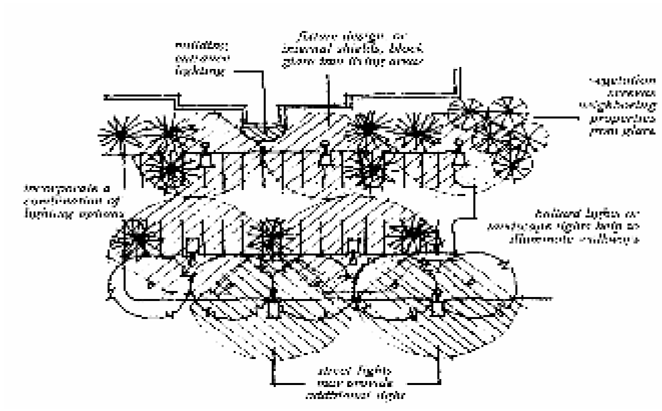
(d) Building mounted lights



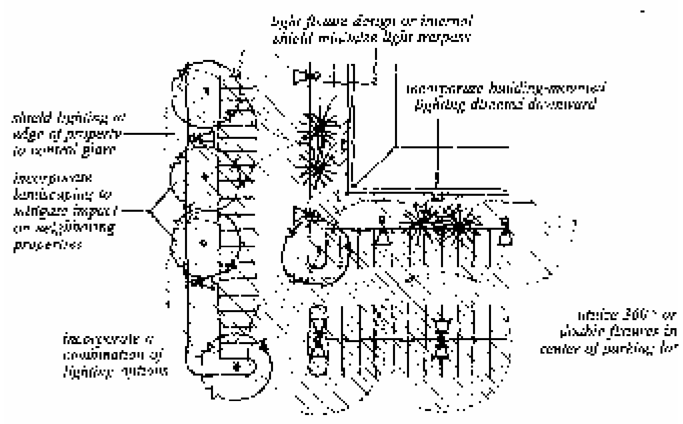
(e) Entrance (decorative) light



(f)options of building lighting



(g) Combination of lighting options-2



(h) Combination of lighting options-1

Figure 8.1: Options of landscaping and building floodlighting

Source: RA, 2004

APPENDIX (9)

Access and paving

Table 9-1: Comparison between the different types of pavements

Pavement type	Description and characteristics	Minimum Thickness	Applicability	O&M
(1) Unbound pavement	Unbound pavements can be formed from gravel, hardcore or water-bound macadam.			
1. Gravel roads	Consist predominantly of stones in the size range 6mm-20mm, with about 10% of fine material to act as a binder. Where washed gravel is used, fine river sand may be used as the binder.	*1- lightly trafficked roads* **(150 mm)**, total compacted thickness for with up to about **100 vehicle** movements per day. *2- heavily trafficked* **(300mm)**, total thickness for *roads with more vehicles*.	- Not used in areas subjected to frequent flooding - Good for formation of new ways - Only when less than 100 vehicles per day - Easily upgraded - Suitable when good gravel readily available locally	- Regular maintenance to replace lost gravel - Deep rut holes due to settlements need pre-filling with stones - Communities can manage total maintenance; requires minimum tools. - Keep some stock of gravel locally is required.
2.Water-bound macadam	Consists of coarse aggregates, mechanically interlocked by rolling and bound together by screenings and/or stone dust and water. Whichever material is used, it should be rolled to achieve compaction, using a 6-8 ton roller. This will not be possible in narrow streets and lanes although reasonable results might be obtained using a small vibrating roller.	1- *lightly trafficked roads* a water-bound macadam thickness of **(115mm)**, laid on **(75mm)** of gravel or clinker, will be appropriate. 2- The maximum size of aggregate should not exceed three quarters of the total consolidated thickness of any one layer of construction. Suggested size ranges for different types of aggregate are:	- lasts for (5) years for up to (100) vehicles per day, depending on quality for aggregates and filler material. - Not suitable for areas subjected to flooding. - Easily upgraded by addition of bituminous surface dressing; good base for flexible or rigid pavements. - used from 0.5 to 2 years prior to surfacing to allow for compaction of underlying soil.	- Annual maintenance costs 5% of original capital costs; renewal of surface after 5 years costs about 50% of original costs. - Occasional spreading of sand or other non cohesive soil over the surface improves performance for vehicular traffic. - Regular repair of pot-holes with aggregate. - spread of gravel or filter material whenever surface is

Pavement type	Description and characteristics	Minimum Thickness	Applicability	O&M
		- Soft stone/broken brick (40-63mm) - Hard stone (20-50mm)		worn out or aggregate is exposed. - Requires mainly unskilled labor and suitable for community involvement. - Aggregate may be exposed if the binding material washes out during the rain. This requires immediate replenishment.
(2) Brick and block pavements	- Bricks are often used to pave slightly trafficked areas. Such pavements are durable, reasonably cheap and have the advantage that they can be laid without expensive equipment. - Where bricks are not available, the option of using commercially produced concrete block pavers is considered.			
1. Segmental paving(Interlock)	**Segmental paving** is a form of paving in which the surface is composed of elements made of stone, precast concrete, burnt clay or timber and small enough to be handled manually. It is a British name for the locally known interlock pavement. **Sett paving** is a surface consisting of rectangular blocks of stone or concrete, laid in a regular arrangement upon a prepared road base. Shaped block/ paver is a block or paver which is not rectangular in plan shape. **Interlock** is the development of friction between adjoining segmental paving units that allows them to act in an integrated structural fashion rather than as individual units.	Thickness are of (6mm) or (8mm) with minimum compressive strength of (45Mpa) **- lanes width <3.5m** Minimum thickness is (100mm); 60 mm paver and 50 mm sand. **- lanes width >3.5m** minimum thickness is (130mm); 80 mm paver and 50mm sand - joints not more than (5 mm) wide, and grouted with sand	- Very good for "pedestrian only" and two-wheeler access. - When a paving system that is adaptable, economic, long lasting and easy to maintain is required. - Where there are requirements both for a structurally practical pavement and for one that is visually attractive. - Easily excavated for service lines. - Useful Where there is a lot of sub-soil settlement; very flexible and does not crack, and easy to replace blocks. - In areas where resistance to softening by oil or petroleum is required. - Easy to lay in irregular pathways and speculative residential areas.	- Potentially low maintenance costs are required. - The maintenance works are limited to day-to-day cleaning and routine inspection for defects or surface irregularities. - The need for more day-to-day cleaning is to keep its visual attractiveness. - The surface cleaning can be done by sweeping which could be carried out manually or mechanically. - Regular routine inspection should be made and defects should be rectified quickly to prevent personal injury accidents. - It is simple to lift the defective units, reconstruct the underlying layers and reinstate or replace

Pavement type	Description and characteristics	Minimum Thickness	Applicability	O&M
	The extent of the interlock will be influenced by the element plan shape and laying pattern or both.		- The versatility of segmental paving forms is regarded to the opportunities to improve the appearance of the landscapes of residential areas, pedestrian precincts, town centers, gardens and parks, and ample scope to exercise their aesthetic design skills. - Can be upgraded to stronger pavement. - Last for 5-10 years; may require total removal and refixing any time after this.	any damaged ones easily and invisibly. - The routine maintenance of these pavements does not require any specialist equipment or skills although extra care is requires in their early life. - Communities can manage total maintenance; require minimum tools. - After excavations for service lines, only blocks on the trench need to be re-fixed. - When settlements or stones are broken, it is advisable to refix entirely using new blocks.
2. Voided paving/ Sett paving	Voided paving is a form of paving built of voided blocks and designed to provide hard-standings for vehicles but still allow grass to grow in the voids. This provides many of the benefits while avoiding appearance of hard landscaping. It name in Germany is Sett paving. The voids are filled to within 10-15mm of the surface with top soil or a soil-and-peat mixture, which is then sown with grass seed. Finally the seed is covered with a thin layer of soil.	- Some voided pre-cast concrete segments are slabs with plan dimensions approximately (600 x 400 mm) and thickness of (125-150 mm) and others are designed to be used in conjunction with proprietary shaped blocks. - They are placed on a lying course of very coarse clean sand, overlying an unbound sub-base. - The nominal laying coarse thickness should be (25 mm), which in these cases must be pre-compacted	Voided blocks are useful compromise paving system in that they provide a hard surface for parking of light vehicles, but still allow vegetation to grow and leave an appearance of a grassed area which breaks the massive appearance of large parking areas. The voids also allow rainwater to percolate through the paving and therefore there is no need for special surface water drainage. The use of this type for large parking areas may result in a higher initial cost, compared with surfacing with bituminous	

Pavement type	Description and characteristics	Minimum Thickness	Applicability	O&M
			material, but it is largely offset by lower surface water drainage costs.	
3. Eco-stone permeable pavement	The Eco-Stone is innovative, environmentally-beneficial pavement. They are true interlocking concrete pavers that offer the structural strength and stability of traditional concrete pavers, and provide a highly durable, yet permeable pavement capable of supporting vehicular loads, combined with benefits of stormwater management.	The dimensions are thickness of (8mm), length of (230 mm) and width of (140mm) It is laid on angular gravel of (30cm) thickness, laid on a bedding layer.	- They are suitable for pedestrian, trafficked and heavy duty applications. - Decreases project costs by reducing or eliminating drainage and retention systems required by impervious pavements and reduces the cost of compliance with many stormwater regulatory requirements.	
(3) 'Black-top' roads: flexible pavements	Conventional black top roads consist of a weather-proof surface layer laid over a granular base; it is the road base which provides structural strength. The base is usually laid over a sub-base. Surfacing materials fall into two main categories.			
1. Surface dressings	Consist of a layer of stone chippings bonded to the road surface by a thin continuous film of bitumen. It is cheaper than bituminous surfacing but has a shorter design life, typically about 6 years as opposed to 10 years or more for a bituminous carpet.		- They can be used for surfacing new roads, when it is usual to apply two or occasionally three layers, and for rehabilitation of existing road surfaces. Surface dressing is frequently used to pave through roads in informal areas. - Surface dressing <u>will not normally be an option for narrow lanes</u>, because (1) other pavement options are cheaper and (2) the rolling which is essential if the surface is to be of good quality will be difficult or impossible.	

Pavement type	Description and characteristics	Minimum Thickness	Applicability	O&M
2. Premixed bituminous surfacing	- Are usually coated macadams, where graded aggregate is coated with a bituminous binder with the aggregate interlock providing most of the strength of the material. - Dense bitumen macadam is sometimes referred to as asphalt concrete. Premixed material is produced by special equipment; it is usually possible to achieve reasonable quality control. A single bituminous layer, laid by a mechanical paving machine, is normally specified with a granular base and sub-base. - Movable small scale `donkey' plants may be used to prepare coated macadams on site for narrow streets but it is difficult to ensure quality control of site mixed material.	- for minor through routes, (150mm) depth is required; (50mm) dense bitumen macadam on (100mm) rolled stone base on (100mm) rolled stone or broken brick sub-base.	- Suitable where there are more than 100 vehicles per day. - Surface dressing can be undertaken by small contractors. - It is rapidly destroyed by petrol; problems arise near automobile repair shops. - Since the life of the pavement depends on the strength of the base; good drainage is essential. - More prone to damage be extreme conditions such as floods than concrete roads. - It is not suitable for use in narrow streets and lanes because of its cost and the physical difficulties involved in using mechanical equipment in restricted areas.	- bitumen syrfaced roads have a 15 year life for up to (3000) vehicle per day. - Annual costs are 2% of capital costs with new seal coat required after no more than 5 years costing 25% and renewal of the road after 15 years costing about 85% of the original capital cost. - regular sweeping and removal; of accumulated earth, which restricts drainage that contributes to rapid deterioration. - regular 'patching' for the repair of pot-holes and spots which have settled. - a trained labor is required to undertake the maintenance. - Manholes covers and frames must be raised since this pavement raises the road level. - Trench excavations for services must be rapidly reinstated to the necessary pavement standard.
(4) Cement Concrete pavements	Rigid pavements must have sufficient beam strength to bridge localized failures of the sub-grade and withstand the stresses that develop. They must also be able to withstand the stresses caused	*For lanes <3.5m* (50mm) 1:2:4 concrete on (60mm) 1:4:8 dry concrete base. *For streets and lanes >*	- Suitable for narrow tertiary streets and lanes. - Suitable for pedestrian and light vehicular traffic. - Widespread applications; hill slopes, weak soils, flood porne	- Durable and almost maintenance free. - Joints are expected in regular intervals and filler material should be replenished whenever required.

Pavement type	**Description and characteristics**	**Minimum Thickness**	**Applicability**	**O&M**
	by the concrete curing and temperature variations. Jointed unreinforced concrete is relatively inexpensive in many parts of South Asia for example; it is long lasting and is widely used to pave pedestrian access ways and lightly trafficked streets.	*3.5m* (50mm) 1:2:4 concrete on (100mm) 1:4:8 dry concrete base. *For minor through routes* (125mm) 1:2:4 concrete over (80mm) stone base	areas. - provides a strong durable, low maintenance surface - High initial cost, but low O&M costs. - lasts for 20 years. - Not used if excavation for services is used. - Good for road-as-drian. - Unsuitable if road level is to be raised in near future. - Construction is relatively quick.	- If surface tears out, either concrete or asphalt can be provided, and this requires skilled workers. Regular cleaning; easily to sweep.
Source: *developed by the researcher, adapted form: Cotton and Tayler, 2000; UNI, 2004*				

Table 9-2a: Cross section design criteria for urban streets

Design element	Arterial	Collector		local	
		Residential	Other	Residential	Other
Number of through traffic lanes	4 – 8	2	2 – 4	1 -2[a]	2 – 4
Width of traffic lanes, m	3.0 – 3.6	3.0 – 3.6	3.3 – 3.6	2.7 – 3.3[b]	3.0 – 3.6
Width of turn lanes, m	3.0	-	3.3 – 3.6	-	3.0 – 3.6
Width of CLT[c], m	3.3	-	3.3	-	-
Width of parking lane, m	3.0 – 3.6	2.1 – 3.0	2.4 – 3.0	2.1 – 2.4	2.7
Width of border/sidewalk area, m	2.4 – 3.6	2.4 – 3.3	2.4 – 3.3	1.5 – 3.0	1.5 – 3.0
Width of median, m	1.2 – 5.4[d]	-	0.6 – 4.8	-	-

a- One lane in low-demsity areas; but one 3.6 m lane flanked with two 2.2m parking lanes for a total roadway width of 8 m is a possible alternative for low-density roads.
b- 3.6 m if only one lane is provided
c- CLT continous two-way left-turn lane
d- Upper end of range based on accommodating left-turn lane at intersections
Note: for residential streets, minimum width of sidewalk is 1.2 -1.4 m wide, with the remaining width devoted to landscaping

Source: Homburger et al., 2001

Table 9-2b: Minimum paved width standards for different streets

Type of traffic	Paved width
Pedestrian only (connecting footpaths)	1.4 meters
Light local traffic (cluster access/local streets)	3.5 meters
Minibus routes (site distributer/ collector)	6 meters
Routes for commercial/ public vehicles (site access/ main street)	7.5 meters

Source: Cotton and Tayler, 2000

Table 9-3: Typical CBR values

		CBR Value (%)	
Soil Type	**Plasticity Index**	**Ground water depth < 600mm**	**Ground water depth > 600mm**
Heavy clay	70	1.5	2
	50	2	2.50
	40	2.50	3
Silty clay	30	3	5
Sandy clay	20	4	6
	10	5	7

Soil Type	Plasticity Index	CBR Value (%) Ground water depth < 600mm	Ground water depth > 600mm
Silt (unconsolidated)	-	1	2
Sand (poorly graded)	Non-plastic	10	20
Sand (well graded)	Non-plastic	15	40
Sandy gravel	Non-plastic	20	60

Source: Cotton and Tayler, 2000

Table 9-4: Minimum pavement thickness

Location	Traffic Intensity	California bearing ratio (%)					
		1.5	**2**	**3**	**5**	**8**	**12**
		Pavement thickness (mm)					
Lanes< 3.5m (footpaths)	Light	150	125	100	75	60	50
Local access lanes and streets > 3.5 (local streets)	Light	210	170	130	100	75	55
Minor through routes (collector streets)	Medium	325	275	230	160	125	90
Major through routes (main streets)	Heavy	610	525	425	300	225	175

Source: Cotton and Tayler, 2000

Table 9-5: Minimum construction standards

Lanes less than 3.5m wide - (min. thickness = 100mm) (footpaths)
- Bricks/ Interlock pavers (60mm) laid on (50mm) sand
- Bricks / interlock pavers(60mm) laid on (20mm) mortar on (25mm) sand
- (50mm) 1:2:4 concrete on (60mm) 1:4:8 dry concrete base
Streets and lanes greater than 3.5m wide – (min. thickness = 130 mm) (Local streets)
- Bricks/ interlock pavers (60/80mm) laid on (50mm) sand
- Bricks/interlock pavers (60/80mm) laid on (20mm) mortar on (25mm) sand
- (50mm) 1:2:4 concrete on (100mm) 1:4:8 dry concrete base
Minor through routes – (min. thickness = 230 mm) (Collector streets)
- (50mm) dense bitumen macadam on (100mm) rolled stone base on (100mm) rolled stone or broken brick sub-base.
- Double surface treatment on (200mm) rolled stone base.
- (125mm) 1:2:4 concrete over (80mm) stone base
Major through routes – (min. thickness = 425 mm) (Main streets)
The pavement construction is dependent on the amount of traffic carried and follows the local standards for highway design

Source: Cotton and Tayler, 2000

Table 9.6: Pavement classes for some roads without known TL

Type of road	Construction calss	Traffic load number (TL)
Service road (footpath)	**V**	10 – 60
Collector road (pedestrian and light traffic)	**IV**	60 – 300
Main road/ industrial road/ pedestrian road with heavy traffic	**III, II**	III **à** 300 - 900 II **à** 900 - 1800

Source: Jendia, 2000, German RStO 86 method for structural paving

Table 9.7: Pavement classes for parking places

Type of use		Construction class	Traffic load number (TL)
Parking places with frequent uses	PC only	VI	<10
	PC, trucks, low buses	V	10-60
Parking places with rarely uses	PC, trucks, low buses	VI	<10
	Trucks, low buses	V	10-60

Source: Jendia, 2000, German RStO 86 method for structural paving

Table 9.8: Thickness of pavement for different types of pavements according to German RStO 86 method

Type of use	Const. Class	Traffic load	Min. pavement thickness	Asphalt paving	Interlock paving
Footpaths	V	10-60	400 mm	---	80 (60)mm (interlock) 30 (50)mm (sand) on subgrade formation of 120MN/m^2 or 300 (270)mm (subbase)
Local and Collector streets	IV	60-300	400 mm	Used for collector streets: *(1) a pavement consists of* (40mm) wearing course, (140mm) asphalt course, (220mm) kurkar sub-base *or* *(2) double-surface treatment consists of:* 2 layers of surface treatment, each one of (15mm) on (100mm) basecourse on 200mm kurkar sub-base.*	80mm (interlock) 30mm (sand) on subgrade formation of 150MN/m^2 or 300mm (subbase) OR 80mm (interlock) 50mm (sand) 270mm (subbase)
Main streets	III	300-900	500 mm	*(1) a pavement consists of* (40mm) wearing course, (40mm) binder course, (140mm) asphalt course on subgrade formation of 120MN/m^2 or (220mm) kurkar sub-base *or* *(2) a pavement consists of*	---

Type of use	**Const. Class**	**Traffic load**	**Min. pavement thickness**	**Asphalt paving**	**Interlock paving**
				(40mm) wearing course, (40mm) binder course, (100mm) asphalt course on subgrade formation of 150MN/m^2 or (320mm) kurkar sub-base	
Parking places with frequent use- (PC only)	VI	<10	400 mm	*(1) a pavement consists of* (40mm) wearing course, (100mm) asphalt course on subgrade formation of 120MN/m^2 or (260mm) kurkar sub-base	80mm (interlock) 30mm (sand) on subgrade formation of 120MN/m^2 or 290mm (subbase)

*Source: Jendia, 2000; * MPWH, 2004*

Table 9.9: Main elements and characteristics of street landscaping/amenities

Element	**Description**
Importance	The landscaping of the streets, including choice of materials, street furniture, and plantings, has a lasting impact on the appearance and use of the street.
Provision	In many countries, the community has a strong impact on the extent of landscaping of the streets, whereas the governments are willing to pay for the capital cost of special items only if the community is willing to participate in their maintenance.
Elements	Trees, paving materials, street furniture, and special lighting.
Trees and other plantings	Planting trees is one of the most effective ways to improve the appearance of a street. Trees should be planted in the ground and not in planters, and only varieties that have been proven to survive on streets, " street trees" should be used.
Paving material	It is a common practice in some countries to provide a strip along the curb of about (1.5m; for wide sidewalks) paved with bricks and locate all trees, signs, fire hydrants, and others within this strip.
Street furniture	This includes benches and seats, tables and wastepaper baskets which make the landscape area more attractive and invite people to use public areas. The cost of maintenance is an important factor in selecting the street furniture. Using standards designs is economical and allows for easy replacement of damaged pieces.
Special lighting	- Streetlights are often positioned to illuminate the roadway and not the sidewalk. Pedestrian areas not reached by regular street lights, and walkways and footpaths need special pedestrian lighting, which are only (3 to 4.5 m) height and create an atmosphere of comfort and safety for pedestrians.
Leftover street space used for pedestrian amenities (small sitting areas or parks)	- They are areas that are left over from the space needed for the actual roadway or sidewalk that can be used for public amenities. - They provide the opportunity for an improvement in public life, especially in low or middle income neighborhoods where people need to escape their small crowded apartments. - Some short service roads are not required; traffic islands can be enlarged or sidewalks extended to create space for additional amenities without adverse impact on smooth traffic flow

Source: developed by the researcher, Adapted from: Rainer, 1990

Table 9.10: Street widths and percentages in selected LCH projects in Gaza Strip

Project name	**Footpaths width**	**Local street width**	**Collector street width**	**Main street width**	**Percentage of the roads, circulation and parking**	**Type of development**
El-zahra city	N.A	12m, 16m	20m	30m	35.34%	Traditional subdivision lots design
El-nuzha-Beit lahia	N.A	12m, 14m, 16m	20m, 25m	34m	35%	Traditional subdivision lots design
مشروع القرعة الخامسة-العطاطرة-بيت لاهيا	N.A	10m, 12m	16m, 20m	20m	38.43%	Traditional subdivision lots design
El-awda city-Naser-gaza	Ranges from 3m, 5m, 6m, 7m,.., 10m, 11m	6m, 7m, 10m, 11m	16m, 20m	30m	38.43%	Cluster design
Tel-elhawa cooperative housing	N.A	12m, 14m	16m, 20m	30m	N.A	Traditional subdivision lots design

Source: based on site plans and information from Ministry of Local Government (MLG)

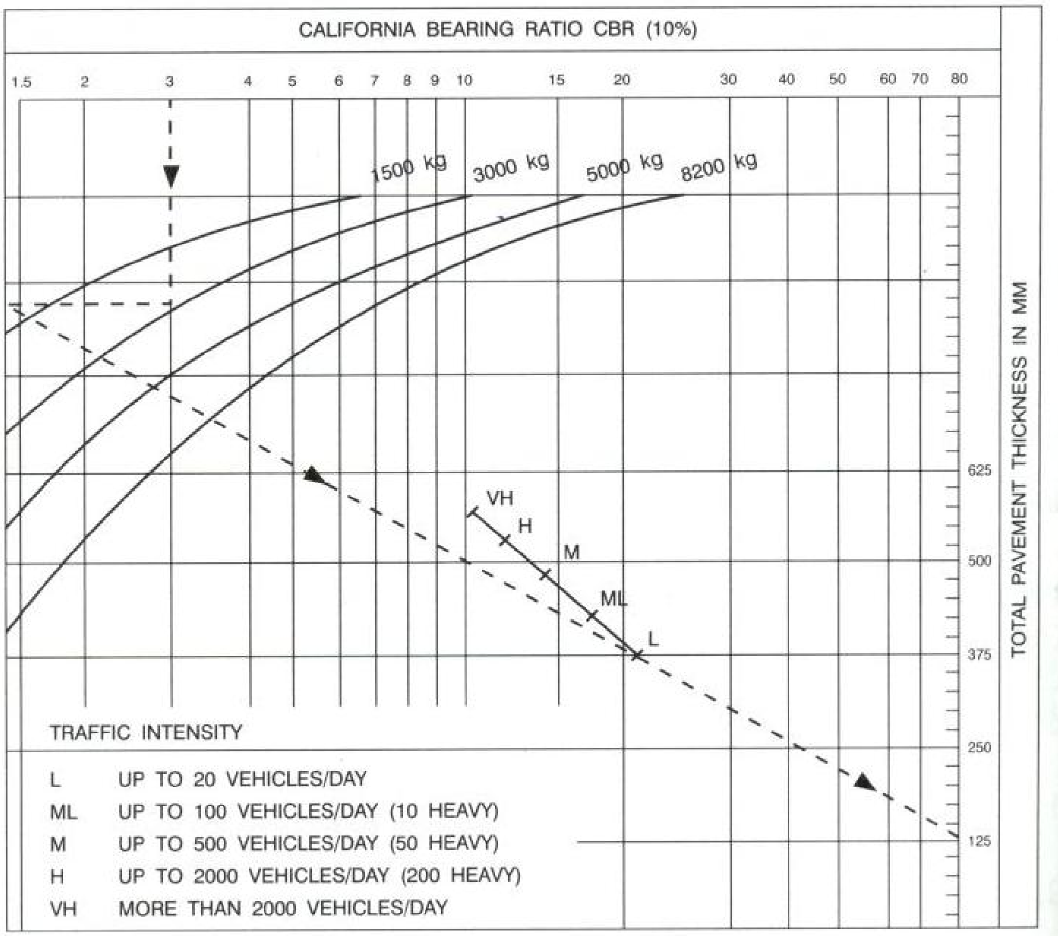


Figure 9-1: Design chart for calculation of pavement thickness

Source: Cotton and Tayler, 2000

APPENDIX (10)

Stormwater drainage

Table 10.1: Run-off Coefficient for Different Surface Types in Gaza Strip

Development	Coefficient
Pavement, Road/Parking	0.90
Commercial / Public lots	0.70
Residential Communities	0.60
Parks /Unimproved Areas/ and grass areas	0.30
Irrigation Areas	0.20
Natural Zones	0.05

Source: Khalaf, 2005

Table 10.2: Average (Avr.) and effective (Pe) Rainfall at different weather stations **in Gaza Strip through the period (1982-2004) calculated according FAO Formula**

Governorate	Average rainfall (mm)	Effective rainfall (mm)
Rafah	241.5	54.7
Khanyounis	306.0	120.0
Deir-Albalah	341.5	143.5
AlMoghraqa	389.1	177.8
AL-Nuseirat	374.6	209.4
ALShatie	428.8	205.1
Gaza	442.2	215.5
Beit-Hanoun	456.7	226.2
Beit-Lahia	472.6	234.7

Source: Khalaf, 2005

Table 10.3: The Intensity Duration Relationship for Various Return Periods in Gaza.

Return Period: 2 years – a: 4.06 – b:-0.636											
Duration	5 min	15 min	30 min	1 h	2 h	3 h	6 h	12 h	18 h	24 h	P_j= p24h X 0.875
Rainfall (mm)	7.3	10.9	14	18	23.2	26.9	34.6	44.5	51.6	57.3	50
Return Period: 5 years – a: 6.18 – b: 0.649											
Duration	5 min	15 min	30 min	1 h	2 h	3 h	6 h	12 h	18 h	24 h	P_j= p24h X 0.875
Rainfall (mm)	10.9	16	20.4	26	33.2	38.2	48.8	62.2	71.7	79.4	69
Return Period: 10 years – a: 7.95 – b: 0.660											
Duration	5 min	15 min	30 min	1 h	2 h	3 h	6 h	12 h	18 h	24 h	P_j= p24h X 0.875
Rainfall (mm)	13.7	20	25.3	32	40.5	46.5	58.8	74.4	85.5	94.2	82
Return Period: 20 years – a: 9.39 – b: 0.665											
Duration	5 min	15 min	30 min	1 h	2 h	3 h	6 h	12 h	18 h	24 h	P_j= p24h X 0.875
Rainfall (mm)	16.1	23.3	29.3	37	46.7	53.5	67.5	85.1	97.5	107	94
Return Period: 50 years – a: 11.89 – b: 0.675											
Duration	5 min	15 min	30 min	1 h	2 h	3 h	6 h	12 h	18 h	24 h	P_j= p24h X 0.875
Rainfall (mm)	20.1	28.7	35.9	45	56.4	56.4	64.3	80.5	100.9	155.1	111
Return Period: 100 years – a: 13.60 – b: 0.682											
Duration	5 min	15 min	30 min	1 h	2 h	3 h	6 h	12 h	18 h	24 h	P_j= p24h X 0.875
Rainfall (mm)	22.7	32.2	40.1	50	62.3	70.9	88.4	110.2	125.4	137.4	120

Source: Khalaf, 2005

Table 10.4: Infiltration Rate of Various Soil Types in Gaza Strip Based on Infiltrometer Reading and Horton's Equation *

Soil Type	**Codes, Locations, area of different soil types			% from the total area	Initial infiltration f_o(mm/min)	Basic infiltration 1.1 f_b(mm/min)	*K*	Infiltration Rate *f(mm/min)*
	Code	Location	Area (m^2)					
Loess Soil	1	Gaza City	18837495	06.6	07.14	2.03	0.08	**07.0**
	4	Wadi Gaza	5082675					
	Total area = 23920170.75							
Dark brown / Reddish brown	2	Gaza, Wadi Gaza	15805892	13.7	17.52	3.48	0.11	**16.0**
	6	Wadi Alslqa +Al-Qarara	4549557					
	11	Beit Hanoun	29290185					
	Total area = 49645634.95							
Sandy Loess Soil	3	Deir Albalah + Zaweda+ Maqhazi	26035828	09.0	4.51	1.10	0.06	**04.3**
	8	Abssan	4615097					
	9	Rafah	1866893					
	Total area = 32517819.55							
Loessial Sandy Soil	5	Deir Albalah+ Al-Qarara Khanyounis + Rafah	82937834	23.0	8.31	2.43	0.08	**07.9**
		Total area = 82937834.35						
Sandy Loess over Loess	7	Khanyounis + Rafah	58324040	16.2	5.96	1.62	0.08	**06.0**
	Total area = 58324040.84							
Sandy regosols	10	It is founded along the Coastal plain of Gaza Strip	113848480	31.5	21.05	6.69	0.24	**18.0**
	Total area = 113848480.34							
Total soil Types Area			***361193981 m^2***	%100				

Source: Khalaf, 2005

Horton equation:** $f = f_c + (f_o - f_c)\, e^{-kt}$*   ** ***Code according to the location of the soil

APPENDIX (11)

Telecommunication / Telephone lines

Table 11.1: Comparison between the types of the telephone cabling plants (current practice

Item	Aerial (aboveground) telephone Network	Underground telephone Network
Size and Location of the new housing project	1) New housing projects in existing urban areas that are already provided by aerial lines. 2) small projects in far rural areas. 3) when new housing development is planned to be implemented incrementally during a long period of time.	1) Housing projects in urban areas. 2) Large housing projects in distant new developed rural or suburban areas.
System description	An old method, but still used when needed.	New method, adopted for all the new developments
Elements of the telephone network	Consists of poles , aerial cables, buildings connections and distribution board and other accessories.	Consists of manholes, underground trenches, pipe conduits for cables, cables, building connection with distribution board at each building and other accessories.
Aesthetic issue	Has undesirable appearance since the cable and wires are visible. .	More aesthetic, since the aerial wires and cables are not visible.
Standards and regulations	According to PALTEL standards and regulations.	
Planning and design works	Done by the PALTEL company, in coordination with MPWH/ developer	
Materials and devices	All the needed materials and devices are defined and purchased by PALTEL company according to its specifications.	
Construction and installation works	Done by : PALTEL Company through contracting a private firm, or by its own staff.	Done by either: 1) PALTEL Company through contracting a private firm. 2) Excavation works and installation of underground ducts are sometimes executed by developer/MPWH contractor under the supervision of PALTEL, while the installation works of cables and devices by PALTEL.
Capital costs	All the capital costs including planning, design, materials, devices, excavations and installation works are paid by the PALTEL company.	
Maintenance works	The maintenance works include the maintenance of the wooden poles and the overhead cables, especially in case of heavy rain or accidents and needs skilled manpower and	The maintenance works are negligible, since all installations are underground and not subjected to external effects, and they are the responsibility of PALTEL.

Item	Aerial (aboveground) telephone Network	Underground telephone Network
	they are the responsibility of PALTEL.	
Life-cycle costs	Aboveground (exposed) cable plants have a much higher life-cycle costs than do underground plants of comparable size.	
Costs and cost recovery	There are two types of fees: (1) One-time paid connection fees for getting the telephone line to recover construction costs. (2) Bimonthly bills which include: (1) constant fees to recover to O&M costs (2) Cost of the calls.	

Source: Developed by the researcher

APPENDIX (12)

O&M and Management

Table 12.1: Types of maintenance

Type of maintenance	**Description**
Preventative maintenance	-It is systematic pre-scheduled activities or programs of inspections and maintenance activities aimed at the early detection of defects and implementation of actions to avoid breakdowns or infrastructure deterioration. - It is "pre-active"; these activities are conducted before a defect occurs. - Their costs are low.
Corrective maintenance	- It is activities conducted as a result of breakdowns or noticeable infrastructure deterioration, such as making repairs, fixing something. - It is "reactive" that is carried out after some defect is discerned.
Routine maintenance	it is preventive and corrective maintenance carried out more than once a year. These activities are defined on the basis of operating hours.
Periodic maintenance	It is preventive maintenance activities carried out less often than once a year, such as once every two to five years. These tasks are often programmed in predetermined plans or schedules.
Rehabilitation	It refers to activities carried out to correct major defects in order to restore a facility to its intended operational status and capacity, without significantly expanding it beyond its originally planned or designed function or extent

Source: HABITAT, 1993

Table 12.2: Summary of EPA guidelines for management of onsite/decentralized wastewater systems

Model Program	Typical Application	Management Objectives	Benefits	Limitations
1	Areas of low environmental sensitivity, where conventional onsite systems are adequate to protect water quality and public health.	**SYSTEM INVENTORY AND AWARENESS OF MAINTENANCE NEEDS** To ensure conventional onsite/decentralized systems are sited and installed properly in accordance with appropriate State/tribal/local regulations and codes and are periodically inspected, maintained, and repaired as necessary. Regulatory agency is aware of the location of Systems and periodically provides owners with operation and maintenance information.	Relatively easy and inexpensive to implement and maintain. (Programs are based upon conventional, prescriptive system designs that rely upon conservative site criteria and system design requirements promulgated in codes.)	No mechanism to ensure operating compliance of systems. No mechanism to identify problems before failures occurs. Limits building sites to those meeting prescriptive requirements.
2	Areas such as wellhead or source protection areas, where sites are marginally suited for conventional systems, requiring alternative, enhanced treatment systems to be implemented.	**MANAGEMENT THROUGH MAINTENANCE CONTRACTS** To allow the use of more complex mechanical treatment options in areas of higher density or some environmental sensitivity. Requires maintenance contracts to be maintained between the owner and equipment manufacturer/ supplier or service provider over the life of all systems.	Reduces the risk of failure through the requirement for routine maintenance of mechanical components by skilled personnel.	State/tribal/local agency may have difficulty tracking and enforcing compliance with the maintenance requirements and/or contract.
3	Environmentally sensitive areas, such as where conventional systems are a potential threat to drinking or shellfish growing waters. Engineered designs are needed, to meet specific performance requirements based on site characteristics.	**MANAGEMENT THROUGH OPERATING PERMITS** To allow the use of onsite/decentralized treatment on sites with a greater range of characteristics than allowed by prescriptive codes. Establishes specific and measurable performance requirements, renewable operating permits, and regular compliance monitoring reports, in addition to requiring maintenance contracts.	Increases the range of sites suitable for onsite/decentralized treatment. Avoids problem of owner not managing system adequately and continues to operate a non-compliant system. Reduces the risk of failures by requiring that performance requirements be met to renew limited term operating permit.	Needs a higher level of technical/engineering expertise to implement.

Model Program	Typical Application	Management Objectives	Benefits	Limitations
4	Areas where there is suspected impairment of receiving waters such as sole source aquifers, critical aquatic habitats, outstanding natural resource waters, or other where the environmental and technology concerns require reliable, long-term system operation and maintenance.	**UTILITY OPERATION AND MAINTENANCE** To ensure that onsite/decentralized treatment systems consistently meet their performance requirements through the creation of public or private utilities that are responsible for the performance of systems within the service area. The utilities are issued operating permits for the systems and maintain them, but system ownership remains with individual property owners.	Responsibility for operation and maintenance is transferred from the owner to a professional utility that has an economic incentive to comply with the operating permit. Routine inspections may identify obvious problems before system failure occurs. Reduced number of permits requiring oversight by regulatory agency.	Additional regulatory oversight needed to evaluate and ensure that the utility is technically and financially viable. Potential conflicts between owner and operator. Requires authorizing legislation.
5	Same environmental and public health conditions as under Model Program4. EPA recommends applying Model Program 5 in areas of new, dense development.	**UTILITY OWNERSHIP AND MANAGEMENT** To provide professional management of the siting, design, construction, operation, maintenance, etc. of onsite/decentralized systems through the creation of public or private utilities that own and manage systems within the service area.	Simulates the municipal model of central sewerage by transferring all responsibility from the property owner to a professional entity, reducing risk of non-compliance to lowest level. Allows effective area-wide wastewater planning through integration of onsite/decentralized systems with conventional sewerage. Avoids conflicts between owner and operator.	Property owner may oppose utility's easement to property for the system. Additional regulatory oversight needed to evaluate and ensure that the utility is technically and financially viable. Greater financial investment by utility due to purchase of systems and components. Requires authorizing legislation.

Source: EPA, 2000b

APPENDIX (13)

Selection of the Case Study

Table 13.1 a: Summary of information of the selected housing projects (1) and (2)

Item	Sub-Item	Housing Project (1)	Housing Project (2)
Name		**Al-Zahra Housing City**	**Austrian Housing Project(AHP)**
		General description	**General description**
Location		5 km south of Gaza City- near Mughraka area	Khanyounis - Adjacent to an Israeli settlement- near Khanyounis Refugee Camp & Naser Hospital
Municipal jurisdiction		Lies under the jurisdiction of Al-Zahra Municipality	Lies under the jurisdiction of Khanyounis Municipality
General description		It started on 1997. it location is considered to be strategic and important, it lies at south of Israeli settlement (Nitsareem). It aims to control the israeli settlement expansion in Gaza Middle. This project is planned to offer adequate housing for the limited income people. The city also includes specified areas for cooperative housing	The project has bben executed under an agreement between the Federal Chancellery of the Republic of Austria and the (MoH) OF THE Palestine National Authority (P.N.A) on the project "residential buildings in Khanyounis and Nublus". The project consists of (10) buildings, 5-stories each. each typical floor area is (420m2) and includes (4 apartments; six buildings include shops in the backside of the ground floor. the Austrian non-repayable contribution of (5 million dollars) has covered the cost of soil investigation, building construction, the on-site infrastructure, and the Austrian consultant fees. the MoH will contribute the land, prepare the design, issue the tenders, supervise the project implementation, pay the necessary fees, and provide the off-site infrastructure.
Targeted brackets of households(Beneficiaries)		(1) Limited income people, (2) Middle income people	Middle income people
Design of the Project	The Designer	Private developers	MoH with cooperation with Austrian consultant
	Site Design Concept	Traditional design	Cluster design
Financial source		Partnership between MoH and private developers	Republic of Austria Governemnt - Khanyounis

Item	**Sub-Item**	**Housing Project (1)**	**Housing Project (2)**
Name		**Al-Zahra Housing City**	**Austrian Housing Project(AHP)**
			Nablus Housing Fund
Implementation of the project		Local contractors for the different project components under direct supervision of the MoH	Local contractors under direct supervision of MoH.
Type/Source of land of the project		Governmental Land	Governmental Land
Total project land area (m2)		**334,000.00**	**20,000.00**
Land Area of implemented housing buildings (m2)		14,000.00	134,090.00
Total future housing units		**2,200**	**1,500**
Expected future population		**15,500**	
		Housing Buildings Information	**Housing Buildings Information**
Housing Buildings Information		**The housing buildings are of five stories, with (4) H.U. per each floor**	**The housing buildings are of five stories, with (4) H.U. per each floor**
No. of planned project phases		**N.A.**	**1**
No. of housing buildings in the planned phases		**33**	**11**
No. of implemented project phases		**N.A.**	**1**
No. of implemented housing buildings		**27**	**8 complete, 2 partial complete, and 1 until ground beams**
No. of stories in each building		**5**	**5**
No. of housing units per floor		**4**	**4**
No. of planned Housing Units (H.U.) in the planned phases		**688**	**220**
Average gross area of H.U. - (m2)		**82.65 & 96.6 & 101.78 & 118.23**	**85.4 & 107.17**

Item	Sub-Item	Housing Project (1)	Housing Project (2)
Name		**Al-Zahra Housing City**	**Austrian Housing Project(AHP)**
No. of implemented housing units (H.U.)		**540**	**188**
TOTAL number of implemeted H.Us.		**540**	**188**
Remarks		**Not executed buildings are due to problems between contractors and ministry**	**Some buildings has (18H.U.) and others has (20H.U.)**
Cost ($) of implemented Housing Buildings-(with vats) **Cost ($) of implemented Housing Buildings-(without vats) – DONOR GRANT FUND**		**15,662,143.10**	**4,472,467.25** **3,543,403.73**
Contingencies (building registration - planning and design - supervision - soil investigation)	These figures are approximate and sometimes are not available or included in other costs NOTES NOTES	**197,223.20** Design & Supervision cost is (1.0$/m2), License Fees is (2.2$/m2) - was not added to final cost	**3,612.50** Soil investigation costs is (3,612.5$) - was added to final cost Planning cost is (3$/m2), License Fees is (2.2$/m2), contingency is (4.41$/m2) - was not added to final cost
Land Cost ($) **NOTE: for land issue**	In case of governmental land, the cost of land is estimated just for calculation but it was excluded from the final cost as Gov. subsidy.	**0.00** the estimated cost of land was (75$/m2)	**0.00** the estimated cost of land was (60$/m2), and the estimated cost of buildable land is (472,560.0$)
Total Cost of Building Construction		**15,859,366.30**	**3,547,016.23**

Item	Sub-Item	Housing Project (1)	Housing Project (2)	
Name		**Al-Zahra Housing City**	**Austrian Housing Project(AHP)**	
		Basic Infrastructure Components (BIC) Information	**Basic Infrastructure Components (BIC) Information**	
Cost ($) of Infrastructure Components	1) Site works, Roads, Side Walks, Open Areas, Parks	797,917.70	1) Site works, Roads, Side Walks, Green Areas with chairs, Parks	163,542.70
	2) Sewege Network (waster collection)	256,477.50	2) Sewege Network Works	39,652.40
	3) (wastewater treatment and disposal)	0.00	3) (wastewater treatment and disposal)	
	4) Water Network Works	88,736.80	4) Water Network Works	18,376.90
	5) Storm Water Network Works	0.00	5) Storm Water Network Works	0.00
	6) Electrical Works:	N.A	6) Electrical Works - High Voltage Network [Transformer rooms No. (3), 1250KVA transormers (2) , UPVC pipes for cables and others]	157,445.20
	7) Telephone Network Works	1,234.00	7) Telephone Network Works	6,545.20
	8) Street Lightening Works	11,741.00	8) Street Lightening Works + Low Voltage Network	50,703.40
			9) Additional Works	45,025.20
Total Cost of (BIC)		**1,156,107.00**	**481,291.00** **NOTE: VAT IS EXCLUDED**	
Total Cost of (Construction & BIC)		**17,015,473.30**	**4,028,307.23**	

Item	**Sub-Item**	**Housing Project (1)**	**Housing Project (2)**
Name		**Al-Zahra Housing City**	**Austrian Housing Project(AHP)**
Percent (%) of BIC costs to the total cost (BIC plus Buildings) of the project		**6.79%**	**11.95%**
Average H.U.(building only) - (with vat)		**26,660.87**	**25,553.80**
Average H.U.(building & land) - (with vat)		**29,678.09**	**27,838.90**
Average H.U.(building & infrastructure) - (with vat)		**29,853.00**	**28,369.30**
Average H.U.(building & land & Infrastructure) - (with vat)		**32,870.30**	**30,654.40**
		Supportive Infrastructure Components (SIC)	**Supportive Infrastructure Components (SIC)**
Planned (SIC)		4 schools, 1 babygarden, 1 health centre, 1 cultural centre,1 mosque, 1 bus station, 1 commercial building, 1 police centre, municipality place, gardens, playgrounds	2 school, 1 mosque, 1 public market, municipal facilities
Implemented public services		1 mosque, 1 school	None

Source: developed by the researcher based on data from MPWH, 2004

Table 13.1 b: Summary of information of the selected housing projects (3), (4) and (5)

Item	Sub-Item	Housing Project (3)	Housing Project (4)	Housing Project (5)
Name		**Sheikh Zayed Housing Township**	**Ein Jalout Housing development**	**Khanyounis Re-housing Project**
Location		Beit Lahya	Nusairat	Khanyounis
Municipal jurisdiction		Beit Lahya Municipality	Nusairat Municipal council	Khanyounis Municipality
General description		the Sheikh Zayed Township when completed will provide for about (3500) housing units and occupied with (25,000) population of middle income, in an integrated planned residenrial community complete with the basic infrastructure of roads, water, sewage, electricity, telephone and support facilities. The Township will appropriately and tastefully landscaped and will be interwoven with a well netted system of footbaths. the Township will be the first major housing development in the Gaza Strip and shall serve as an example and catalyst for future housing developments.	N.A	This project has been planned and implemented to re-house the refugee femilies whise homes were demolished by the Israeli army during El-Aqsa Intifada and bacme homeless. It is executed in governmental land and funded by foreign donors. The project has been designed and executed by UNRWA. Thus, it has taken into consideration the Unrwa criteria of housing projects. the project land has been distributed into parcels and each one includes one building of (1-3)floors according to the number of couples for each family.
Targeted brackets of households(Beneficiaries)		Middle income people	(1) Limited income people, (2) Middle income people	Refugee families whose homes have been demolished during El-Aqsa Intifada.
Design of the Project	The Designer	Diwi Consultant Internatioal in Association with AJ/B and AA Associates	Palestinian Coumcil for Housing	UNRWA
	Site Design Concept	Cluster design	Traditional design with Multistory	Small land lots with compact design. The housing building in each lot consists of (1-3) floors for households from the same family (extended families) for considerations of social

Item	Sub-Item	Housing Project (3)		Housing Project (4)	Housing Project (5)	
Name		**Sheikh Zayed Housing Township**		**Ein Jalout Housing development**	**Khanyounis Re-housing Project**	
					issues. Cutting down the costs while raising the quality of the dwelling unit.	
Financial source		Abu Dhabi Fund for Development - Grant from President Sheikh Zayed Bin Sultan Al Nahyan		European Union	Foreign donors	
Implementation of the project		The main contractor is the CCC International Company, which subcontract local Palestinian contractor (Zafer Company) under the direct supervision of Diwi Consultant and top supervision of the MPWH, for all components of the project		Private local contractors	Private local contractors	
Type/Source of land of the project		Part of the land area is governmental, and the other part is privately owned		private land	Governmental land provided from the PLA	
Total project land area (m2)		**527,000.00**		**10,000.00**	**67,000.00**	
Land Area of implemented housing buildings (m2)		134,090.00		134,090.00	134,090.00	
Total future housing units		**3,500**		**N.A.**	N.A.	
Expected future population		**25,000**		**N.A.**	N.A.	
		Housing Buildings Information		**Housing Buildings Information**	**Housing Buildings Information**	
Housing Buildings Information		**Type(1)- five story building - (2) H.U. per floor**	**Type(2)- twelve story building - (3) H.U. per floor**	**Type(1)- nine story building - one ground floor and eight repeated floors, (4) H.U. per floor**		
No. of planned project phases		**1**	**2**	**1**	**4**	
No. of housing buildings in the		**70**	**25**	**10**	**224**	

Item	Sub-Item	Housing Project (3)		Housing Project (4)	Housing Project (5)
Name		Sheikh Zayed Housing Township		Ein Jalout Housing development	Khanyounis Re-housing Project
planned phases					
No. of implemented project phases		1	2	1	3
No. of implemented housing buildings		70	1	10	149
No. of stories in each building		5	12	9	ranges from 1 to 3
No. of housing units per floor		2	3	4	1
No. of planned Housing Units (H.U.) in the planned phases		700	900	320	206
Average gross area of H.U. - (m2)		123.85	136.00	102.5 & 116.5	41 & 60 & 80 & 98 & 121
No. of implemented housing units (H.U.)		700	36	320	206
Total number of implemented H.Us.		736		320	206
Remarks					The fourth phase has been postponed due to not availability of fund
Cost ($) of implemented Housing Buildings-(with vats)		39,436,561.00		8,803,935.00	3,215,997.22
Cost ($) of implemented Housing Buildings-(without vats) - DONOR GRANT FUND					

Item	Sub-Item	Housing Project (3)	Housing Project (4)	Housing Project (5)
Name		**Sheikh Zayed Housing Township**	**Ein Jalout Housing development**	**Khanyounis Re-housing Project**
Contingencies (building registration - planning and design - supervision - soil investigation)			**264,838.00**	**340,237.33**
Land Cost ($) **NOTE: for land issue**	In case of governmental land, the cost of land is estimated just for calculation but it was excluded from the final cost as Gov. subsidy.	**0.00** the estimated cost of land was (42.86$/m2), and the estimated cost of buildable land is (472,560.0$)	**1,000,000.00**	**0.00**
Total Cost of Building Construction		**39,436,561.00**	**10,068,773.00**	**3,556,234.55**
		Basic Infrastructure Components (BIC) Information	**Basic Infrastructure Components (BIC) Information**	**Basic Infrastructure Components (BIC) Information**
Cost ($) of Infrastructure Components	1) Site works, Roads, Side Walks, Open Areas, Parks	2,970,000.00	150,000.00	has been provided without cost information
	2) Sewege Network (waster collection)	1,210,000.00	19,952.00	has been provided without cost information
	3) (wastewater treatment and disposal)		N.A.	has been provided without cost information
	4) Water Network Works	1,120,000.00	N.A.	has been provided without cost information
	5) Storm Water	Included in sewage networks	N.A.	has been provided without cost information

Item	Sub-Item	Housing Project (3)		Housing Project (4)	Housing Project (5)
Name		**Sheikh Zayed Housing Township**		**Ein Jalout Housing development**	**Khanyounis Re-housing Project**
	Network Works				
	6) Electrical Works:	2,400,000.00		189,794.00	has been provided without cost information
	7) Telephone Network Works	350,000.00		N.A.	has been provided without cost information
	8) Street Lightening Works	Included in electrical works networks		Included in electrical works networks	has been provided without cost information
Total Cost of (BIC)		**10,840,338.00**		**359,746.00**	**1,272,299.80**
Total Cost of (Construction & BIC)		**50,276,899.00**		**10,428,519.00**	**4,828,534.35**
Percent (%) of BIC costs to the total cost (BIC plus Buildings) of the project		**21.56%**		**3.45%**	**26.35%**
Average H.U.(building only) - (with vat)		**53,582.28**	**53,582.28**	**28,339.92**	**17,263.27**
Average H.U.(building & land) - (with vat)		**57,548.82**	**55,693.68**	**31,464.92**	**N.A.**
Average H.U.(building & infrastructure) - (with vat)		**58,359.90**	**56,125.42**	**29,464.12**	**23,439.49**
Average H.U.(building & land & Infrastructure) - (with vat)		**62,631.44**	**58,510.61**	**32,589.12**	**N.A.**

Item	Sub-Item	Housing Project (3)	Housing Project (4)	Housing Project (5)
Name		**Sheikh Zayed Housing Township**	**Ein Jalout Housing development**	**Khanyounis Re-housing Project**
		Supportive Infrastructure Components (SIC)	**Supportive Infrastructure Components (SIC)**	**Supportive Infrastructure Components (SIC)**
Planned (SIC)		9 schools, health center and clinic, cultural centers, commercial centers, 2 mosques, 1 bus station, 1 benz station, gardens, playgrounds	N.A.	N.A.

Source: developed by the researcher based on data from MPWH, 2004; PCH, 2004; UNRWA, 2004

Table 13.2: Definition of criteria and weight factors for optimal selection

N	Criteria	Range of Criterion Options		Range of Criterion Score (1-10)	Weight Factor
1	Access to Information	(a)	Easy to access	Largest Score is (10)	**0.15**
		…	………	……..	
		(y)	Difficult to access	Smallest Score is (1)	
2	Location of Housing Project (Proximity to existing infrastructure facilities)	(a)	lies in the proximity of existing infrastructure facilities- (easy to connect with them)	Largest Score is (10)	**0.15**
		…	………	……..	
		(y)	lies far from the existing infrastructure facilities- (needs long network lines and separate water wells/ septic tanks/..etc)	Smallest Score is (1)	
3	Site planning & design	(a)	Cluster/compact/small land lots	Largest Score is (10)	**0.11**
		…	………	……..	
		(y)	Traditional/row-lined	Smallest Score is (1)	
4	Adequate Basic Infrastructure Components(BIC) Provision (roads/landscaping/water/sewerage/stormwater/electricity/street lighting/telephone)	(a)	Complete provision	Largest Score is (10)	**0.15**
		…	………	……..	
		(y)	Poor provision	Smallest Score is (1)	
5	Adopted techniques to lower the cost of Basic Infrastructure Components(BIC)	(a)	Used	Largest Score is (10)	**0.14**
		…	………	……..	
		(y)	Not-used	Smallest Score is (1)	
6	Availability of fund for BIC	(a)	Complete Availability	Largest Score is (10)	**0.05**
		…	………	……..	
		(y)	Very Poor Availability	Smallest Score is (1)	
7	Adopted techniques to lower the cost of Housing Units (H.U.)	(a)	Used	Largest Score is (10)	**0.1**
		…	………	……..	
		(y)	Not-used	Smallest Score is (1)	
8	Implementation Technique (Execution Firm)	(a)	Local Contractor / local supervision	Largest Score is (10)	**0.05**
		…	………	……..	
		(y)	Foreign Contractor/ Foreign Consultant	Smallest Score is (1)	
9	Long-term Management Strategy	(a)	Considered & arranged	Largest Score is (10)	**0.05**
		…	………	……..	
		(y)	Not- Considered & arranged	Smallest Score is (1)	
10	State of Completion	(a)	Housed by residents	Largest Score is (10)	**0.05**
		…	………	……..	
		(y)	Not- Housed yet	Smallest Score is (1)	
Summation					**1.00**
Note: Summation of weighted factors should be (1.0)					

Source: developed by the researcher

Table 13.3: Articulation of the selected housing projects over the multiple criteria

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		(10)	
Criteria	**Access to information**		**Location of Housing Project**		**Site Planning &design**		**Adequate Basic Infrastructure Components (BIC)**		**Adopted techniques to lower the cost of (BIC**		**Availability of fund for BIC**		**Adopted techniques to lower the cost of Housing Units (H.U.)**		**Implementation Technique/ (Execution Firm)**		**Long-term Management Strategy**		**State of Completion**	
Decision Variables	Criterion Score	Weight Factor	Criterion Score	Weight Factor	Criterion Score	Weight Factor	Criterion Score	Weight Factor	Criterion Score	Weight Factor	Criterion Score	Weight Factor	Criterion Score	Weight Factor	Criterion Score	Weight Factor	Criterion Score	Weight Factor	Criterion Score	Weight Factor
	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)
Sheikh Zayed Township																				
Austrian Housing Project (AHP)																				
El-Zahra City		0.15		0.15		0.11		0.15		0.14		0.05		0.1		0.05		0.05		0.05
Ein Jalout Housing Project																				
Khanyounis Rehousing Project																				

Source: developed by the researcher

Table 13.4: Optimization of the selected housing projects (Decision analysis)

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		(10)		**Weighted rating**	**Sorting the Case-Study**
Criteria	**Access to information**		**Location of Housing Project**		**Site Planning &design**		**Adequate Basic Infrastructure Components (BIC)**		**Adopted techniques to lower the cost of (BIC**		**Availability of fund for BIC**		**Adopted techniques to lower the cost of Housing Units (H.U.)**		**Implementation Technique/ (Execution Firm)**		**Long-term Management Strategy**		**State of Completion**			
Decision Variables	Criterion Score	Weight Factor#	Criterion Score	Weight Factor#	Criterion Score	Weight Factor#	Criterion Score	Weight Factor#	Criterion Score	Weight Factor#	Criterion Score	Weight Factor#	Criterion Score	Weight Factor#	Criterion Score	Weight Factor#	Criterion Score	Weight Factor#	Criterion Score	Weight Factor#		
	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	(1-10)	(0-1)	**(1-10)**	**(0-1)**
Sheikh Zayed Township	3		9		9		9		2		10		2		2		9		5		**5.92**	**4**
Austrian Housing Project (AHP)	9		7		9		9		8		10		7		9		9		8		**8.36**	**1**
El-Zahra City	9	**0.15**	7	**0.15**	7	**0.11**	5	**0.15**	1	**0.14**	2	**0.05**	6	**0.1**	9	**0.05**	6	**0.05**	9	**0.05**	**5.96**	**3**
Ein Jalout Housing Project	1		5		5		6		1		10		4		3		4		9		**4.19**	**5**
Khanyounis Rehousing Project	4		7		6		8		3		10		8		9		5		8		**6.33**	**2**

Source: developed by the researcher

APPENDIX (14)

Case Study: Drawings and Pictures

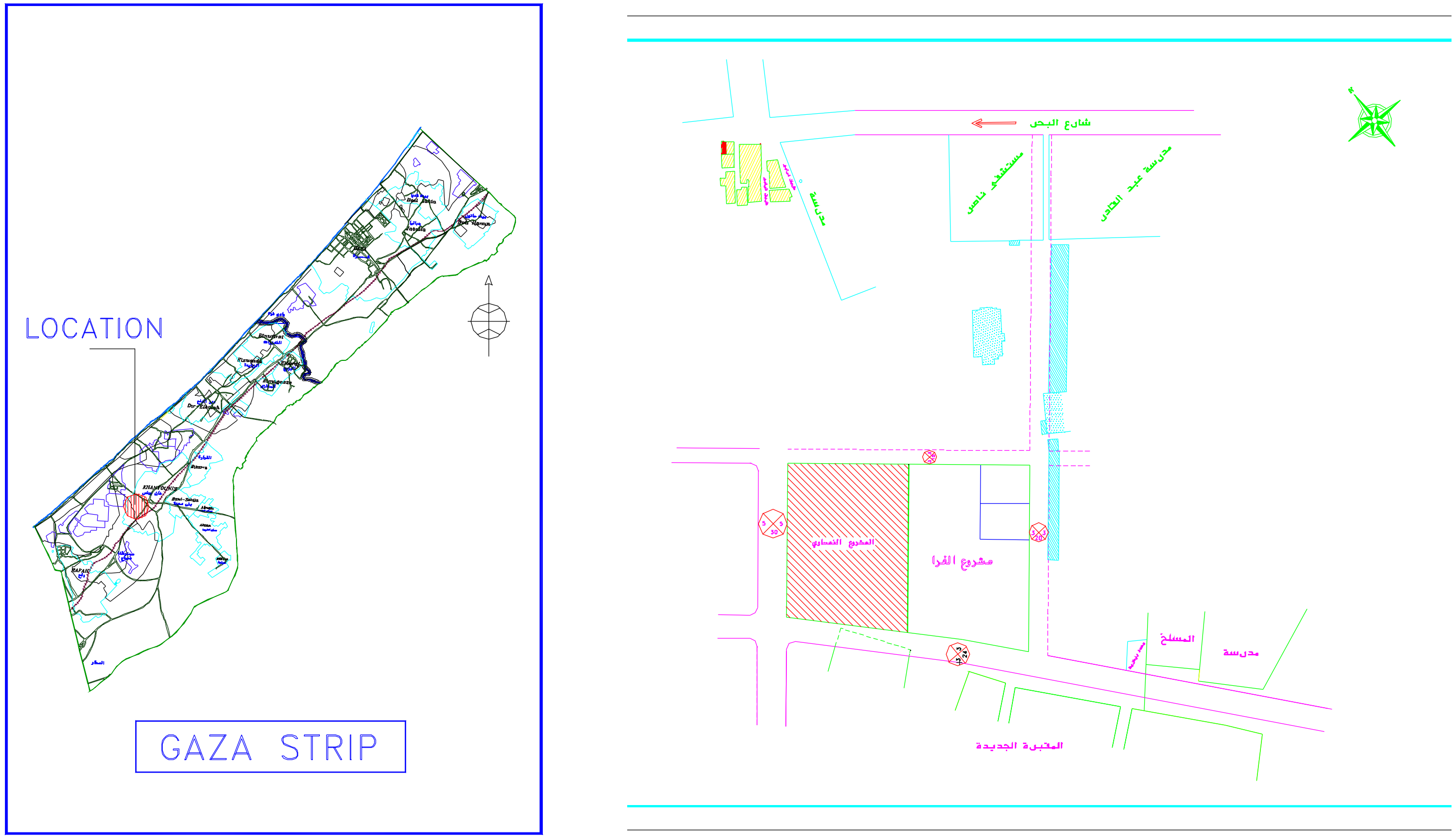


Figure S-1: Location of the AHP

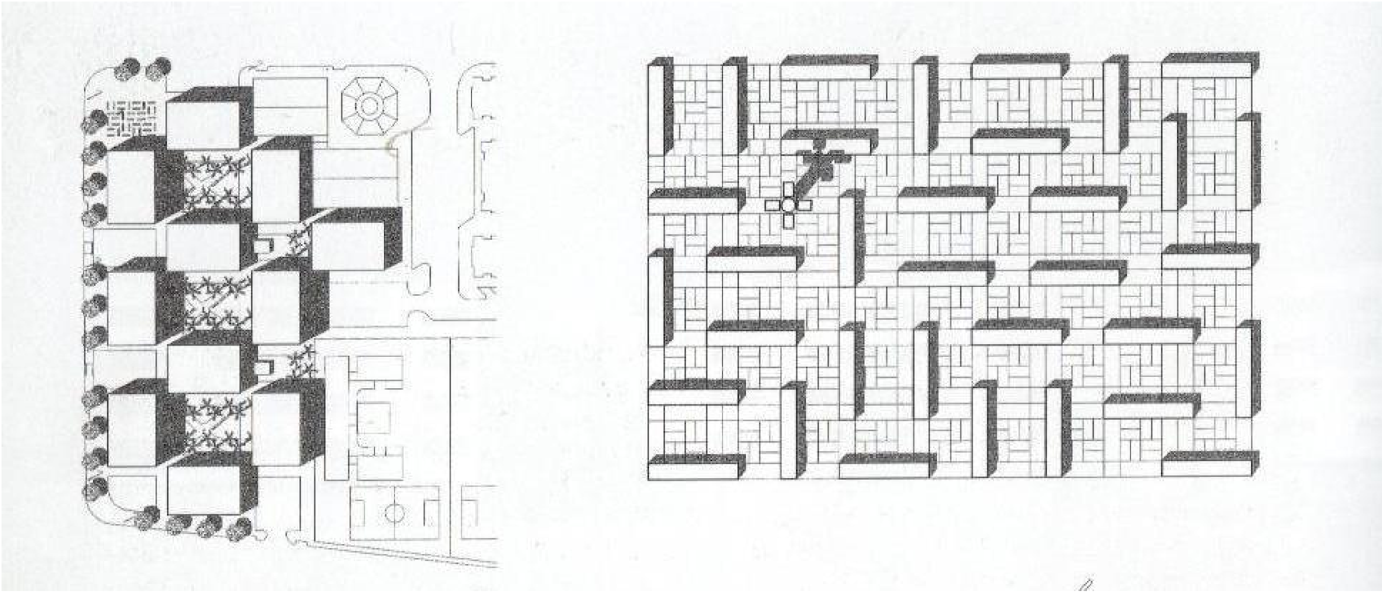


Figure S-2: Cluster design of the AHP

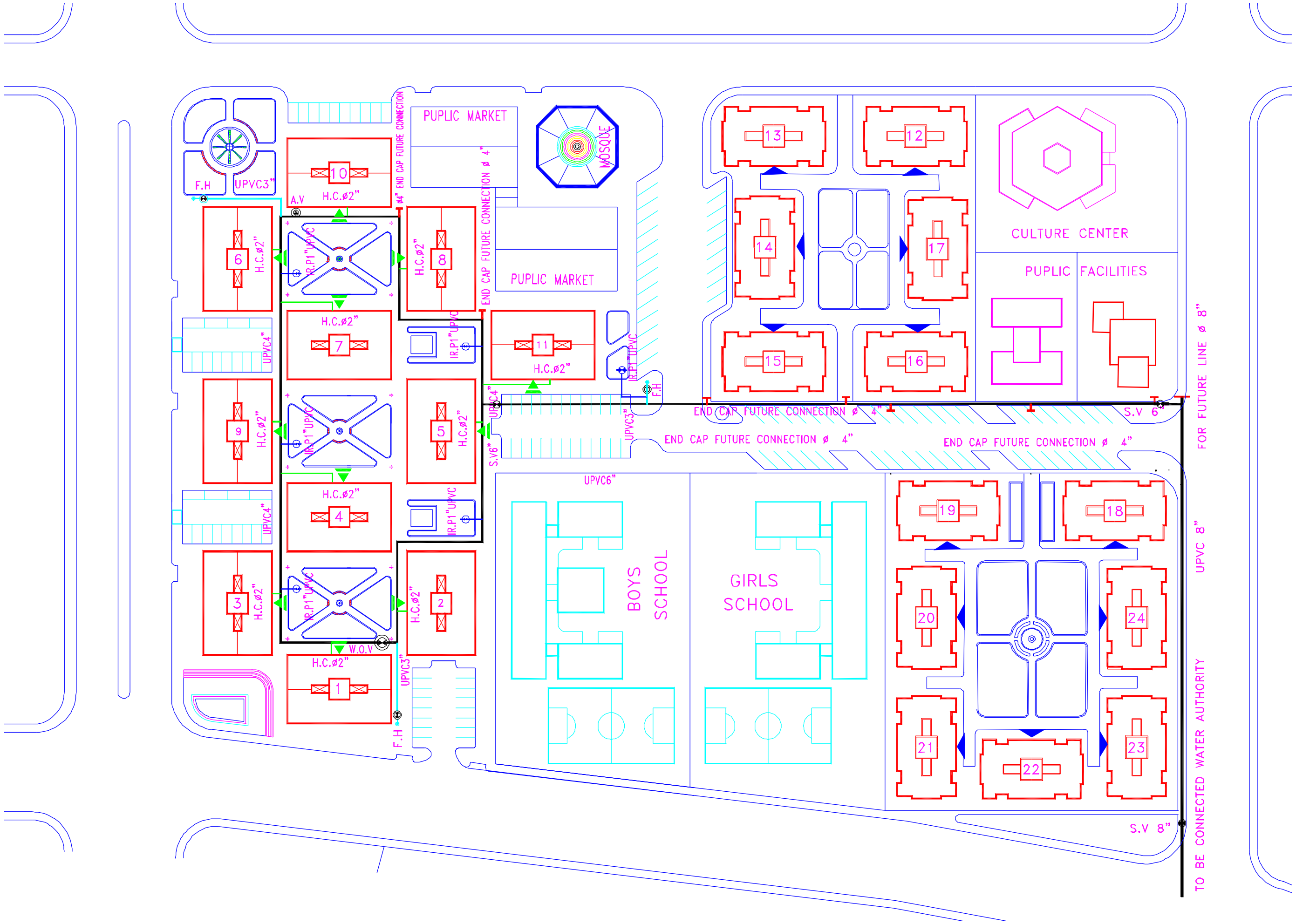


Figure S-3: Site plan of the AHP and EL-Farra project

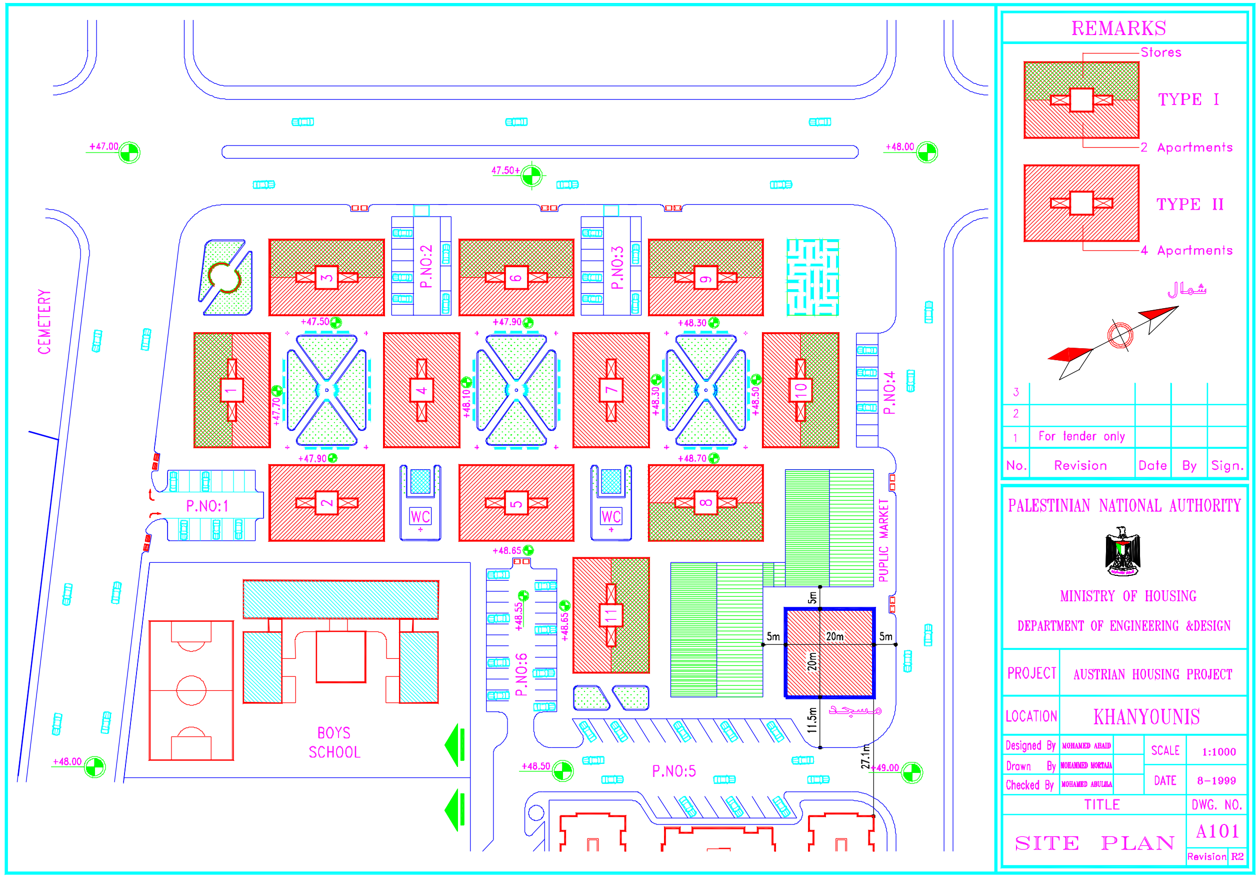


Figure S-4: Site plan of AHP

Figure S-5: Complete construction of 8 Bldgs. (1,2,3,4,6,7,9 and 10) – Bldgs. 3, 6 and 9 at front of the picture

Figure S-6: Partially constructed Bldg. 8 and Bldg. 11 up to the ground beam

Figure S-7: Damages to the AHP during EL-Aqsa Intifada

Figure S-8: EL-Farra project – nearby the AHP (damaged also)

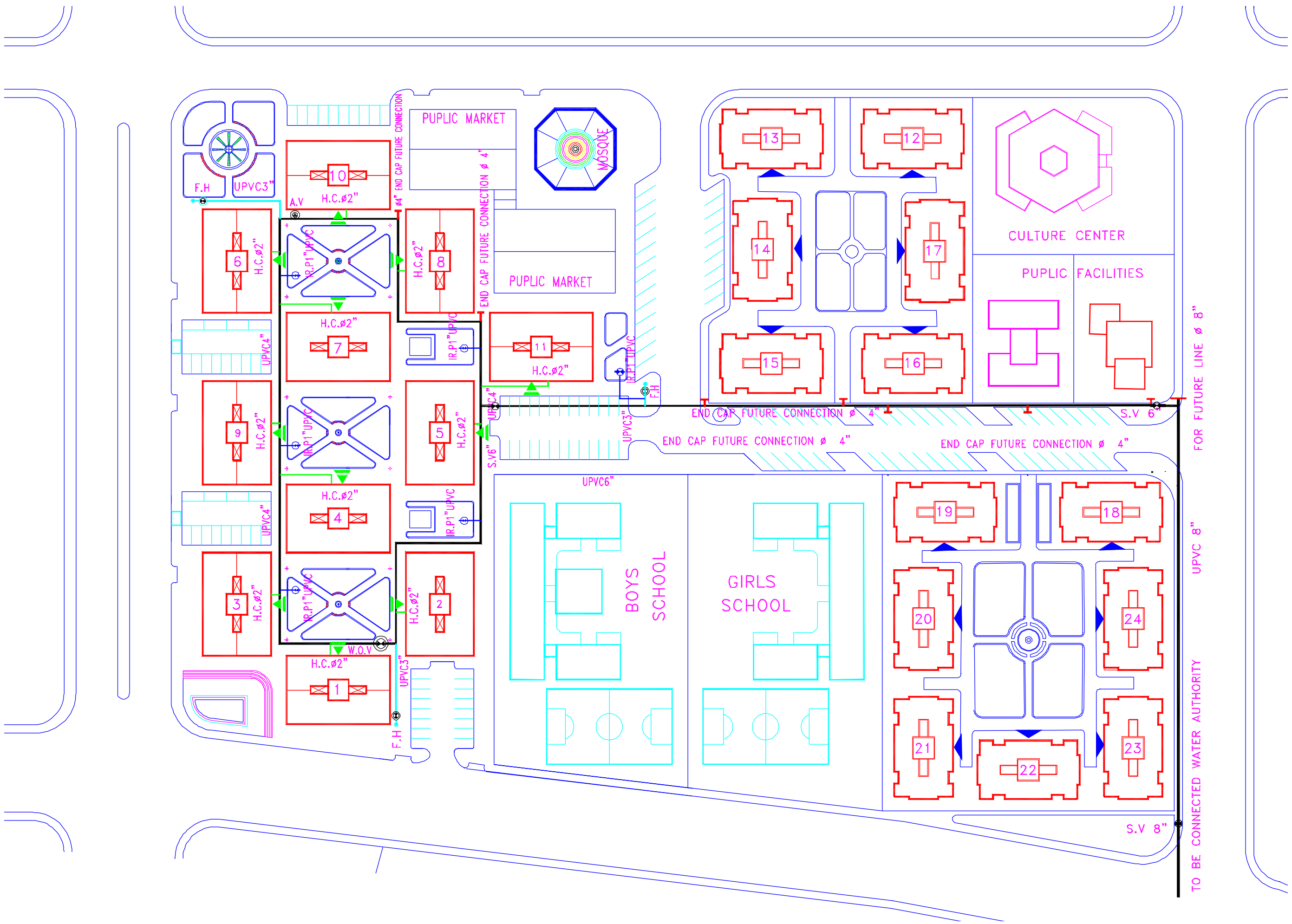


Figure C1-1: Water supply network

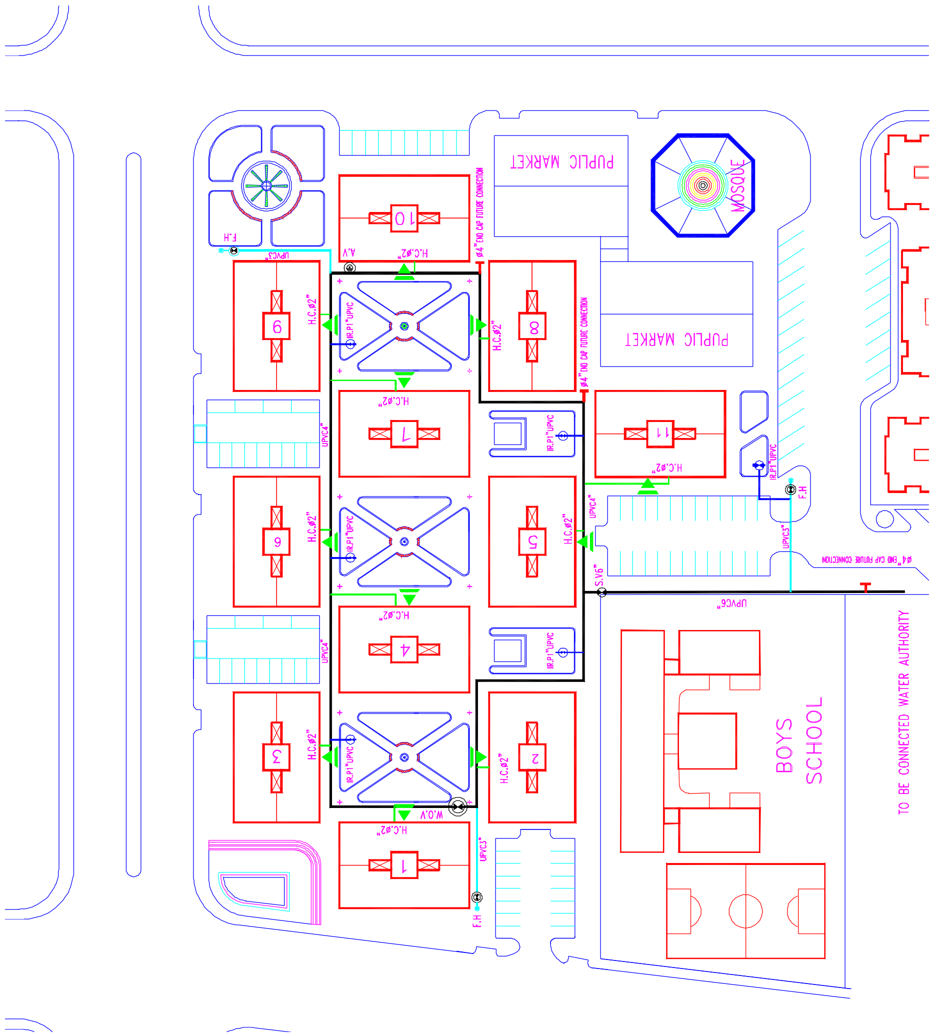


Figure C1-2: Water supply secondary and tertiary mains

Figure C1-3: Water storage roof tanks and ground tanks with pumps

Irrigation point with meter

a

b

Figure C1-4: Provision of fire fighting demands and irrigation points

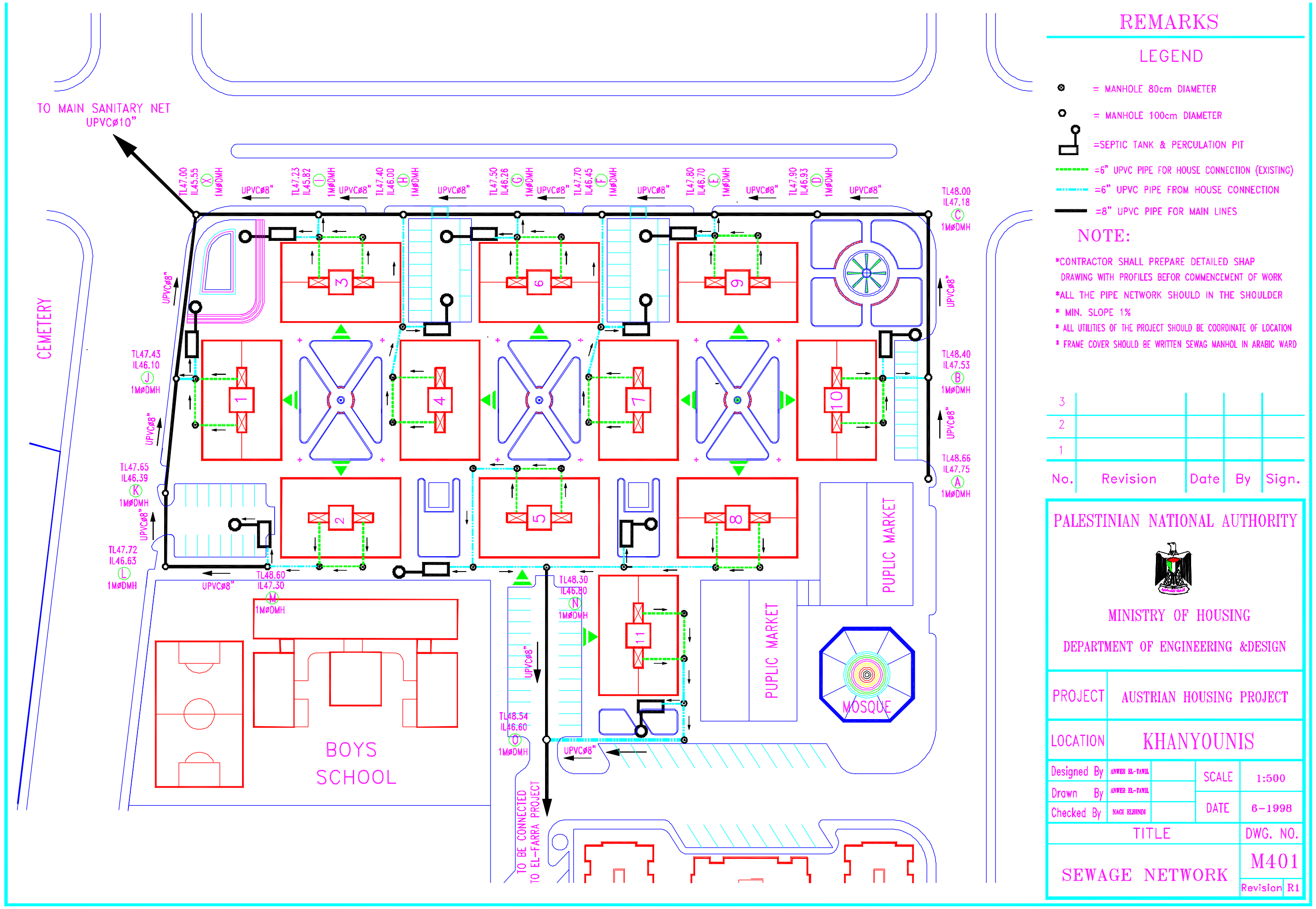


Figure C2-1: Initial design of sewerage network

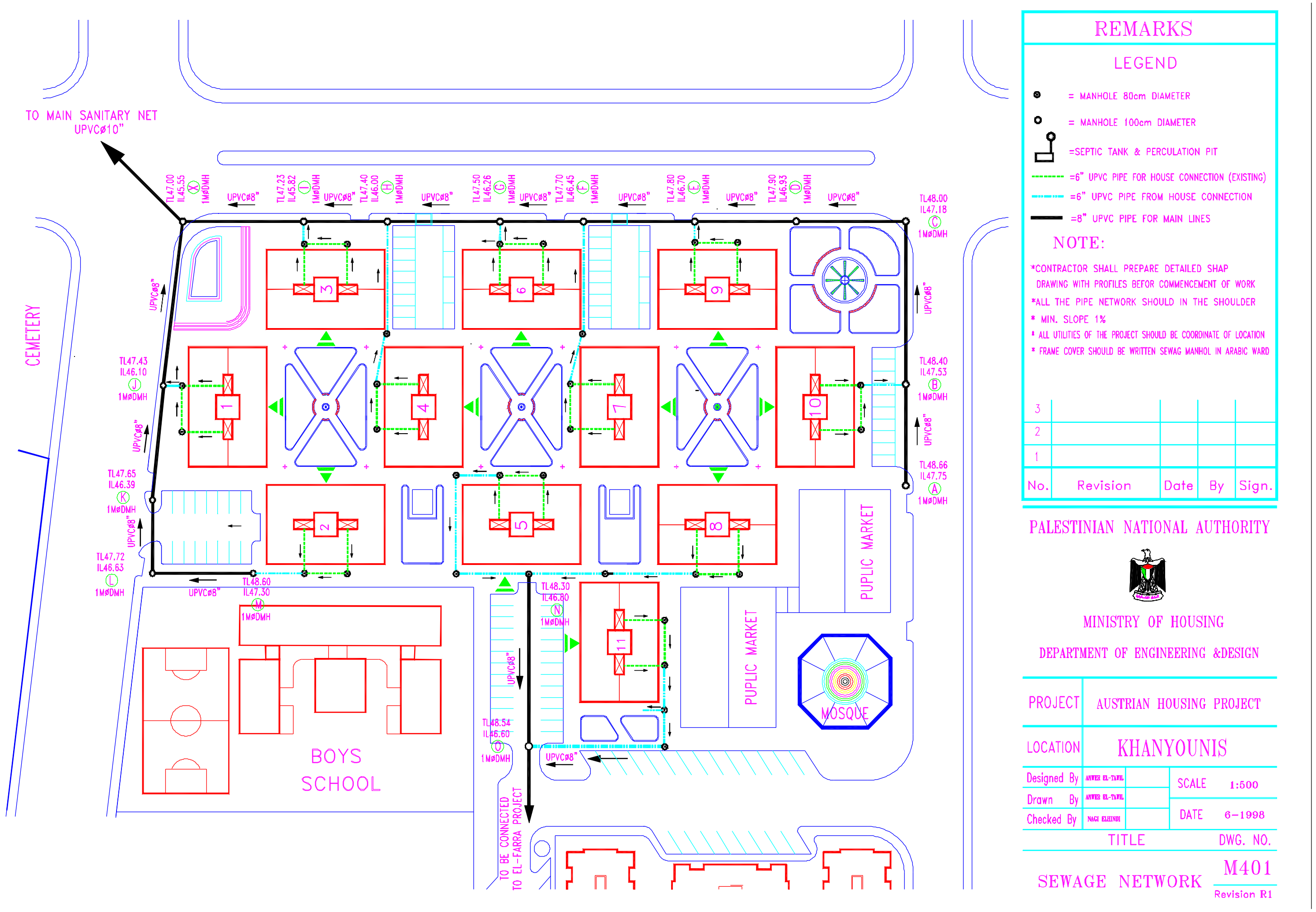


Figure C2-2: Final design of sewerage network

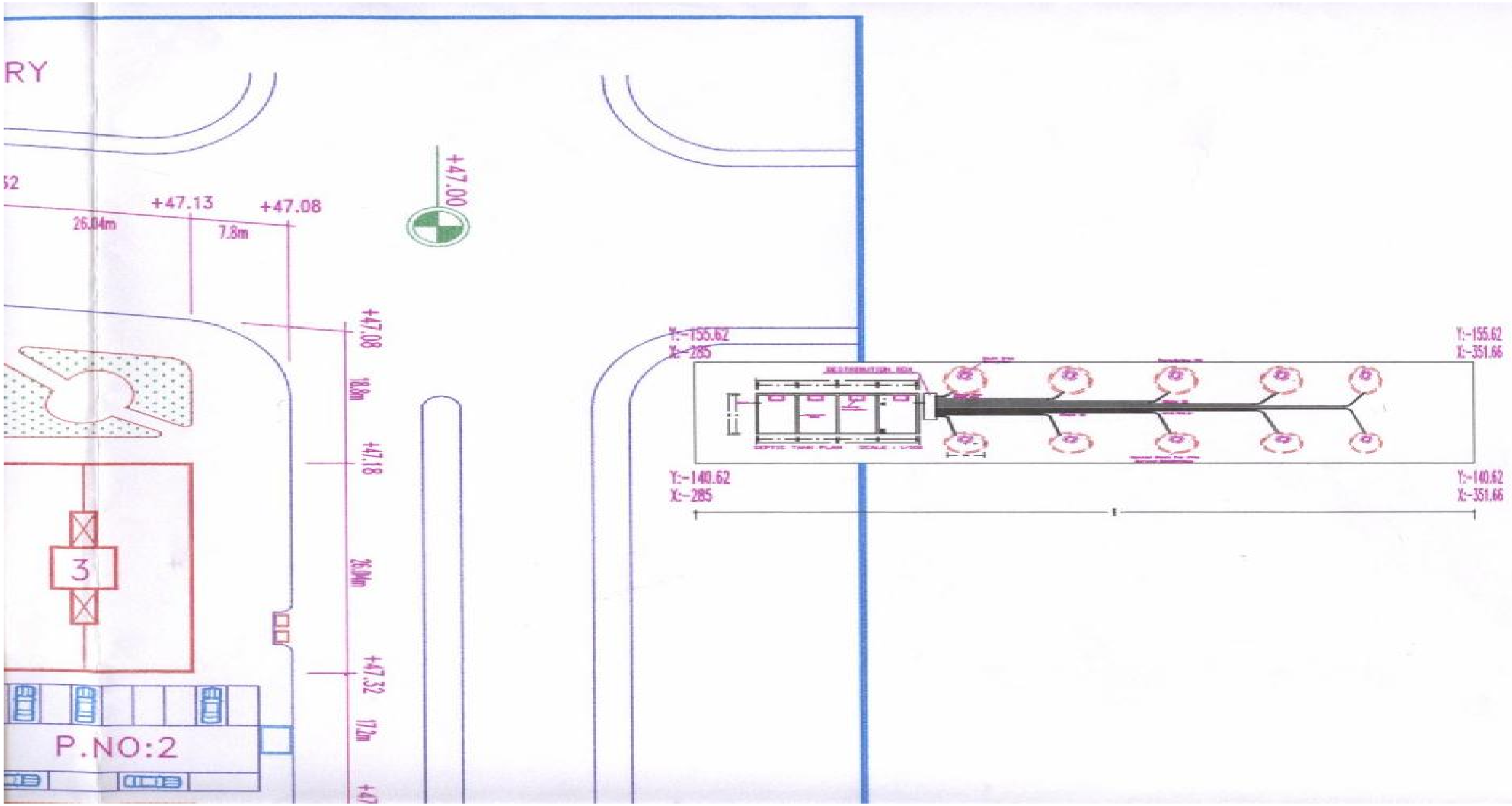


Figure C3-1: Septic tank and percolation pits system

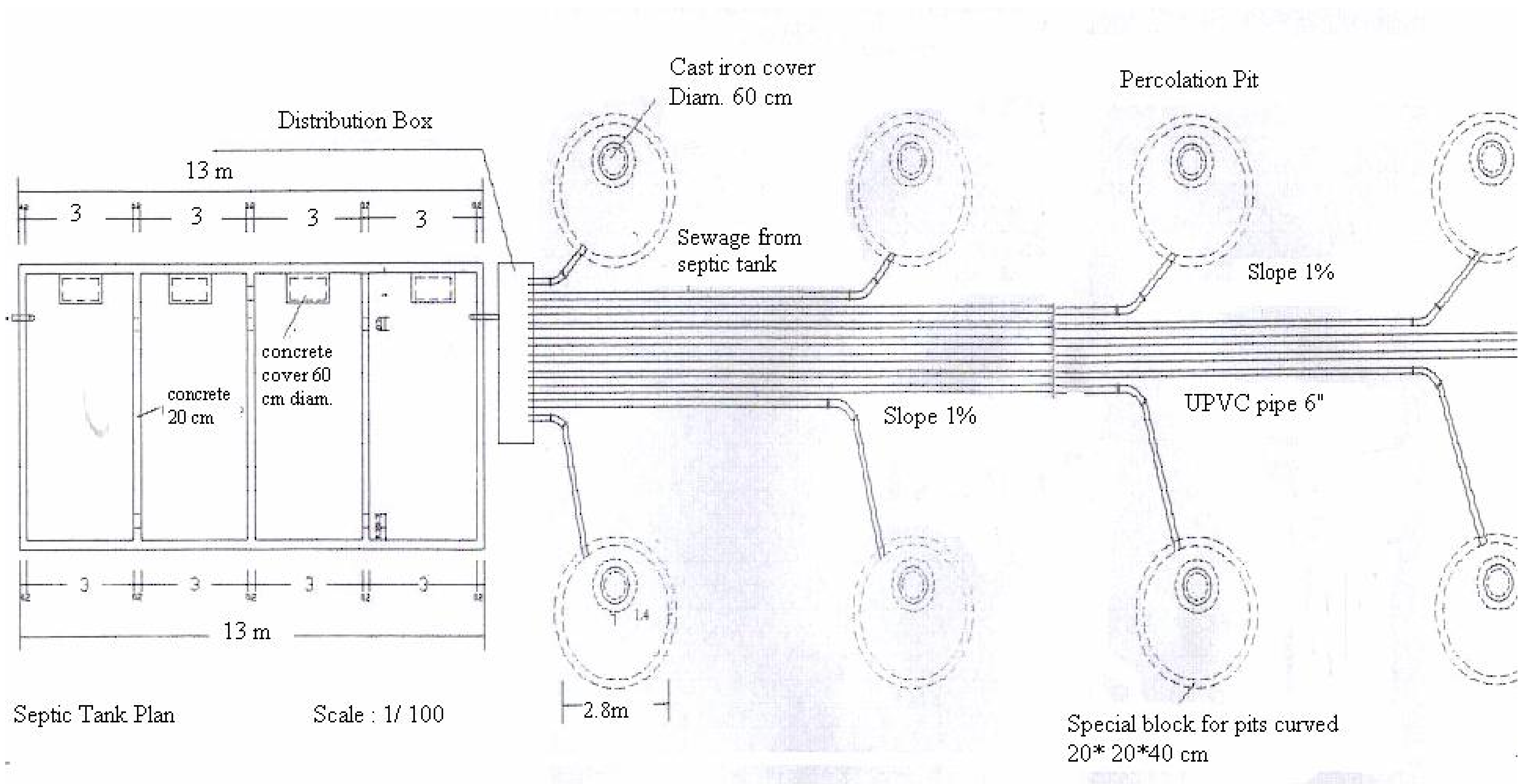


Figure C3-2: Plan view of septic tank and percolation pits system

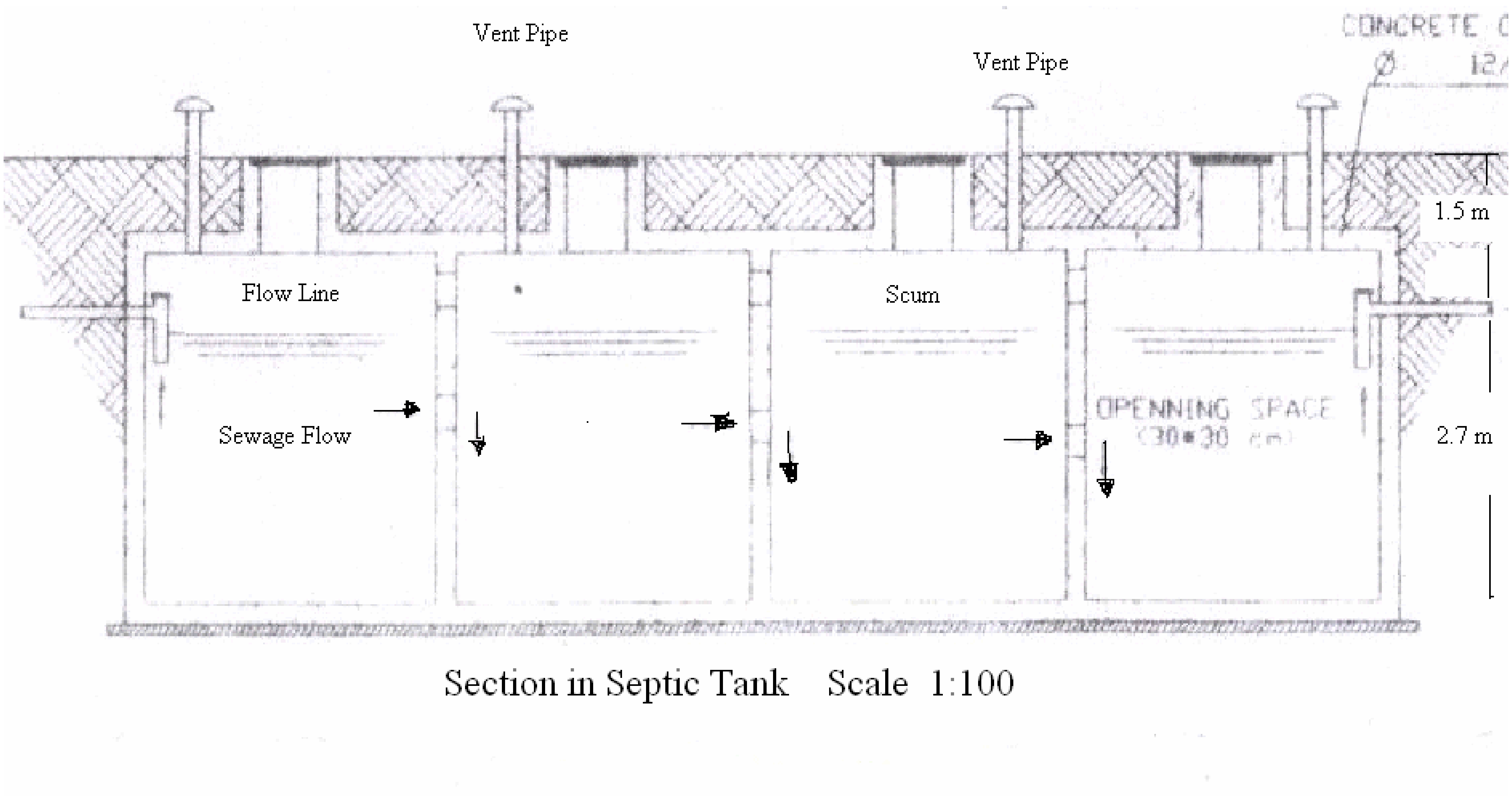


Figure C3-3: Cross section of the septic tank

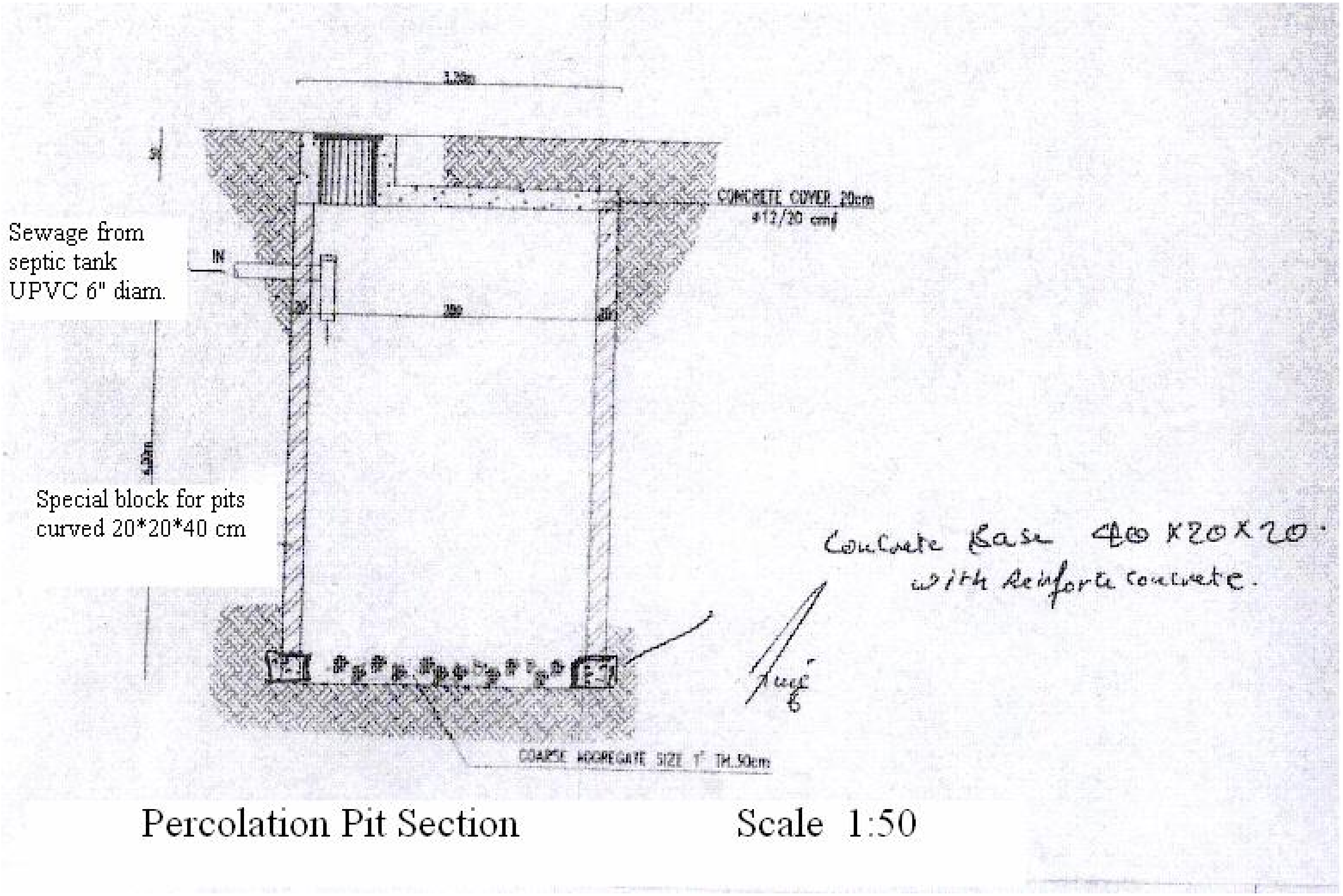


Figure C3-4: Cross section in a percolation pit

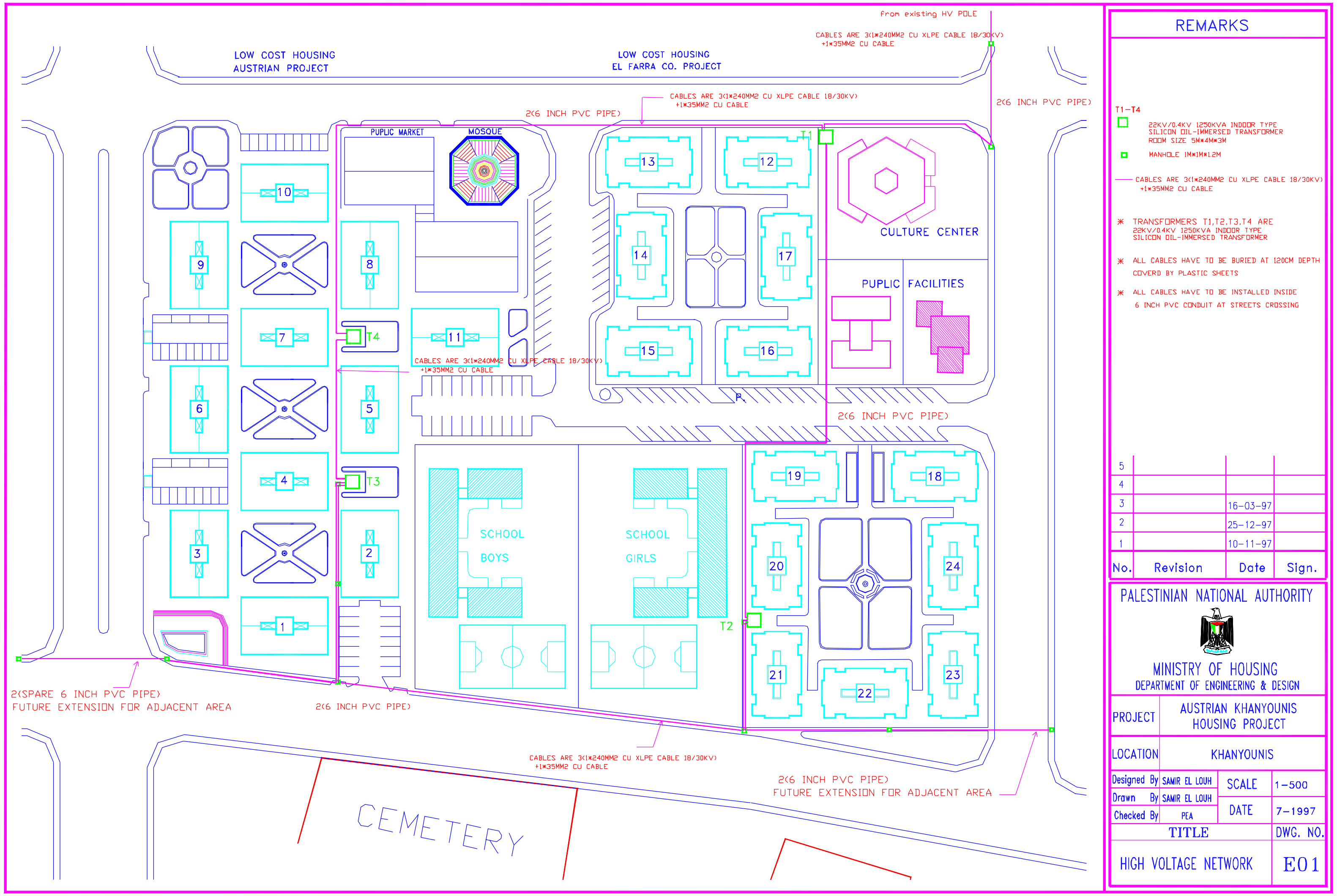


Figure C4-1: Electricity high voltage network

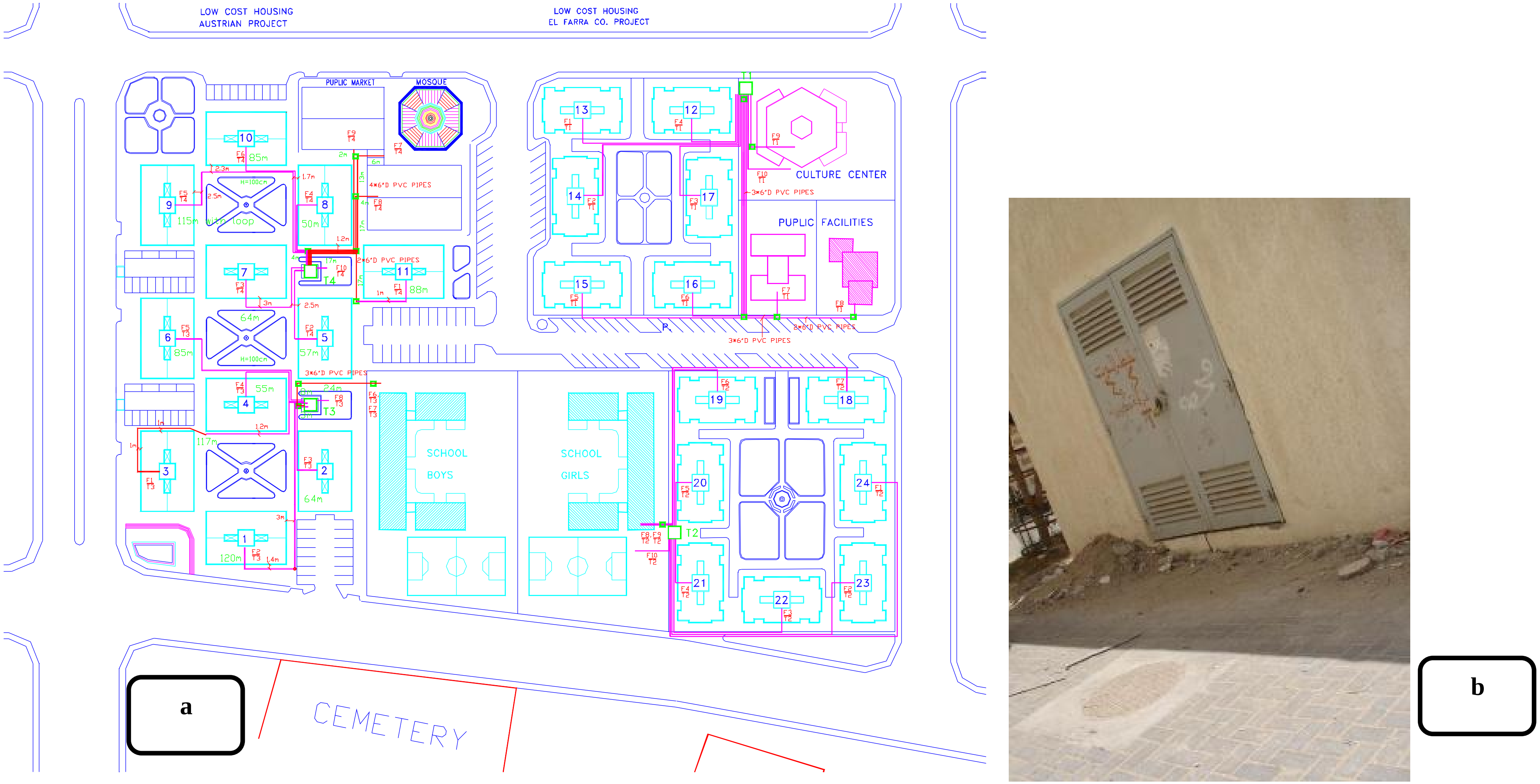


Figure C4-2: Electricity low voltage network , and picture of one of the two transformer rooms

a

b

c

Figure C4-3: Conservation measures: Insulation of buildings to save energy *and* Solar power gain (flat- plate collectors)

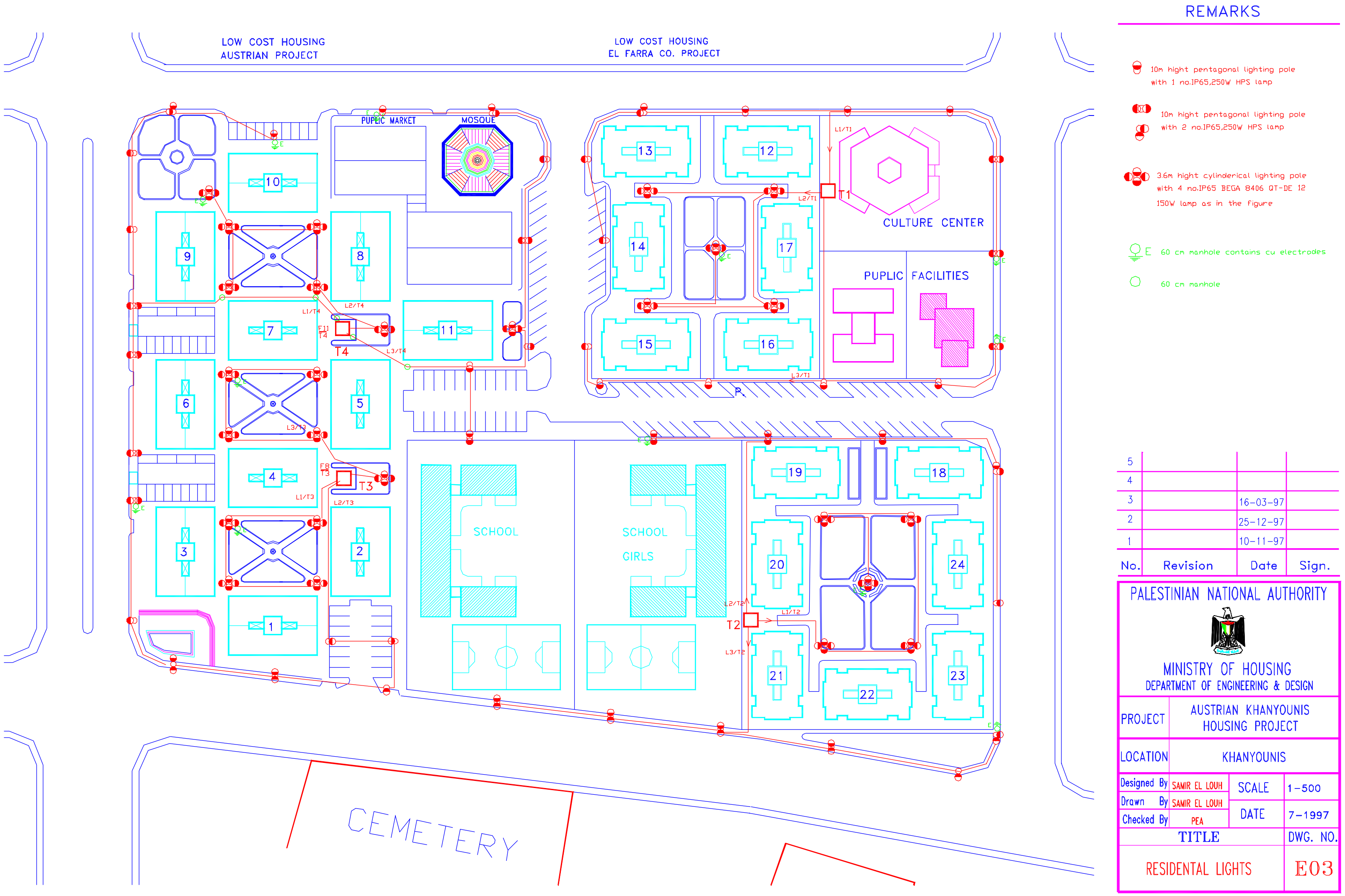


Figure C4-4: Overall security lighting network

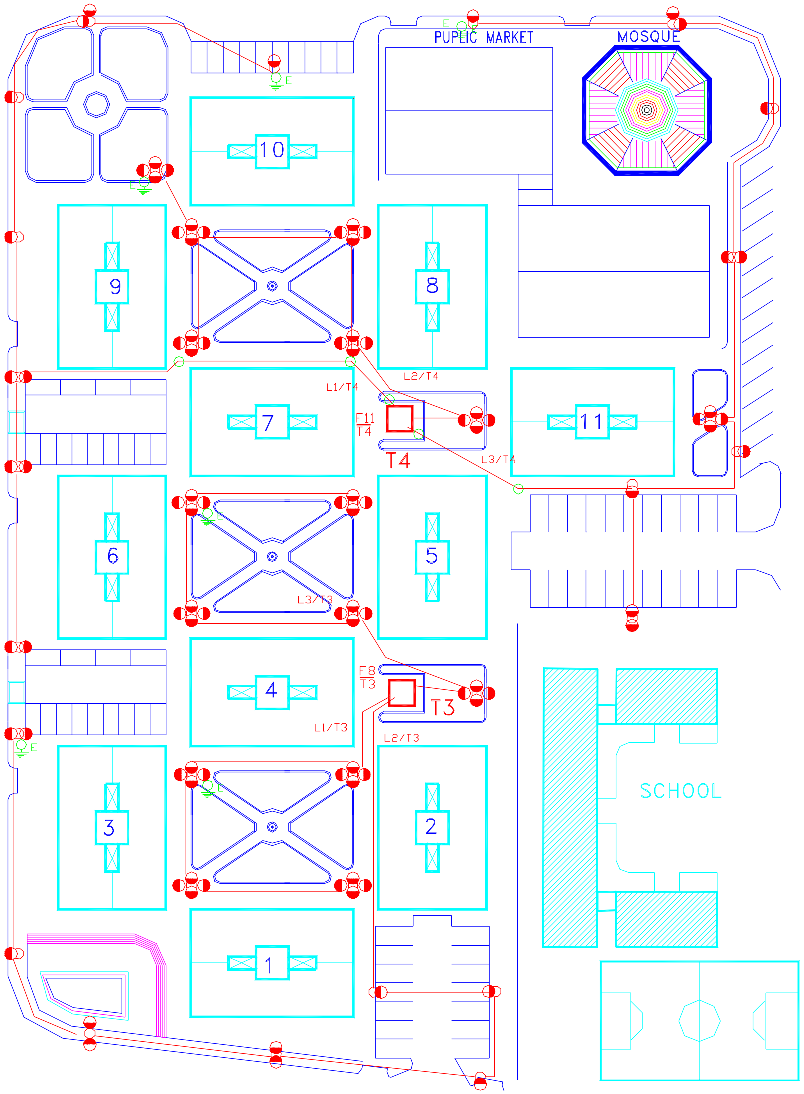


Figure C4-5: Security lighting network of AHP

Figure C4-6: Security lighting - Street Lighting poles

Figure C4-7: Security lighting - Cluster special Lighting poles

Figure C4-8: Security lighting - Cluster special Lighting –pole- mounted (could be wall-mounted)

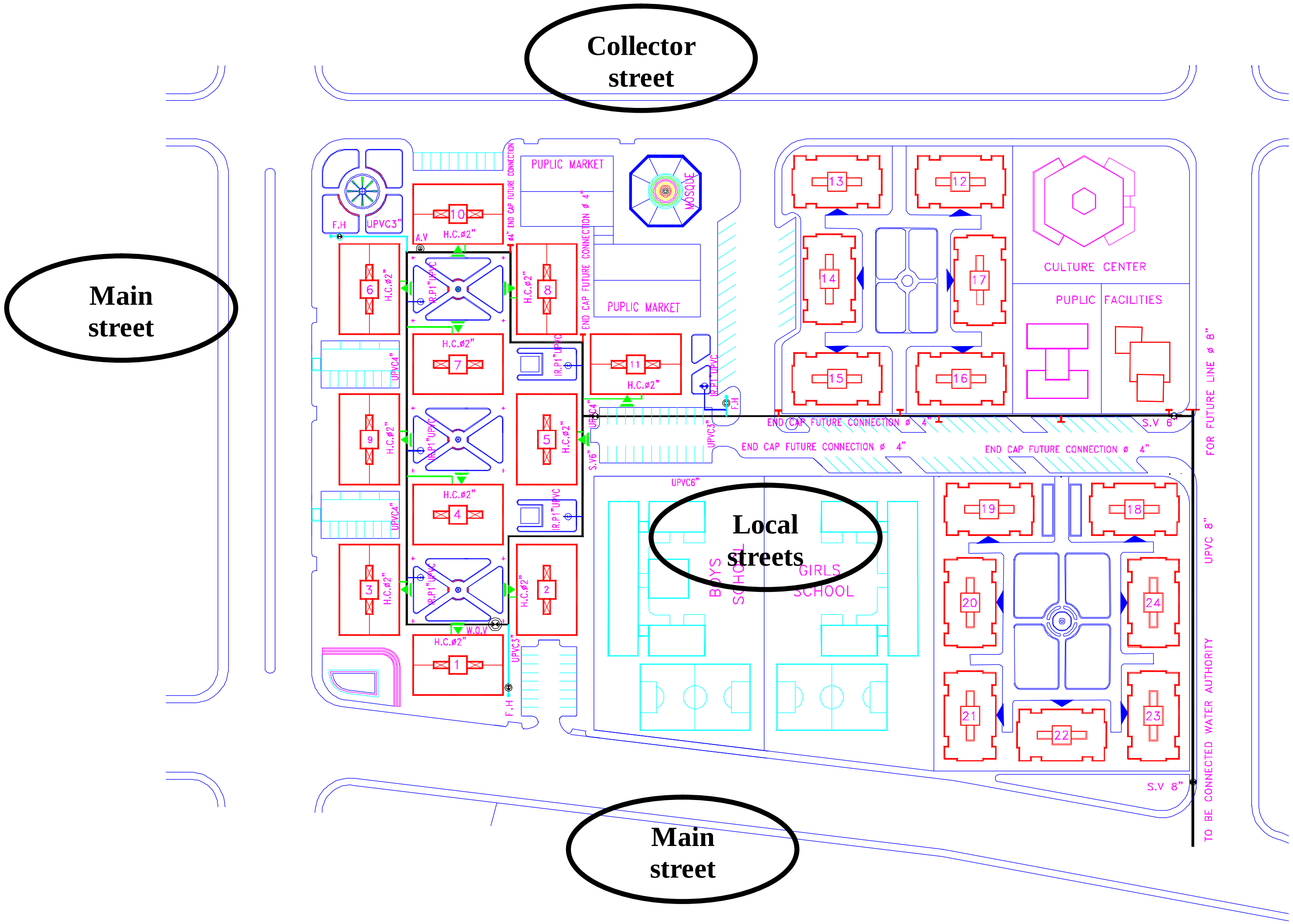


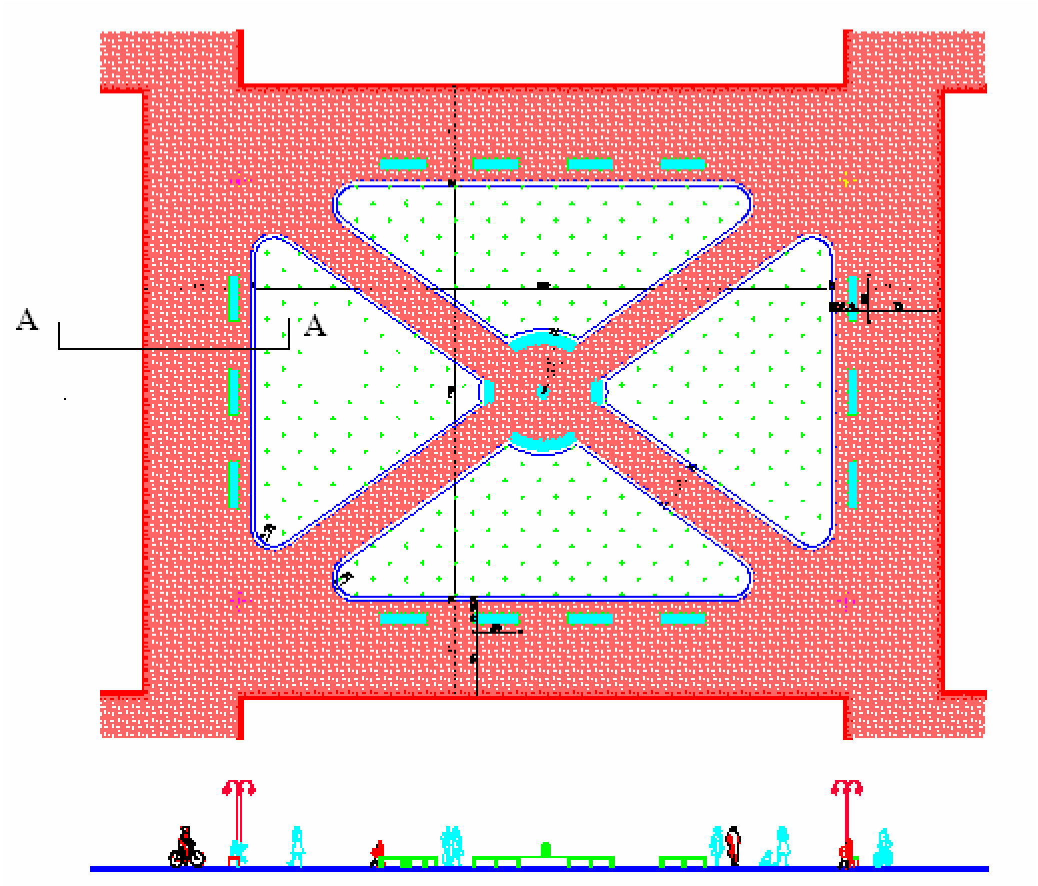
Figure C5-1: Streets hierarchy of AHP

Figure C5-2: Unpaved Main and collector roads

Figure C5-3: Sidewalks and corner garden

Figure C5-4: Footpaths between buildings with interlock pavement

Figure C5-5: Footpaths inside the clusters with interlock pavement



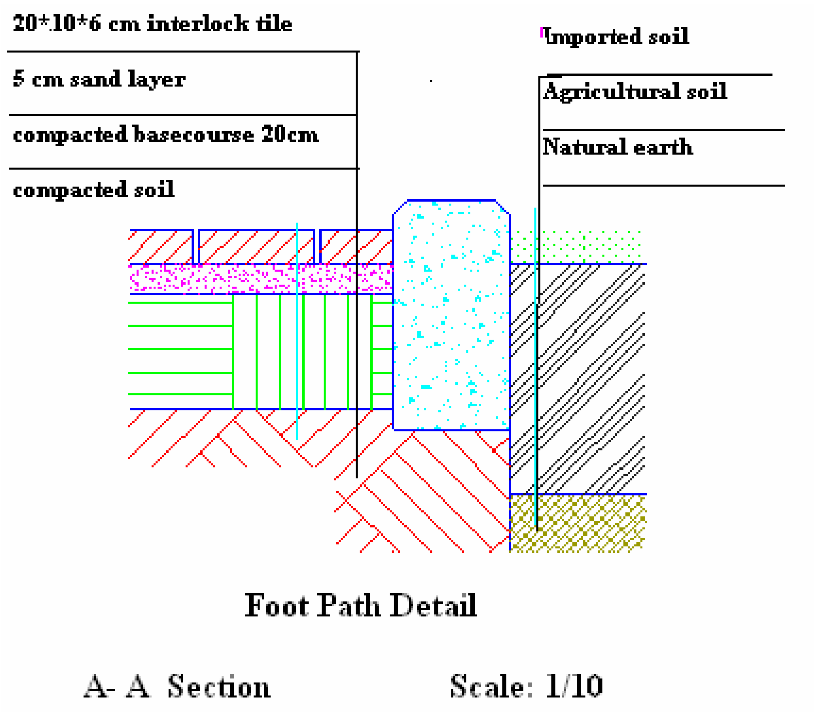


Figure C5-6: Detail of footpath Pavement and courtyard green area

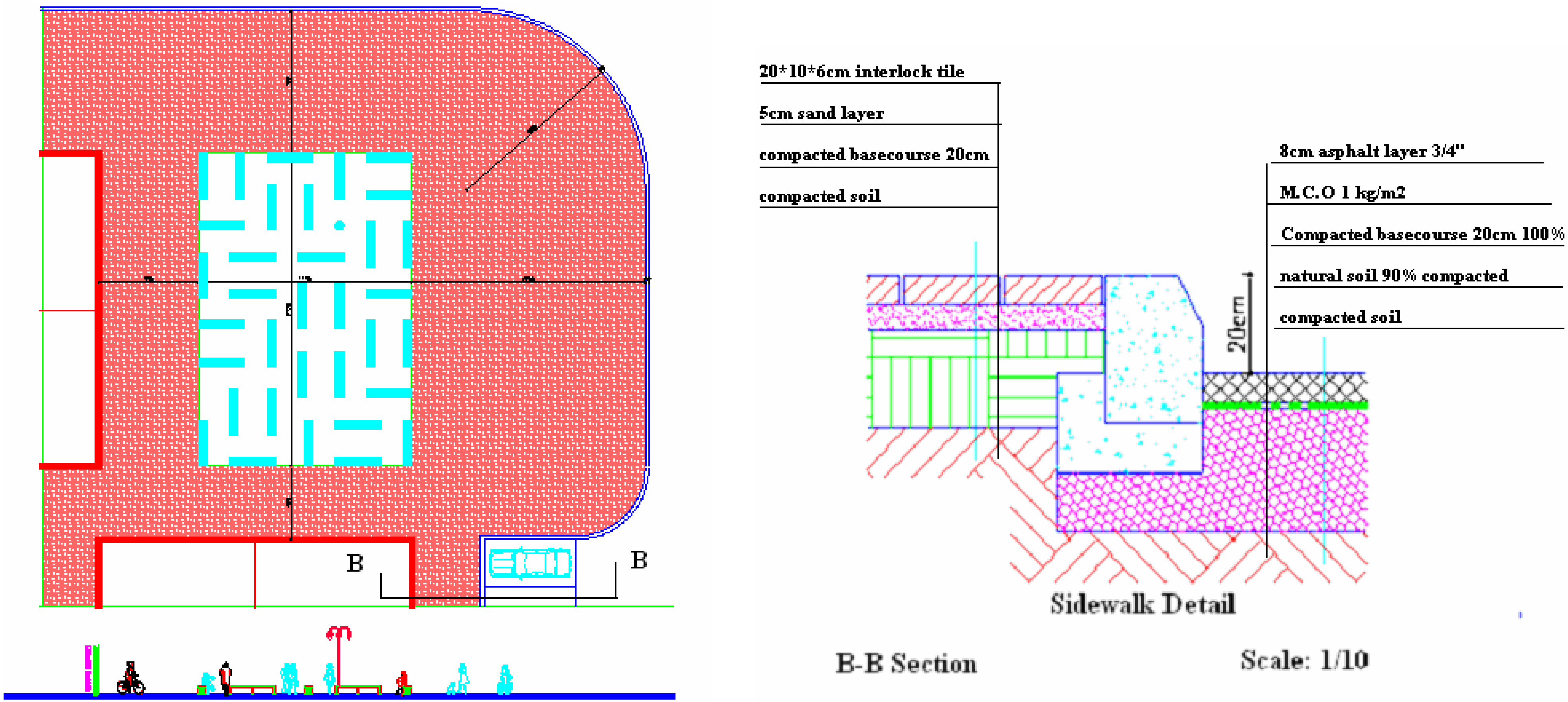


Figure C5-7: Detail of sidewalk Pavement and sitting area pavement

Figure C5-8: Sidewalks and Sitting area with public amenities

Figure C5-9: Internal footpaths for walking and cyscling only

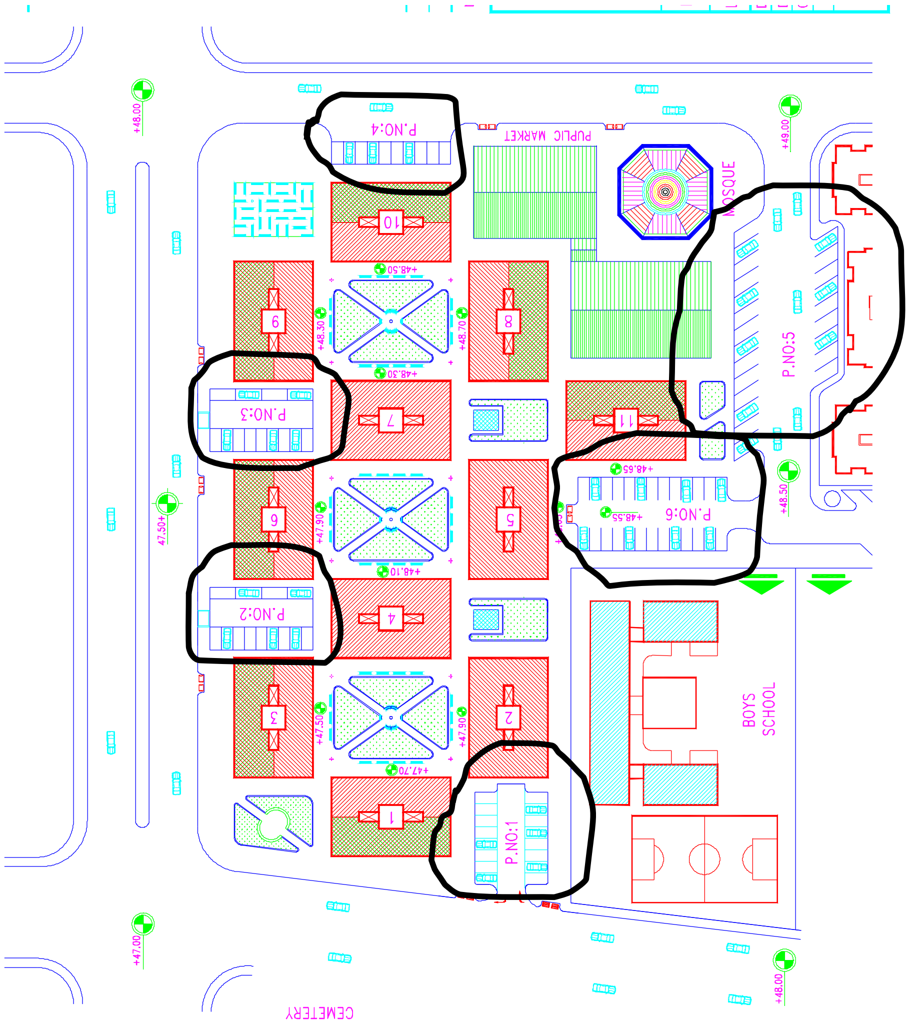


Figure C5-10: Parking areas in the AHP

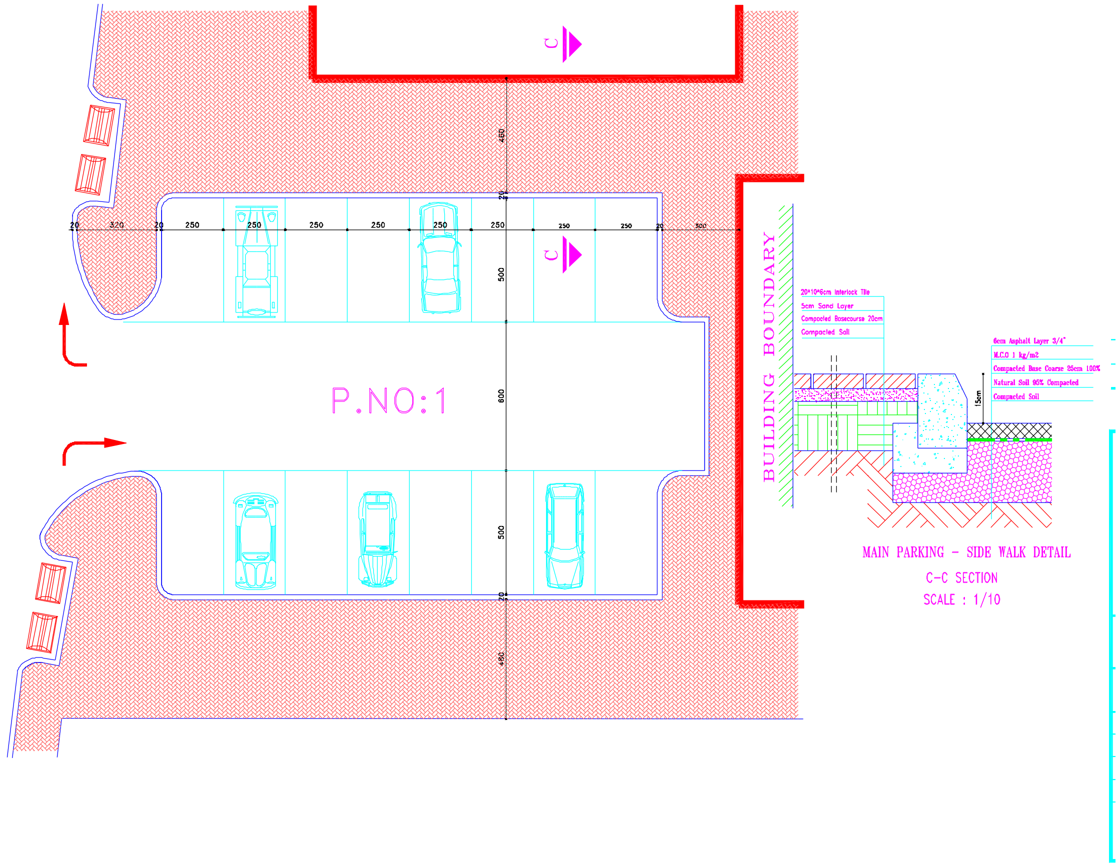
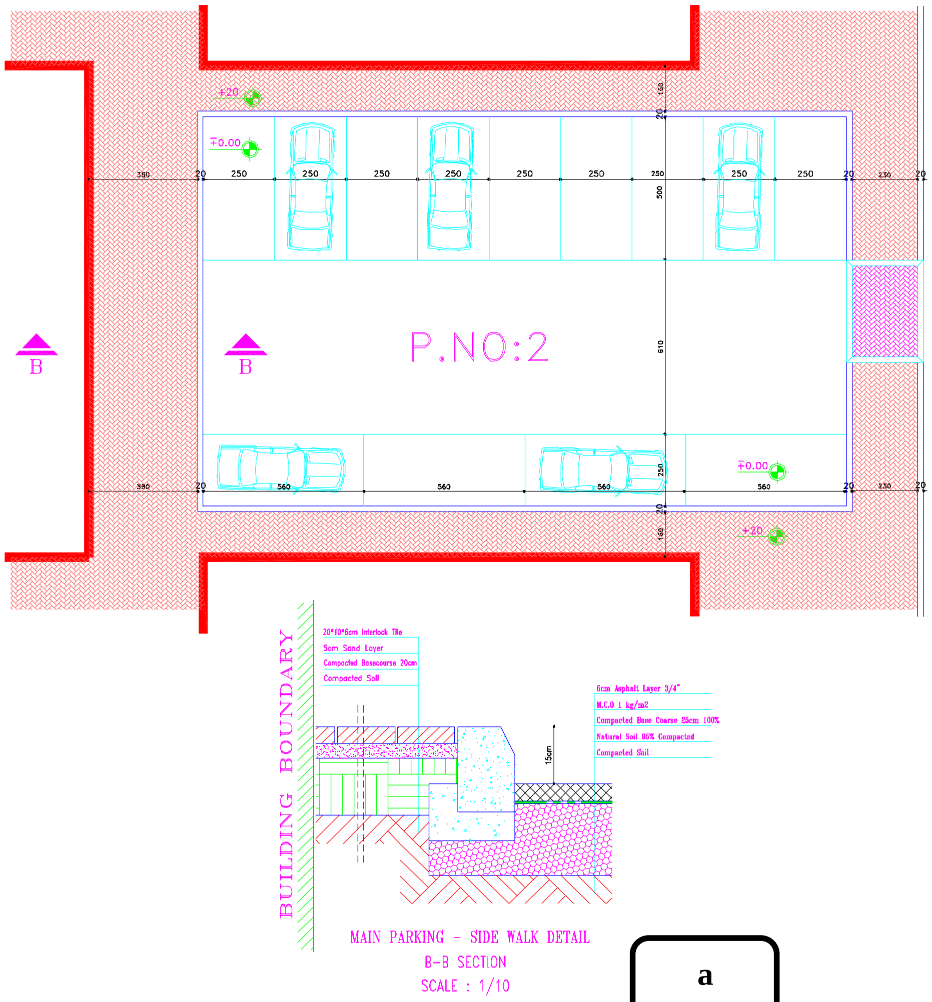


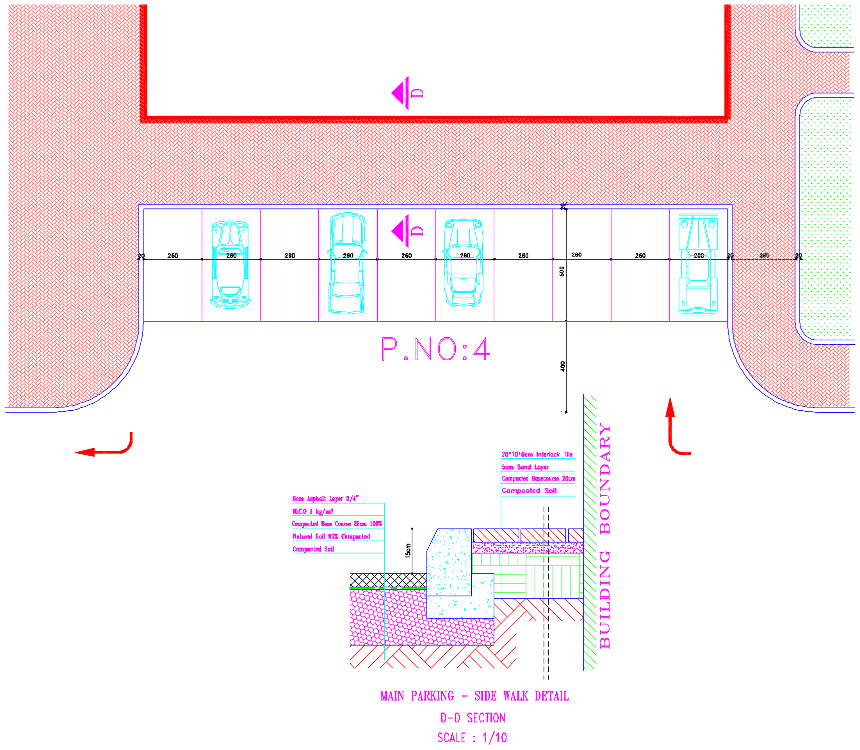
Figure C5-11: Parking area – P.NO.1



a

b

Figure C5-12: Parking area – P.NO.2 and P.NO.3



a

b

Figure C5-13: Parking area – P.NO.4

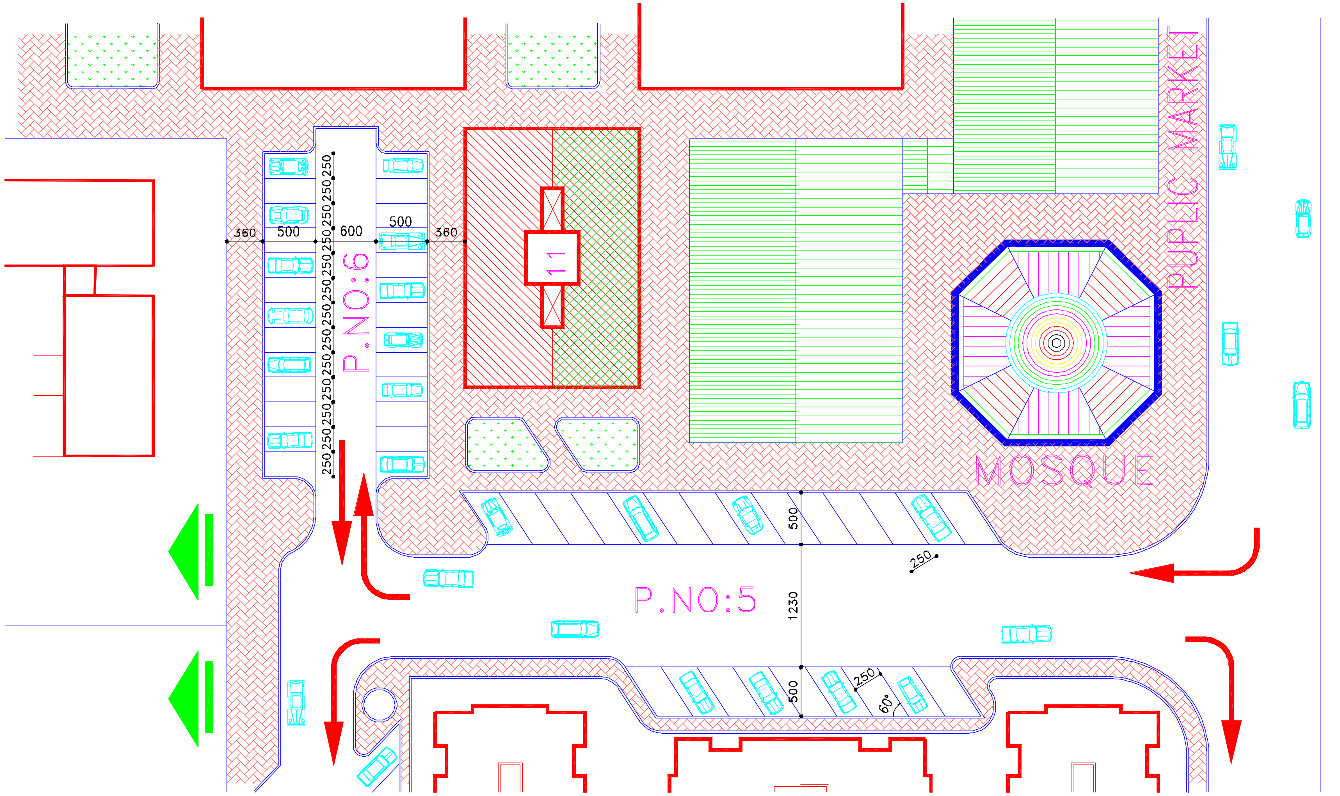


Figure C5-14: Parking area – P.NO.5 and P.NO.6

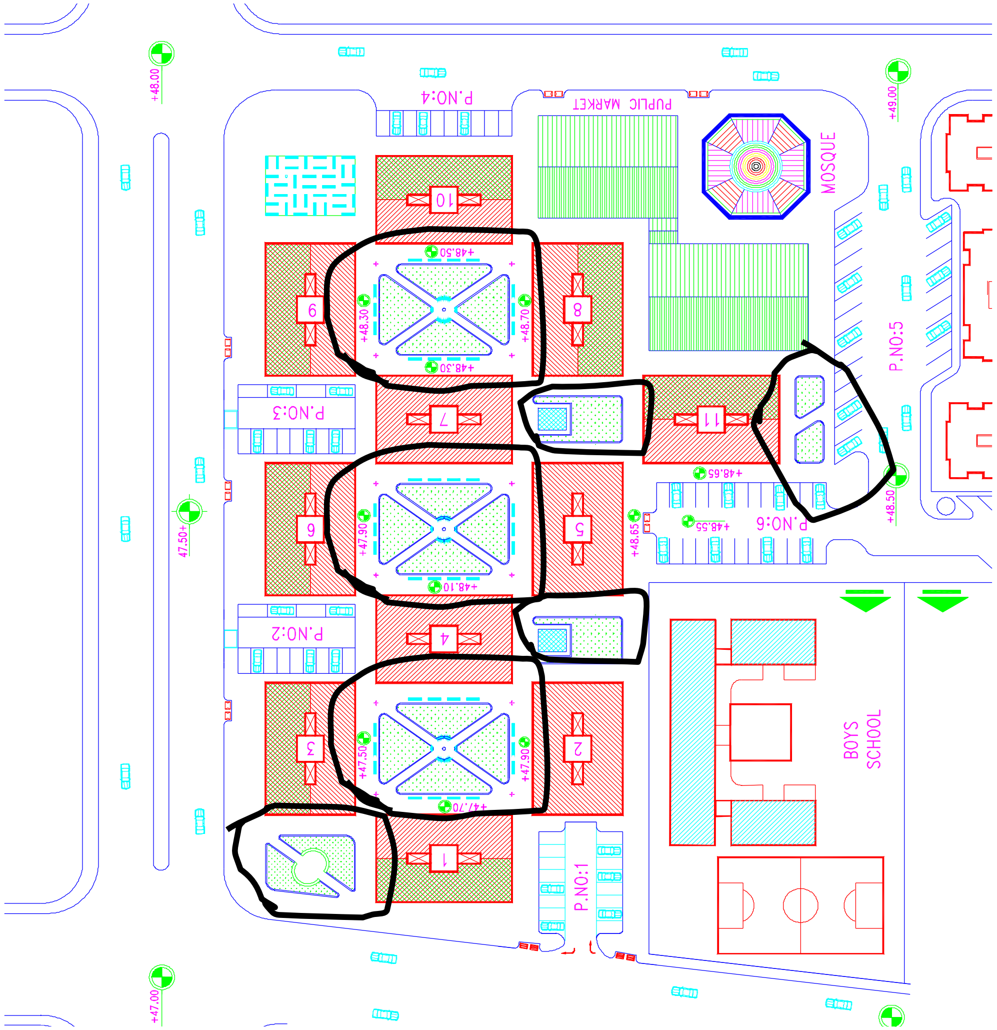


Figure C6-1: Stormwater drainage- Green areas

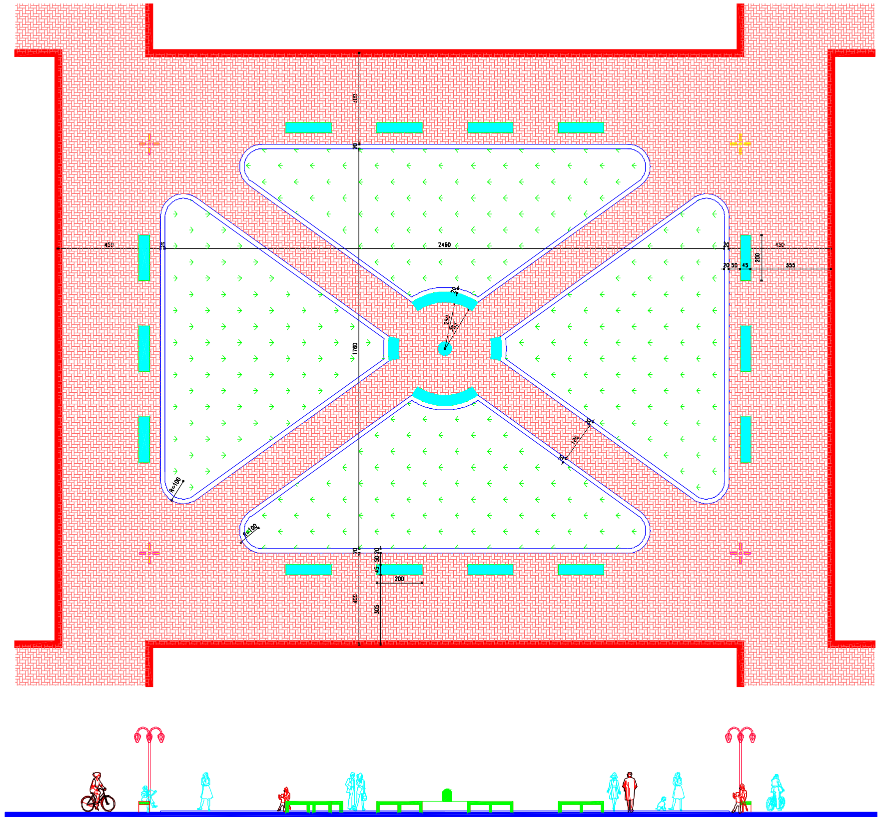


Figure C6-2: Plan detail of courtyards No. 1, No. 2 and No.3

Figure C6-3: Photo of courtyards No. 1, No. 2 and No.3

Figure C6-4: Central courtyards - green area (1)

Figure C6-5: Central courtyards - green area (1) prevent good drainage and infiltration , tree planters are raised with curbstone

Figure C6-6: Corner garden area and tree planters

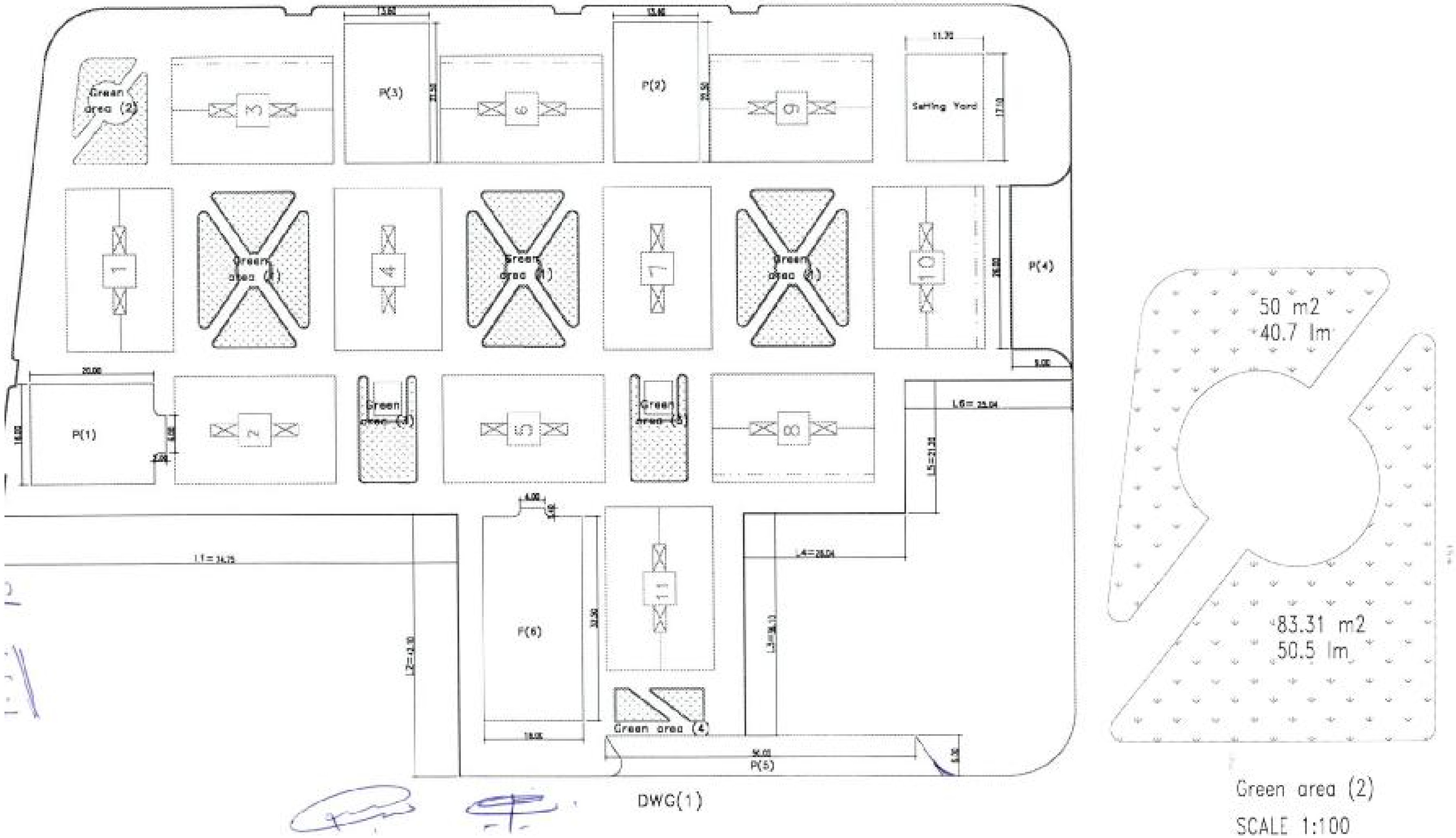


Figure C6-7: total green areas and green area(2)

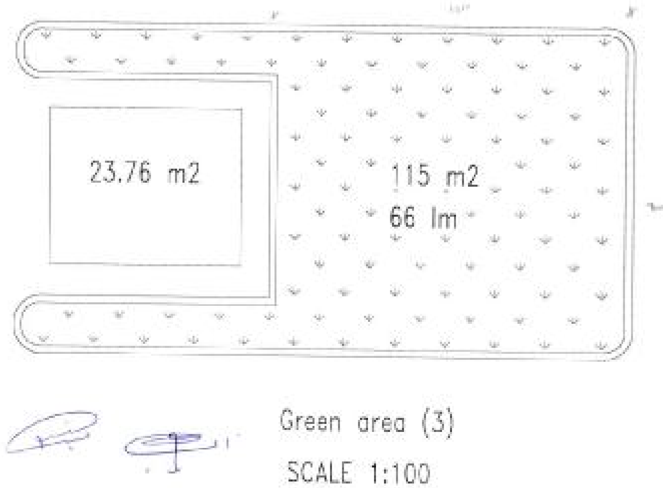


Figure C6-8: Green area(3) – Transformer room area

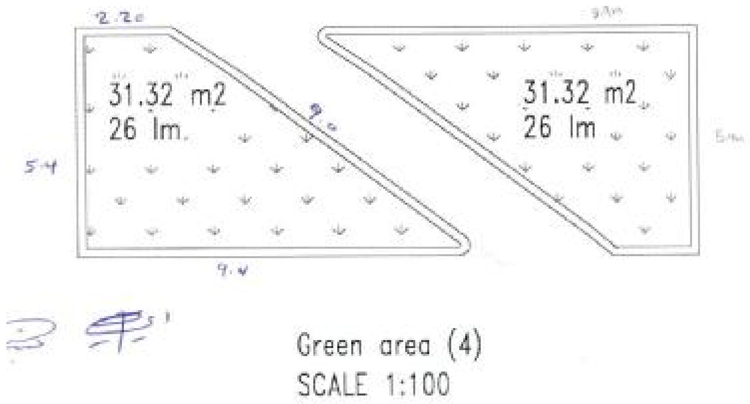


Figure C6-9: Green area (4)

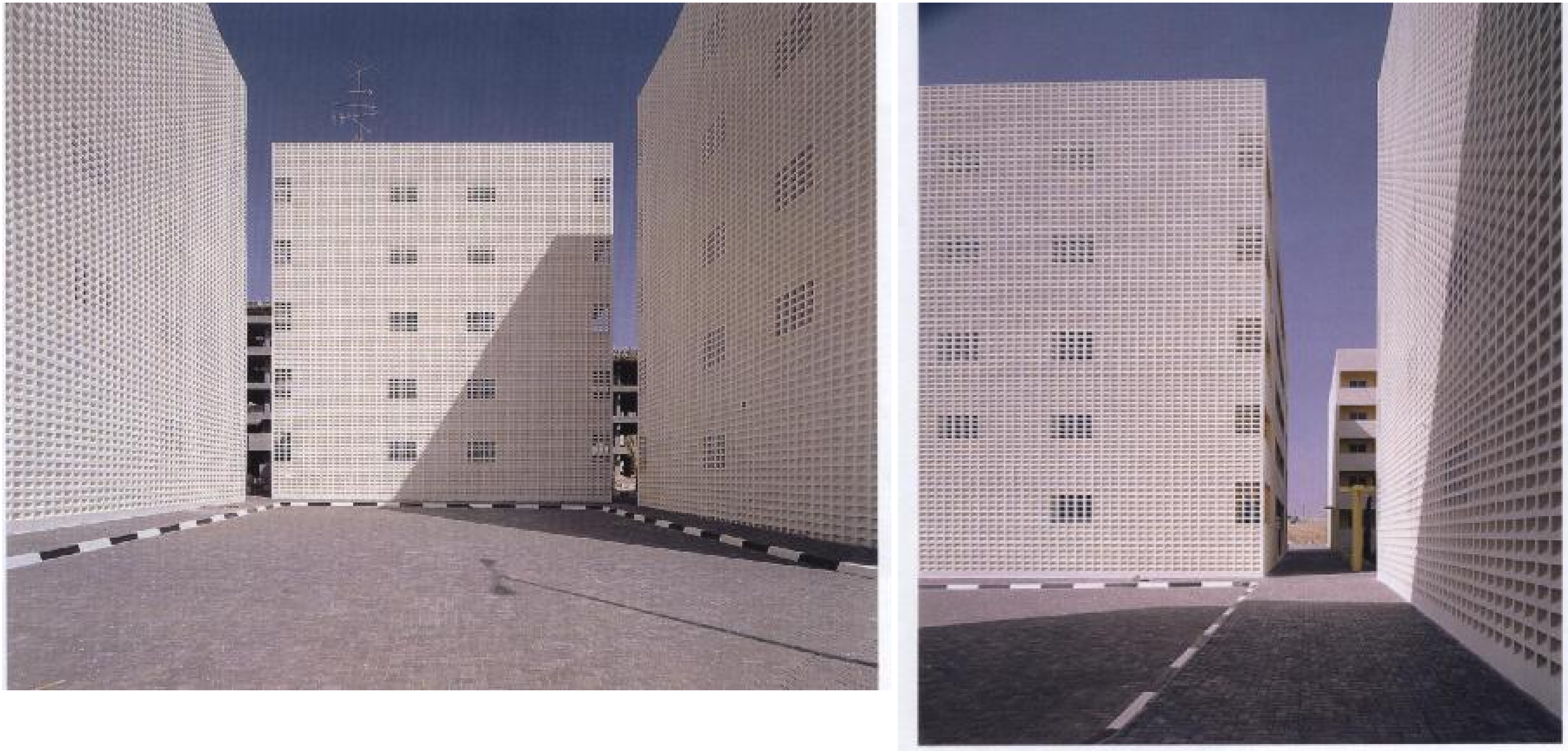


Figure C6-10: Parking areas (P.NO.2, PNO.3) paved with interlock

Figure C6-11: Sidewalks and parking area P.NO. 4: massive pavement, no bioretention islands

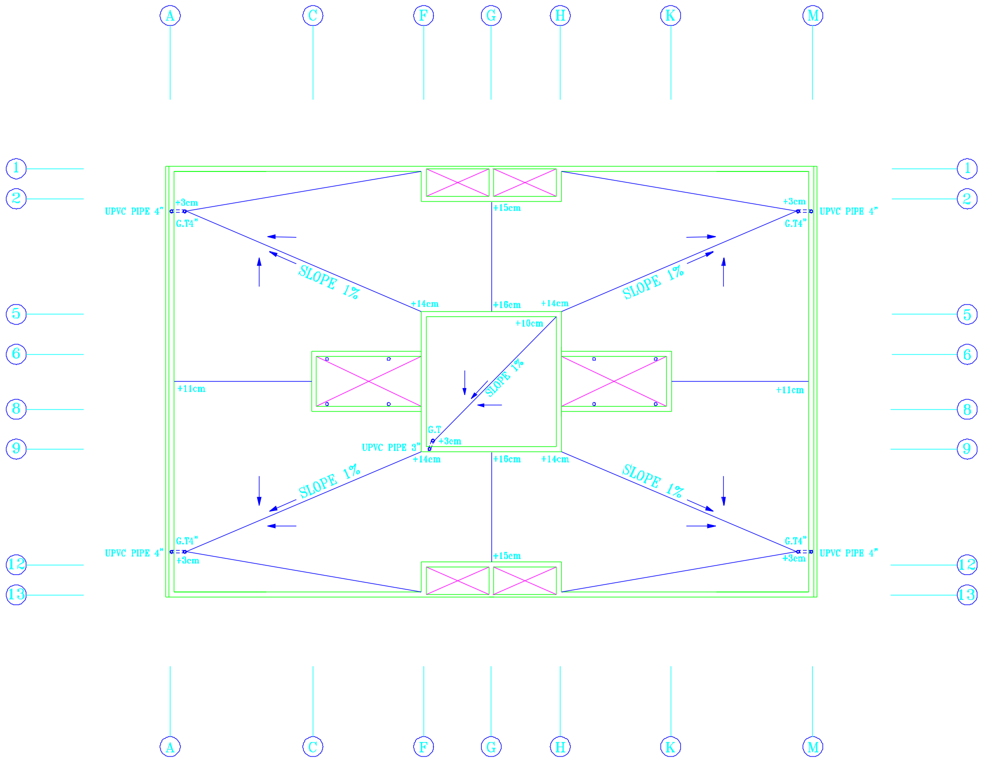


Figure C6-12: Roof drainage

Figure C6-13: Roof drainage spouts opened into the footpaths

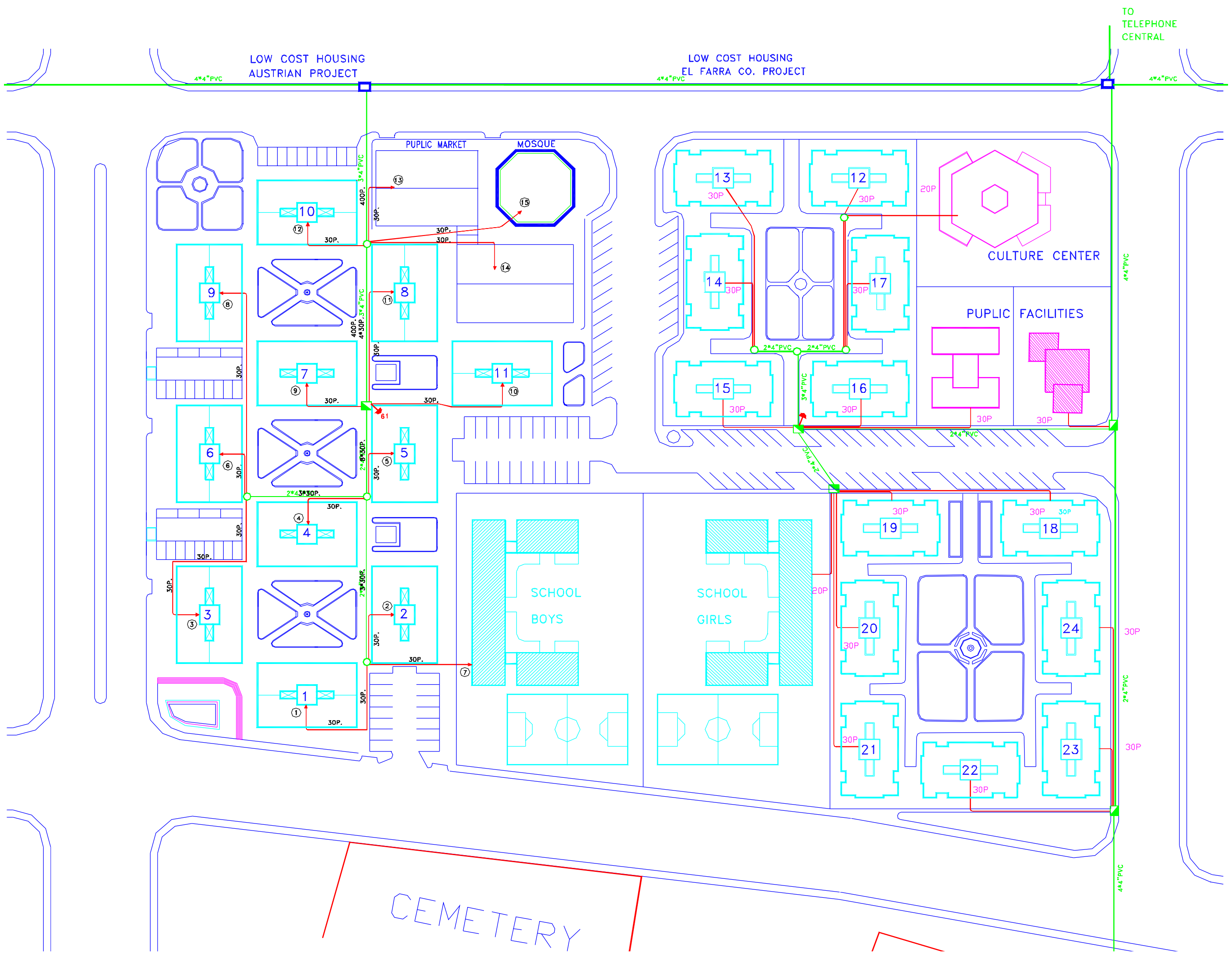


Figure C7-1: telephone lines