MAKING URBAN PLACES

Principles and Guidelines for Layout Planning

CONTEMPORARY POLICY ISSUES

Roger Behrens and Vanessa Watson

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Urban Problems Research Unit,

University of Cape Town

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Summary of Approach

At the most fundamental level this handbook is concerned with the quality of urban environments. Current urban settlement formation in the developing urban areas of South Africa tends to be of poor quality - site and service developments in particular, have little chance of developing into vibrant, enriching and efficient urban environments. While the reasons for poor environmental quality are undoubtedly diverse and complex, having political, economic and social dimensions, it is argued that the prevailing approach to layout planning in South Africa is part of the problem.

This handbook represents a serious attempt, on the part of the funders and consultants involved in its preparation, at developing an alternative approach that is more appropriate and more likely to produce layout plans with the ability to initiate urban environments of quality. The handbook is neither technically detailed, nor comprehensive and definitive - it raises an appropriate set of concerns and suggests ways of addressing these in space. As such it is a guide and stimulus, not a prescriptive set of solutions.

The approach to layout planning, presented in the handbook, argues that the starting point of the plan formation process is, appropriately, a set of normative concerns around the quality of urban environments and the levels of performance that they should achieve.

The stages of the plan formation process, outlined in the handbook, therefore centre around the task of converting these normative concerns into a set of contextual layout proposals. This task is complex, and fraught with conflicting demands and requirements. It involves prioritising concerns, recognising functional and spatial relationships, making trade-offs, and understanding the social, financial, environmental and end-user implications of layout decisions. The handbook is intended to provide a basis upon which some of these priorities, relationships, trade-offs and decisions can be made. It moves from a discussion of the more abstract (sections 1, 2 and 3), to a discussion of the more technical (sections 4 and 5).

The approach to layout planning is informed by a view that the establishment of urban settlements is a process - not a designed end product. It is neither possible nor desirable, at any one point in time, to 'design' an urban settlement. Enriching urban environments are the result of successive collective and individual actions, and reactions, over time. The purpose of a layout plan is therefore understood to provide a spatial framework within which numerous collective and individual investments can be accommodated over time, in a mutually reinforcing and developmental manner. The layout plan is therefore seen as initiating and facilitative, rather than prescriptive. This implies that the layout plan should indicate a minimum set of spatial interventions, rather than attempting to be entirely comprehensive.

The layout planning task is not to simply optimize the provision of services, facilities and amenities sectorally, but to ensure that together these infrastructural elements operate in a developmental and systemic way - this often necessitates trade-offs and sometimes technical inefficiencies. In essence, it is less about what infrastructure is provided, than about how the infrastructure that is provided, is arranged in space, that initiates the development of urban environments of quality.

The concerns expressed in the handbook centre around: (1) the making of unique places, (2) the scaling of urban environments to human dimensions, (3) the maximisation of access for the greatest number of people, (4) the creation of economic opportunities, (5) the efficient use of limited resources, and (6) the maximisation of choices available to communities. It is argued that layout planning should be centrally informed by these concerns, and by the kinds of spatial relationships which are required in order to address them.

As a result of this set of concerns, a very different urban environment is envisaged to that which results from the application of current approaches to layout planning in South African urban developments. The approach to layout planning is different from prevailing approaches, in the following main respects:

Firstly, instead of applying standardised layout concepts, the handbook promotes context specific layout planning responses to the particular cultural and natural features of a site. Context specific responses are central to the creation of a sense of uniqueness, or place, in urban developments.

Secondly, instead of roads and their movement functions, the handbook promotes a hierarchical network of public spaces as the main structuring, or ordering, element of urban settlements. Public spaces facilitate socialising and trading opportunities and act as extensions to crowded dwellings.

Thirdly, instead of closed car-orientated road geometries, the handbook promotes open, flexible road geometries. Open road networks facilitate public transport service operations and enable easy pedestrian access.

Fourthly, instead of a strict functional road hierarchy, the handbook promotes a network of multi-functional roads. Multi-functional road networks accommodate all road users and uses, and enable changes in the functions of roads to occur over time.

Fifthly, instead of creating introverted and spatially defined neighbourhood cells, the handbook promotes the location of public facilities in an extroverted and systemic pattern. Extroverted public facility location, around public transport stops, makes facilities as accessible to the greatest number of potential users as possible.

Sixthly, instead of exclusively residential functions, the handbook promotes the design of infrastructure networks which provide for both collective and residential service needs. Collective services are essential for the creation of trading, manufacturing and socialising opportunities, and as such are part of the basic infrastructure around which the consolidation of residential, commercial, industrial and public buildings occurs.

The following table summarises the layout planning principles, presented in the handbook, that emerge from the normative concerns discussed above.

Summary of Layout Planning Principles

CONCERN		LAYOUT PLANNING PRINCIPLE
place making	*	focus on a hierarchical system of hard public spaces (eg. squares, markets) as the main structuring element of urban areas, in order to establish loci for social interaction and community events, and create places that shape enduring impressions of the settlement
		respond to the cultural context of a site by understanding traditional ways of making the local cultural landscape (eg. patterns of planting, road alignments, locations of symbolic or sacred buildings and spaces), and incorporating these into layout plans, in order to ensure that existing forms of the cultural landscape are maintained
		respond to the natural context of a site by identifying the implications of natural characteristics (eg. topography, vegetation, climate) for layout planning, in order to accentuate uniqueness, and bring the presence of the natural landscape visually into the settlement
	*	improve, where necessary, the protective and visual qualities of the natural landscape (eg. shade, wind protection, topographical interest), in order to enhance the comfort of urban places, and provide structure to processes of settlement formation
scale	*	define hard open spaces (eg. squares, road reserves) through the juxtaposition of public buildings, public furniture and tree-planting, in order to create outdoor 'rooms' which provide a sense of enclosure, greater

		safety through public surveillance, and protection from the natural elements
	*	link soft open spaces (eg. public parks, playing fields), in order to form networks of recreational space which provide opportunities for the creation of continuous walkways, and greater levels of urban biodiversity
	*	provide middle and lower order road networks with a continuous functional gradation of road types, in order to reconcile the needs of numerous road functions (eg. social, economic, aesthetic) and road users (eg. pedestrians, street traders, motorists), and accommodate different modes and types of traffic movement (eg. through, stop-start, access-seeking)
access	*	integrate the local road network with the surrounding movement system and land use pattern, in order to improve levels of interconnection, extend important routes through the area, and provide opportunities for increased coverage and penetration of public transport operations
	*	prioritise pedestrian movement by providing direct, safe and convenient routes between different land use activities and public transport stops, in order to increase levels of intra-district access for the most vulnerable, and very often poorest, group of road users
	*	facilitate efficient and effective public transport services by making provision for prerequisite road geometries and thresholds (ie. residential density) within layout plans, in order to improve inter-district accessibility for lower income households, and reduce the need for congesting and polluting motor car travel
	*	design open and flexible middle and lower order road geometries which offer numerous possible through connections, in order to enable complex systems of movement to emerge (eg. the mix of through, local and pedestrian movement associated with vibrant 'activity streets'), facilitate unrestricted pedestrian movement, provide public transport vehicles with direct and unconvoluted service routes, and be most able to respond to changes in sub-metropolitan movement patterns, land-use distribution and modal split
	*	expose the public facility system by locating the majority of facilities along main public transport routes, in order to make them as accessible as possible, enable complex patterns of use between different neighbourhoods, and create the conditions necessary to encourage private commercial and industrial investments

opportunity	*	concentrate local through-movement onto continuous connecting 'activity' routes through the routing of public transport services and the location of movement generators (eg. public facilities, modal interchanges), in order to create the passing consumer thresholds necessary to support viable small and large-scale commercial activities
	*	provide hard public spaces at points of greatest access (eg. modal interchanges, intersections), in order to create the spatial conditions necessary for formal commercial investment and informal trading opportunities
	*	cluster collective service points around hard public spaces, in order to create favourable small-scale manufacturing and trading conditions (by providing the necessary utility services and attracting potential consumers to specific points in space), and in cases where these services perform residential functions as well, enable a single trip to satisfy numerous household needs
	*	incorporate public markets (ie. agglomerated services and stalls) at points of greater access, as an element of essential public infrastructure, in order to assist small-scale manufacturers and traders by providing central trading locations and creating agglomerations of small traders capable of competing effectively with larger commercial establishments
efficiency	*	cluster public facilities according to their hierarchical and lateral functional relationships (eg. medical referrals, book circulation), in order to facilitate the sharing of resources (eg. halls, playing fields, teaching equipment) between facilities, and enable a number of household needs to be satisfied in a single trip
	*	integrate public open space networks with utility services like major stormwater management systems (eg. retention and retarding ponds) and solid waste disposal sites, in order to enable these spaces perform numerous functions (eg. public open spaces acting as overflow facilities in the event of severe storms, and stormwater storage facilities providing landscaping features)
	*	facilitate efficient service provision and land utilisation by optimising the layout for the particular combination of service options provided (eg. avoiding steep or flat road gradients, reducing road length per erf), in order to enhance the affordability of a development through reductions in the unit cost of land acquisition and service provision

	*	align trunk services (eg. sewer mains, electricity sub-stations, water ring mains) to more intensive movement routes which link public facility clusters and non-residential land uses, in order to ensure that full service connections are made to public facilities, commercial services and small-scale manufacturers, from the beginning of the infrastructure provision process
	*	address the collective functions of services, in order to provide the basic infrastructure around which vibrant urban settlements and embryonic local economies develop, and where all service needs cannot be met within the individual dwelling, allocate limited resources to benefit entire communities, rather than limited numbers of households
choice	*	provide contrasting public spaces of greater and less intensity, in order to create spaces of relief and relaxation in bustling areas, create spaces of exchange and interaction in quieter areas, and initiate pulses of urban activity that generate vibrancy and interest in urban settlements
	*	facilitate a range of housing forms and housing processes (eg. aided self-help unit consolidation, walk-up units, subletting backyard dwellings, operating home businesses) by varying the size of erven and the level of service provision per erf within a layout plan, in order to accommodate the diverse range of housing needs that exist within end-user communities
	*	meet the spatial requirements (eg. road reserve widths) of future infrastructure upgrade, in order to ensure that, where every erf is not provided with a high or full level of services, it is possible to upgrade the initial level of service provision at a later date

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Introduction

1. Background

In December 1993, the Urban Problems Research Unit (UPRU) of the University of Cape Town obtained a commission from the Community and Urban Services Support Project (CUSSP) to undertake research into layout planning guidelines appropriate to developing urban areas in South Africa. This document is the product of this research.

The research project was driven primarily by a concern for urban environmental quality, or in other words, the development of urban environments that enrich the lives of the people who live in, and experience, those environments.

The research project was motivated by three main concerns.

The first concern related to the need for a set of layout planning principles and guidelines that are appropriate to developing urban areas in South Africa. Current South African layout guidelines, in the form of the 'blue', 'green' and 'red books', are based on inappropriate planning concepts (eg. 'neighbourhood units' and 'environmental areas') imported from 'First World' countries like the United States and Britain. Amongst other things, these concepts assume household incomes and levels of private car ownership that do not exist in lower income communities.

The second concern was that the process of layout planning in South Africa has, with a few exceptions, become a highly sectoral exercise. Transport and civil engineers tend to approach layout from the perspective of maximising the efficiency and operation of the infrastructural element with which they are dealing. Town planners and urban designers, on the other hand, who are concerned with the socio-economic implications of layout as well, are generally producing layout plans in isolation from an understanding of technical and engineering constraints. All too frequently, as a result, planning and urban design concerns are lost in the drive for technical efficiency and cost reduction. As important however, is the fact that development opportunities which arise from the organisation of infrastructure and land uses in space, tend to be overlooked.

The third concern related to the need for information regarding layouts and services to be packaged in a way that enables informed community participation in the process of layout and infrastructure design.

The research project therefore has two interrelated products. The first is this document, which takes the form of a handbook providing a set of layout planning principles and guidelines for use by urban professionals. The second product takes the form of a set of workshop materials aimed at enabling end-user communities make informed decisions relating to layouts and services.

2. Aim of the Handbook

The aim of the handbook is to promote an alternative, more appropriate approach to layout planning in the developing urban areas of South Africa.

The term 'layout planning' (or 'layout design') is generally used to refer to the geometric design of road networks, public spaces, block alignments, and erf subdivisions, and the identification of appropriate locations for public facility investment. Closely associated with layout planning is the design of reticulated infrastructure networks. 'Infrastructure design' generally refers to the design of water supply, sanitation, road structure, stormwater disposal, energy supply, public lighting, solid waste removal and communication networks.

The interrelated processes of layout planning and infrastructure design require the participation and coordination of numerous disciplines. Road, block and erf plans are conventionally prepared by town planners, urban designers and transport engineers, staked by land surveyors, and passed onto civil, electrical and telecommunication engineers for the design of service reticulation.

This handbook has been prepared for use by town planners, urban designers, engineers and architects engaged in the preparation of layout plans at the local urban scale. Whilst the handbook discusses traffic, utility services and public facilities, it is not intended to be a traffic engineering, service provision or structure planning design manual. The handbook is concerned primarily with layout planning, and discusses these related disciplines only in so far as they are connected to, and influence, layout plans. It is intended to assist town planners in their interactions with other urban professionals.

The handbook should not therefore be seen as a reformulation or replacement of current South African guidelines (ie. the 'red book'). The handbook criticises those sections of current guideline documents that deal with layout planning, and presents a very different alternative, but makes no attempt to replicate the technical guidelines on infrastructure design and traffic engineering.

The layout concepts that are used in specific urban development projects are however, ultimately applied at the discretion of the designers or professionals involved. The handbook presents an approach, rather than a prescriptive set of solutions, or 'blueprint' - since every development project must develop its own particular solutions to its own particular problems.

The handbook has been prepared for use in the urban areas of South Africa. It is recognised however, that major regional differences exist (eg. hilly topography in Natal). It is the position of the authors that the concerns and their spatial implications, presented in the handbook, are valid for all parts of the country, and that difference in context should play a role in informing how the concepts are applied. It must be emphasised that the conceptual diagrams provided in the document, are purely conceptual - unless they are 'warped' and moulded to a particular context, the result will be exactly the kind of urban sterility which the handbook seeks to combat.

The handbook is therefore intended as a guide and stimulus - it raises an appropriate set of concerns and suggests ways to address these. There is no substitute for innovative and informed planning and engineering practice in the preparation of appropriate layout plans.

3. Outline of Sections

The handbook is divided into six sections:

The first section presents a normative set of concerns appropriate to guiding layout planning in the South African context, reviews major chronological shifts in approach to layout planning internationally, traces the evolution of South African layout planning guidelines, outlines the origins of, and conceptual approach to, layout planning, adopted in current South African guideline documents, and provides a critique of these guidelines on the basis of the normative concerns presented.

The second section discusses some principles that should inform the layout planning process, provides a guide to the steps involved in a layout planning process, and indicates how the following sections on layout concepts and guidelines should be used to formulate a physical plan - in other words how the ideas and concerns presented in the handbook can be used in practice.

The third section presents a set of layout planning principles, as an alternative conceptual approach to layout planning to that provided in current South African guideline documents, and illustrates the spatial implications of these principles at different scales, and in 'greenfield' and 'upgrade' contexts. The planning principles are discussed in terms of the normative concerns presented in the first section.

The fourth section essentially translates the layout planning principles in section three into a set of more technical layout planning guidelines. The layout guidelines are presented in terms of roads, intersections, facilities, blocks, and erven. The distinction between a principle and a guideline is that whereas a guideline provides quantifiable spatial and geometric directives, a principle adopts a position or approach to an aspect of layout planning, without necessarily having quantifiable design instructions.

The fifth section identifies the range of infrastructural elements within the layout plan, and discusses their functions, service options and implications for layout design. Water supply, sanitation, roads, stormwater disposal, energy supply, public lighting, solid waste removal, communications, public spaces, and markets are identified as the elements of layout infrastructure.

HOW TO USE THE HANDBOOK WHEN PREPARING A LAYOUT PLAN

When confronted with the task of preparing a layout plan for a site, one of the first steps is to develop a method (ie. how the plan should be prepared) and an associated work programme (ie. what should be done when). *Section 2 of the handbook has been written to assist in developing such a method.*

It is argued in section 2 that the stages of the layout plan formation process centre around converting concerns for the quality of urban environments, into a set of contextual layout proposals. *Section 1 of the handbook suggests an appropriate set of concerns.*

The process of layout plan formation has five main tasks, each of which is revisited, in a cyclical fashion, during the planning process. Public participation occurs, at certain strategic points, throughout the process - community workshop materials, that are another product of this research project, are intended to facilitate this participation.

* The first task involves an analysis of the physical, socio-economic, financial and regulatory context. *Part 2.1 of section 2 of the handbook provides an indication of the key questions that should be asked in such an analysis.*

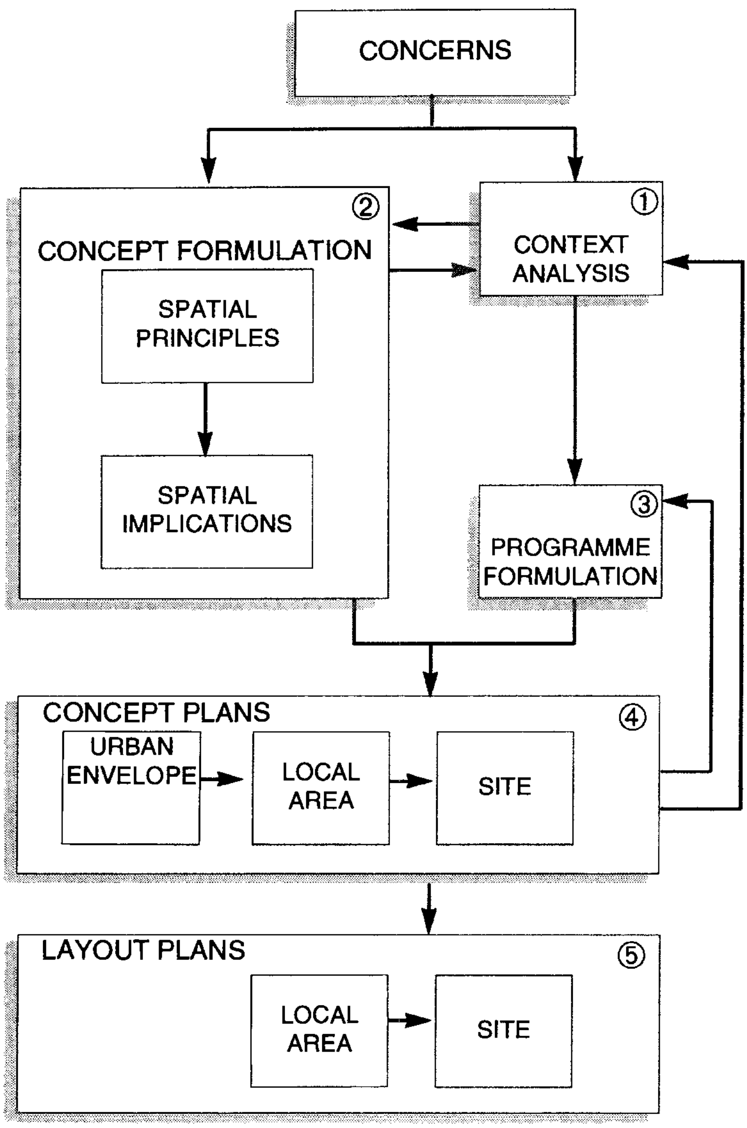
* The second task involves the conversion of normative concerns into guiding layout planning principles, expressed as a set of written statements, and the identification of their implications for spatial relationships, expressed as a set of acontextual concept diagrams. *Section 3 of the handbook provides a set of layout planning principles and illustrates their spatial implications.*

* The third task involves the quantification of needs into a programme of required facility, amenity and infrastructure investments. *Part 2.3 of section 2 and part 3 of section 4 of the handbook provide assistance in formulating such a programme.*

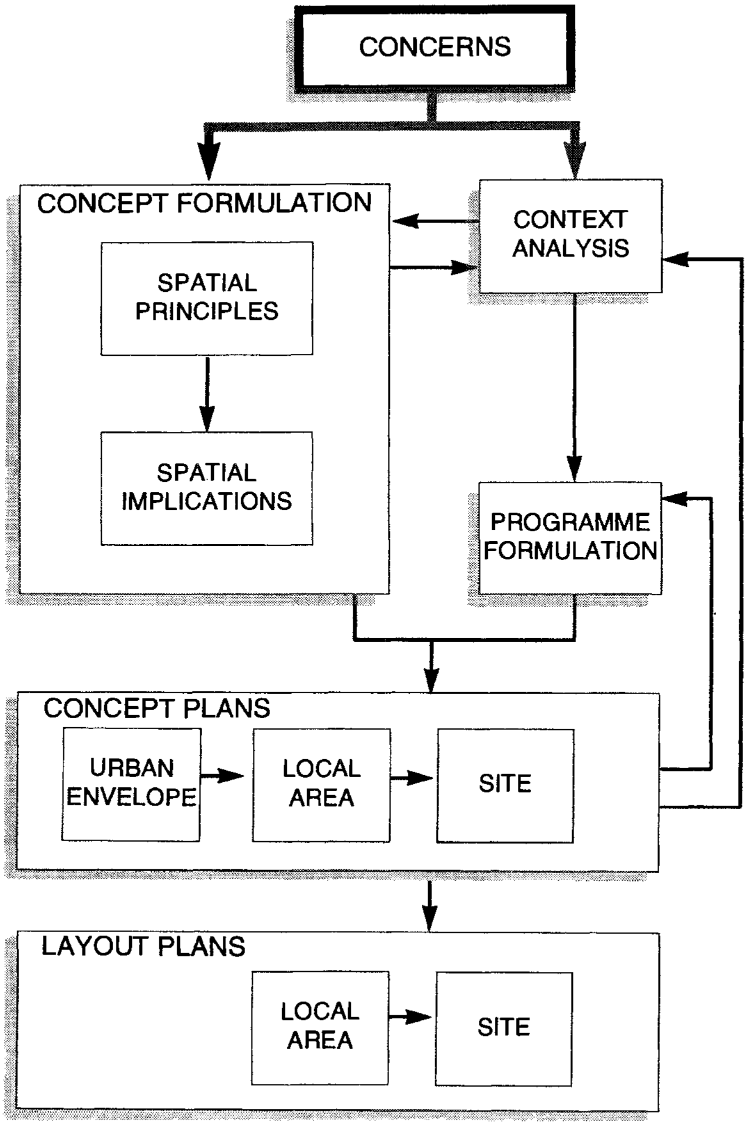
* The fourth task involves bringing together context analysis, guiding layout planning concepts and programme, to form concept plans at a range of scales. *Part 2.4 of section 2 of the handbook discusses the formation of concept plans.*

* The fifth task involves attaching widths, lengths and areas to the lines drawn on concept plans, to form more detailed layout plans. *Sections 4 and 5 of the handbook provide discussion and guidelines on technical issues relating to detailed layout plans.*

The following diagram illustrates the relationship between the main tasks of the layout planning process. At the beginning of each section of the handbook, this diagram appears with those tasks the section is intended to inform, highlighted.


CONCERNS
② CONCEPT FORMULATION
SPATIAL PRINCIPLES
SPATIAL IMPLICATIONS
① CONTEXT ANALYSIS
③ PROGRAMME FORMULATION
CONCEPT PLANS ④
URBAN ENVELOPE
LOCAL AREA
SITE
LAYOUT PLANS ⑤
LOCAL AREA
SITE

Section 1:
Layout Planning Concerns



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Section 1:
Layout Planning Concerns

This section (1) presents a normative set of concerns appropriate to guiding layout planning in the South African context, (2) reviews major chronological shifts in approach to layout planning internationally, (3) traces the evolution of South African layout planning guidelines, (4) outlines the origins of, and conceptual approach to, layout planning, adopted in current South African guideline documents, and (5) provides a critique of these guidelines on the basis of the normative concerns presented.

1. Normative Concerns

Normative concerns in layout planning have tended to change as technological innovation, rates of urbanisation, economic growth, and environmental destruction have altered the context within which urban development occurs. The review of chronological shifts in approach to layout planning in the next part of this section, will illustrate how a fairly constant set of objectives has, over time, been pursued by various design approaches with very different sets of concerns.

It is argued that within the current South African context, where levels of poverty, unemployment and spatial inequality have reached alarming proportions, the development and management of urban settlements generally, should be motivated by three overarching concerns: (1) the first is for the satisfaction of human needs and for an improvement in the human condition, (2) the second is for establishing a sustainable relationship between urban settlements and their surrounding natural environment, and (3) the third is for the most efficient use of resources.

Within these overarching concerns it is argued that, more specifically, layout planning should be guided by the sets of concerns that follow. At the most fundamental level this handbook is concerned with environmental quality, or in other words, the development of urban environments that enrich the lives of the people who live in, and experience, them. The following concerns provide an indication of what is meant by the term 'enriching' or 'quality' urban environments, and of their main characteristics.

1.1 Place Making

The first set of concerns relates to place making. The term 'place making' is used to refer to the creation of urban environments with a unique sense of place. The concept of place making lies at the heart of the issue of environmental quality in urban settlement formation. The creation of urban settlements which reflect a sense of place and express the unique nature of their natural and cultural setting, should be one of the central concerns of layout planning and, in fact, a central concern of all of professions concerned with the urban environment.

The creation of a sense of place is neither a luxury nor a romantic concern - it is essential. The concept does not equate simply to the creation of picturesque landscapes or pretty streets, but to a recognition of the importance of a sense of belonging. Different places offer different life experiences, and these experiences mould peoples' perceptions, values and self-identity. Urban places are records and expressions of the cultural values and experiences of those who create and live within them. In essence, the place of which people are a part, is a part of them.

1.2 Scale

The second set of concerns relates to the scale of an urban environment. Layouts should be planned to a human, as opposed to a vehicular, scale.

The term 'human scale' is used to refer to the design of the heights, widths, surfacings and operations of the various elements of a layout plan, from the perspective of the person on foot. In the context of inadequate housing conditions, the scale of an urban environment has a profound impact on the quality of life experienced by lower income households. Of particular importance are concerns for: the ability of residential streets and public spaces to act essentially as extensions of small crowded dwellings, providing opportunities for playing, meeting and celebrating important events, and more broadly, the creation of a public environment that is convenient, safe and comfortable for the person on foot.

1.3 Access

The third set of concerns relates to levels of access and convenience. The road layout and the location of facilities should be concerned with matching the circulation needs of end-user communities and ensuring that levels of access are maximised for the greatest number of people. In the context of low levels of private car ownership, the circulation network should enable easy pedestrian access to public transport stops and non-residential activities.

1.4 Opportunity

The fourth set of concerns relates to the economic opportunities that are created by the arrangement of infrastructural investments in space. In the context of high levels of unemployment, layout plans should be concerned with maximising the economic opportunities that are inherent in large agglomerations of people, by creating the necessary spatial pre-conditions for viable small commercial enterprises and informal street trading.

Economic opportunity across space is closely related to the accessibility of various locations to consumers. In this regard, the design and location of *inter alia* intersections, public transport stops, public facilities which attract movement, and the treatment of public spaces, are of importance in creating these conditions.

1.5 Efficiency

The fifth set of concerns relates to efficient land utilisation and efficient service provision, and a recognition of the functional and spatial relationships between different elements of the layout plan. Low levels of affordability in lower income developments make the ability of layout designs to minimise serviced land costs of critical importance. The functional interrelationships between public facilities, between facilities and amenities, and between facilities and services should be recognised so that facilities, amenities and services can be planned in an efficient and systemic way.

1.6 Choice

The sixth set of concerns relates to the maximisation of choices available to end-user communities. Layout plans that offer as many different choices as possible, regarding housing consolidation, service provision, urban surroundings, movement modes and so on, are more likely to meet the diverse range of household needs that exist, than layouts that offer limited choices. Very often minimalist public intervention in layout planning results in a maximisation of private choice.

In short, layout planning should be guided by a concern to create urban environments that are enriching, sustainable and convenient, providing opportunities and choices to its inhabitants, in a way that makes efficient use of limited resources. The concern should not be to simply optimize the provision of infrastructure sectorally, but to ensure that together these infrastructural elements operate in a developmental and systemic way - this often necessitates trade-offs and sometimes technical inefficiencies. In essence, it is less what infrastructure is provided, than how the infrastructure that is provided is arranged in space, that initiates the development of urban environments of quality. In this regard spatial concepts and ideas are very important.

2. Shifts in Approach to Layout Planning

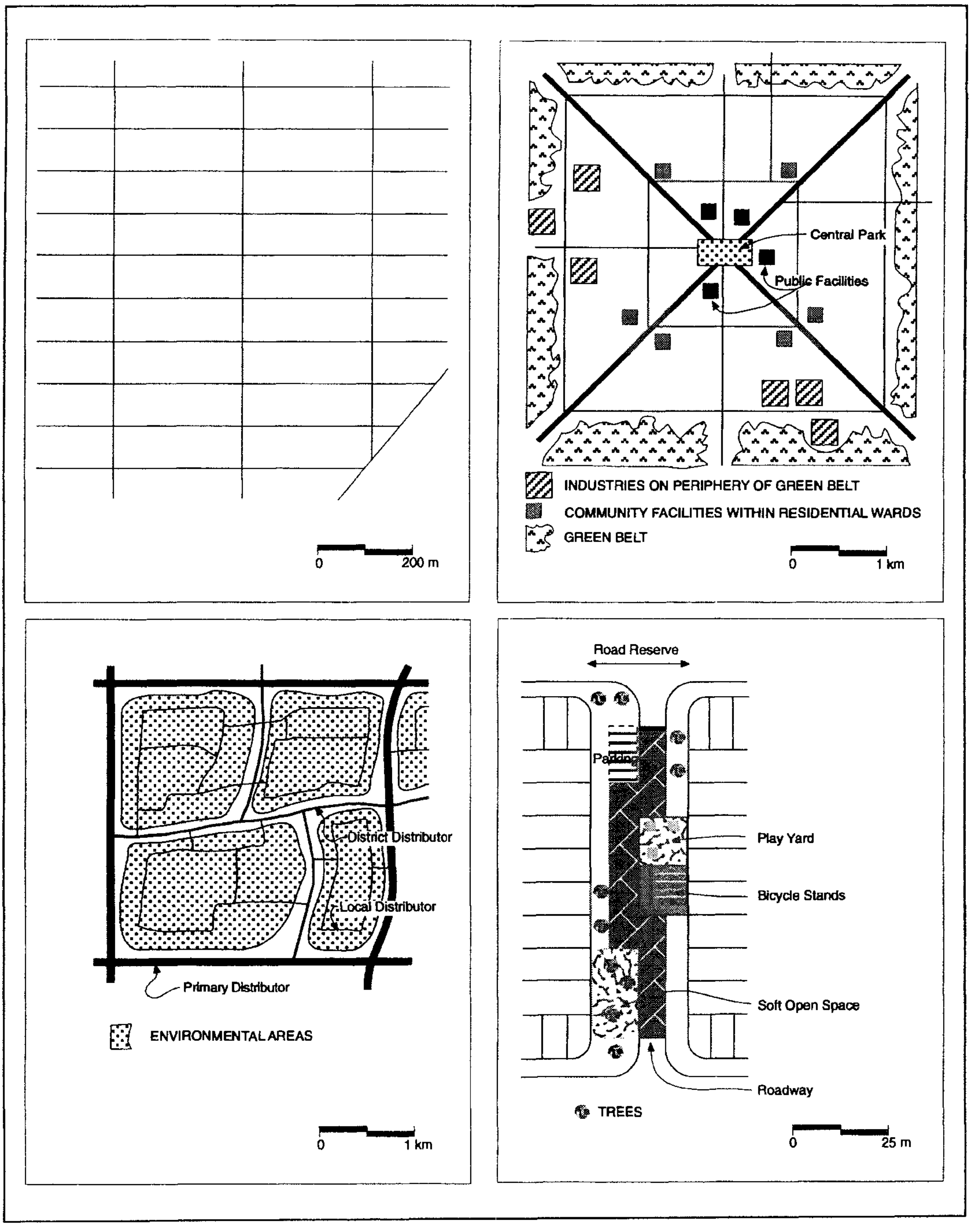
The history of modern town planning has experienced shifts in approach to layout planning. Definite shifts are difficult to identify, as each new approach draws from earlier concepts, and different approaches have been developed at different scales and levels of abstraction. The approaches outlined below therefore illustrate only broad shifts, and cannot claim to be comprehensive. The chronology is intended only as a base from which the conceptual origins of current South African layout guidelines can be identified.

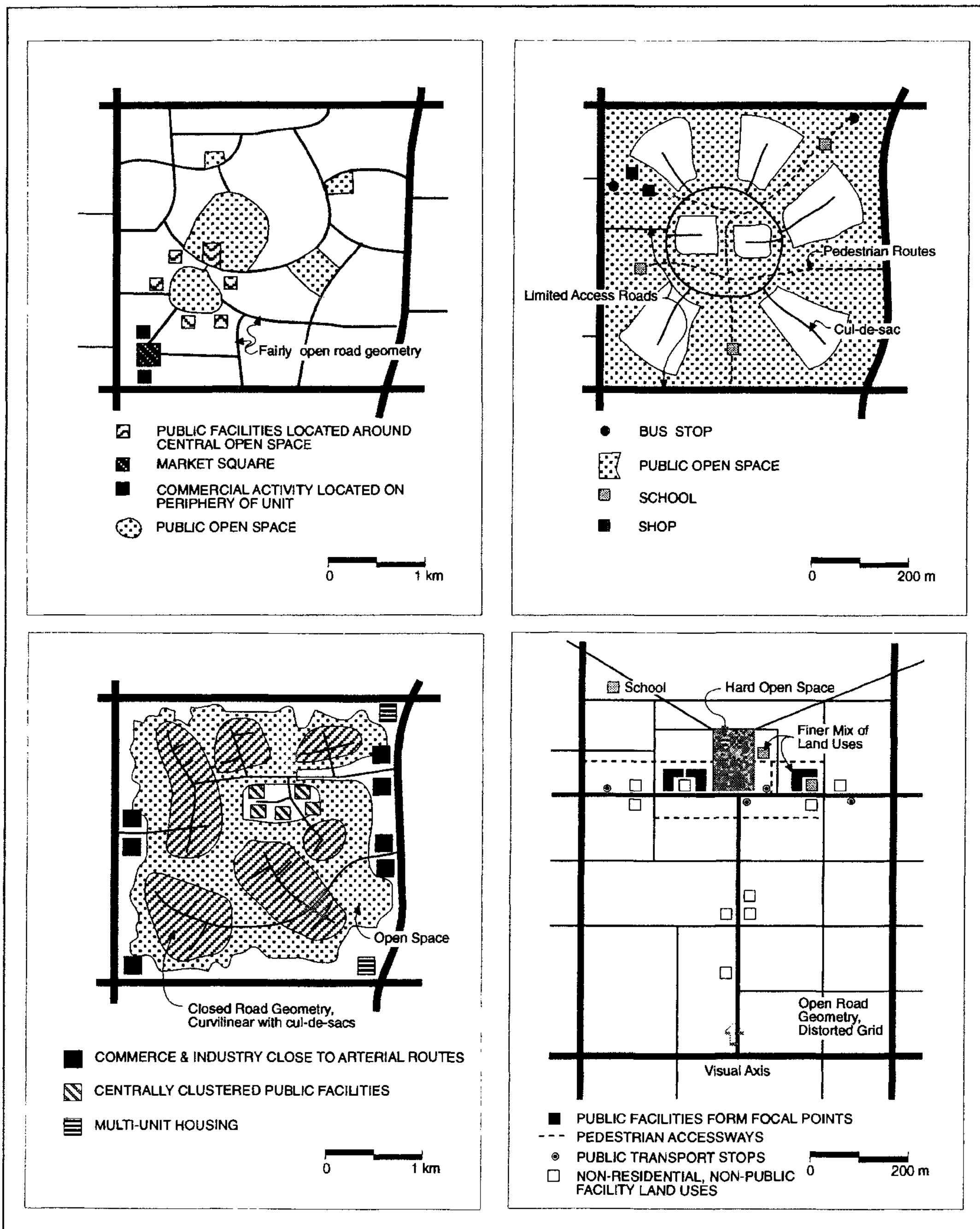
The different approaches are discussed in terms of their guiding concerns, and how they address what have, either explicitly or implicitly over the last hundred years of modern town planning, been regarded as the basic tasks in designing an urban layout.

These tasks have been: (1) to create an urban environment that improves, in a social, economic and psychological sense, the quality of life of those communities that experience that environment, (2) to facilitate, through a variety of transport modes, the circulation of people, goods and services within a local neighbourhood, and between the neighbourhood and its larger city environment, (3) to facilitate the provision of public facilities and amenities, by identifying appropriate locations for, and quantities of, facilities and amenities, and (4) to facilitate the provision of the full range of utility services, by ensuring that the spatial and topographical requirements of the various services are met within the layout.

The criticisms of the different approaches listed in the chronology, are those commonly cited in the literature.

FIGURE 1: Layout Planning Concepts




Fairly open road geometry
PUBLIC FACILITIES LOCATED AROUND CENTRAL OPEN SPACE
MARKET SQUARE
COMMERCIAL ACTIVITY LOCATED ON PERIPHERY OF UNIT
PUBLIC OPEN SPACE
0 1 km
Pedestrian Routes
Limited Access Roads
Cul-de-sac
BUS STOP
PUBLIC OPEN SPACE
SCHOOL
SHOP
0 200 m
Open Space
Closed Road Geometry, Curvilinear with cul-de-sacs
COMMERCE & INDUSTRY CLOSE TO ARTERIAL ROUTES
CENTRALLY CLUSTERED PUBLIC FACILITIES
MULTI-UNIT HOUSING
0 1 km
School
Hard Open Space
Finer Mix of Land Uses
Open Road Geometry, Distorted Grid
Visual Axis
PUBLIC FACILITIES FORM FOCAL POINTS
PEDESTRIAN ACCESSWAYS
PUBLIC TRANSPORT STOPS
NON-RESIDENTIAL, NON-PUBLIC FACILITY LAND USES
0 200 m

2.1 Gridiron

The layout plan most common at the turn of the century was the gridiron plan, which originated from early European settlements. The increased population growth of the later nineteenth century saw the adoption of the gridiron layout in most planned developments of the colonised world. The gridiron was adopted most extensively in North America, in cities like San Francisco, Philadelphia, New Haven, Savannah, and New Orleans.

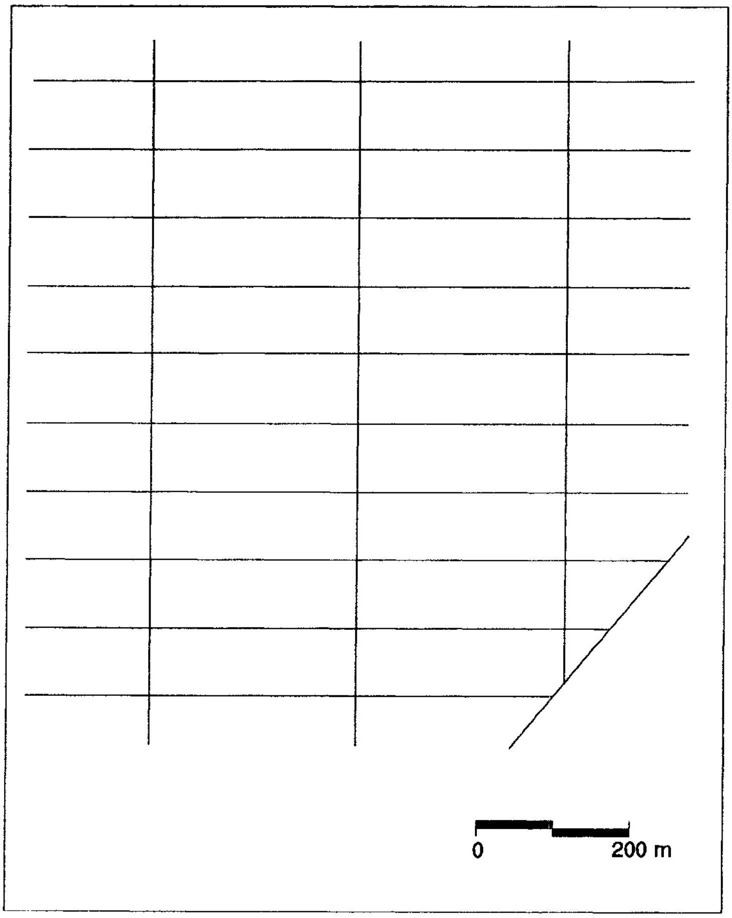


FIGURE 2: Gridiron

The principle concern behind the gridiron layout was the ease with which land conversion (and speculation) could take place. The simple geometric pattern of the gridiron yielded the greatest possible number of erven from a parcel of land, and enabled the survey of blocks and erven to occur in a quick and efficient manner.

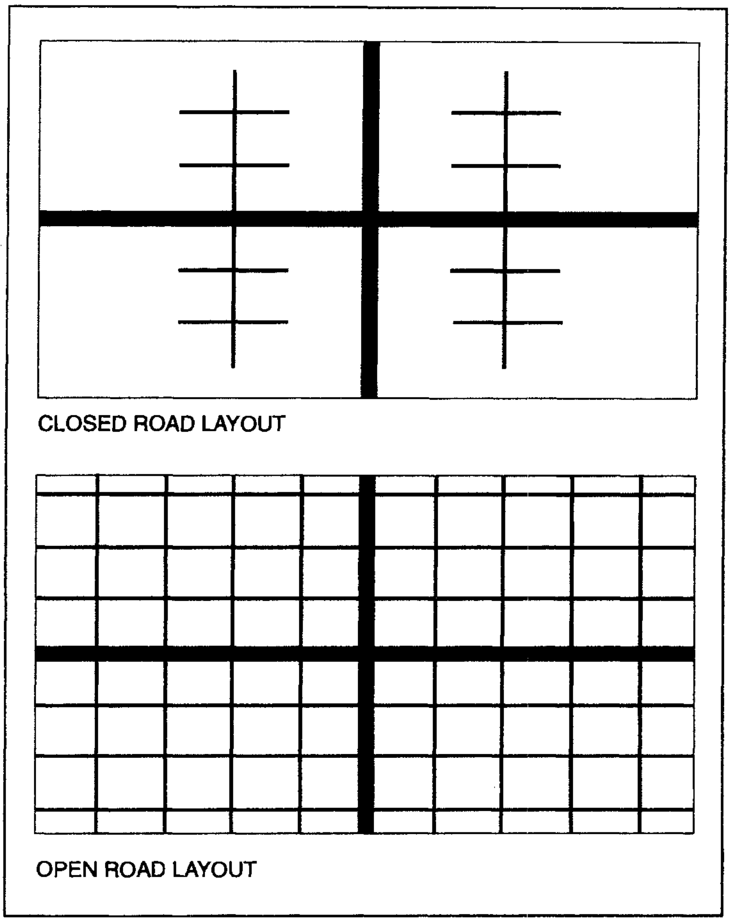


FIGURE 3: Closed and Open Road Geometries

The gridiron layout has an open[1] road network, without a clearly defined hierarchy of through-routes. The layout is designed to facilitate the circulation of pedestrians and public transit - which were the dominant modes of transportation at the turn of the century. Roads are long and straight, and intersections take the form of 90° 4-legged junctions. Local roads extend continuously throughout the layout, and intersect with

1. In identifying shifts, it is useful from the outset to identify the two generic types of road layout: closed road networks, and open road networks. A closed (or limited-access) road network consists of a functional hierarchy of roads, within which higher order roads do not intersect with lower order roads. This road system establishes clearly defined movement routes between any two points within the network, and offers few or no alternatives. An open road network on the other hand consists of a system of roads of differing widths and importance intersecting freely with one another. This road system offers a choice of numerous alternative routes between any two points within the network. In practice, certain characteristics of these generic road layouts have been combined with specific approaches to open space design and facility location, resulting in numerous different layout design concepts.

more intensive movement routes. Public facilities are generally located along more intensive movement routes carrying public transport services.

The main criticisms of the gridiron layout have been that: (1) when imposed on a site with little consideration of topography, gridiron layouts often result in steep road gradients which increase the cost of drainage and sewer reticulation, (2) as levels of private car ownership and traffic volumes increase, all roads become through-routes to a greater or lesser extent, so that fairly heavy traffic is experienced in all residential areas, (3) the number of intersections is high, the incidence of 4-legged intersections[2] with a high number of points of conflict resulting in a proportionally greater number of accidents, (4) traffic speeds on the often long, straight sections of road are inconsistent with environmental and safety needs in a residential area, and (5) when applied over large tracts of land the gridiron results in a monotonous urban environment.

2.2 Garden City

The British Garden City Movement emerged at the turn of the century, motivated largely by the writings of Ebenezer Howard. Howard's garden city concept sought a balance between the best attributes of cities and countryside. The concept involved a system of self-contained satellite towns, of approximately 30 000 people, surrounded by green open spaces. The satellite towns were characterised by detached dwellings, large erven, low residential densities, and a separation of incompatible land uses.

Raymond Unwin and Barry Parker were the first designers to draw on Howard's garden city concept to inform layout, and Letchworth and Welwyn were the first garden city suburbs to be constructed. It should be noted that most garden city developments departed fairly significantly from Howard's initial concept.

The primary concerns which motivated the development of the garden city concept were rural depopulation, and the overcrowded and polluted housing conditions which had developed in London during the industrial revolution.

The road layouts of the early garden city developments are relatively open networks characterised by radial routes and fairly straight lengths of road. The road layout was essentially designed to facilitate public transport services - which were the dominant mode of transportation in the early 20th Century. Even though curvilinear road alignments and cul-de-sacs appear in some garden city layouts, design features were used more to beautify roads, than to manage vehicular traffic.

Public facilities and amenities are located differently in Howard's schematic diagram and Unwin and Parker's garden city designs. Whereas Howard located core public

2. Intersections have proven to be points within the road network where accidents rates are particularly high - 4-legged intersections have sixteen potential conflict points, whereas 3-legged intersections have only three.

buildings around a centrally orientated park, and schools within residential 'wards', Unwin and Parker located public facilities adjacent to railway stations, making them accessible to surrounding neighbourhoods.

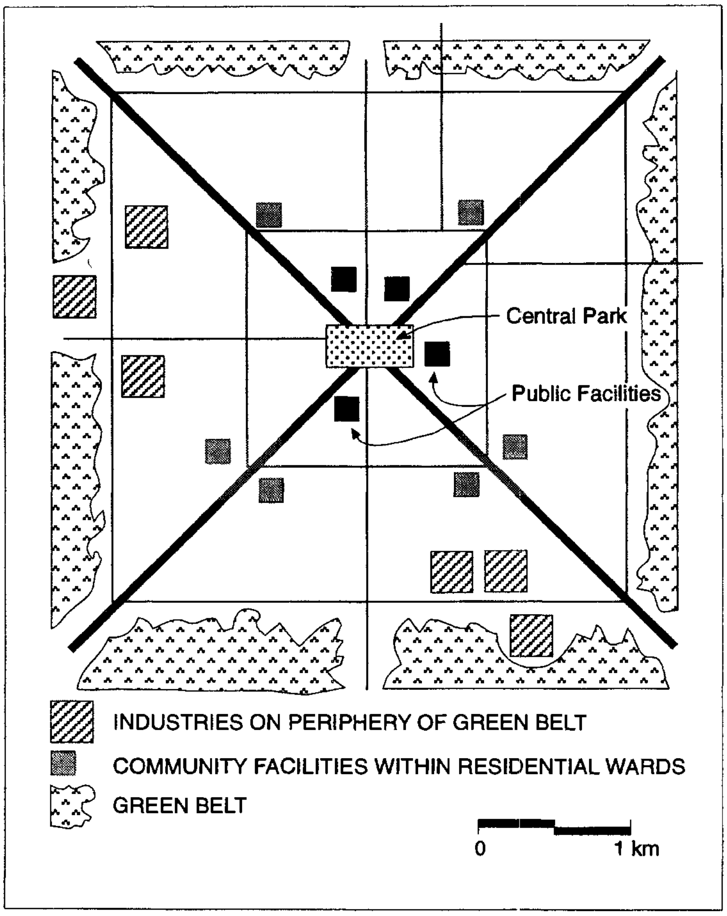


FIGURE 4: Garden City

The main criticisms of the garden city concept have been that: (1) its' characteristically low residential densities are insufficient to provide the quantity of consumers necessary to support the suburb's planned public facilities and commercial services - the assumption that the garden city would be self-contained has therefore proven incorrect as facilities and commercial services have been forced to concentrate in single locations, in order to generate the consumers necessary for their viability, and (2) the spatial separation and concentration of different land uses results in increased work and non-work trip lengths - for households with limited private mobility, garden suburbs are therefore inconvenient places in which to live.

2.3 Neighbourhood Unit

The neighbourhood unit concept was developed in the United States in the 1920's, by Clarence Perry. The concept emerged in response to the rapid urbanisation that occurred in American cities at the turn of the century, and the perception that in this process, the traditional community life of the newly urbanised population was being eroded due to the socially alienating nature of large metropolitan centres. The unit sought to recreate the neighbourliness and community cohesiveness of the small rural town.

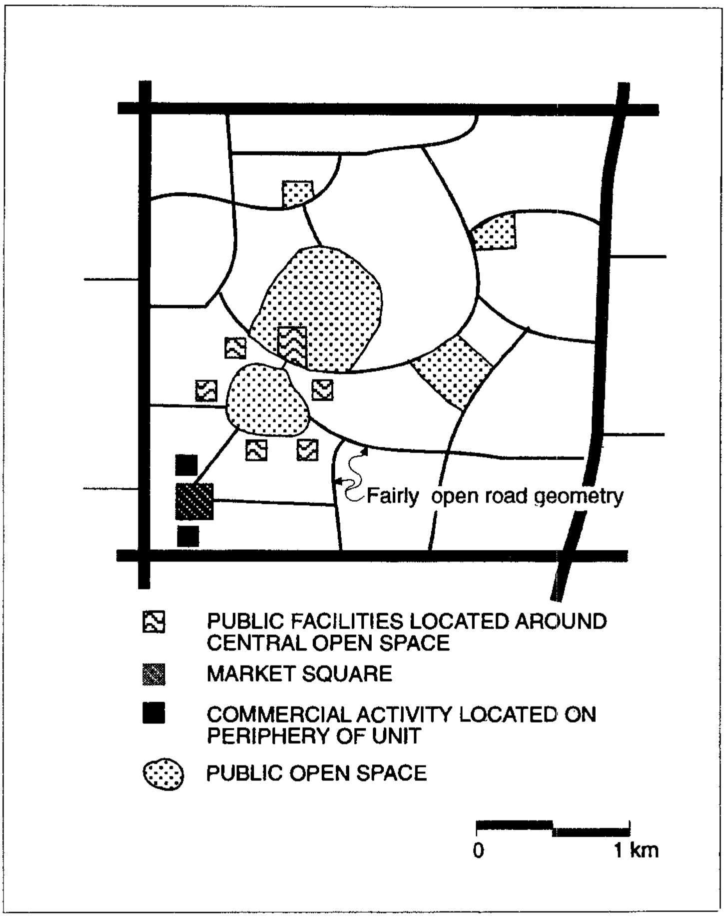


FIGURE 5: Neighbourhood Unit

Like the garden city concept, the neighbourhood unit was characterised by low residential densities, large expanses of open space, and localised public facilities. The ideal size of a neighbourhood unit was considered to be approximately 10 000 people - based on the population required to support an elementary school.

The primary concerns which motivated the development of the neighbourhood unit concept were the creation of clearly identifiable, independent social units, and to a lesser extent, the minimisation of conflicts between school children and through-traffic.

The neighbourhood unit has a fairly open road network, characterised by a curvilinear street pattern, and enclosing arterial routes. The road layout is designed to protect neighbourhood schools, roads and parks from heavy traffic, by confining through-traffic to the arterial routes on the periphery of the unit. Through-traffic is discouraged from entering the unit by increasing the width (and capacity) of the bordering arterial routes, decreasing the width of internal roads, and adopting curvilinear road alignments.

Public facilities are located within the neighbourhood unit, grouped around a central public open space or common. The playing fields of the elementary school are distributed throughout the unit in order to combine open spaces with housing areas. The inwardly orientated facilities and amenities of the unit are intended to serve only local residents.

Unlike public facilities and amenities, shops and services are located at traffic intersections adjacent to other units, and are supported by the residents of more than one neighbourhood unit.

The main criticisms of the neighbourhood unit concept have been that: (1) the concept oversimplifies the complex social relationships and interactions that develop a sense of community identity, and overestimates the ability of spatial planning to create defined social units, (2) the sharing of inwardly orientated facilities is difficult when this becomes necessary due to either changes in the demographic composition of the neighbourhood or resource scarcity, and (3) the unit represents an attempt to segregate social classes into spatially exclusive urban environments.

2.4 Radburn Superblock

The Radburn concept was developed by Clarence Stein and Henry Wright in 1928, in New Jersey. The conceptual origins of the Radburn layout are in the British garden city, and the 'private streets' introduced by Julius Pitzman in the gridiron layout of St Louis in the late 19th Century. The Radburn layout is characterised by cul-de-sacs, a superblock free from through-traffic, and the physical separation of pedestrian and vehicular movement.

The primary concerns which motivated the development of the Radburn concept were for the removal of conflict between pedestrians and vehicles, and the creation of identifiable community units. Whereas the garden city and neighbourhood unit concepts regarded the creation of identifiable social units as the primary concern in layout design, the Radburn concept viewed concerns for the creation of social units and the safety of pedestrians as equally important.

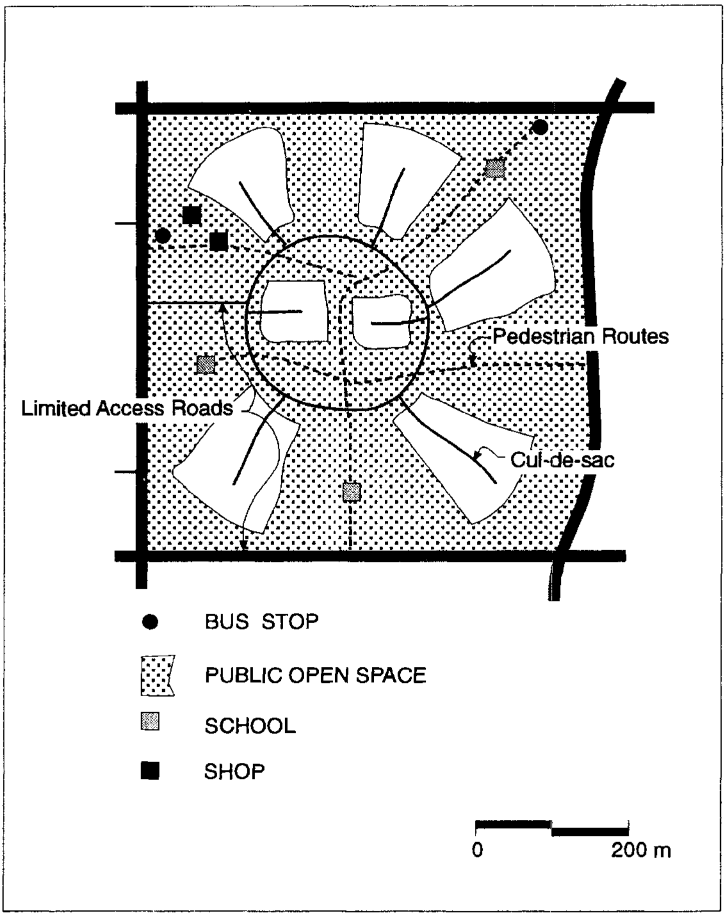


FIGURE 6: Radburn Superblock

The Radburn superblock represented a significant departure from the contemporary approach to road layout planning. The Radburn layout has a closed road network in which access to major arterial routes is limited, and networks for pedestrian and vehicular circulation are planned as physically independent systems. An individual dwelling has access to both a cul-de-sac or service road, and a footpath. The network of footpaths enables pedestrian access to facilities, shops and public transport without the necessity to cross roads.

Public facilities and shops are located within the superblock, along the pedestrian network, and embedded within a network of public open space. Public transport stops are connected to the pedestrian network and located adjacent to arterial routes

The main criticisms of the Radburn concept have been that: (1) it incorrectly assumes that pedestrian and vehicular movement can be totally separated - more specifically that many pedestrian trips are to commercial and employment centres which are not easily separated from the road network, and (2) when the facilities and shops within a superblock do not meet the needs of its residents, not all non-work destinations can be accessed via the pedestrian network - resulting in either increased car travel or the need for pedestrians to cross major arterial routes in order to reach facilities and shops outside the superblock.

2.5 Environmental Areas

The environmental area concept was developed in the United Kingdom by a working group on traffic chaired by Colin Buchanan in 1963.

The Buchanan report differed from previous traffic reports which had generally approached the traffic problem from the 'outside in' - by road-widening programmes and establishing a hierarchy of by-passes from the region to the town centre. The Buchanan report instead approached the traffic problem from the 'inside out' - dividing cities into cellular environmental areas and managing traffic first within the individual cells, and then throughout the larger urban area. People were to live, work, and shop in environmental areas relatively free from the hazards of vehicular traffic, while a complementary grid of interlacing highways enabled the rapid distribution of traffic between cellular environments.

The precursor to the environmental area concept was the 'precinct planning' concept developed by Alker Tripp in 1938. Tripp proposed the classification of roads into a strict hierarchy (arterial, sub-arterial and local roads), and the establishment of limited access shopping, business or residential precincts within sub-arterial routes.

The primary concerns which motivated the development of the environmental area concept included a decline in the utility of motor cars due to congestion, and a deterioration in the safety and quality of urban environments. Of these concerns, the latter was regarded as most important. Both the problems of increased congestion and decreased pedestrian safety were seen to be the result of rapid increases in private vehicle usage, and the form and arrangement of road networks. Even though similar to the Radburn superblock in its approach to traffic management, the environmental area concept did not include any social intention to create community units.

The report argued that older, open road networks were too narrow and had too many intersections to accommodate the modern motor vehicle. The increasing number of road accidents in London motivated proposals for sweeping physical changes to road layout design in order to reduce the number of opportunities for conflict between vehicles and pedestrians. The report did not seek to reduce vehicular traffic, but rather to organise it more efficiently and safely. It was assumed that increases in car ownership were inevitable, and that every household would eventually own a car.

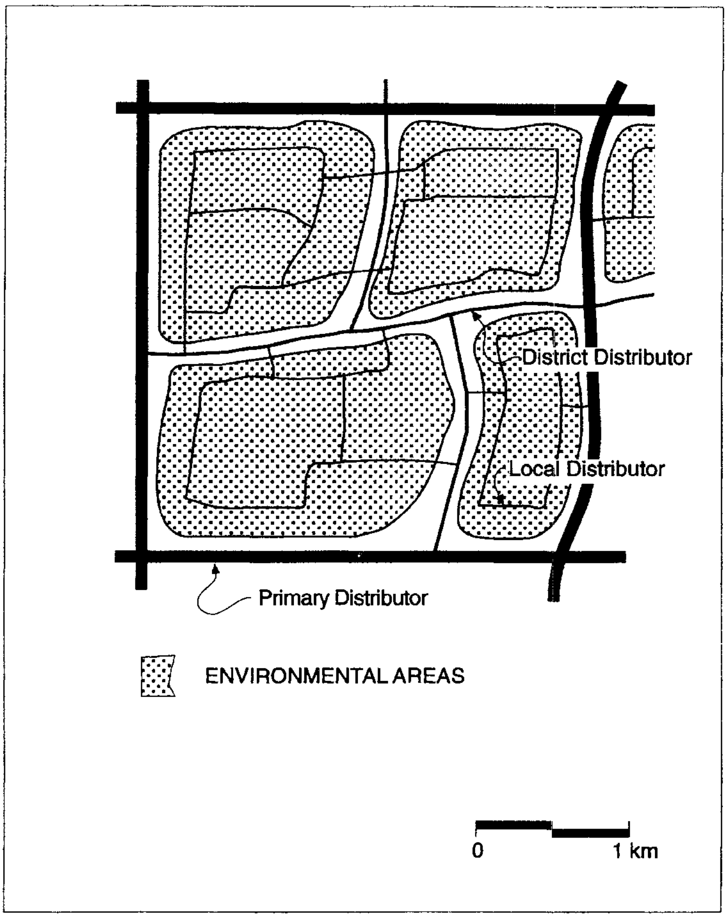


FIGURE 7: Environmental Areas

The environmental area concept has a closed road network, in which roads are categorised into a clear hierarchy (primary distributors, district distributors and local distributors). The environmental areas are surrounded by a network of highways which enable rapid, uninterrupted flows of vehicular traffic. The area has limited access points, which restrict the entry of extraneous traffic. Limited access to major roads is achieved through 'backup design', where the first row of erven back onto the major road without having access to it.

Different environmental areas can take very different forms, with different arrangements of land uses and facilities. Within the area, concerns for street aesthetics, noise and air pollution predominate over the flow of traffic.

The main criticisms of the environmental area concept have been that: (1) its interpretation of the circulation problem centred on the motor car and the mobility of its owner, and tended to ignore other transport modes - specifically pedestrians and public transport, and (2) the recommendations that arose from the concept led to the allocation of resources to massive road building programmes and the reconstruction of traditional road networks, while these resources may have been better used to reduce the demand for private car usage by improving public transport services.

2.6 Woonerf

The *woonerf* concept was developed by Niek de Boer in 1963, implemented by the Municipality of Delft, and later adopted in the national traffic legislation of the Netherlands in 1976. The *woonerf* (or residential yard) represented a significant departure from the contemporary role of residential streets. Unlike the Radburn layout, traffic and pedestrians are integrated, only traffic is forced to behave according to a set of pedestrian rules. In essence, the local street is designed for the pedestrian, not the motor car.

The primary concerns which motivated the development of the *woonerf* concept were for an improvement in road safety, a reduction of through-traffic on residential roads, and the restoration of streets as the focal points for walking, recreation and social events.

The *woonerf* is characterised by low speed limits (15-20 km/h), treeplanting, public furniture, changes in road direction and surfacing, defined parking spaces, and an integrated pavement and roadway (with a central mole-drain) for use by both cars and pedestrians. *Woonerven* have been introduced in both closed and open road networks.

A critique of the *woonerf* has been that when applied to individual streets on an *ad hoc* basis, traffic problems are simply diverted to other streets. For this reason, in Germany, the *verkehrsberuhigung* (or traffic calming) concept emerged, which applied *woonerf* principles on an area-wide basis. Area wide traffic restraint in Germany differs from the environmental area concept, in that traffic is restrained on all classes of road, and public transport, as an alternative to private car usage, is actively promoted. Traffic is calmed through road design features, rather than a specific form of road network.

The main criticism of the *woonerf* and *verkehrsberuhigung* concepts has been that the standards set for road surfacing, landscaping and public furniture in *woonerf* construction have proven too expensive for the implementation of traffic calming polices throughout an urban area. For this reason, in some cases, traffic problems have continued to be diverted to other areas, and public transport usage has not increased.

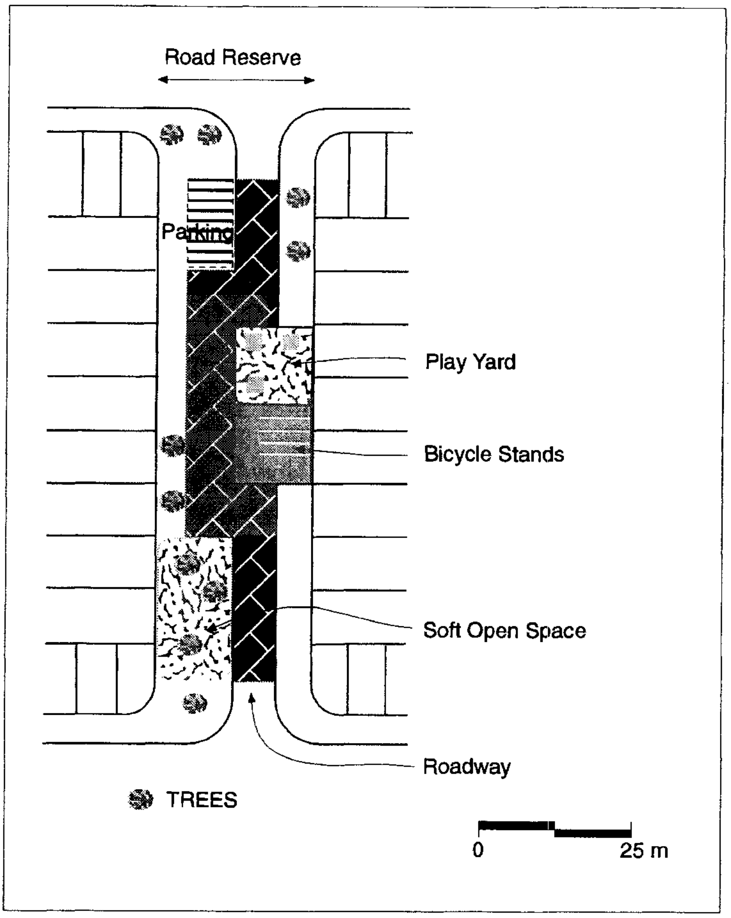


FIGURE 8: Woonerf

2.7 Planned Unit Development

Planned unit developments emerged in the United States in the 1960's and 70's. Planned unit developments (PUD's) are characterised by dwellings grouped into clusters in order to release more land as open space, a mix of housing types including townhouses and apartments, higher residential densities than conventional American housing projects, and a planned mix of residential, commercial and industrial land uses.

The forerunner to the PUD concept was cluster development, which emerged in the late 1950's. Cluster layouts differ from PUD's in that they are exclusively residential developments. The total number of dwellings is the same as a conventional suburb, only they are situated on smaller erven and grouped more closely together, so that the remaining land can be released for use as public open space.

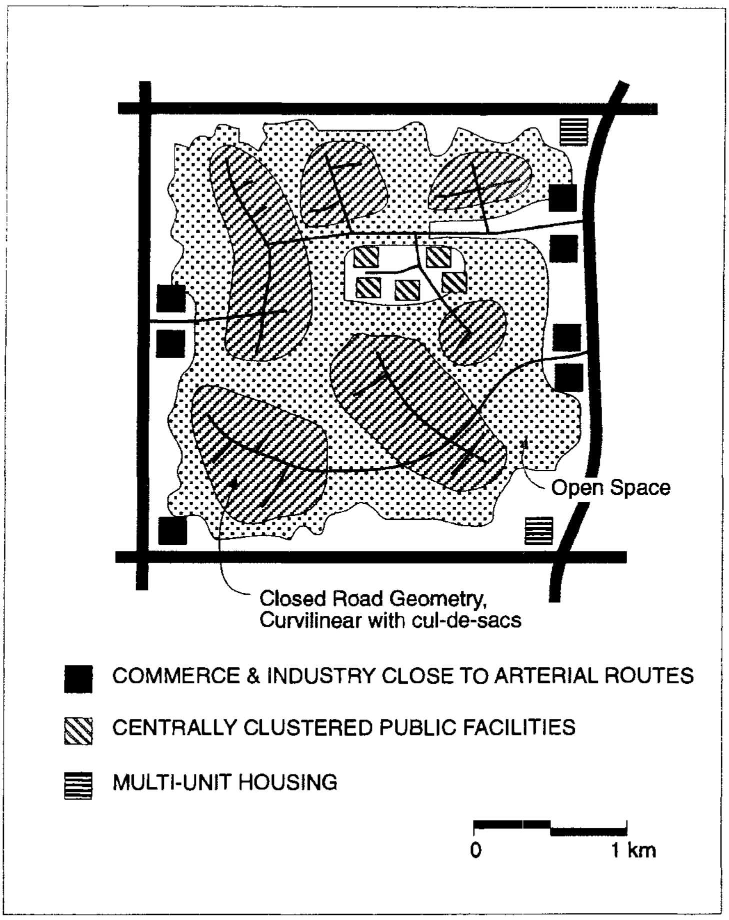


FIGURE 9: Planned Unit Development

The primary concerns which motivated the development of the PUD concept were for the ever increasing cost of suburban land development, and for the destruction of vast tracts of open land and the steadily increasing trip lengths that resulted from leapfrogging suburban developments of the 1960's.

The PUD has a closed road network, characterised by 3-legged intersections, collector roads with curvilinear alignments, and cul-de-sacs. The concepts of road hierarchy and limited access, developed in the Radburn and environmental area concepts, are adopted in the PUD layout.

Public facilities are located within the PUD, clustered around a central point, while commercial and industrial land uses tend to be located closer to the surrounding arterial routes. Housing clusters are set within a web of green open space.

The main criticisms of the PUD concept have been that: (1) like the environmental area and neighbourhood unit, the PUD road network is designed to facilitate the mobility of private motor vehicles, at the expense of pedestrians and public transport services, and (2) the sharing of inwardly orientated public facilities between PUD's is difficult when this becomes necessary due to demographic changes or resource scarcity.

2.8 Traditional Neighbourhood Development

Traditional neighbourhood development (also known as neo-traditional development) is a generic term, that has emerged in the United States over recent years, to describe development proposals influenced by urban settlements that were built prior to the dramatic increase in car ownership that occurred in the 1950's. Traditional neighbourhood developments (TND's) are characterised by pedestrian access to most non-work destinations, higher residential densities, a finer mix of land uses than in planned unit developments, and the abandonment of limited access curvilinear layouts.

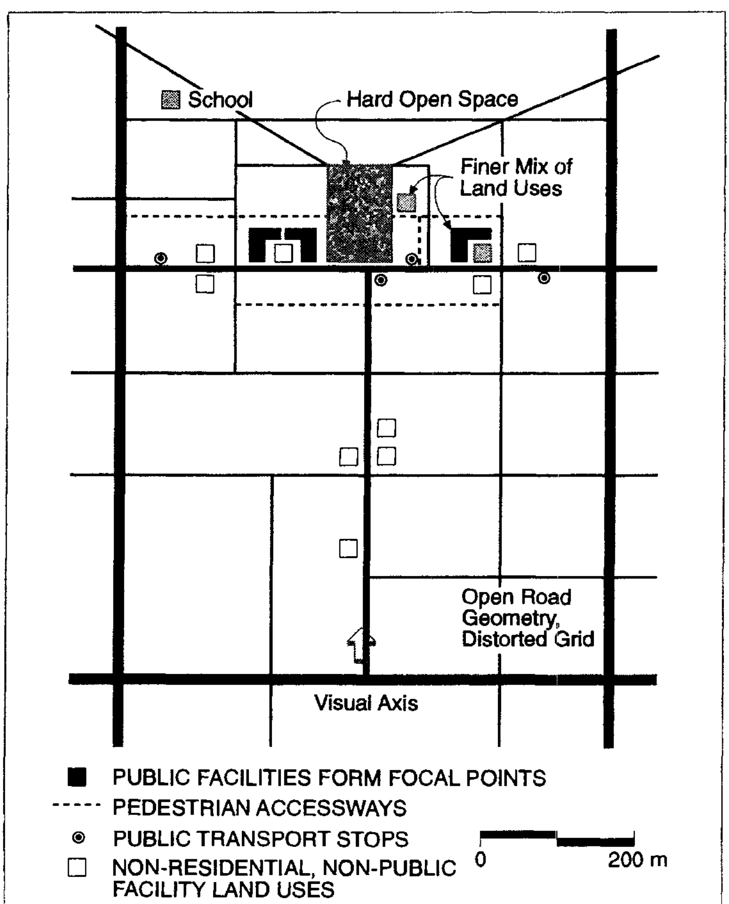


FIGURE 10: Traditional Neighbourhood Development

The primary concerns which motivated the development of the TND concept were for the excessive trip lengths and congestion that result from limited access low-density developments, the income exclusivity of housing provision in conventional PUD's, and the capture of a stronger sense of place through the design of public buildings, streetscapes and open spaces.

The TND has a relatively open road network, in which a distorted rectilinear grid layout is broken with radial streets and traffic circles, in order to reduce the problems associated with unbroken lengths of road and numerous 4-legged intersections, that emerged in earlier gridiron layouts. Streets are scaled to pedestrians, through the incorporation of narrow road reserves, wide pavements and treeplanting. The open circulation system is intended to reduce travel distances by providing more connections between any two points within a development, and to facilitate better pedestrian access to public transport stops. Greater pedestrian access together with higher residential densities, enhance the viability of public transport services.

TND's differ from PUD's in that while the latter are planned as closed, self-sufficient settlements, the open road network and public transport connections of the TND are intended to integrate the development with the larger metropolitan area.

Public facilities are located to create focal points within the development, and open spaces are designed more formally than in PUD's. Core public buildings are positioned to provide open spaces with a sense of enclosure so that public spaces function much like outdoor rooms.

The main criticism of the TND concept to date has been of its assumption that it is possible to impel higher income households to abandon their cars in favour of walking and public transport, and that when this does not occur, the traffic problems associated with earlier open road networks reemerge.

3. The Evolution of South African Guidelines

Guidelines for 'layout planning' and 'infrastructure design' in South Africa have conventionally been combined in single documents. Of primary interest here are the sections in these guideline documents that deal with aspects of layout planning.

Perhaps the earliest set of unofficial layout design guidelines in South Africa were prepared by T B Floyd in 1951. The document, entitled "Township Layout", was prepared in the absence, at the time, of guidelines which dealt with layout planning peculiar to South African conditions.

Later, in 1976, the South African Institution of Civil Engineers, with assistance from the South African Institute of Town and Regional Planners, produced a further set of unofficial guidelines. The document, entitled "Guidelines on the Planning and Design of Township Roads and Stormwater Drainage", was prepared to provide a basis for cooperation between the various disciplines involved in the planning, design and construction of road networks, and to provide minimum standards to guide planners and assist local authorities in the preparation of by-laws and town planning (or zoning) schemes.

3.1 The 'Blue Book'

The guidelines produced by the South African Institution of Civil Engineers in 1976, provided the conceptual basis for the first official set of guidelines produced in the early 1980's.

In 1983, the Department of Community Development produced a document entitled "Guidelines for the Provision of Engineering Services in Residential Townships" - which became commonly known as the 'blue book'. The 'blue book' was prepared for the Department of Community Development, by the National Building Research Institute of the Council for Scientific and Industrial Research (CSIR).

The need for a set of standardised national norms for service provision was identified by the Fouche Commission of Enquiry into matters relating to housing costs and township establishment of 1977. The commission expressed a concern for the increasingly high cost of serviced erven, and the lengthy delays experienced in the approval and development of residential townships due to disagreements surrounding the standard of internal engineering services required in different parts of the country.

The 'blue book' provides non-mandatory guidelines for layout planning and service provision for application in middle to higher income residential developments. The guidelines are concerned with the planning of road layouts and their geometric design standards, the structural design of roads, urban stormwater management, sewerage, water supply, and electricity distribution. The guidelines regarding infrastructure design are based on high standards.

Even though non-mandatory, standards are sometimes interpreted by local authorities as minimum requirements, rather than 'guidelines'. Local authorities often require developers to provide a high standard of service in an attempt to reduce the likelihood of expensive operating and maintenance costs in the long term.

3.2 The 'Green Book'

In 1986, the Department of Development Aid produced a document entitled "Guidelines for Services and Amenities in Developing Communities" - which became commonly known as the 'brown book'. The 'brown book' was a draft version of the later 'green book' - released as "Toward Guidelines for Services and Amenities in Developing Communities" in 1988.

The 'green book' was prepared for the Department of Development Aid, by the Division of Roads and Transport Technology, the Division of Building Technology (formerly the National Building Research Institute), and the Division of Water Technology of the Council for Scientific and Industrial Research (CSIR), along with the CUTA Technical Sub-Committee on Stormwater Management.

The need for the 'green book' arose when 'blue book' guidelines, intended for middle to high-income developments, were applied to low-income developments. This resulted in a level of service that was not affordable to poorer communities. 'Green book' guidelines are therefore based on lower standards and are applicable to lower income residential development. Like the 'blue book', the guidelines in the 'green book' are not legally enforceable.

The 'green book' guidelines are concerned with the planning process, layout planning, residential planning, geometric standards for roads, public transport services, the structural design of roads, stormwater management, water supply, sanitation, and solid waste management. The guidelines of the 'green book' concerning layout design did not present a significant conceptual departure from the 'blue book', rather they extended the prevailing approach in higher income developments to lower income layout design, by reducing standards.

3.3 The 'Red Book'

In 1992, the Engineering Services Working Group of the South African Housing Advisory Council (SAHAC) produced a document entitled "Guidelines for the Provision of Engineering Services and Amenities in Residential Township Development" - which has been referred to as the 'red book'. The 'red book' was prepared by the SAHAC, along with the Divisions of Roads and Transport Technology, Building Technology and Water Technology within the CSIR, and the CUTA Technical Sub-Committee on Stormwater Management. After numerous delays, the 'red book' was released in 1994.

The need for the 'red book' guidelines arose when, in different contexts, conditions (eg. soil type, slope) required a combination of both 'blue book' and 'green book' standards. In these cases there has been confusion as to what appropriate or affordable engineering services are. The 'red book' therefore combines the guidelines of the 'blue book' and 'green book' into a single document, to provide a set of diversified guidelines from which appropriate standards can be selected. The guidelines deal with every level of service from the most basic to the most sophisticated, and provides discussion on possible routes for upgrading as funds become available to do so.

Much of the motivation for the 'red book' was to provide a non-prescriptive matrix of service levels to enable end-user communities make decisions and trade-offs regarding the standard of services constructed in their settlement.

The 'red book' guidelines are concerned with layout planning, stormwater management, geometric road design standards, the structural design of urban roads, water supply, sanitation and solid waste management.

4. Current Layout Planning Concept

The conceptual origins of the guidelines provided by the 'blue', 'green' and 'red' books are essentially the same. Differences in the guideline documents relate more to engineering standards, than to layout planning concepts.

The conceptual approach presented in these documents will now be discussed in terms of how their guidelines address what have, over the last hundred years of modern town planning, conventionally been regarded as the basic tasks of layout planning: (1) creating environmental quality, (2) facilitating circulation, (3) facilitating facility and amenity provision, and (4) facilitating utility service provision. These tasks provide a useful framework through which an analysis of the conceptual approach presented in the 'blue', 'green' and 'red' books can be undertaken.

4.1 Environmental Quality

With regard to the task of creating an urban environment that improves the quality of life of its inhabitants, the current layout planning concept has been influenced by the visions of tranquil suburbia presented by the garden city and neighbourhood unit movements of Britain and the United States.

The main concerns expressed in the guidelines, regarding the creation of enriching urban environments, are for the aesthetics of the streetscape.

The guidelines attempt to promote street aesthetics by creating visual interest through curvilinear road alignments, promoting the creation of quiet residential areas without extraneous traffic, and recommending that the road layout, dwelling units, public spaces, landscaping and engineering services, are designed as an integrated concept.

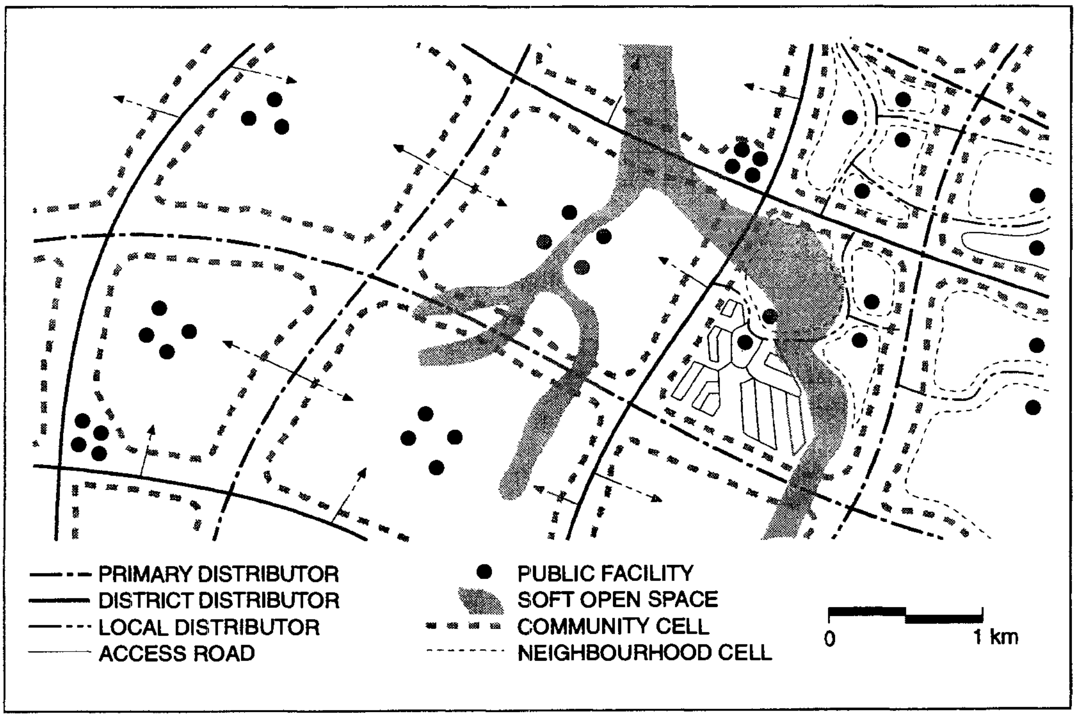
4.2 Circulation

With regard to the task of facilitating the circulation of people, goods and services throughout an urban development, the current layout planning concept has been heavily influenced by notions of limited access and road hierarchy proposed in the environmental area and Radburn concepts. The cellular environmental area concept in fact provided a useful spatial logic for past group area policies of racial segregation.

The main concerns expressed in the guidelines, regarding the facilitation of circulation, are for enabling uninterrupted flows of vehicular traffic on arterial roads, and for minimising accidents involving pedestrians and motorists - especially on residential access roads.

The guidelines promote the functional efficiency of arterial routes and road safety by establishing a strict hierarchy of roads, encouraging 3-legged intersections, and limiting extraneous traffic in residential areas.

FIGURE 11: Functional Road Hierarchy Linking District, Community and Neighbourhood Cells (after Department of National Housing 1994)



The road hierarchy classifies roads according to function and traffic distribution. Each class of road in the hierarchy carries only the traffic generated by its length, its interconnections and the land uses which abut it. Long distance, high speed traffic is confined to higher order roads, and shorter distance, low speed traffic to lower order roads. The hierarchy includes: class 1 trunk roads, class 2 primary distributors, class 3 district distributors, class 4 local distributors, class 5a access collectors, and class 5b-f access roads.

Within the hierarchy, two main distinctions exist - that between mobility and access (classes 1-4 : class 5) and that between through-traffic and local-traffic (classes 1-2 : classes 3-5). These distinctions form a basis for understanding the nature of vehicular traffic using the various levels of the hierarchy.

The guidelines minimise the opportunity for conflict by reducing the number of intersections, promoting 3-legged junctions with fewer conflict points than 4-legged junctions, and preventing higher order roads (eg. class 3 district distributors) from intersecting with lower order roads (eg. class 5 access roads). Roads intersect only with roads on a level above or below them in the hierarchy.

The circulation network combines aspects of open and closed road networks. Higher classes of road form an open system, while lower classes of road form a closed system. The limited access nature of lower order circulation systems, effectively prevents extraneous traffic, particularly heavy vehicles, from entering residential areas. Through 'back-up design', all residential erven gain access to the circulation network via access roads and local distributors.

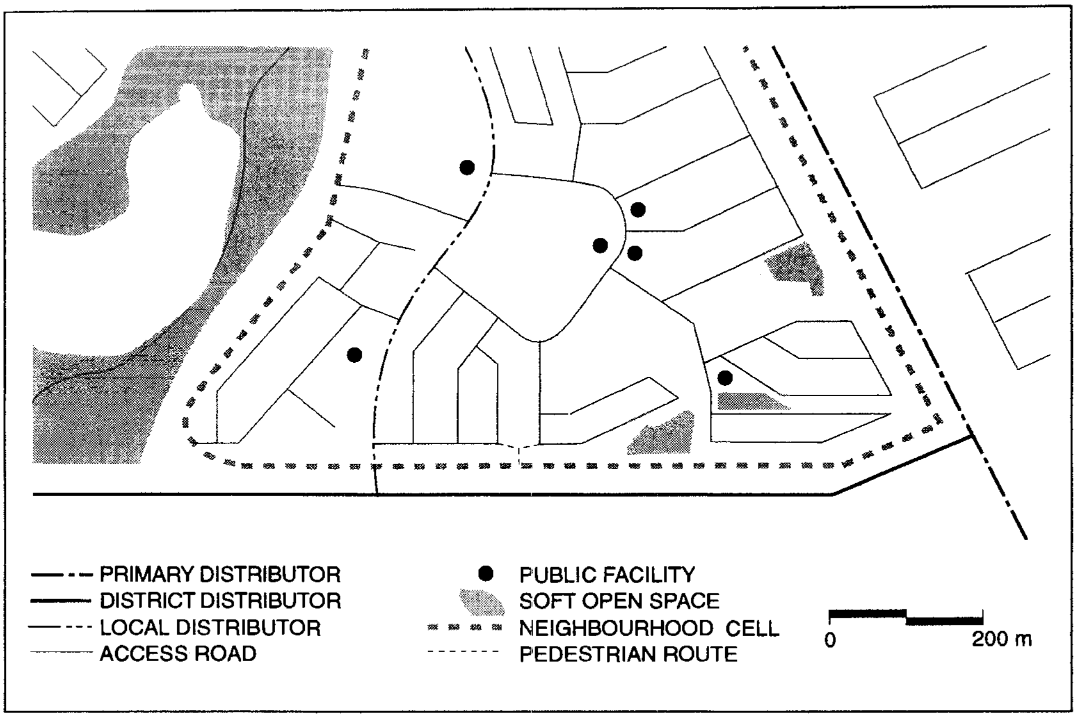
4.3 Facility and Amenity Provision

With regard to the task of identifying appropriate locations for, and quantities of, public facilities and amenities, the current layout planning concept has been heavily influenced by the notion of spatially defined communities, proposed by the neighbourhood unit concept. In the same way as the environmental area concept coincided with group areas policies, the introverted neighbourhood unit concept provided a useful spatial logic for past separate amenities legislation.

The main concerns expressed in the guidelines regarding the location of facilities and amenities, are for convenient access to public facilities by local households, and the use of residential access roads as open space.

The guidelines promote access to local facilities and the use of access roads as open space, by locating public facilities within the centre of cellular residential areas and limiting through-traffic on access roads.

FIGURE 12: Functional Road Hierarchy Serving a Neighbourhood Cell (after Department of National Housing 1994)



Public facilities like schools are located within the centre of 'community' or 'neighbourhood' cells, along class 5a access collectors and class 4 local distributors. These facilities are intended to serve only the residents of the neighbourhood cell. More intensive traffic-generating facilities and local commercial services are located on class 4 local distributors, near the entrances to community or neighbourhood cells and adjacent to higher order roads. Larger commercial centres are generally located on the higher order road network, at the intersections of class 2 and 3 distributors.

Linear shopping strips adjacent to the roadway are discouraged. It is argued that this prevents local congestion from occurring and avoids the increase in potential points of conflict which would result from the increase in direct access.

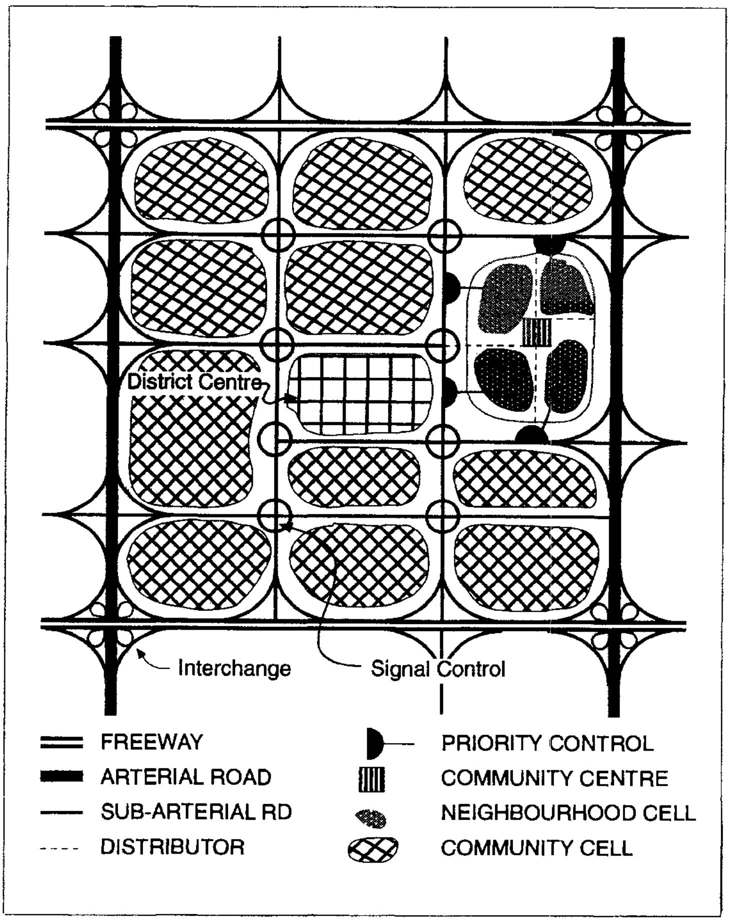


FIGURE 13: Cellular Urban Structure (after Cameron 1977)

4.4 Utility Provision

With regard to the task of facilitating the provision of the full range of utility services, the current layout planning concept is concerned mainly with the economical provision of roads, stormwater drainage, water, sanitation and solid waste collection services, the functional efficiency of these services, and the protection of public health and safety.

The 'red book' provides a non-prescriptive matrix of service levels, from which appropriate combinations of service technologies can be selected according to site conditions and the ability of end-user communities to pay for these services. Guidelines are therefore provided for a range of service standards, from very low to very high.

The guidelines seek to maximise service utility to the individual household. The emphasis in service provision therefore tends towards individualised service connections to residential erven. Other than roads, stormwater drainage and public lighting which are communal by definition, collective provision (in the form of public water standpipes and solid waste collection points) is recommended only as an option in the face of severely restricted resources.

The guidelines promote the derivation of appropriate road reserve widths according to context specific factors, like the nature of reticulation (eg. mid-block vs. street) or on-street parking requirements, rather than the application of prescriptive width standards.

5. Critique of Current Layout Planning Guidelines

The following critique of the layout concept expressed in the current South African guideline documents is concerned only with those sections that deal with aspects of layout planning - it is not concerned with technical engineering guidelines. Criticisms are identified on the basis of the normative concerns presented earlier in this section (1).

A general criticism of the current guideline documents is that a guiding vision of appropriate urban form has all but disappeared. Initially, guidelines and development control systems promoted suburban settlement - a world in which dwellings are detached, population densities are low, open space is maximised in the form of large private gardens, and levels of mobility are high.

Over recent decades, as it has become increasingly clear that suburbia is neither financially attainable nor environmentally sustainable, the suburban vision has essentially shrunk. Erven are smaller and the size of dwelling units have been reduced, or have disappeared altogether - due to overcrowding and backyard shacking, population densities are often high, little quality open space, neither private nor public, is provided, and very few households can afford to own a car.

Concerns for urban form and the quality of urban environments have largely been substituted by concerns relating to administrative ease, civil engineering issues, capital costs and public participation procedures. The results have become known as 'toilet' and 'matchbox' towns - sterile and standardised low-income townships which are inaccessible for the person on foot, which frequently entrench an inefficient city structure, and which provide few opportunities for self-generated income.

Instead of tranquil suburbia, the guidelines are now geared to the delivery of small serviced starter houses or serviced sites which create a very different environment, yet the guiding suburban model has not been replaced. Urban development is occurring without a clear vision of appropriate urban form.

More detailed criticisms of the current South African layout guidelines include the following.

With regard to place making, the creation of a sense of place in new urban developments is not adequately addressed - a fairly uniform suburban environment is promoted. As a result, a concern for making places, as opposed to simply serviced land, has been, with a limited number of exceptions, almost entirely lacking in South African layout planning over recent decades.

The guidelines provide little indication of how a layout plan should respond to a specific natural and cultural landscape, and of the role hard public spaces like public markets and squares play in urban living.

With regard to scale, the guidelines fail to address the need for definition, surveillance and protection in hard public space provision (ie. market places, squares and streets). The public environment promoted is essentially 'overscaled', in that a vehicular scale dominates over a human scale - widths, distances and surfacings are treated primarily from the perspective of the mobility of vehicles.

With regard to access, four main criticisms are identified.

TABLE 1: Journey-to-Work Modal Split in Metropolitan Cape Town by Population Group

	% MODAL SPLIT		*NO. OF MOVEMENTS*
	1980	*1990*	*1990*
WHITE			
Public Transport	25%	15%	37 950
Walking	5%	5%	12 650
Motor Car	70%	80%	202 400
'COLOURED'/BLACK			
Public Transport	64%	54%	349 920
Walking	12%	9%	58 320
Motor Car	24%	37%	239 760
ALL POPULATION GROUPS			
Public Transport	48%	44%	396 440
Walking	10%	8%	72 080
Motor Car	42%	48%	432 480

Source: The journey-to-work modal split estimates have been derived through the Echenique Land Use/Transportation modelling process, using 1980 census data - Metropolitan Transport Planning Branch, Cape Town City Council, in personal communications (1995) with Paul Mann of Liebenberg and Stander Consulting Engineers

Note: Journey-to-work movement estimates assume that 'earner per household' provides an indication of the number of journey-to-work movements per household, per day. These estimates are approximate. Over the last five years major changes have occurred - there has been an increase in mini-buses, and a related decline in public transport use due to *inter alia* assaults on buses and decreased safety. It should also be noted however that many trips are not journey-to-work movements. Housewives, school children, pensioners and the unemployed for instance, often do not have access to private cars and are reliant on public transport services, bicycling and walking in order to move - perhaps suggesting that estimates of overall modal split on the basis of journey-to-work movements, overemphasize motors cars.

Firstly, guidelines regarding road hierarchy and geometric layout are concerned primarily with facilitating unrestricted private vehicle mobility, local pedestrian and cycle access to internalised public facilities, and enhancing road safety. Consequently pedestrian movement beyond local schools, churches and shops (ie. to employment centres and higher order commercial services and facilities) is disadvantaged, and the operation of local public transport services is difficult.

The car-orientated approach to layout planning results in closed road networks in lower income areas very similar to networks in higher income areas, despite very different levels of private car ownership.

TABLE 2: Levels of Car Ownership in Metropolitan Cape Town

	CARS PER HOUSEHOLD
Segment 1	1,56
Segment 2	0,91
Segment 3	0,59
Segment 4	0,19
Segment 5	0,21

Source: Metropolitan Transport Planning Branch, Cape Town City Council, in personal communications (1994) with Paul Mann of Liebenberg and Stander Consulting Engineers

Note: Segments 1 to 5 indicate the range of income groups in metropolitan Cape Town. Segment 1 corresponds to high-income groups, while segment 5 corresponds to low-income groups.

The closed road geometry concept is based upon the implicit assumption that virtually every household will eventually own at least one motor car, and that as a result, traffic volumes will increase and private vehicles will gain an ever increasing share of modal split. This assumption fails to acknowledge the low combined monthly incomes of most urban households. Lower income urban environments experience relatively low car traffic - traffic consists mainly of pedestrians, mini-buses, and buses. In Cape Town for instance, approximately 52% of commuters are dependant on either public transport or walking to get to work, and in low-income areas approximately one household in every five owns a car.

Secondly, the guidelines promote a road network that is inflexible, and unable to adapt to changes in the function of roads and the nature of abutting land use activities.

This inflexibility stems from closed road networks, and a limited conception of vehicular movement - which is essentially restricted to concentrating large volumes of traffic onto distributor routes. Other forms of movement, like stop-start traffic associated with activity streets, which facilitate an intensive mix of commercial, light industrial and residential activities, are not accommodated in the hierarchical network.

The functional road hierarchy concept is based upon the implicit assumption that it is possible to anticipate, and within reasonable limits plan for, the functions of every road within the road network, and that these functions will remain relatively constant over time. This assumption oversimplifies the diverse range of road users, and their respective needs, that exist, and fails to acknowledge the dynamic technological, demographical and political nature of urban systems. The frequent use of particular stretches of roadway for hailing and alighting from mini-buses, the use of roads adjacent to rail stations as mini-bus ranks, and the common occurrence of street traders at signalised freeway intersections, are some obvious examples of this.

Thirdly, the internalised or introverted location of lower order public facilities, to serve only single neighbourhood cells, makes the sharing of facilities between cells difficult when, because of demographic changes or facility backlogs, the needs of one neighbourhood population cannot be met within a single neighbourhood cell. This often results in a considerable decline in pedestrian safety, as people are forced to cross major arterial routes in order to reach public facilities in adjoining neighbourhood cells.

The neighbourhood cell concept is based upon two implicit assumptions.

The first is that it is possible, through the organisation of movement routes and public facilities, to create spatially defined social units. More specifically that there is a constant demand for facilities and services over time within any one particular cell, and that the functional linkages between households and public facilities respond to a hierarchy of 'districts', 'communities', 'neighbourhoods', and 'development blocks' - in other words, that it is possible to match the movements of households to and from facilities of varying orders, with an urban environment comprised of a series of cells of varying orders. This assumption oversimplifies the complex social relationships that exist within a city, as well as the multifarious functional linkages between individual households and the range of public facilities and commercial services they frequent. Family doctors, dentists or favourite grocery stores for instance, are often located in very different parts of a city. In particular, children in the post-apartheid era do not always attend the pre-primary, primary or secondary school in their local area.

The second assumption is that there are sufficient fiscal resources to provide each residential cell with the range of public facilities it was planned to contain. This assumption overestimates the ability of the State to raise sufficient revenue to finance the provision of public facilities to match need, and its ability to effectively deliver these facilities equitably. The backlog of education and health facilities in many predominantly black urban areas is evidence of this.

Fourthly, the location of higher order public facilities at accessible points within the distributor network facilitates easy vehicular access only, at the expense of public transport and pedestrian access. Consequently higher order facilities are least accessible to the poorest income groups who do not own motor cars.

With regard to creating opportunity, two main criticisms are identified.

Firstly, little consideration is given to the implications of layout planning for the creation of economic opportunities. The physical separation of road classes and the restriction of extraneous vehicular traffic to higher order classes, does not create favourable conditions for small commercial enterprises or informal street trading. The concentration of through-traffic onto uninterrupted, limited access distributors prevents local traders from gaining access to non-local consumers.

The hierarchical approach to road layout greatly simplifies possible movement paths through the road network and, being essentially exclusive of through-movement, removes the opportunities and uncertainties which arise through integration. The result, while being technically efficient, is hostile to economic development.

Secondly, the functions of services are narrowly defined - generally around satisfying residential consumption needs only. The more collective functions of services, regarding street trading, small scale manufacturing, social interaction and recreation tend to be ignored.

Consequently the minimum level of services associated with hard public spaces, necessary to support vibrant public life and embryonic local economies, are overlooked. Public squares and markets with standpipes, solid waste bins, public telephones, public toilets, metered electricity dispensers are not provided.

With regard to efficiency, two main criticisms are identified.

Firstly, public facility space standards are large and inflexible, resulting in a reduction of the amount of land available for residential purposes and therefore a reduction of gross residential densities.

Standards for individual facilities are assessed by considering their 'optimal' spatial requirements in isolation of each other. The approach to standards is not geared towards resource sharing - standards should be related to facility performance rather than space *per se* (eg. numbers of pupils per library or playing field).

Secondly, the guidelines fail to adequately illustrate to town planners and urban designers which geometric road layouts and subdivision patterns most effectively facilitate the efficient reticulation of engineering services, and what the functional and spatial relationships between different services are.

With regard to choice, the guidelines fail to recognise the importance of choice and variety in enriching the experiences of those individuals that live within, or pass through, particular urban environments.

TABLE 3: Summary of Criticisms

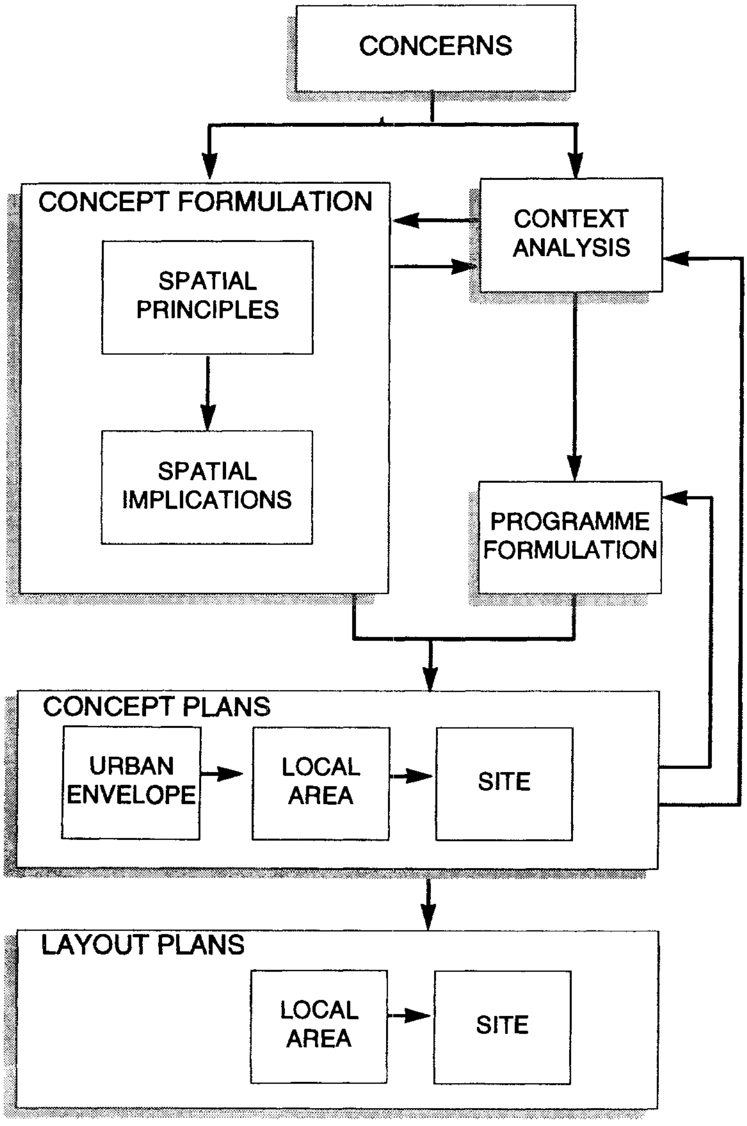
CRITERION		CRITICISM
place making	*	place making and the provision of hard public spaces are ignored
scale	*	public environment is dominated by a vehicular scale
access	*	car-orientated road networks result
	*	inflexible road networks are produced
	*	facility location is introverted
	*	higher order facilities are inaccessible to public transport users and pedestrians
opportunity	*	economic opportunities associated with road layouts are ignored
	*	collective functions of services relating to trading and manufacturing are ignored
efficiency	*	facility space standards are inappropriate
	*	implications of layout for efficient service reticulation are ill-defined
choice	*	importance of choice in urban surroundings is ignored

In short, the current layout planning guidelines are based on a narrow set of concerns regarding primarily motor car access, pedestrian safety and the creation of spatially defined communities through introverted facility location, and a limited interpretation of the elements of essential layout infrastructure.

The guidelines are concerned more with the attainment of technical efficiency and economy, than with social and developmental considerations. Development responses to layouts designed from this perspective have been limited - often owing more to local initiative than to planning effort. These concerns and infrastructural elements are fundamentally incomplete in the context of high levels of poverty, unemployment and spatial inequality.

Social and developmental considerations are at least as important as the attainment of technical efficiency standards - requiring a reassessment of the approach adopted to layout planning. There is a need therefore for a shift in concern towards greater public transport and pedestrian access, the integration of urban environments, the facilitation of economic opportunity, and a more collective and systemic approach to facility and service provision.

Section 2:
The Layout Planning Process



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Section 2: The Layout Planning Process

This section (1) discusses some principles that should inform the layout planning process, (2) provides a guide to the steps involved in a layout planning process, and (3) indicates how the following sections on layout concepts and guidelines should be used to formulate a physical plan - in other words how the ideas and concerns presented in the handbook can be used in practice.

1. Process Principles

Modern town planning has, during the course of its' history, experienced some major shifts in thinking about planning process or method, and considerable theoretical debate has taken place around this issue. 'Method' essentially describes the steps to be undertaken in the formulation of a plan, and is fundamentally influenced by the philosophical approach adopted to procedural theory (eg. systems theory, radical theory, hermeneutics), and the way this influences the planner's ethic and perceived role in society.

The method put forward here is based on the following set of principles:

1.1 Process Orientated

That the approach to layout planning is informed by a view that the establishment of urban settlements is a process - not a product. The development of infrastructure and housing in particular, are processes intimately involving end-user communities, not designed end products.

It is neither possible nor desirable, at any one point in time, to 'design' an urban settlement. Enriching urban environments are the result of successive collective and individual actions, and reactions, over time. This is evidenced by the fact that urban settlements so seldom resemble exactly the structure plans or layout plans, planners and engineers envisaged.

The purpose of a layout plan is therefore understood to provide a spatial framework within which numerous collective and individual investments can be accommodated over time, in a mutually reinforcing and developmental manner. The layout plan is therefore seen as initiating and facilitative, rather than prescriptive. This implies that the layout plan should indicate a minimum set of spatial interventions, rather than attempting to be entirely comprehensive.

1.2 Value Driven

That the planning process is not purely a technical or neutral exercise. The outcome of any planning exercise must be the creation of urban environments which meet the requirements of human need and environmental sustainability. It is therefore particularly important to make these values explicit at the start of the planning process (see section 1 of this handbook) and to ensure that goals, objectives and plans are consistent with these values.

1.3 Continuous Public Participation

That those individuals and communities who will be influenced by planning action (where they can be identified during the planning stage) have an important role to play in the planning process. The nature of the interaction between planners and other related professionals, and those to be affected by planning, is commented on below (1.4).

1.4 Interactive Design

That the planner does not operate in isolation from other design and development professionals - ideally the planning process is undertaken by a team of professionals (including project coordinators, urban designers, civil, transport and electrical engineers, land surveyors, etc.). The particular contribution of the planner is an understanding of how the broad spatial ordering of physical elements can meet the concerns of environmental quality and human need.

The planner has a particular area of expertise - his or her role is not simply to respond to demands put forward by the various stakeholders in a planning process. The role of the planner (in a layout planning exercise) lies in an ability to understand the potentials and constraints offered by a particular site, an ability to understand the role of a site within a broader context, an ability to understand how basic human and environmental concerns can be addressed through the organization of urban space, and an ability to understand the effectuation of planning ideas.

1.5 Context Driven

That there is no 'blueprint' method which can be adopted for all planning exercises - essentially the nature of the context and the nature of the problem must define an appropriate planning process. However, the basic elements of the method discussed in the latter part of this section should remain constant.

1.6 Cyclical Refinement

That the planning process is not linear. Over recent decades, layout planning practice in South Africa has tended to be dominated by the procedural (or systems) planning approach, in which analysis and problem definition gives rise to a series of alternative outline layout plans, which are then evaluated often on the basis of technically based ranking criteria or public consultation, and one chosen for detailed planning and implementation. This process is essentially linear, and abrogates the planner's responsibility of taking explicitly value-driven decisions.

The method put forward here is normative and cyclical, not 'technical' and linear. As with any planning process, there is both value judgement and repetition involved in the bringing together of contextual and conceptual investigations, end-user participation, and the formulation and testing of ideas at various scales.

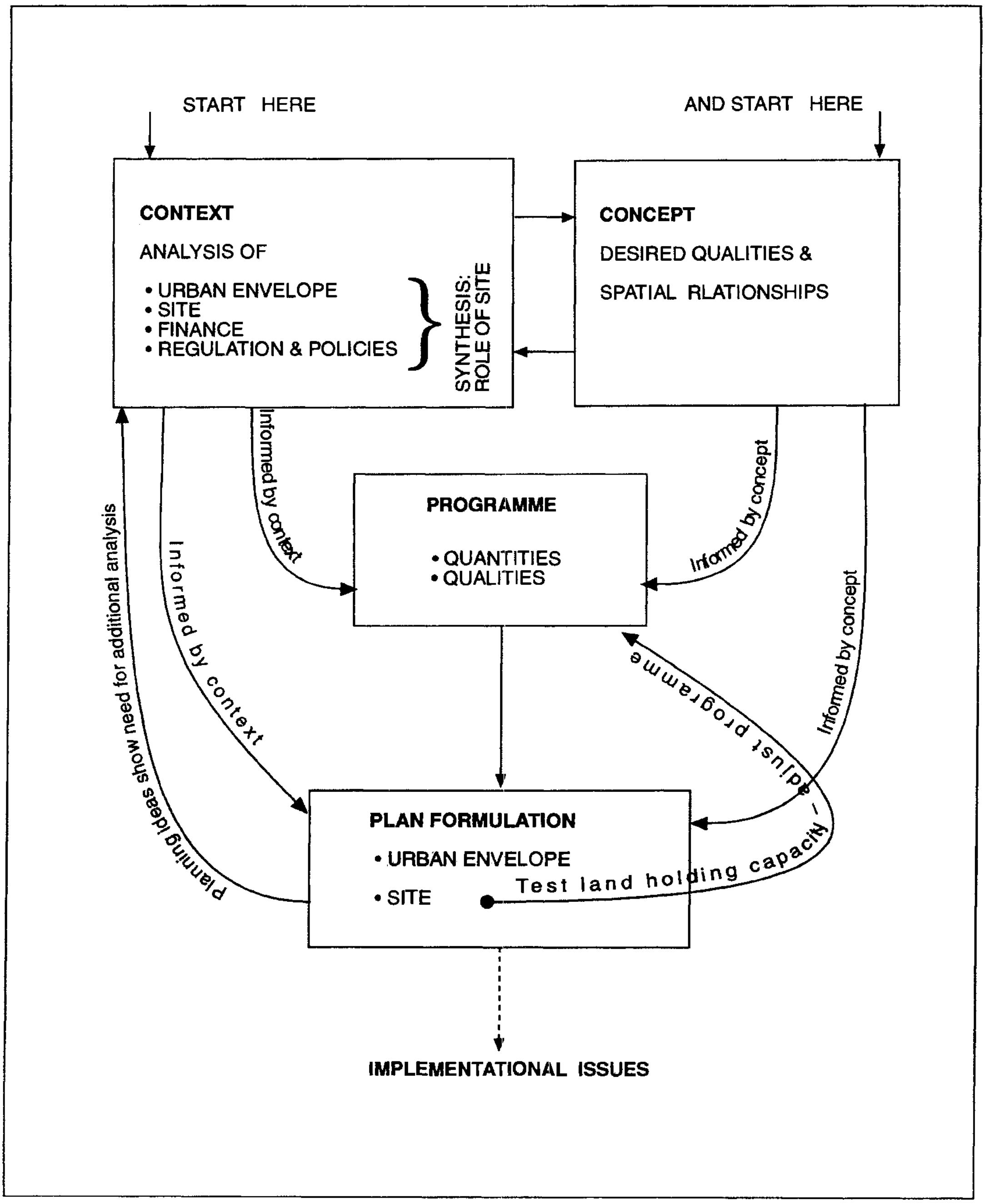
2. Process Guidelines

The following tasks, while listed sequentially, cannot be undertaken in a simple sequential fashion - figure 14 provides an indication of the kinds of circularities and interrelationships which can be involved in the layout planning process.

Depending on the nature of the planning problem, the different tasks outlined below will require greater or less emphasis. For example, where the site is a large one, an important area of emphasis in the analysis will be on understanding the interrelationship between the site and the larger city structure, or where settlement of the site is to be very rapid (ie. a managed land settlement case) analysis and plan formulation may have to occur in a very short period of time and will thus have to be strategic and targeted. Alternatively, where the occupants of the site are already settled (ie. an ***in situ*** upgrade situation) a significant emphasis in the analysis will be on understanding their needs and priorities. Every planning problem is likely to be unique, and will require judgment as to how the layout planning process should be conducted.

The cyclical layout planning process has four main stages, each of which is revisited during the planning process. These stages include: (1) an analysis of context, (2) the formation of a guiding design concept, (3) programme formulation, and (4) the formation of layout plans. The process that is outlined below, in essence, indicates how normative concerns can be converted into detailed layout plans.

FIGURE 14: Layout Planning Process



2.1 Context Analysis

Context analysis should involve an investigation of (1) the physical and socio-economic context at the urban 'envelope' and site scales, (2) financial parameters, and (3) regulatory constraints.

2.1.1 *Physical and Socio-Economic Context*

Physical and socio-economic context analysis needs to occur at two scales, which can be undertaken simultaneously. The issues identified below can all be examined at a superficial level initially, to establish feasibility of the project and to help identify the need for any additional areas of analysis. Later, more in-depth, analysis will probably be required in order to gain a better understanding of the issues and also to test out some initial planning ideas.

Analysis can never be undertaken in an entirely objective or neutral fashion - the entire planning process is guided by a broad concept of the qualities which should be present in an urban environment, and a central purpose of analysis is the testing of the form which these qualities could take on the ground.

(1) Analysis of the broader 'urban envelope' of which a local site forms part

This analysis will give rise to a set of preliminary ideas about the role of the site and the nature of the land uses which it could hold. These ideas are preliminary because there may be factors emerging from the other areas of contextual analysis which would modify them.

In the case of a small site, some of the following questions may require less emphasis, and in the case of a managed land settlement, analysis may be limited to sources such as aerial photographs and maps.

GUIDING QUESTIONS IN THE ANALYSIS OF THE BROADER 'URBAN ENVELOPE'

* Does the population in the urban envelope have particular needs (for facilities or amenities) which could be met on the site?

* What are the trends with regard to the land uses, urban structure and built environment around the site, and what implications do these have for the site?

* What major movement systems occur around the site which could be used to link the site into the broader environment?

* What informants occur on the edge of the site (major land uses and interfaces with movement systems) which may have implications for planning decisions on the site itself?

* What features are there in the surrounding natural or man-made environment which could be used to focus or orientate development on the site - these may be mountains, tree lines, views, or prominent buildings?

* What implications do sun and wind direction have for the orientation of development on the site?

* What are the potentials and constraints in terms of bulk servicing and transport infrastructure?

* What is the socio-economic profile of the population in the surrounding area and does this have implications for the occupation of the site? Does this population potentially offer a market or a support for uses on the site?

* What is the nature of the residential accommodation in the surrounding area and does this have implications for the occupation of the site?

* What organizations exist which will need to be brought into the planning process?

The product of this phase of analysis would be a map and a statement identifying the fixes, opportunities and constraints at this scale. From this scale of analysis some preliminary ideas would be formed about the possible role of the site.

(2) Analysis of the site

This analysis will give rise to an understanding of the potentials and constraints to development on the site, and will indicate whether or not the ideas developed at the broader scale have validity. If there are occupants or users of the site, or if the end user community can be easily identified, some form of community survey or interactive process will have to be carried out as well.

GUIDING QUESTIONS IN THE ANALYSIS OF A 'GREENFIELDS' SITE

* What is the nature and pattern of the natural systems affecting the site (eg. climate, hydrology, soils, flora, fauna, landforms, slope, etc.)? What opportunities and constraints do these present? Do they preclude any land uses which may be considered appropriate, or do they suggest new ones?

* What are the important natural features on the site (eg. trees, elevated ground, water bodies, unique vegetation, etc.) which should be preserved or enhanced and which could start to inform the place-making concerns of layout?

* Which uses may be suited to different parts of the site?

* What is the pattern of land ownership and tenure and what constraints or opportunities do these present?

* Are there other legal constraints to the use of the land?

The product of this phase of analysis would be a map and a statement identifying the fixes, opportunities and constraints at the scale of the site. It would also include a rough calculation of developable land on the site.

Much of this information will also be of use to the engineer who will be evaluating the constraints on service provision. It is important, however, that the dictates of engineering efficiency (eg. earthworks to create suitable gradients for gravity services) do not simply override the need to provide a habitable urban environment (which, for example, may require the preservation, or creation, of raised landforms as a windbreak or place-making feature). Clearly cost is a major consideration here, but trade-offs need to be carefully made.

GUIDING QUESTIONS IN THE ANALYSIS OF AN IN SITU UPGRADE SITE, IN ADDITION TO THOSE FOR A 'GREENFIELD' SITE

* What is the nature and pattern of land use and the built environment on the site? Particularly, where are the more important movement routes, gathering places and clustering of non-residential uses? Are there important points of visual and functional focus?

* Are there aspects of the history of the settlement which should be taken into account?

* Are there aspects of local culture which need to find functional or physical space in the development?

* What is the socio-economic profile of the residential population and what is the nature of its needs and priorities? What is the range of variation of this pattern of need and how is it likely to change over time?

* What is the likely growth rate of the residential population which may result from natural increase and in-migration?

It is important that the complex, dynamic and unpredictable nature of individuals and households is recognized. Survey or workshopping processes give a partial indication, at a particular point in time, of the nature of the community or future users of the site, but this can and does change significantly over the life-cycle of the built environment. A sense of generic human need must always be a major informant, and therefore the planning of urban environments must always be flexible enough to accommodate changing needs over time.

The product of this aspect of site analysis would be a map indicating (in addition to the features mapped for a 'greenfields' site) the existing pattern and use of space, and the fixes, constraints and opportunities which this use of space presents. A further product would be a statement reflecting an understanding of the needs of the residential community and the implications of these for urban layout.

2.1.2 *Financial Analysis*

Financial analysis involves the investigation of possible sources of end-user finance, the terms of available loan finance, the qualifying conditions of available housing subsidies, and so on. It also involves an investigation of public/private partnership arrangements which may be possible, and arrangements which may be necessary to bring these about (eg. the formation of trusts or section 21 companies). From a financial analysis, an understanding of the financial and organizational parameters of the project should be developed.

2.1.3 *Regulatory Analysis*

Regulatory analysis involves an investigation of relevant legislation, policies and zoning restrictions which will inform transport, land use, infrastructure plans, and so on. From a review of regulations, an understanding of the policies, plans and rules that have to be complied with in the layout plan, should be developed. For instance, regulations promulgated in terms of the Environment Conservation Act will require that an environmental impact assessment is to be carried out for all larger projects.

The regulatory analysis will also indicate where attempts may need to be made to change or waive regulations and policies which may hinder the form of development contemplated.

2.1.4 *Analytical Synthesis*

The results of the analysis of the urban envelope (2.1.1(1)) need to be synthesised with the results of the analysis of the site itself (2.1.1(2)). At this point, preliminary ideas developed at the larger scale as to the composition of land uses on the site and its possible role in the larger urban area, can be evaluated in terms of the potentials and constraints on the site itself.

For example, an analysis of the larger context may have suggested a pressing need for as much new residential land as possible, but an analysis of the site may show that the location of an underground aquifer, or unstable ground, make parts of the site unsuitable for residential development.

At this point in the analysis, then, conclusions can be drawn as to the role (ie. broad composition of uses and characteristics) which the site can play in contributing to the fulfillment of broader urban development imperatives, and in optimising the potentials and constraints of the site itself.

These conclusions then have to be examined further in relation to the financial and regulatory analysis in order to understand the constraints which these might impose.

2.2 Concept Formation

Concept formation involves (1) the conversion of normative concerns (eg. those set out in section 1(1) of the handbook) into guiding design principles, and (2) an identification of the implications of these principles for spatial relationships. For example, a concern for access would result in a principle that prioritised pedestrian movement, which would in turn indicate a need for open, humanly scaled road networks.

This phase of the work can take the form of a statement and a series of conceptual diagrams, clarifying the principles which are to guide layout and the nature of the spatial relationships which can achieve them.

2.2.1 *Spatial Principles*

The identification of guiding design principles involves the specification of the important qualities and levels of performance which need to be achieved in an urban environment. Section 3(1) of the handbook, which follows, identifies, at the level of principle, such qualities and levels of performance.

2.2.2 *Spatial Relationships*

The identification of the implications of design principles for spatial relationships (ie. the formulation of conceptual spatial concepts) is usually informed by studies of relevant precedent (ie. learning from the successes and failures of layout plans that have had to address similar problems in similar contexts), and by the judgement of the planning team. However, spatial concepts are also partly informed by context - much of the inconvenience and sterility of new urban developments in South Africa is the result of the application of concepts without a questioning of their validity to specific local contexts.

This phase should therefore be undertaken simultaneously with contextual analysis (see 2.1 of this section), as the two areas of work need to inform each other - clarification of the qualities which need to be achieved on the site can suggest additional areas of analysis (eg. a desire to create an environment with a unique sense of place will indicate the need to identify features on and around the site which can be used for orientation and focus), and an understanding of the context can inform the range of spatial relationships which need to be explored conceptually.

Section 3(2) of the handbook discusses, at the level of principle, the spatial relationships which are required in order to achieve the qualities and levels of performance that are presented as desirable.

2.3 Programme

Programme formulation allows conclusions to be drawn about the quantities and qualities of uses on the site. In part it is an arithmetic exercise (ie. how many people on the site, therefore how many schools, clinics, etc.). But a consideration of quantities must also be centrally informed by a sense of the urban qualities to be achieved on the site. For example, if principles relating to improved access to community facilities and resource efficiency require that schools, libraries and other facilities be clustered, this will have implications for the number of facilities and the amount of space they require. 'Concept' and 'context' therefore both inform 'programme'.

The arithmetic aspect of programme begins with estimations of the number of people which can be expected to occupy, use and pass through the site. This in turn is derived from estimates of developable land (see 2.1.1(2) of this section) and ideas about the role of the site and the uses which could occupy it; from the relation of the site to major movement routes; and from ideas about regional facilities which the site may hold (eg. if a large scale sports stadium is to be located on the site it will intermittently attract a large additional population, and may generate additional needs for private and public facilities).

If the site is already occupied, future population estimates will also be derived from an understanding of the extent to which the site can or cannot hold additional people.

Estimates of the residential population are often based on the assumption that each erf will be occupied by a single, average size household (usually of 5 people). In most developing urban areas of South Africa such assumptions have proved to be highly unrealistic - the extensive subletting and sharing which takes place in most lower income areas means that actual populations can be two or three times the size of planned populations. This consideration needs to inform service and facility provision.

Central to the estimation of population numbers is obviously a consideration of densities and built form. Arguments are made in this document for the promotion of densities which are significantly higher (50-100 or more dwelling units per hectare gross) than the current accepted norm. This in turn has implications for built form (higher densities may require multi-storey accommodation) but there may in turn be cost and affordability constraints on the form of accommodation provision, and therefore on density.

Population estimates will form the basis for calculations of numbers of public facilities and the amount of land which they may consume (see section 4(3)). This calculation must be tempered by the realisation that, very rarely, do all planned facilities materialise.

The product of this task will be a first draft of a land use programme for the site. Once an attempt has been made at plan formulation (see 2.4 and 2.5 below) on the site, the programme will need to be tested and possibly revised.

2.4 Plan Formation: Concept Plans

The formation of concept plans involves the bringing together of concepts and context, at a range of scales (see figure 15). In this process, acontextual spatial concepts become warped to meet the demands and constraints of the context, and possibilities for forms of development of the site are raised which could not have emerged from an analysis of the context on its own.

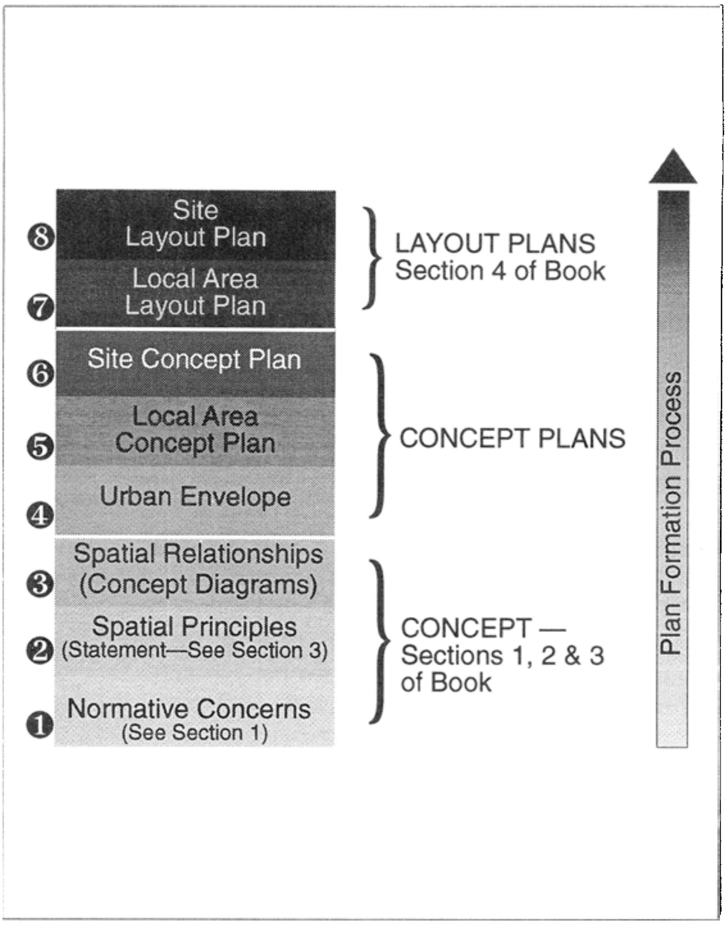


FIGURE 15: Stages in the Plan Formation Process

Attempts to understand how the spatial concept can be implemented may well indicate new areas of analysis which need to be undertaken in order to determine feasibility and appropriateness. The method is thus again circular - initial 'broad-brush' analysis may need to be deepened in order to successfully contextualise concepts.

The definition used here of a 'concept plan' is important - it is the public investment 'skeleton', which comprises the public spaces, movement routes and public facilities. This in turn will act as the major informant of the layout of engineering services, and it is important that planners and engineers work together at this point.

Also important is the form which the plan will take, and again this will vary depending on the nature of the planning problem.

In the case of a large unsettled site, plan formulation will require a concept plan for the whole site (identifying the major structuring elements such as the higher order of the public investment skeleton), and for the first phase of development (identifying lower order structuring elements). The detailed layout of these structuring elements, at both broader and local scales) will also have to be considered. The layout and subdivision of all other local parts of the site may well be left to a later round of planning.

In the case of a small site (eg. for a couple of hundred households) plan formulation will require a concept plan for the site and the layout details of all structuring elements. This will also be the case with a smaller *in situ* upgrade initiative, and in this case the public investment skeleton will be highly informed by the current pattern of land use.

In the case of a managed land settlement, it may be possible to do no more than indicate the position of the routes and public spaces, to be pegged out on the ground prior to occupation of the site. Under these circumstances the boundaries of blocks can be defined and households settled within them. The space requirements of individual households can be determined after settlement, once the space needs of individual households have been negotiated. The tenure provisions of the new Development Facilitation Act (which allow for the rapid establishment of a form of tenure known as 'initial ownership') can be useful here.

Plan formulation can be considered at a number of scales:

2.4.1 *Urban Envelope*

While intervention beyond the boundary of the local site may fall outside the scope of the project, it is nonetheless important to consider the desired future of the larger area surrounding the site, as this may have implications for the way in which the local site is developed. For example, a local development on a buffer strip may offer the opportunity to integrate two areas which have hitherto been separated and introverted. Moreover, proposed developments on the site may have implications for action beyond the boundaries of the site (eg. a new residential population may require changes to transport infrastructure, or new higher order facilities), and the feasibility of these has to be tested.

2.4.2 *Local Area Concept Plan*

This refers to the overall concept plan for a larger site, where parts of the site will have to be subject to a further level of concept planning. The 'local area concept plan' can have two components: the public investment skeleton, and a guideline statement.

In developing the local area concept plan, the first and most important concern is for place-making. The dimensions of, and informants of place-making are discussed in Section 3 (1.1) of the document. Ideas about place-making in turn begin to inform the orientation of routes, the nature and scale of public spaces and the location of public facilities.

The local area concept plan provides the basis for the future physical structure of the local area. It also provides the framework within which private investment can take place, but successful and enriching urban environments can only emerge when individuals and groups are given maximum opportunity to express their spatial needs. In the case of an *in situ* upgrade some of these spatial needs will have already found expression, and it will be important that the concept plan as far as possible respects these.

Thus while the main structuring elements of the concept plan need to be firmly defined, the greatest levels of choice and flexibility need to be allowed for in the rest of the urban environment. For example, private investment in commercial and service activity cannot, and should not, be predetermined by the prior allocation of sites designated as commercial. Rather, where the emergence of commercial activity can be anticipated (along the more important routes and around community facilities) larger sites can be created, which can be later subdivided, or housing can be designed for easy conversion into commercial outlets.

In the case of larger sites, where detailed layout is not to be carried out immediately for the whole site, the second component of the local area concept plan is the guideline statement. This should describe the desired character, content and functioning of the various parts of the site, and how the parts relate to each other. This statement would include indications of density and how this could be influenced by the land subdivision process and housing provision, special treatment of vegetation or landform, expectations regarding other forms of investment in the area, and so on. The guideline statement provides an informant for later site concept planning and the design of the rest of the larger site.

At this stage of plan formation, key interactions with other urban professionals, mainly civil and transport engineers, centre around the design of land profiles, the accommodation (where necessary) of bulk infrastructure on the site, the alignment of trunk services, and the alignment of major arterial roads and public transport routes. These decisions have major implications for place making design actions, and facility and amenity locations.

2.4.3 *Site Concept Plan*

For a smaller site, or the first phase of a larger site, spatial concepts need to be applied to the site to indicate local movement systems and public spaces, local services and facilities, blocks and erven. The form which these take has as important an effect on the quality of the urban environment as planning decisions at other scales, and the 'site concept plan' needs to be centrally informed by the conceptual understanding of how spatial relationships can achieve these qualities (see Section 3(2)).

It is at this point that earlier assumptions about densities (and hence total population numbers and programme) can be tested out, and the programme adjusted if necessary.

2.5 Plan Formulation: Layout Plans

The formation of layout plans involves the detailed and precise design, to scale and on a map, of the elements defined in concept plans. It involves making decisions as to the dimensions of roads and public spaces, the amount of land needed for public facilities and amenities, and so on - in essence it involves attaching widths, lengths and areas to the lines drawn on a concept plan. Some guidelines to assist with this stage of the layout planning process are contained in Section 4 of the handbook.

At this stage of plan formation, key interactions with other urban professionals, mainly urban designers, land surveyors, and civil, electrical and transport engineers, centre around the design of public spaces, design of road geometries, traffic management and signalisation, road gradients, and service reticulations. These decisions have major implications for the public space system, road networks, block alignments, and the spatial dimensions of erven and road reserves. Section 5 of the handbook provides a discussion on the implications infrastructure provision has for layout design, in order to facilitate this kind of interaction between planners and engineers as much as possible.

2.5.1 *Local Area Layout Plan*

Layout plans will be required to accompany the local area concept plan, where the broader elements of settlement structure need to be shown at scale on a map. This level of layout plan is termed here a 'local area layout plan'.
At the local area scale, layout plans indicate dimensions relating to public facility space requirements, public squares, soft open spaces, major movement routes, and so on.

2.5.2 *Site Layout Plan*

Layout plans will also be required to accompany the site concept plan, where the elements of settlement structure need to be shown in detail, at scale on a map. This level of layout plan is termed here a 'site layout plan'.

At the site scale, layout plans indicate dimensions relating to road reserve cross sections, blocks, erven, and so on.

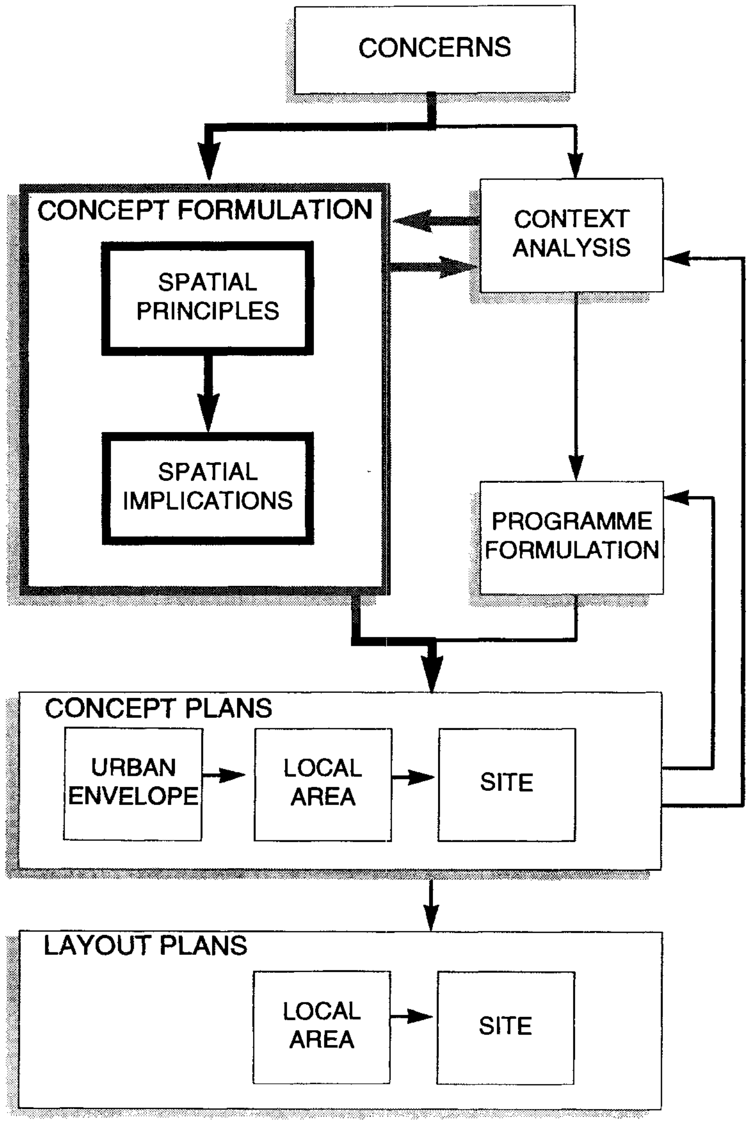
3. Interface with Community

Where the future residents of a site can be identified, as is the case with an *in situ* upgrade or where they are identifiable from a waiting list, there are significant benefits to be gained from their close involvement in the planning process. Benefits lie not only in an urban environment which can more closely meet their needs, but also in the process of education and empowerment which can accompany this involvement.

A discussion of how to best achieve this ideal of mutual benefit to the planning team and residents, and the structures through which it can occur, is a much debated area and lies beyond the scope of this document.

The important point, from the perspective of the planning process, is that interface with the community occurs from the start of the planning process, and not only at the end when a final product is put forward for a response. The other product of this research, which is a set of community workshop materials (including panels, games, computer spreadsheets) together with a user manual, discusses the question of interface with the community at length, and suggests strategic points at which important community decisions should be made. These workshop materials, along with the associated user manual, can be obtained directly from the Community and Urban Services Support Project (CUSSP).

Section 3:
Layout Principles



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Section 3:
Layout Principles

This section (1) presents a set of layout planning principles, as an alternative conceptual approach to layout planning to that provided in current South African guideline documents, and (2) illustrates the spatial implications of these planning principles at different scales, and in 'greenfield' and 'upgrade' contexts.

The planning principles, and the associated acontextual conceptual diagrams that follow, are intended to inform the concept formation stage of the layout planning process (see 2.2 of section 2). The application of these concepts to a site, in order to produce concept plans, can obviously only occur in each particular context. Section 4 of the handbook is intended to inform the more technical exercise of converting concepts plans into layout plans - in other words, the attachment of specific widths, lengths, areas and gradients to the lines drawn on a concept plan.

1. Planning Principles

Planning principles are discussed in terms of the normative concerns presented in section 1 of the handbook: (1) place making, (2) scale, (3) access, (4) opportunity, (5) efficiency, and (6) choice. The discussion of planning principles in terms of concerns, represents a conscious decision to move away from a more conventional sectoral discourse. The motivation for a cross-sectoral discussion is to ensure that the necessary functional and spatial relationships between circulation, facility, amenity and utility systems are identified. It is in the combination and arrangement of these systems that the key to designing and planning quality urban environments lies.

The basic theoretical assumption underlying the layout planning principles presented, is that public investment into facility, amenity and utility infrastructure provides a framework around which private investment into residential, commercial and industrial activities responds. In essence, that it is possible, through the geometric arrangement of movement routes, the design of public spaces, and the location of public facilities, amenities and services, to create the spatial conditions necessary to influence the course of development in a local area - that spatial arrangements matter.

Some of the planning principles presented arise from a combination of concerns, and could therefore sometimes be considered under different sections. For instance, the principle of clustering public facilities to enable resource sharing (1.5.1) arises out of a concern for efficiency of resource use, as well as a concern for improved end-user access - this design principle could therefore be discussed under sections relating to both efficiency and access.

1.1 Place Making

The concept of a 'sense of place' has been the subject of considerable intellectual exploration within a variety of disciplines, and has been imbued with numerous layers of meaning. Contained within the concept are a number of meanings or dimensions which have direct implications for the development of an appropriate urban planning consciousness and for layout planning:

The first dimension is a sense of uniqueness. The creation of a sense of place requires embracing, and consciously seeking to promote, uniqueness, as opposed to standardisation. The second dimension is a sense of balance. A characteristic of quality urban places is the degree to which there is a sustainable balance with natural systems, and a responsive balance with human needs. The third dimension is a sense of symbolism. Over time, certain places frequently acquire historical significance and are elevated over other places in terms of perceptual importance to communities. The fourth dimension is a sense of legibility - the ability of people to anticipate, and orientate themselves within, settlements they do not know intimately. It is this quality which provides the particular spatial structural language of a place.

The concept of a 'sense of place' is therefore clearly complex. Its attainment cannot be achieved through the application of standardised planning actions. Rather, it results from imaginative, appropriate actions based on an understanding of site, human need, function and culture.

In addition, it does not take on end-state form - it is continually being moulded by processes of human action and reaction. If the actions are sensitive and appropriate, it is an enhancing process. If they are not, it can be damaging and even destructive to the sense of place.

It is important to stress however that the concept is not so abtruse that it cannot guide layout planning, or that it only results from accidental events over long periods of time. The concept has direct implications for layout planning.

It is suggested that the approach to facilitating a process of place making should be guided by the following planning principles:

1.1.1 *Focus on public space as the main structuring element of urban settlements*

A hierarchical system of public spaces should form the main organising structure of urban settlements - as opposed to vehicular movement channels dictating settlement structure. The principle structuring elements of urban settlements are public institutions and facilities, and public spaces are the main mechanisms for the gathering and ordering of these.

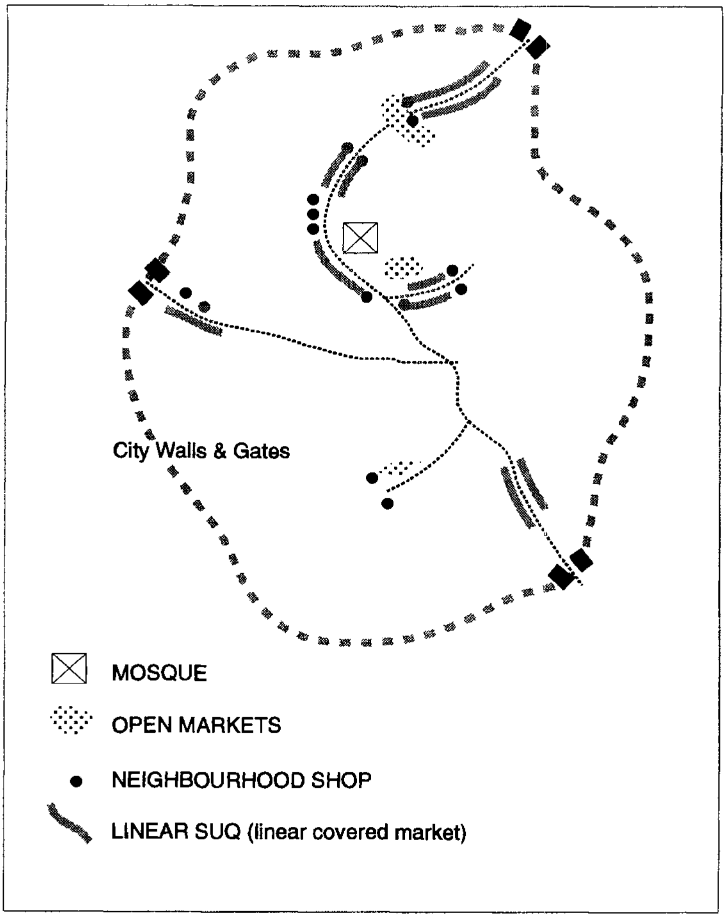


FIGURE 16: Diagram Illustrating How Hard Public Spaces Structure the Traditional Islamic City

Note: A *suq* is a linear covered market.

The location of public spaces should be closely integrated with the movement system (particularly public transport), with the largest spaces gathering around them facilities and activities requiring the greatest degrees of public exposure. This principle of using public spaces to organise public facilities should be used across settlements regardless of scale.

Central to place-making is the creation of a number of special public places. Public spaces and public institutions represent the focal points of community life. Hard public spaces (ie. squares and public markets) and streetscapes in particular, so frequently provide the focal points for social interaction, community events and street trading. They become the places which accommodate symbolic statements, reflecting shared community values and events (eg. accommodating statues or other objects of remembrance), and become the 'memorable' places which shape lasting perceptions of a settlement.

Public spaces play a number of central roles in the creation of quality urban environments.

Firstly, they are the places where people engage in collective life, and which accommodate the informal activities and events which are the essence of urban life. The social role of public spaces is particularly important in poorer communities where fewer household activities can be conducted satisfactorily in (necessarily limited or inadequate) private space. In a real sense therefore, public spaces operate as extensions to the individual dwelling unit.

Secondly, quality public spaces can exude a sense of permanence which encourages processes of housing upgrade and improvement. Conversely, when public spaces are undefined, unscaled and unpleasant, as they are in most low-income settlements in South Africa, the entire environment is uninspiring, regardless of how much investment goes into individual dwellings.

Thirdly, the distribution of public spaces is central in determining the distribution of urban activities in space. The reason for this lies in the relationship between public spaces and patterns of accessibility. Public spaces are the places where people gather and move, and it is this pattern of gathering and movement which sends out investment 'signals'. Those activities most dependent in public exposure for instance, will seek the most accessible locations. Over time, this dynamic interaction between moving, gathering and surrounding uses creates a strong hierarchical dimension to the spatial system, with spaces ranging from very intensive to very private. Some spaces are quiet, secretive and residential in character and almost exclusively serve the units which surround them, while other spaces gather the major institutions of the settlement and are intensive and very public.

A focus of investment on public spaces makes sound economic and social sense. Given the scale of the housing problem in South Africa, the physical and social needs of every household cannot possibly be met adequately via the dwelling unit within the foreseeable future. There will always be some who benefit from housing policy and more who do not. Clearly, therefore, important issues of equity cannot be engaged at this level. It makes good sense to ensure that every community has an equivalent set of public investments, benefitting all inhabitants. Wherever possible therefore, design skills and public investments should be directed towards making public spaces responsive, attractive and comfortable to the end-user community.

1.1.2 *Respond to the cultural context*

The layout plan should respond to the cultural features of the context, by understanding traditional ways of making the local cultural landscape and the logic underpinning this, and ensuring that existing forms of this cultural landscape are conserved.

The term 'cultural landscape' refers to an interdependence between natural landscape, human activity and urban development. Typically the main features of a cultural landscape result from the way in which the importance of the main institutions of society (eg. education, religion, exchange, governance) is signalled in space.

Over long periods of time, identifiable patterns of urban development in response to cultural and landscape characteristics, have emerged in most regions (eg. particular patterns of planting to accommodate or modify local climatic conditions, the location of settlements, the alignment of important routes, the announcement of places of arrival, the location of significant public buildings, the consistent use of local materials, etc).

Layout planning should recognise, conserve and strengthen this cultural landscape by incorporating essential features into new developments. In the unlikely event that such a cultural landscape does not exist, in even rudimentary form, it is necessary for layout plans to initiate it.

Awareness of cultural landscapes in new urban development involves an acknowledgement of higher cultural, spiritual and cosmic orders of authority, power and organisation. This acknowledgement frequently informs the location of settlements, the identification of sacred places, the siting of symbolic institutions, statements and events, and the internal organisation of the settlement.

Responses to cultural landscape in new urban developments typically include: Firstly, using the location of major social institutions and spaces for symbolic, as well as functional, purposes. This usually takes the form of locating public buildings in relation to formal public spaces and important roads (eg. by aligning certain straight roads to core public buildings, such as community centres and places of worship to create vistas) and enabling the informal dimensions of their activities spill into the space. Secondly, encouraging the use of cultural symbols in designing important public spaces and public facilities. The decoration of institutions and spaces with the particular cultural symbols of the community in question so often become some of the dominant memories of the place. Thirdly, giving public buildings visual dominance in the settlement (eg. by occupying high ground, by dominating the skyline, etc.), so that they become reference points for inhabitants - thereby reinforcing their symbolic importance.

1.1.3 *Respond to the natural context*

The layout plan should respond to the natural features of the context, by consciously identifying the implications of the landscape for urban form, seeking ways of accentuating its uniqueness, and investigating ways of bringing its presence visually into the settlement.

Ongoing responses to the natural landscape are the generator of local culture and find form in art, architecture, music, values, beliefs, and social institutions. The repetitive cycles of responses are enriching and recognisably appropriate - they define the uniqueness of the place.

The distinguishing features and characteristics (ie. topography, vegetation, climate, etc.) of the natural landscape should be identified and emphasized in layout planning. The particular characteristics of a natural landscape will often suggest the appropriate pattern of land use activities in the layout plan.

Sensitive urban settlement for instance will occur on the worst land and improve the landscape, while insensitive urban settlement will frequently seek the most beautiful sites and in the process destroy the very qualities which made the sites desirable in the first place. The clear implication of this is that one of the central layout decisions relates to where urban development should not go.

Responses to natural landscape in new urban developments typically include: Firstly, retaining existing landscape features and vegetation to the greatest possible degree. The leveling of sites in the interests of engineering efficiency for instance, is often destructive to natural place. Secondly, creating vistas to prominent topographic features through road alignments and the location of public spaces. Thirdly, orientating roads, buildings and public spaces to optimise light and temperature and to avoid excessive wind-funnelling.

1.1.4 *Improve the protective and visual qualities of the natural landscape*

In some cases it may be necessary to consciously improve the protective and visual aspects of the natural landscape - a concept referred to as 'site making'.

An important judgmental issue is the degree to which a sense of place needs to be made through planned urban interventions or the degree to which it can be left to human processes operating more organically on the landscape. Some landscapes provide little natural place making assistance and require higher degrees of conscious action, while in others the dominant sense of place results from nature and human action needs to be moulded sensitively to complement this.

The concept of site making is based on the realisation that nature can, and often must, be improved in order to give direction, logic and assistance to processes of settlement formation. For example, in desert conditions, one set of concerns appropriately informing urban form relates to the creation of shade, shelter and maximising the benefits and the presence of water, while in other climates, a different set of issues may prevail.

Site making actions typically include: Firstly, initiating vigorous tree planting programmes in conditions where natural vegetation is lacking to provide areas of shade and recreation, supplementary sources of fuel and building materials, wind protection, and space definition. Secondly, creating topographical interest and greater environmental choice through earthworks and solid waste landfill programmes where site conditions are flat (while at the same time creating the gradients necessary for effective sewerage and stormwater drainage).

1.2 Scale

A concern for human scale - the design of the heights, widths, surfacings and operations of the various elements of a layout plan from the perspective of the person on foot - has implications for the planning and design of public facility, amenity and circulation systems. It is suggested that the achievement of a human scale in layout plans should be guided by the following planning principles:

1.2.1 *Define hard open spaces*

Hard open spaces[3] should be defined by trees and public buildings in order to provide a sense of enclosure, greater safety through public surveillance, and a clear definition between public, semi-private and private space.

Public facility buildings should be located adjacent to public spaces, so that, in an urban design sense, the spaces announce the public buildings and accommodate the informal activities that respond to these buildings - in essence creating outdoor public 'rooms'. As a general rule, the largest and most important public buildings should be located in association with the largest and most important hard open spaces.

3. Hard open spaces generally take the form of either public squares, or road reserves (ie. verges, footways and roadways) that perform an open space function as well as a circulation function. These spaces are can be surfaced with a range of treatments including gravel, bituminous, asphalt and paved surfaces. The quality and type of surfacing affects the use of the space (eg. defining a gradation of emphasis from primarily vehicular to primarily pedestrian use).

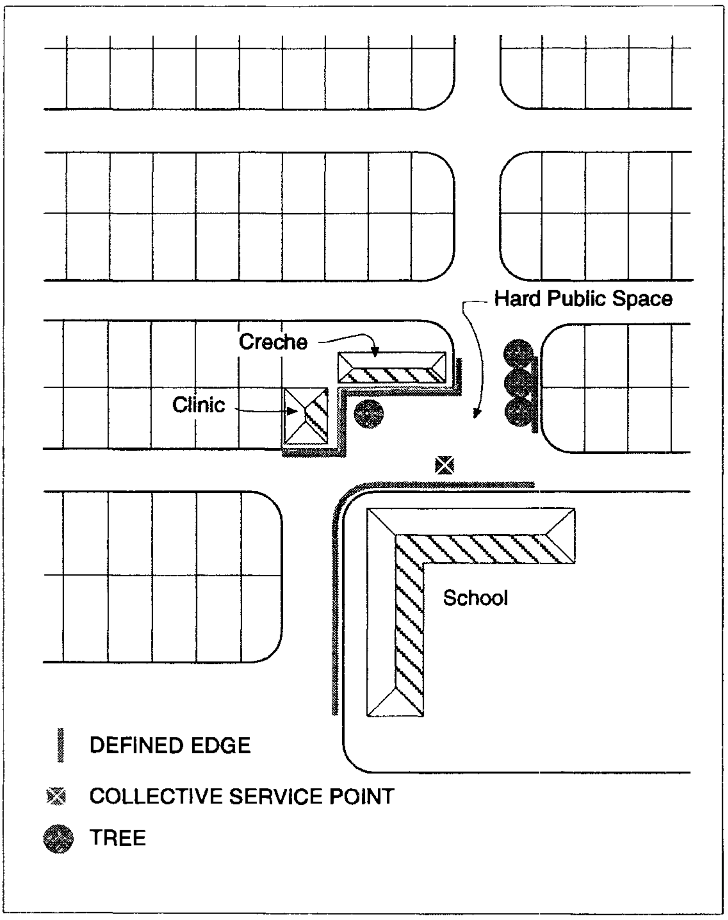


FIGURE 17: Diagram Illustrating the Use of Public Buildings and Trees to Define Hard Open Space

The definition and enclosure of hard public spaces creates a comfortable human scale. The design[4] of these spaces should consciously address issues of human comfort, in terms of *inter alia* shelter from sun, wind and rain, choice between shade and sunlight, public lighting, and seating.

1.2.2 *Link soft open spaces*

Soft public open spaces[5] and playing fields should be linked to form interconnected webs of recreational space, threading through the built environment. Linked open

4. It should be noted that the design of hard public spaces, and the 3-dimensional arrangement of buildings around them, is generally the task of urban designers.

5. Soft open spaces take the form of public gardens, parks and recreational walkways. Soft public spaces are usually landscaped with trees and plants, and surfaced with grass. Gravelled or paved cycle and footpaths

spaces provide opportunities for the creation of continuous walkways and greater levels of urban biodiversity. Linear arrangements of soft open space should be located along water courses and floodplains.

An important considerable however, especially in areas where levels of crime and violence are high, is the degree to which such relatively large stretches of soft open space offer potentially dangerous and unseen spaces. In such circumstances it is important that housing and other land uses front onto the space to maximise surveillance (as opposed to backing onto it), and that the width of the linear parkway enables users to see across the space - in essence to see any possible dangers. In areas where safety is of critical importance, smaller and fewer soft spaces and a greater number of defined hard spaces, are more likely to minimise potential dangers.

Within the open space network, defined pedestrian paths should be provided to facilitate easy movement, and playing fields should be clustered to facilitate sharing by groups of schools and sports clubs. The location of schools close to public open spaces, enables the multi-functional use of these spaces as playtime areas

1.2.3 *Provide multi-functional roads*

The majority of routes within a road network should accommodate numerous functions and users. The road network should be able to accommodate a diverse range of social, environmental, developmental as well as movement functions. Roads should be viewed as a series of complex social and economic spaces which accommodate people, as opposed to purely circulation channels which accommodate vehicles.

Roads should be planned to reconcile the needs and requirements of a multiplicity of users, recognising that no one use will operate with optimum efficiency. Equitable provision should be made for all road users - allocating road space to reflect the various demands which are made upon it.

A diverse and continuous network of multi-functional roads should therefore replace the current functional hierarchy of middle and lower order roads (see 1.1 of section 4 for a more detailed discussion around functional road hierarchy). A functional road hierarchy produces a technically efficient road layout - road investment is minimised, and high practical capacities are attained through restraining or eliminating other potentially conflicting functions - but does not however adequately accommodate non-movement functions and pedestrian movement.

Multi-functional routes should accommodate the type of traffic movements conventionally associated with district distributors, local distributors and access roads

are often provided within the soft surfaces. The nature of the landscaping and surfacing affects the use of the space (eg. large expanses of grassed surface being suitable for informal sports and outdoor concerts).

in terms of the current hierarchy[6], as well as traffic movements associated with activity corridors, activity streets and *woonerven*[7].

Routes should be continuous and functionally connected. The middle order and local road network should have a continuous gradation of road types, with different road types accommodating different combinations of functions and users - an attribute of good road network design should be the range and variety of routes. A continuous network should have a logical structure or sense of order - reflected in the scale of routes, and the allocation of space to various users.

1.3 Access

A concern for access - the meeting of circulation needs and the maximisation of levels of access to commercial, facility and employment opportunities for the greatest number of people - has implications for *inter alia* road network design, public transport operations and city-wide land use distribution patterns. With regard to layout more specifically, a concern for access has implications for the planning and design of circulation and public facility systems. It is suggested that the achievement of high levels of access in layout plans should be guided by the following planning principles:

1.3.1 *Integrate the road layout with the surrounding movement system*

The local circulation system should be totally integrated into the broader movement system and land use pattern. The various movement facilities provided should form an integral part of the overall system of movement in the larger area, and should not be regarded as an independent sub-system merely linking or connecting to the larger surrounding movement system.

The geometric road layout should form a logical progression and extension of the broader movement system. In a sense, the layout should be 'stitched' into the broader

6. Under the current functional hierarchy, district distributors connect districts, and link primary and local distributors. These routes tend to have moderate route capacity, high intersection capacity and moderately high operating speeds. Local distributors distribute traffic from adjacent district distributors to access roads within an area. Road-based public transport services normally concentrate on district and local distributors. Access roads (including collectors, loops, cul-de-sacs, ways, courts and strips) give direct access to erven - traffic volumes are light, with routes normally serving no more than 200 dwellings.

7. Activity corridors and activity streets (sometimes referred to as class 3a district distributors and class 4a local distributors respectively, in terms of the current functional hierarchy), accommodate stop-start traffic, characterised by a mix of local and though traffic, as well as pedestrian and public transport movements. Frontage access is not restricted. The difference between 'corridors' and 'streets' is the intensity of movement - with corridors accommodating a greater intensity than streets. *Woonerven* are residential streets scaled to the pedestrian, where cars are forced to behave according to a set of pedestrian rules.

urban fabric by the roads that are provided, in order to improve levels of interconnection and extend important routes through the area.

In particular, the local road network should allow for existing public transport operations to be complemented, providing additional opportunities for routing and service provision. It should enable the range and variety of services to be extended, the overall efficiency of operation to be increased, and the coverage and penetration improved.

1.3.2 *Prioritise pedestrian movement*

The ease of access of the pedestrian movement system to non-residential land use activities and public transport stops, along with the convenience and safety of the pedestrian system, should receive priority in layout planning. Pedestrians are the most vulnerable group of road users, meeting their needs and requirements should therefore attract greater attention than other users. Almost all trips in low-income areas are dependent on walking for at least part of the journey, and many trips are made entirely on foot. The great majority of pedestrian movement is local in nature, rarely exceeding more than 3 km in total trip length - most movement takes place on footways adjacent to carriageways.

Pedestrian routes should be located to provide the shortest practical routes between activities - links throughout the area being direct and convenient, connecting and integrating the layout with surrounding areas.

Where roadways are used for both pedestrian and vehicular movement, the changed nature of the road should be readily apparent. The subservient nature of motorised movement should be reinforced in the design of the road layout - through the use of design features like road narrowings or 'pinch points'.

1.3.3 *Facilitate efficient and effective public transport services*

The requirements of efficient and effective public transport services should receive priority in layout planning. The geometric and threshold (ie. residential density) requirements of different public transport modes should inform layout design (see 1.3.4 for a discussion of road geometries which facilitate public transport operations).

An efficient public transport service is an effective mechanism for improving general inter-district accessibility, increasing potential development opportunities, integrating different neighbourhoods, and reducing the need for congesting and polluting motor car travel. In low-income areas, for personal mobility, commuters are generally heavily dependent on public transport services, which either connect a range of destinations or interchange with a mix of public transport service types that do. Public transport services take a variety of forms, including passenger rail, light rail, express bus, local bus and mini-bus (or combi-taxi) services. Different services are suited to different types of trips (eg. long and short haul distances).

Wherever possible therefore, all areas should be served by a well planned public transport network. The form the public transport network should take is input to the layout planning process and special provision should be made for it within the layout plan.

1.3.4 *Design open and flexible movement systems*

Movement systems should be designed to improve levels of access for the greatest number of people. As mentioned earlier (see 1.3.2 and 1.3.3), in the developing urban areas of South Africa, movement systems should be designed to facilitate, primarily, the needs of pedestrian and public transport movement - as opposed to designing road networks that accommodate only the needs of private vehicular movement.

The implication of this that road geometries (ie. the pattern of a road network) should be open. The lower order road network (ie. routes other than regional and primary distributors) should provide a system of through connections, that offer a number of possible alternative routes between two points, rather than funnelling all movement onto a few collector and arterial routes. The network should be well-connected to adjoining areas - the routes that are provided being logical and convenient routes for traffic to use in that sector. The profligate use of cul-de-sacs that restrict pedestrian access should be avoided.

The exact geometric form of a network is likely to be distinct and dependant on context specific factors like topography, stormwater drainage requirements and the spatial distribution of traffic generating activities in surrounding areas. Road layout design should not be based on the application of rigid design standards, and should not therefore resemble a stylised road layout or 'blueprint'

Open road geometries offer the greatest advantages to pedestrians, by allowing generally unrestricted and direct pedestrian movement to all principle activities. By comparison, closed geometries do not provide direct connections between areas - unless a separate pedestrian footpath system is provided (with associated security risks and cost implications). Open road geometries also offer the greatest advantages to road-based public transport services, by enabling direct and unrestricted pedestrian movement to stops, offering public transport vehicles direct or unconvoluted routes, and being more adaptive to changes in service routing and the number and location of stops than closed geometries. (For a more detailed discussion of the geometric requirements of pedestrian and public transport systems - see 1.2.1 of section 4.)

An open, multi-functional road network, in the form of a distorted rectilinear grid, enables complex systems of movement to emerge (eg. stop-start traffic and the mixing of through, local and pedestrian movement associated with vibrant 'activity streets'), creates numerous intersection points which offer trading opportunities, and are most able to respond to changes in sub-metropolitan movement patterns, land-use distribution and modal split resulting from developments in surrounding areas.

Open road geometries should be considered in both lower and higher income urban developments. In lower income developments, where dependance on pedestrian and public transport movement is high, they are an obvious necessity. In higher income developments, where peripheral low density housing is sprawling outward at an alarming pace, with concomitant impacts on economic thresholds, service provision and loss of natural amenity, they are important to actively promote pedestrianisation and public transport use. The approaches that have emerged in Germany in the form of ***verkehrsberuhigung***, or traffic calming, and the United States in the form of traditional neighbourhood developments, provide more useful models or concepts for higher income development in South Africa, than the garden city, neighbourhood unit and planned unit development concepts that have been so influential in the past. (See section 1 of the handbook for discussion on these layout concepts.)

1.3.5 *Expose the facility system*

The current introverted approach to facility location should shift to a more extroverted approach. The overriding aim in planning a public facility network should be to make facilities as accessible to the greatest number of end-user households as possible, and to use these public investments as a way of creating the conditions necessary to encourage private investments in commerce and industry.

The majority of public facilities should be located in positions with maximum exposure, along main public transport routes - as opposed to being located to serve only a spatially defined residential cell. Higher order public facilities should be clustered around highly accessible public transport stops, adjacent to major road intersections. Lower order facilities should be located at lower order road intersections along important public transport routes. This exposure of facilities enables complex patterns of facility use between different neighbourhoods to occur, and serves to integrate, rather than to isolate, residential neighbourhoods. In this way the problems associated with cellular systems of facility provision, mentioned earlier, can be avoided.

The specific locational requirements of facilities and amenities are influenced by factors like the functional relationships within facility hierarchies, the functional relationships between different facility systems, access and mobility requirements, and noise and safety considerations.

Broadly speaking, facilities can be divided into five categories on the basis of their locational requirements:

The first category of facilities are those that need to distribute emergency vehicles like fire engines, ambulances and police cars, across an urban area, at speed. As a result, these facilities require easy, but not direct, access to the distributor network - they should be located on higher order multi-functional routes that intersect with regional or primary distributors. Examples of this type of facility are fire stations, police stations and provincial or academic hospitals.

The second category of facilities are those that need to be as visible and as accessible to the greatest number of people as possible. As a result, these facilities require easy access to public transport stops or interchanges, and high levels of exposure to more intense activity routes. The location of these facilities along linear public transport routes facilitates the provision of road-based services, and the alignment of trunk services to enable adequate service connections to public facility buildings. Examples of this type of facility are post offices, community centres and libraries.

The third category of facilities are those that need to be as accessible to the greatest number of people as possible, but situated in relatively quiet and safe surroundings. As a result, these facilities require easy access to public transport stops or interchanges, but should be located a block or two back from more intense activity routes. Examples of this type of facility are primary and secondary schools, day-hospitals and clinics.

The fourth category of facilities are those that need to be accessible to pedestrians, and require quiet and safe surroundings. As a result, these facilities should be located inside quiet, predominantly residential areas, within easy walking distance of user households. An example of this type of facility is a creche or day-care centre. Creches are also however, often required in commercial and employment centres, for the convenience of working mothers.

The fifth category of facilities are those that need to be as visible and as accessible to pedestrians as possible. As a result, these facilities should be located within easy walking distance of user households, on busier road intersections. Examples of this type of facility are collective servicing points like post collection boxes, solid waste collection points, public telephones and water standpipes.

The functional relationships between public facilities and amenities have to be understood within the context of each development. Different government and parastatal agencies are responsible for the delivery of different pubic facilities, and it is often extremely difficult to establish co-ordination between these agencies. In order to provide facilities, some government departments and parastatal agencies require the identification and reservation of land at the layout planning stage, while others simply respond to established backlogs once land has been settled upon (eg. post offices generally occupy rented space within shopping complexes). It is necessary therefore, to identify which facilities require land identification and reservation for each development, so this can be incorporated into the layout plan.

1.4 Opportunity

A concern for opportunity - the maximisation of the economic opportunities inherent in large agglomerations of people through the arrangement of infrastructural investments in space - has implications for *inter alia* small business support programmes, training programmes, retail management policies and development control systems. With regard to layout more specifically, a concern for the creation of economic opportunities and local economic development has implications for the planning and design of circulation, amenity and utility systems. It is suggested that the generation of economic opportunities through layout plans should be guided by the following planning principles:

1.4.1 *Concentrate local through-movement onto stop-start activity routes*

Local through-traffic should be concentrated onto continuous connecting routes in order to create the passing consumer thresholds necessary to support viable commercial activities, (while ensuring that, where possible, longer distance through-traffic has the choice of using alternative faster moving movement routes).

The overriding aim in designing a circulation network should be to create the spatial conditions necessary for the development of vibrant urban economies, and to enable people gain direct and easy access to urban opportunities. The nature, extent and distribution of potential development opportunities is heavily influenced by the movement patterns, and ensuing degrees of accessibility to particular properties, that result from the circulation network.

Vehicular and pedestrian movement can be concentrated onto stop-start activity routes through the alignment of different public transport modes and services along shared routes for a portion of their service length, and the location of movement generators like major public facilities and public transport modal interchanges along the route.

1.4.2 *Provide accessible public spaces which create opportunities for collective activity*

Opportunities for collective activity should be created by providing public spaces in accessible locations. The location of hard open spaces together with the design of the movement system are key elements in creating the spatial conditions necessary to facilitate and initiate urban environments which create opportunities for formal commercial investment and informal self-generated income.

In the majority of cases, the hierarchy of hard public spaces (mentioned in 1.1.1) should be synchronised with the movement system. The largest and most important hard spaces should generally be located at points of maximum accessibility (ie. intersections between more intensive movement routes and public transport mode interchanges) where commercial activity is anticipated, and should provide opportunities for intensive informal trade. Smaller hard spaces should generally be located at points where collective services (eg. post collection points, water standpipes, public telephones, etc.) are situated, and should provide opportunities for less intensive informal trading.

The location of public spaces should also however, be influenced by factors like the existence of points of particular cultural, spiritual or symbolic significance.

The importance and significance of public places in urban community life is in part derived from, and strengthened by, their dominant location in terms of the movement system, and from a common perception of the significance of the public activities and institutions they house (eg. carnivals and ceremonies) or announce (eg. religious or educational buildings).

1.4.3 *Cluster collective services around public spaces and public markets*

Collective[8] service points (eg. public standpipes, public telephones, post collection points, solid waste collection points, metered electricity dispensers, and public toilets) should be clustered around public markets and hard open spaces, to create favourable small-scale manufacturing and trading conditions, and, in cases where these services perform residential[9] functions as well, enable a single trip to satisfy numerous service needs. The clustering of service points provides the utilities necessary for small trading operations, and attracts potential consumers to specific points in space.

Public facilities (that should be clustered around public spaces - see 1.2.1 and 1.5.1) are intensively used by large numbers of people, and, through the creation of 'load centres', can generate the largest demand for utility services. As a result they can be used to 'pull' service mains economically through a settlement, with facilities, and the public spaces they abut, accommodating a range of services often not supplied to individual residential erven (eg. telecommunications, solid waste collection, postal delivery).

8. Collective services are those services consumed off-site, to satisfy either domestic household service needs or community service needs. Community service needs relate to movement, drainage, public safety, outdoor manufacturing, market trading and social interaction. In the case of domestic household needs, the service is transported to the site for consumption within the dwelling or on the site. In the case of community needs the service is used within the public environment. Collective services include: water supply in the form of public standpipes, sanitation in the form of public toilets, roads, stormwater drainage, energy supply in the form of metered electricity dispensers in public markets, public lighting, solid waste removal in the form of rubbish collection points, and communications in the form of public telephones and post collection points.

9. Residential services are those services consumed on-site, to satisfy domestic household service needs. The service is used either in the individual dwelling, or on the site. Residential services include: water supply in the form of house or yard taps, sanitation in the form of in-house or out-house toilets, energy supply in the form of electricity or gas, solid waste removal in the form of kerbside rubbish collection, and communications in the form of private telephones and postal delivery.

Through an understanding of the range and threshold requirements of, and functional relationships between, collective services, layout plans should locate public markets and squares, and their associated collective servicing points, to ensure that all households have convenient pedestrian access and that a single trip can satisfy a number of service needs.

In cases where it is necessary to provide public toilets, they should be located next to facilities like schools, clinics and libraries, so that once there is adequate individualised sanitation, they can simply be incorporated into public facilities. In this way redundant service provision can be avoided.

1.4.4 *Incorporate public markets as an element of essential public infrastructure*

Public markets, in the form of agglomerated services and shelters, should be incorporated as an element of essential publicly provided infrastructure. Markets enable many unemployed to generate income through a variety of small scale manufacturing, service and retail activities, and can therefore play a significant role in terms of poverty alleviation.

Public markets offer assistance to informal sector manufacturers and traders by providing central trading locations for small operators, and by creating agglomerations of small traders capable of competing effectively with larger commercial establishments.

Viable public markets depend on concentrations of consumers, and are therefore most successful in geometric road layouts which concentrate rather than disperse pedestrian and vehicular movement. Public transport orientated, open road geometries, with a few dominant activity routes which enable stop-start traffic and pedestrian circulation, are most effective in concentrating pedestrian flows.

Also important for market support is a continuous flow of traffic in both directions - not simply a morning and evening pulse of activity with little occurring in between. In layout terms, this requires that dominant routes are continuous, and link adjacent residential areas - as opposed to segregated neighbourhood cells and discontinuous routes.

There are three main factors that should be taken into consideration in locating public markets.

The first is the location of major movement generators like modal interchanges, large employment centres, and commercial complexes. Market traders are highly dependent on passing pedestrian and vehicular traffic - the optimal location is where pedestrian flow can be physically intercepted. The exception to this can be found where markets are large (ie. several hundred stalls) - the number of stalls and the diversity of products sold, acts as a magnet to customers in its own right. Larger markets therefore have a higher degree of locational flexibility, although they still need to be well integrated into the major concentrations and flows of urban activity.

The second is the sources of supply and this is particularly important when a market has a large fresh produce component. Fresh produce markets need to have good access to wholesale markets or to direct supplies from farms. If access is poor then the smaller traders who do not have access to a vehicle will be disadvantaged in favour of the larger entrepreneurs who do. Fresh produce retail markets therefore need to be close to, or have good connections to, wholesale markets.

The third is the relationship between markets and public transport. Close access to public transport stops is important not only for customers, but also for market operators who sometimes need to transport supplies to the market.

1.5 Efficiency

A concern for efficiency - the cost effective utilisation of land and financial resources - has implications for *inter alia* land use policies, transport policies, and capital investment programmes. With regard to layout more specifically, a concern for efficiency has implications for the planning and design of public facility, amenity and utility systems. It is suggested that the most efficient use of resources in layout plans should be guided by the following planning principles:

1.5.1 *Cluster facilities to enable resource sharing*

Public facilities that are functionally related should be located in clusters, so that in the face of limited public funds, the sharing of resources (eg. halls, libraries, playing fields, teaching equipment, etc.) between facilities is made possible. The spatial clustering of facilities also enables a number of household needs to be satisfied in a single trip.

It is important that the hierarchical relationships (eg. the relationship within the health care system, with regard to referral procedures and medical supplies, between mobile clinics, day-hospitals and community hospitals) and lateral relationships (eg. the relationship, with regard to book sharing, between municipal libraries and schools or colleges) between facilities are understood, so that the spatial conditions necessary to facilitate resource sharing can be accommodated within the layout plan.

A recognition of functional interrelationships and the accommodation of their spatial preconditions in the layout plan, facilitates resource sharing and the multi-functional use of facility buildings and spaces.

1.5.2 *Integrate open spaces with utility services*

The design of public open space networks should be integrated with the design of infrastructure networks.

In particular, interconnected soft open space systems should be integrated with major stormwater management systems (ie. open stormwater channels, retention and retarding ponds, etc.). Open spaces and clusters of playing fields, should take up low-lying land subject to periodic flooding, acting as overflow facilities in the event of severe storms, while stormwater outfall and storage facilities should be used as landscaping features within the amenity network.

Further, the landscaping of public parks located away from water courses, which act as 'green islands' within the built environment, can be incorporated into service programmes like solid waste disposal and fuelwood planting.

1.5.3 *Facilitate efficient service provision and land utilisation*

Layout plans should, without compromising other normative concerns regarding urban environmental quality, facilitate the efficient provision of reticulated and road-based engineering services, and efficient land utilisation. The layout plan should seek to reduce the cost of serviced land. There are two main ways to reduce costs, the one is to lower standards - which is a policy decision requiring participation with the end-user community, and the other is to optimise the layout for the particular combination of service options provided - which is a design decision requiring a knowledge of the implications different geometric layouts and erf sizes have for the cost of providing different service technologies.

With regard to efficient service provision, the spatial and topographical requirements of the range of reticulated and on-site services should be accommodated in the layout design. It needs to be emphasized however that the concern should not be to optimize the provision of infrastructure sectorally, but to ensure that together these infrastructural elements operate in a systemic way - this often necessitates trade-offs and sometimes even technical inefficiencies.

Engineering services should be accommodated by *inter alia* avoiding steep or flat road gradients, reducing road length per erf, minimising sewer and stormwater manhole requirements through block length and road curvature, and ensuring suitable erf dimensions for on-site services.

The circulation of regular road-based public services, in the form of public transport, solid waste collection and postal delivery, should be accommodated by ensuring that these services operate on adequately structured, surfaced and drained roads. In cases where adequate road surfacing is not affordable on all roads, these routes, at the very least, should be adequately surfaced.

With regard to efficient land utilisation, the layout plan should minimise the take-up of land for road reserves, and ensure that the size of residential erven and public facility space standards enable the development of higher gross residential densities (in the region of 50 to 75 du's/ha). Greater residential densities enhance the affordability of a development through reductions in the unit cost of land acquisition and service provision.

1.5.4 *Align trunk services to important routes*

Where possible trunk service lines should be aligned to more intensive movement routes which link public facilities and non-residential land uses, and electricity sub-stations (which transform high voltage current into low voltage current for the purposes of residential reticulation) should be located close to public facility clusters (ie. 'load centres').

In this way full water, sewerage, electricity, public lighting and telecommunication connections can be made to commercial services, small-scale manufacturers, and public facilities like schools and health clinics, from the beginning of the infrastructure provision process. Similarly, in cases where adequate road surfacing is not affordable on all roads, public facilities should be connected by a network of surfaced roads to ensure the effective provision of regular road-based services.

In situations where water reticulation to residential areas is not designed for additional fire fighting flows, water supply ring mains with greatest capacity and pressure should, where possible, be aligned to intensive activity routes, to ensure that at the very least public facilities like schools and community centres are adequately covered by fire hydrants and associated fire fighting services.

1.5.5 *Address the collective functions of services*

The collective functions of services should receive equal priority to residential functions, in lower income urban development. These functions are central to the basic infrastructure around which vibrant urban settlements develop.

Currently, the minimum level of services typically provided in low-income urban developments includes: (1) public water standpipes, (2) waterborne sewerage (generally depending on water table and soil conditions), (3) gravel access roads and bitumen surfaced bus routes, (4) unlined stormwater channels, (5) communal solid waste collection points, (6) high-mast security lighting, and (7) occasionally prepayment electricity dispensers. The provision of public telephones, post collection points and electricity connections usually occurs later, once sites have been occupied and a demand for these services has been established.

This assessment of minimum levels of service defines the functions of services narrowly. As mentioned earlier in section 1 of the handbook, the current approach to service provision is generally geared towards satisfying residential consumption needs only - the more collective functions of services, regarding street trading, small scale manufacturing, social interaction and recreation, tend to be ignored. Consequently the minimum level of services necessary to support vibrant public life and embryonic local economies, in the form of public standpipes, solid waste bins, public telephones, public toilets and metered electricity dispensers associated with hard public spaces and public markets, are often omitted in low-income urban developments.

In conditions of resource scarcity, where the service needs of households cannot be met within the individual dwelling alone, collective services allocate limited resources to benefit the entire end-user community, rather than a limited number of end-user households (see 1.1.1 for further discussion on this).

Despite a need for greater emphasis on collective provision in resource scarce developments, individualised sanitation services remain essential. Experience in operating public toilets has generally been that these facilities are difficult to maintain due to a lack of user care. In conditions of extensive backyard shacking and overcrowding however, public toilets, in addition to individualised sanitation services, may often be required to meet sanitation needs.

1.6 Choice

A concern for choice - the maximisation of the range of choices available to end-user communities regarding housing consolidation, service provision, urban surroundings, movement modes and so on - has implications for the planning and design of circulation, amenity and utility systems. It is suggested that the maximisation of choice in layout plans should be guided by the following planning principles:

1.6.1 *Provide contrasting spaces of intense activity and relief*

Choice between very busy areas and very quiet areas should be provided. The quality of urban environments is influenced by the positioning of public spaces in order to achieve contrast. Public space should be used as a mechanism of release and relaxation in very intense developed areas, and as a generator of intensity and interaction in quiet, very private areas. It is these pulses of urban activity that provide vibrancy and interest in urban environments.

1.6.2 *Facilitate a range of housing processes*

In order to accommodate the diverse range of housing needs that exist in South African cities, layout and infrastructure designs should facilitate numerous housing forms and housing processes.

The size of erven and the level of service provision per erf should therefore be allowed to vary within a layout plan - reflecting the range of housing needs of the end-user community. A variety of housing processes should be accommodated, ranging from an individual household consolidating an erf with a basic level of services, to a household using a larger fully serviced erf as a source of income by subletting additional dwellings or operating a home business, to a group of households occupying an entire block and arranging their own internal subdivisions with service connections to individual erven occurring later.

1.6.3 *Meet the spatial requirements of future infrastructure upgrade*

In cases where it is not possible to provide every erf with a high level of services, the spatial dimensions of the layout - particularly road reserves - should ensure that it is possible to upgrade the initial level of service provision at a later date.

Over time, as the necessary resources become available, reticulation networks can therefore be extended, and erf connections made. In order for this to occur it is obviously necessary that engineers inform town planners, responsible for layout plans, of the spatial requirements of realistic future infrastructure upgrades.

2. Spatial Implications

The following set of twelve conceptual diagrams illustrate the spatial implications of the planning principles presented in the first part of this section, at different scales and in 'greenfield' and 'upgrade' contexts. The diagrams are intended to inform the latter part of the concept formation stage of the layout planning process (see 2.2.2 Spatial Relationships, of section 2).

The first eight conceptual diagrams are acontextual, and are intended only to illustrate a set of spatial relationships in a 'greenfield' context. The last four conceptual diagrams are based on an existing informal settlement in Cape Town, and are intended to illustrate spatial relationships in an *in situ* upgrade context.

As the diagrams focus primarily on relationships - in other words, how the various elements of layouts should relate to each other spatially - they are intended to be read as a series of overlaying diagrams, not as a separation of concepts into sectors. Spatial relationships are illustrated in terms of conceptual diagrams relating to: (1) hard spaces (eg. public squares, road reserves, etc.), (2) facilities (eg. schools, libraries, creches, etc.), (3) soft spaces (eg. parks, sports fields, etc.), and (4) utilities (eg. water supply, sanitation, energy supply, etc.).

2.1 Spatial Implications at a Larger Scale

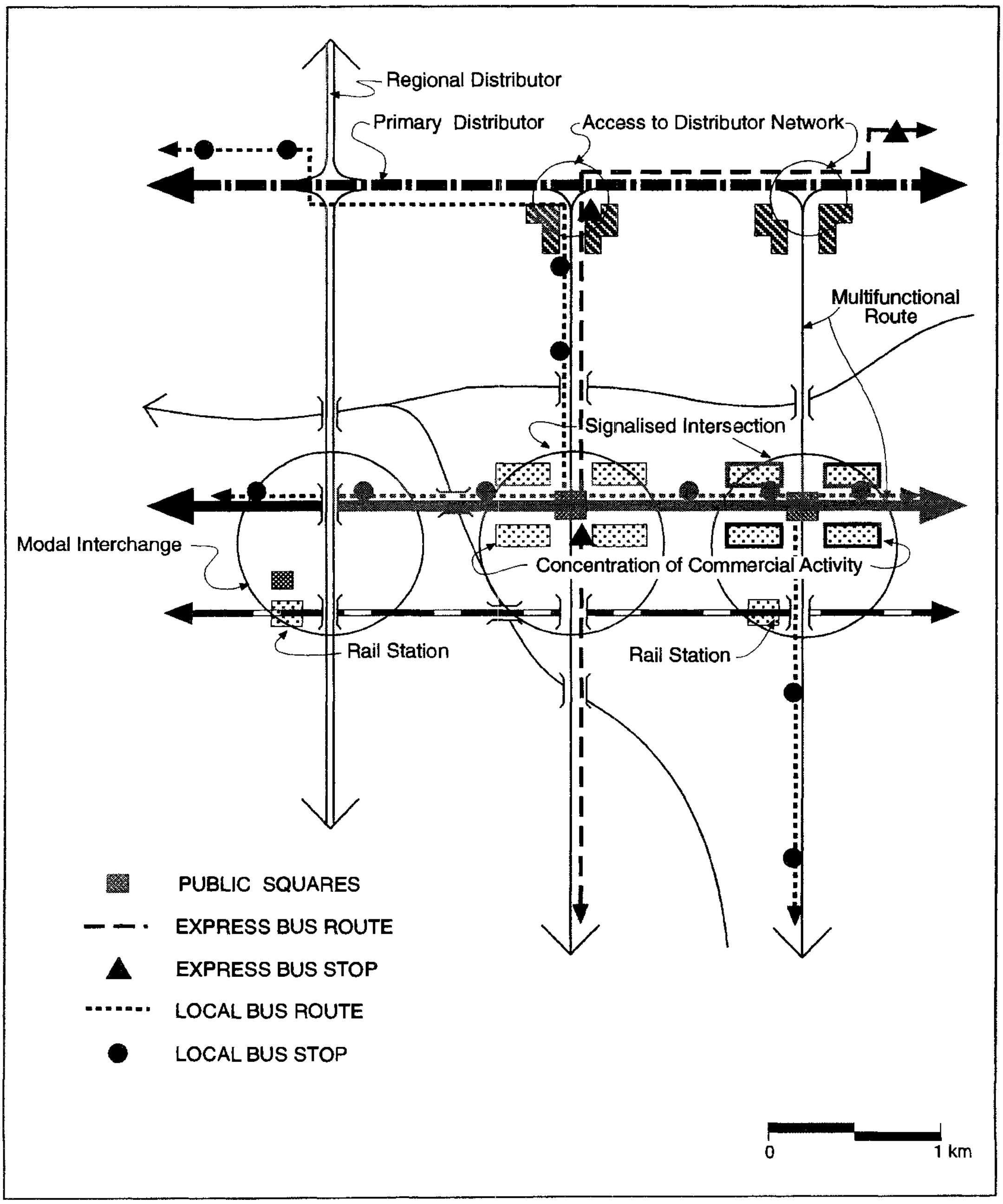
2.1.1 *Hard Spaces*

* *Facilitate efficient and effective public transport services* (see 1.3.3).
Spatial implications include: (1) the location of modal interchanges between rail, mini-bus, local and express bus services at points of greatest access within the movement system, and (2) the provision of direct and continuous roads for public transport service routing.

* *Concentrate local through-movement onto stop-start activity routes* (see 1.4.1).
Spatial implications include: (1) the routing of different express and local bus services along the same route for a portion of their service length, and (2) the provision of an alternative faster moving distributor route for longer distance through-traffic with connections at ± 1-2 km intervals.

* *Provide accessible public spaces which create opportunities for collective activity* (see 1.4.2).
Spatial implication: the location of the largest and most important public squares at points of greatest accessibility, where commercial activity is anticipated - at major road intersections between higher order multi-functional routes and at public transport modal interchanges.

FIGURE 18: Conceptual Diagram of Key Spatial Relationships Relating to Hard Spaces, at a Larger Scale



2.1.2 *Facilities*

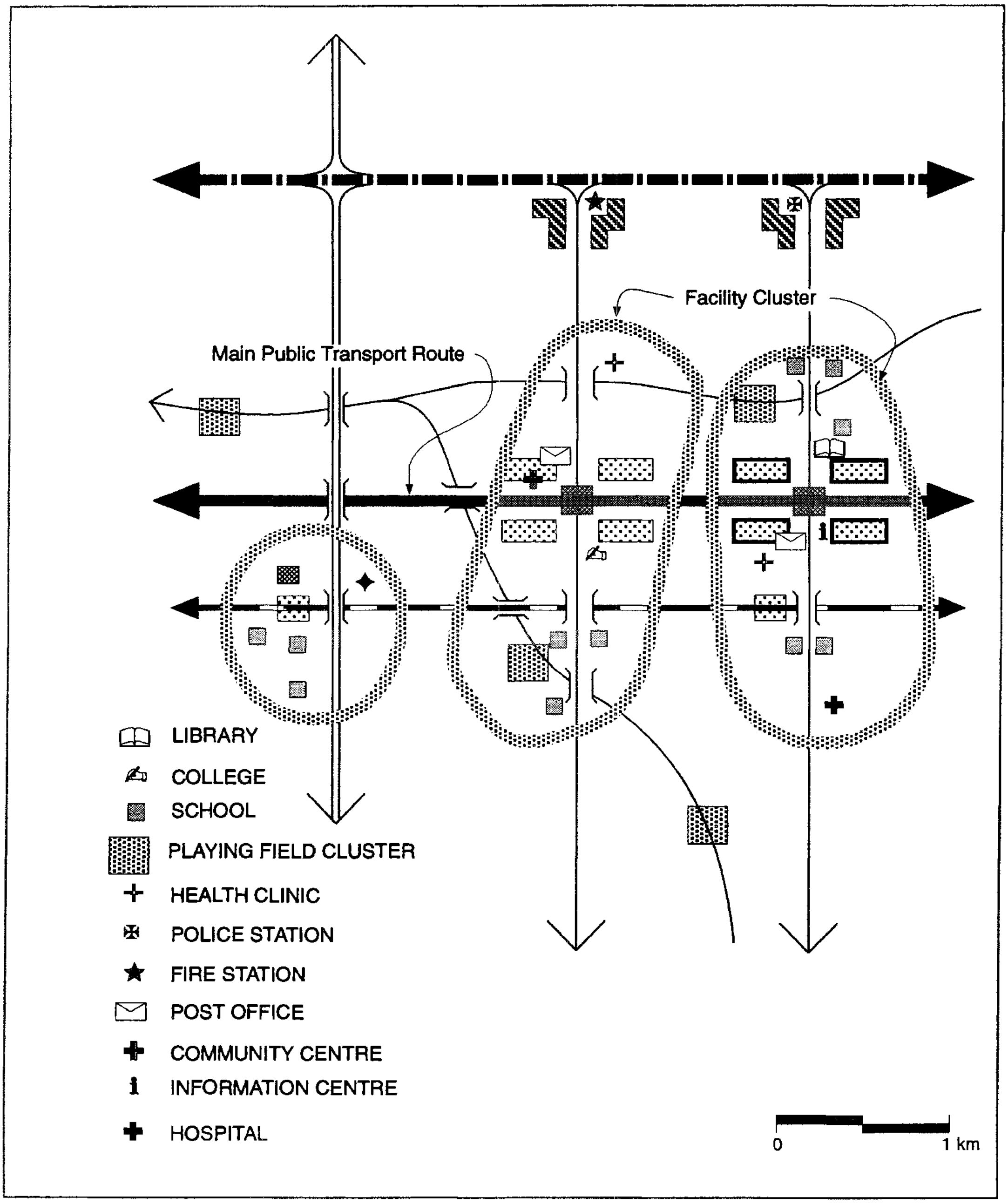
* *Focus on public space as the main structuring element of urban settlements* (see 1.1.1).
Spatial implication: the location of major public facilities around the most important hard public spaces.

* *Expose the facility system* (see 1.3.5).
Spatial implications include: the location of the bulk of public facilities along the main public transport corridor, with the greatest number of higher order facilities located at the most accessible point along this corridor (ie. the at-grade intersection close to the rail station). Three categories of facility location requirements are illustrated: (1) easy access to the distributor network, (2) easy access to public transport services and high levels of exposure to activity routes, (3) easy access to public transport services and low levels of exposure to activity routes

* *Concentrate local through-movement onto stop-start activity routes* (see 1.4.1).
Spatial implication: the location of the major movement-generating public facilities along the route.

* *Cluster facilities to enable resource sharing* (see 1.5.1).
Spatial implication: the location of facilities in groups around points of greatest access.

FIGURE 19: Conceptual Diagram of Key Spatial Relationships Relating to Facilities, at a Larger Scale

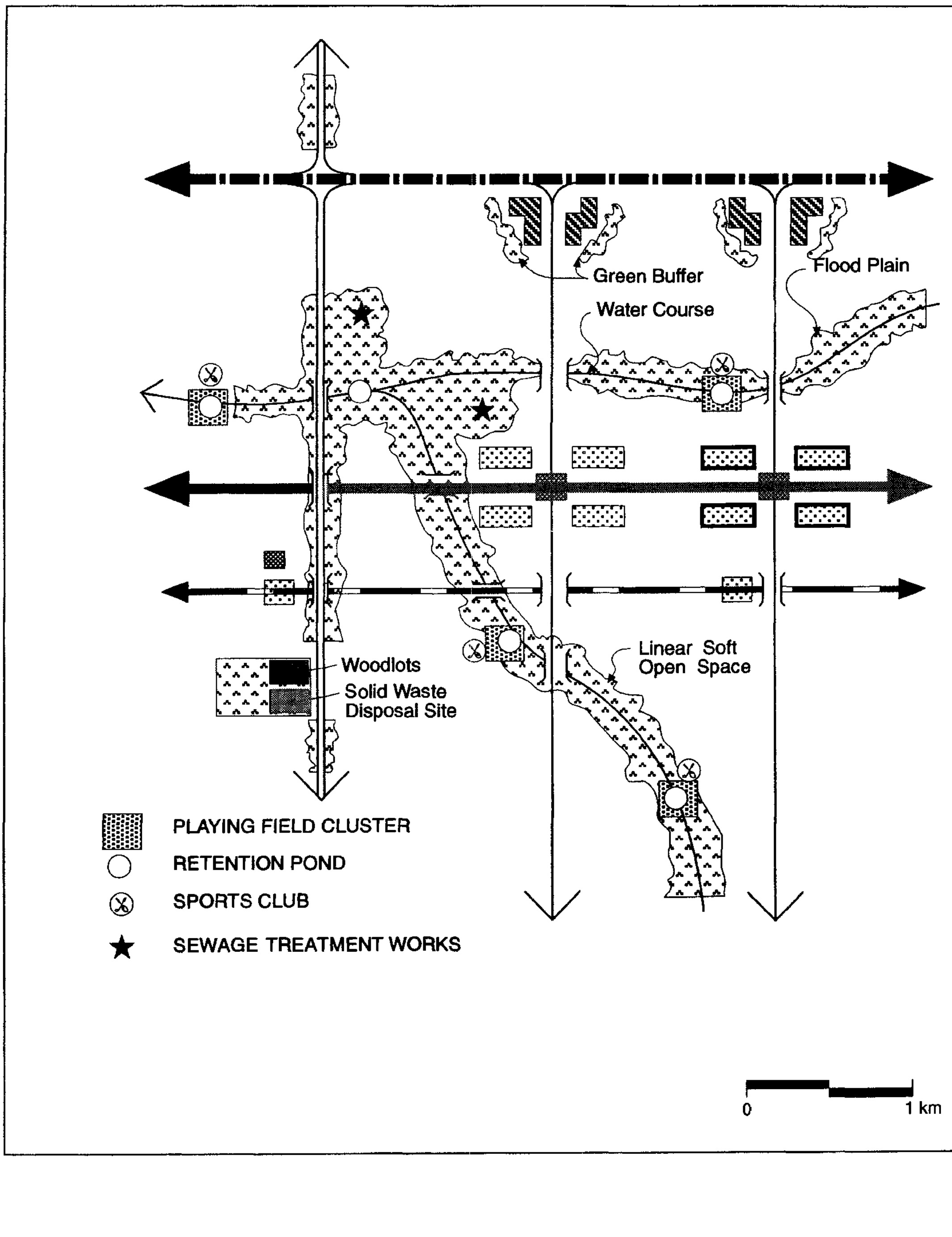


2.1.3 *Soft Spaces*

* *Link soft open spaces* (see 1.2.2).
Spatial implications include: (1) the location of linear soft spaces along water courses and floodplains, and (2) the interconnection of soft public open spaces with playing fields and green buffer spaces surrounding sewage treatment works and regional distributor routes.

* *Integrate open spaces with utility services* (see 1.5.2).
Spatial implications include: (1) the incorporation of stormwater retention ponds and sewage treatment works into the linear open space network, and their use as recreational amenities and wetland nature reserves respectively, (2) the use of playing fields as stormwater overflow facilities in the event of severe storms, and (3) the incorporation of fuelwood planting and solid waste disposal sites into public parks, and their use as landscaping features.

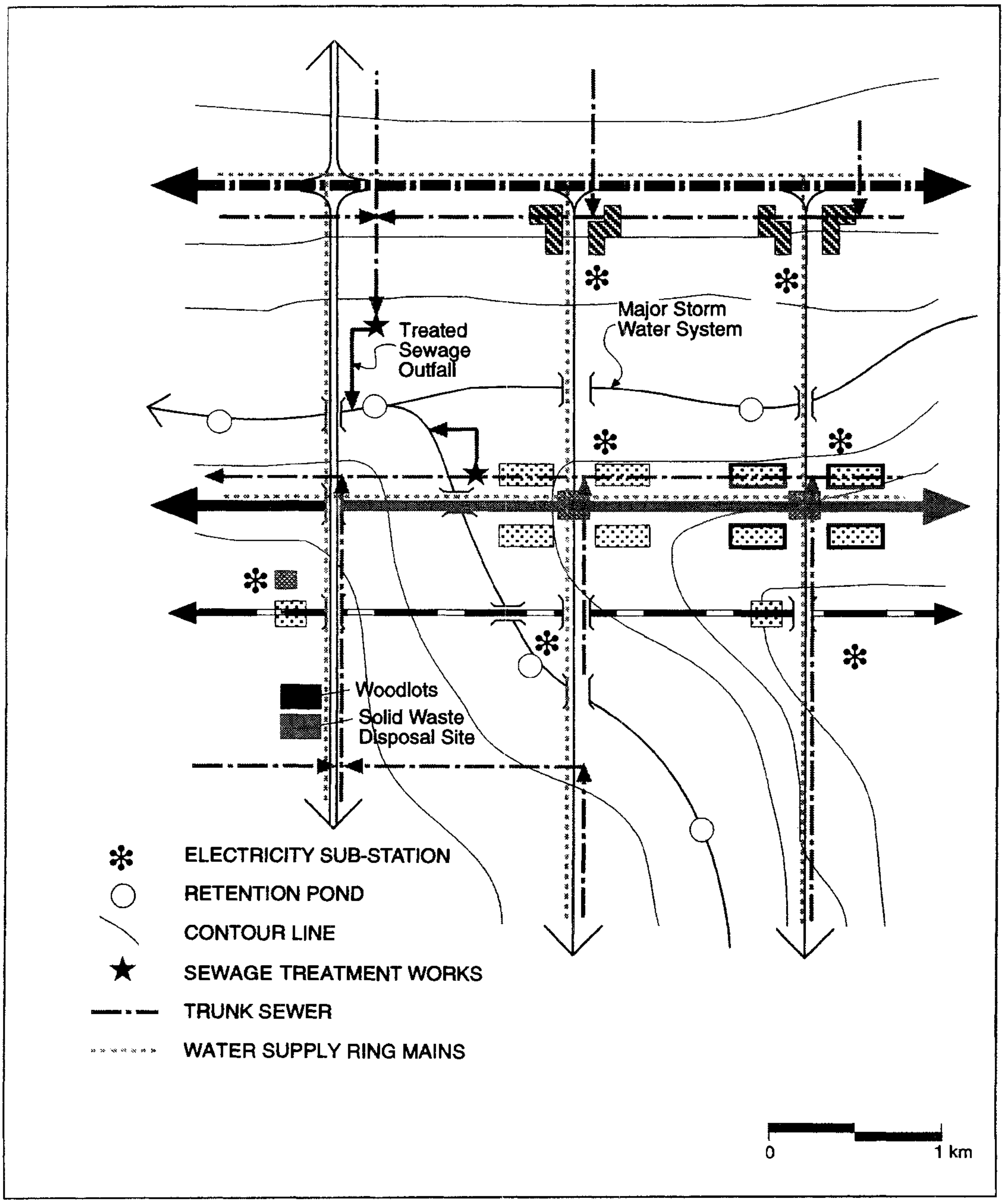
FIGURE 20: Conceptual Diagram of Key Spatial Relationships Relating to Soft Spaces, at a Larger Scale



2.1.4 *Utilities*

* *Align trunk services to important routes* (see 1.5.4).
Spatial implications include: (1) the location of trunk (or link) sewers and water supply ring mains adjacent to routes along which public facilities, commercial and industrial activities are located, and (2) the location of electricity sub-stations, where electrical current is transformed to low voltage current for reticulation purposes, within 'load centres' made up of clusters of public facilities and non-residential land uses.

FIGURE 21: Conceptual Diagram of Key Spatial Relationships Relating to Utilities, at a Larger Scale



2.2 Spatial Implications for 'Greenfield' Projects at a Smaller Scale

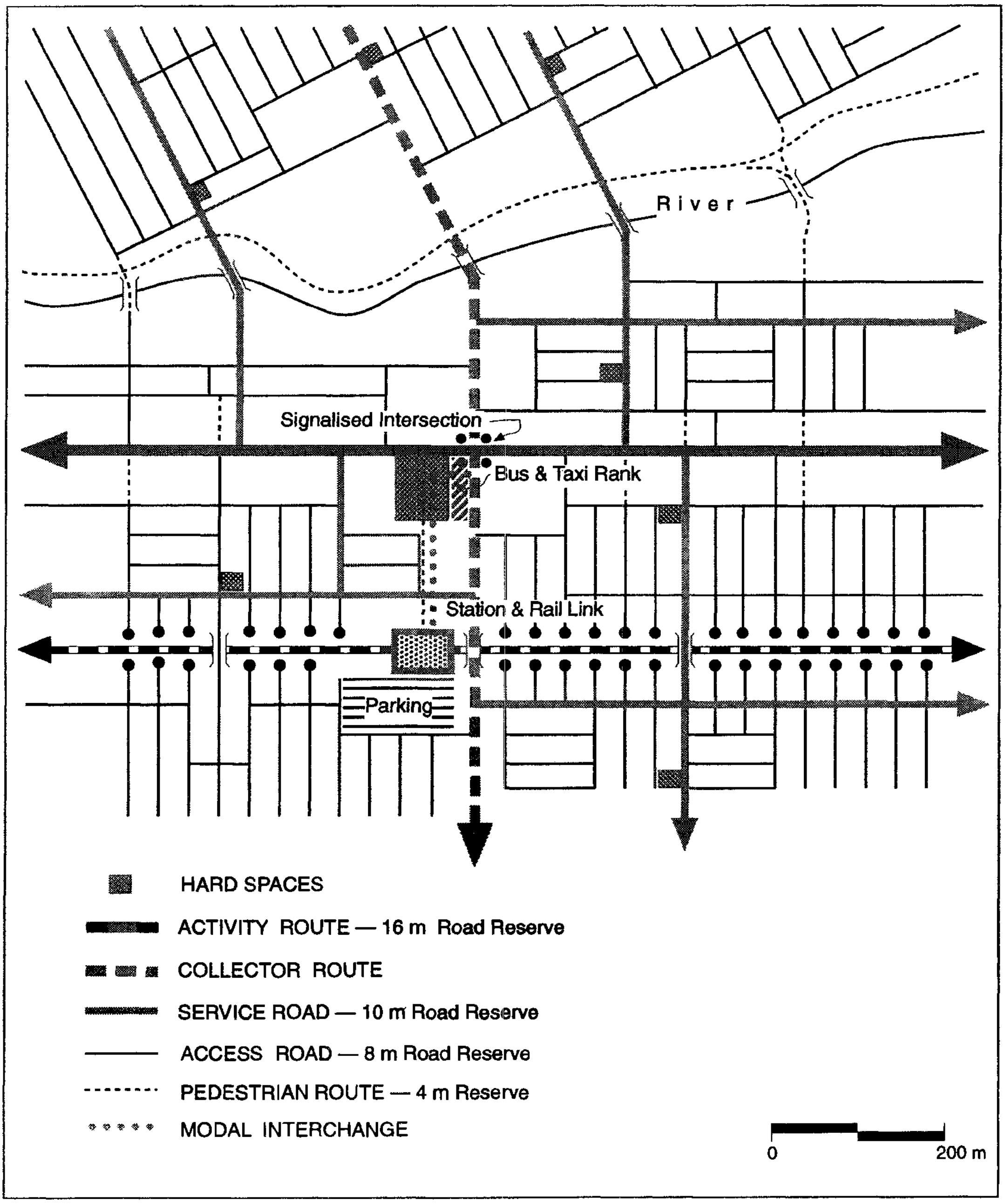
2.2.1 *Hard Spaces*

* *Focus on public space as the main structuring element of urban settlements, and provide accessible public spaces which create opportunities for collective activity* (see 1.1.1 and 1.4.2).
Spatial implications include: (1) the distribution of a hierarchy of hard public spaces throughout the area, and (2) the location of hard spaces at road intersections, with the largest and most important space located at the most accessible intersection.

* *Provide multi-functional roads, integrate the road layout with the surrounding movement system, facilitate efficient and effective public transport services, and design open and flexible movement systems* (see 1.2.3, 1.3.1, 1.3.3 and 1.3.4).
Spatial implications include: (1) the absence of a strict functional road hierarchy, (2) a continuous gradation of road types, (3) the relatively free intersection of different road types, and (4) the provision of a range alternative routes between any two points.

* *Prioritise pedestrian movement* (see 1.3.2).
Spatial implications include: (1) the design of short residential blocks of ± 100 m to maintain easy pedestrian access, (2) the limiting of the length of straight roadways without signalised intersections controls and the frequent use of T-intersections, to manage vehicle speeds, and (3) the continuation of pedestrian routes through public open spaces and longer blocks of ± 150-200 m which run parallel to, (and reduce the number lower order road intersections with), the activity route.

FIGURE 22: Conceptual Diagram of Key Spatial Relationships Relating to Hard Spaces within 'Greenfield' Projects, at a Smaller Scale

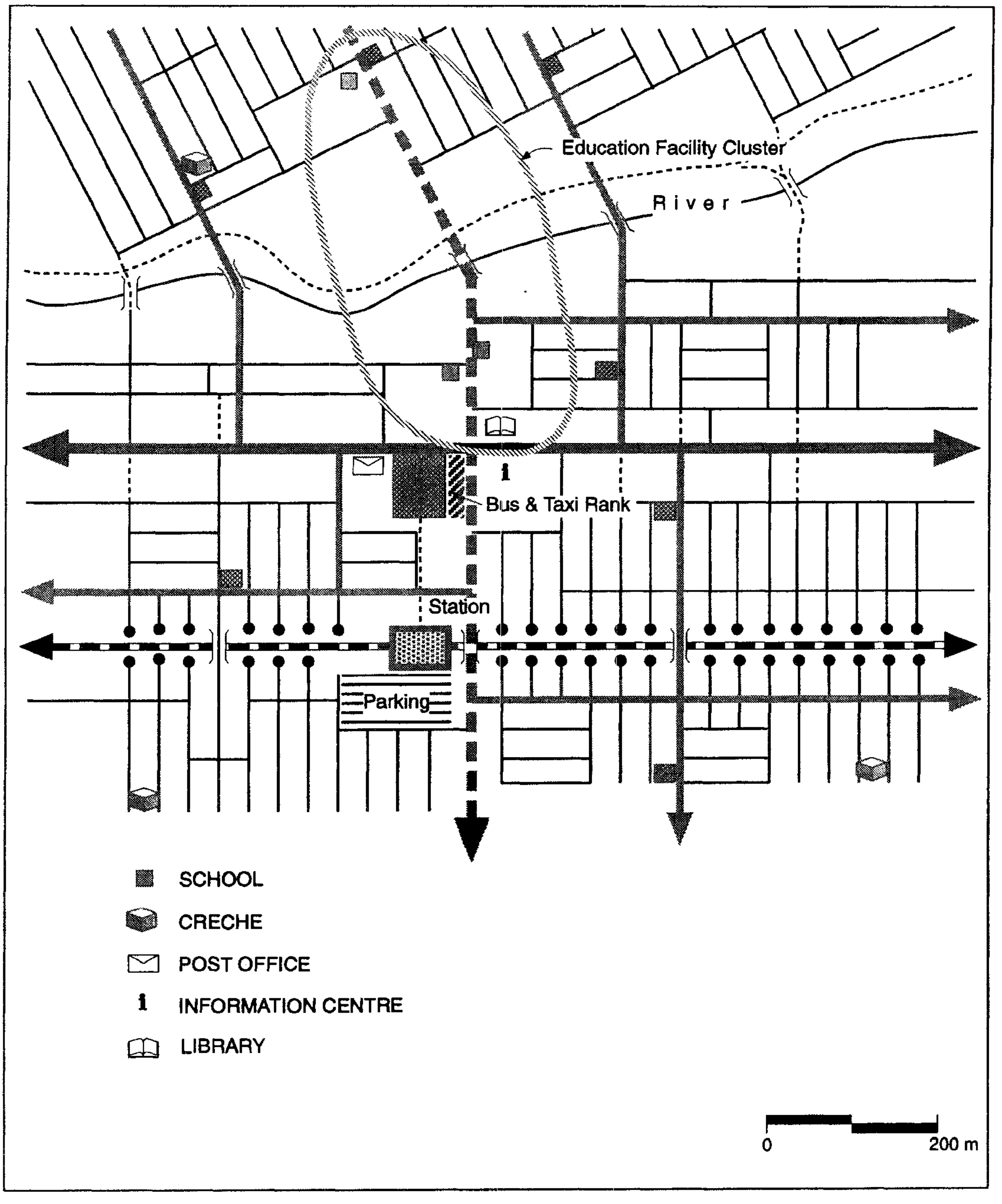


2.2.2 *Facilities*

* *Focus on public space as the main structuring element of urban settlements, and define hard open spaces* (see 1.1.1 and 1.2.1).
Spatial implications include: (1) the location of public facilities around hard public spaces, and (2) where possible, the location of public facility buildings to front directly onto hard spaces.

* *Cluster facilities to enable resource sharing* (see 1.5.1).
Spatial implication: the clustering, for example, of the three schools and the library in order to facilitate the sharing of library books, teaching equipment, playing areas, halls, sports fields, and so on.

FIGURE 23: Conceptual Diagram of Key Spatial Relationships Relating to Facilities within 'Greenfield' Projects, at a Smaller Scale



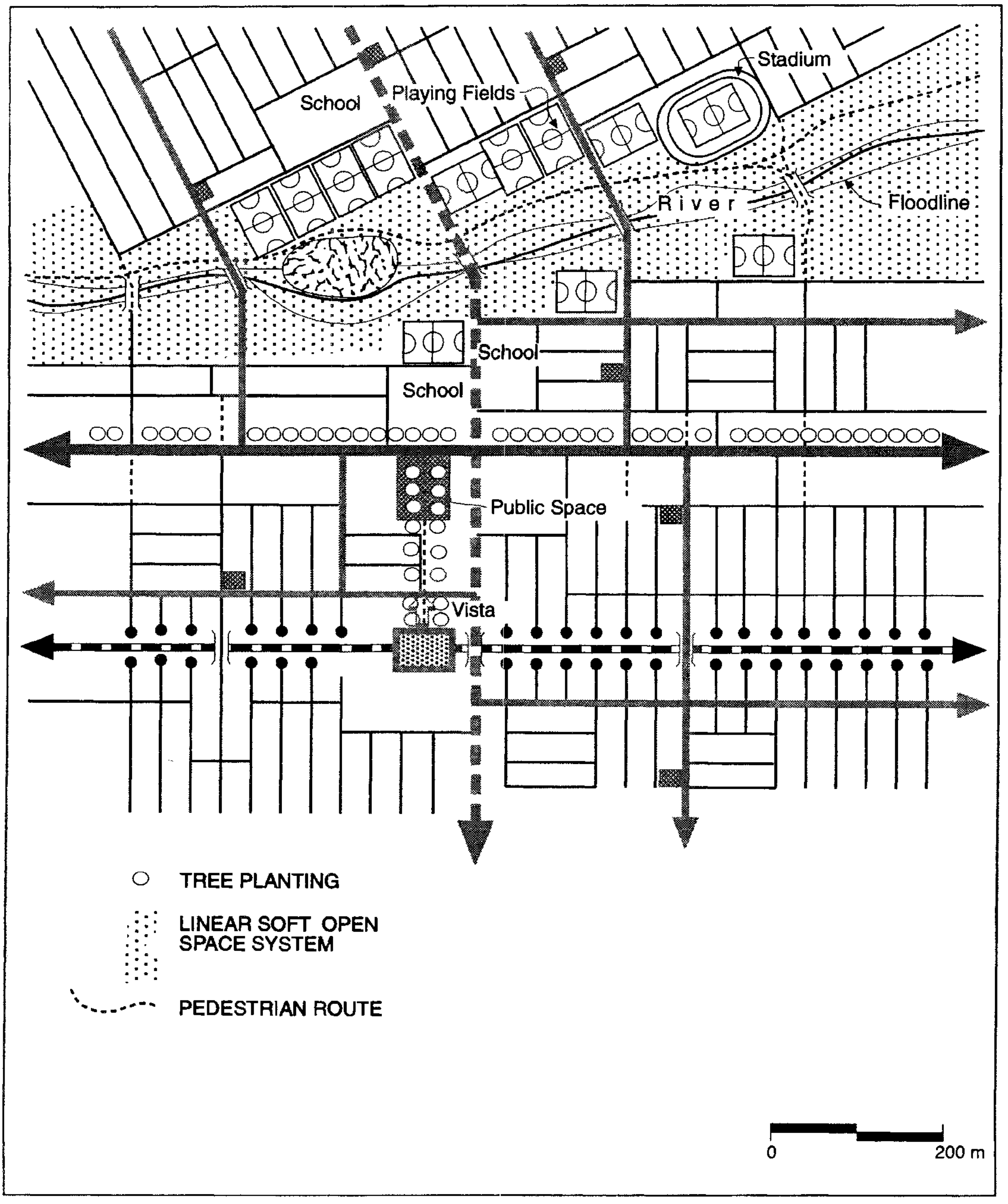
2.2.3 *Soft Spaces*

* *Define hard open spaces (see 1.2.1).*
Spatial implication: the use of treeplanting to create a sense of enclosure along the activity route, the access route to the rail station from the large public square, and around the large and small public squares.

* *Integrate open spaces with utility services* (see 1.5.2).
Spatial implications include: (1) the incorporation of the stormwater retention pond into the linear soft open space, and its use as a recreational amenity, and (2) the use of playing fields as stormwater overflow facilities in the event of severe storms.

* *Provide contrasting spaces of intense activity and relief* (see 1.6.1).
Spatial implication: the location of soft open space close to the largest public square, around which the greatest level commercial activity is anticipated.

FIGURE 24: Conceptual Diagram of Key Spatial Relationships Relating to Soft Spaces within 'Greenfield' Projects, at a Smaller Scale



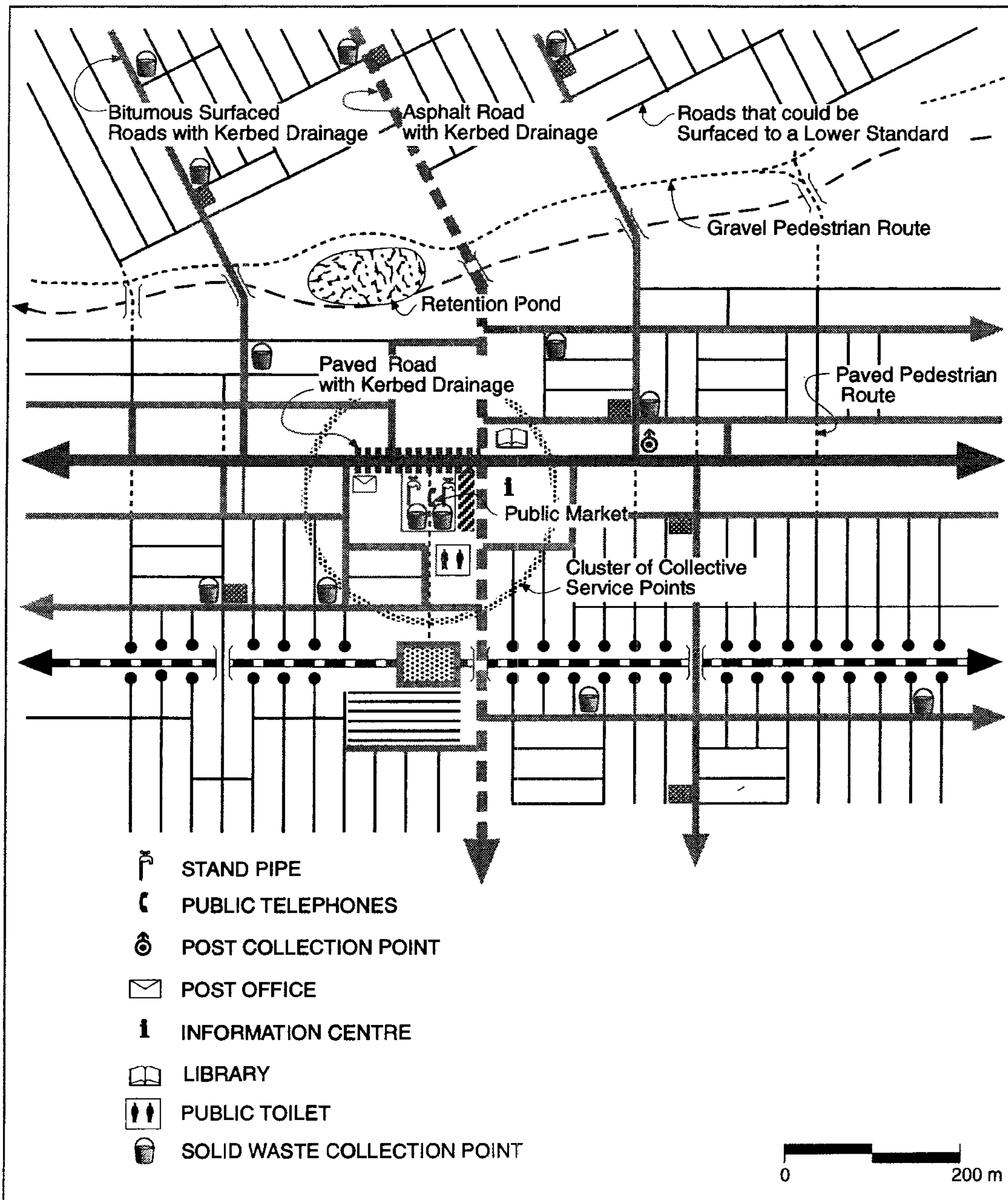
2.2.4 *Utilities*

* *Address the collective functions of services, and cluster collective services around public spaces* (see 1.5.5 and 1.4.3).
Spatial implications include: (1) the location of water standpipes, public telephones, solid waste bins, a public toilet and a post collection point around the public square, and (2) the distribution of solid waste collection points throughout the area (erven are assumed to have a yard tap, on-site sanitation and an electronic prepayment electricity dispenser).

* *Incorporate public markets as an element of essential public infrastructure* (see 1.4.4).
Spatial implications include: (1) the use of the large public square, located at the point of greatest accessibility (where pedestrian flows to and from the rail station, bus stop and taxi rank can be intercepted), as a public market, and (2) the periodic closure of a portion of the adjacent activity route for the purposes of street trading - and the surfacing of this section of roadway with interlocking concrete blocks of varying colours, to signify the nature of this space.

* *Facilitate efficient service provision and land utilisation* (see 1.5.3).
Spatial implications include: (1) the design of ± 100 m block lengths to minimise sewer and stormwater manhole requirements, and (2) the operation of regular road-based public services (eg. public transport, solid waste collection and postal delivery) on asphalt (eg. premix) or bituminous (eg. single seal) roads with kerbed and piped stormwater drainage, to ensure the minimum of disruption during wet seasons.

FIGURE 25: Conceptual Diagram of Key Spatial Relationships Relating to Utilities within 'Greenfield' Projects, at a Smaller Scale



2.3 Spatial Implications for Upgrade Projects at a Smaller Scale

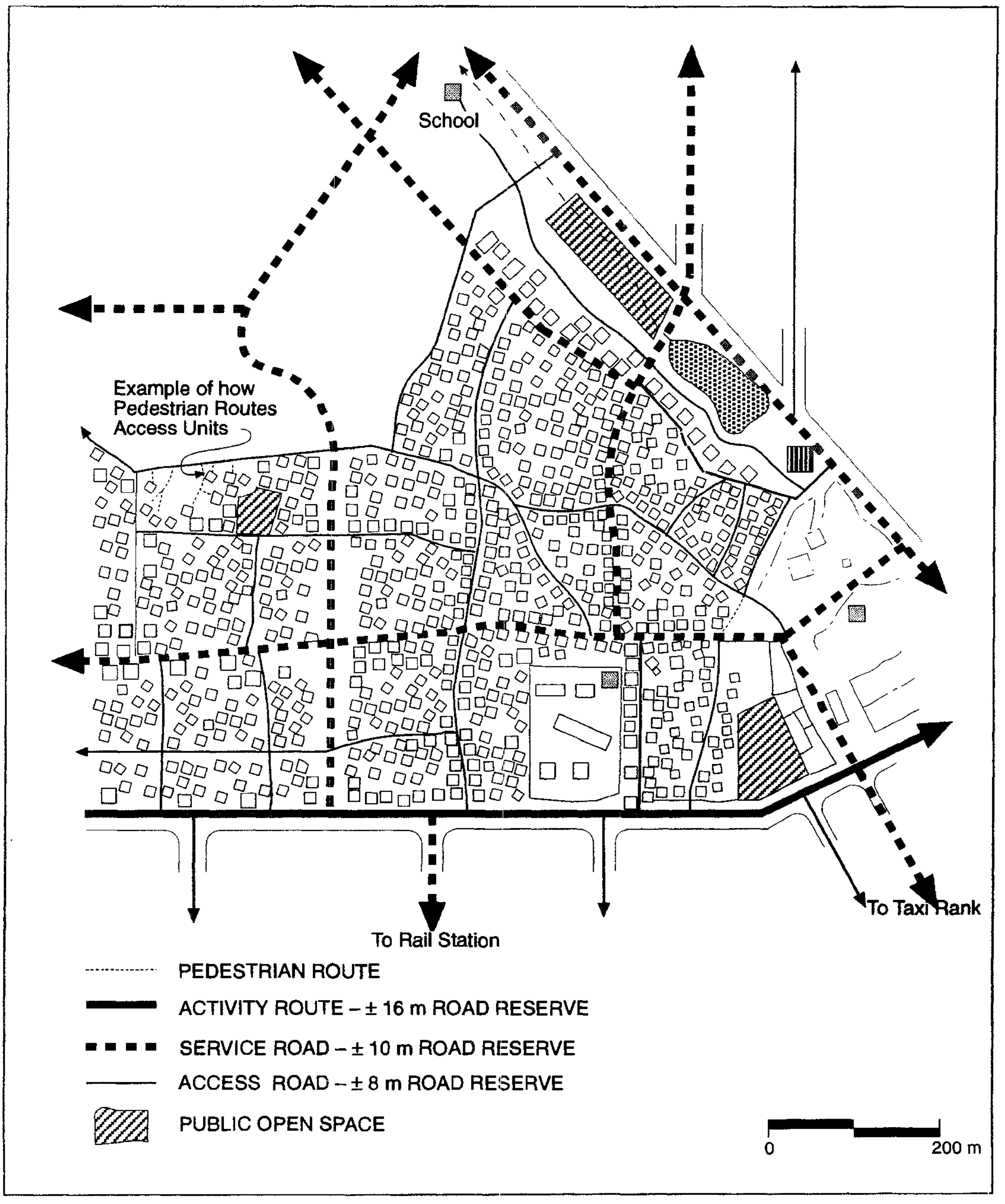
2.3.1 *Hard Spaces*

* *Focus on public space as the main structuring element of urban settlements, and provide accessible public spaces which create opportunities for collective activity* (see 1.1.1 and 1.4.2).
Spatial implication: the location of four hard public spaces within unbuilt spaces, at intersections along, or close to, higher order roads.

* *Provide multi-functional roads, integrate the road layout with the surrounding movement system, and design open and flexible movement systems* (see 1.2.3, 1.3.1 and 1.3.4).
Spatial implications include: (1) the absence of a strict functional road hierarchy, (2) a continuous gradation of road types, (3) the relatively free intersection of different road types, and (4) the provision of a range of alternative routes between any two points, while following existing patterns of movement and minimising disruption of the existing settlement pattern wherever possible.

* *Prioritise pedestrian movement* (see 1.3.2).
Spatial implications include: (1) the design of short blocks of ± 100 m to maintain easy pedestrian access, and (2) providing pedestrian access routes to dwellings within blocks of fairly conventional dimensions (ie. 100 m X 30 m)

FIGURE 26: Conceptual Diagram of Key Spatial Relationships Relating to Hard Spaces within 'Upgrade' Projects, at a Smaller Scale

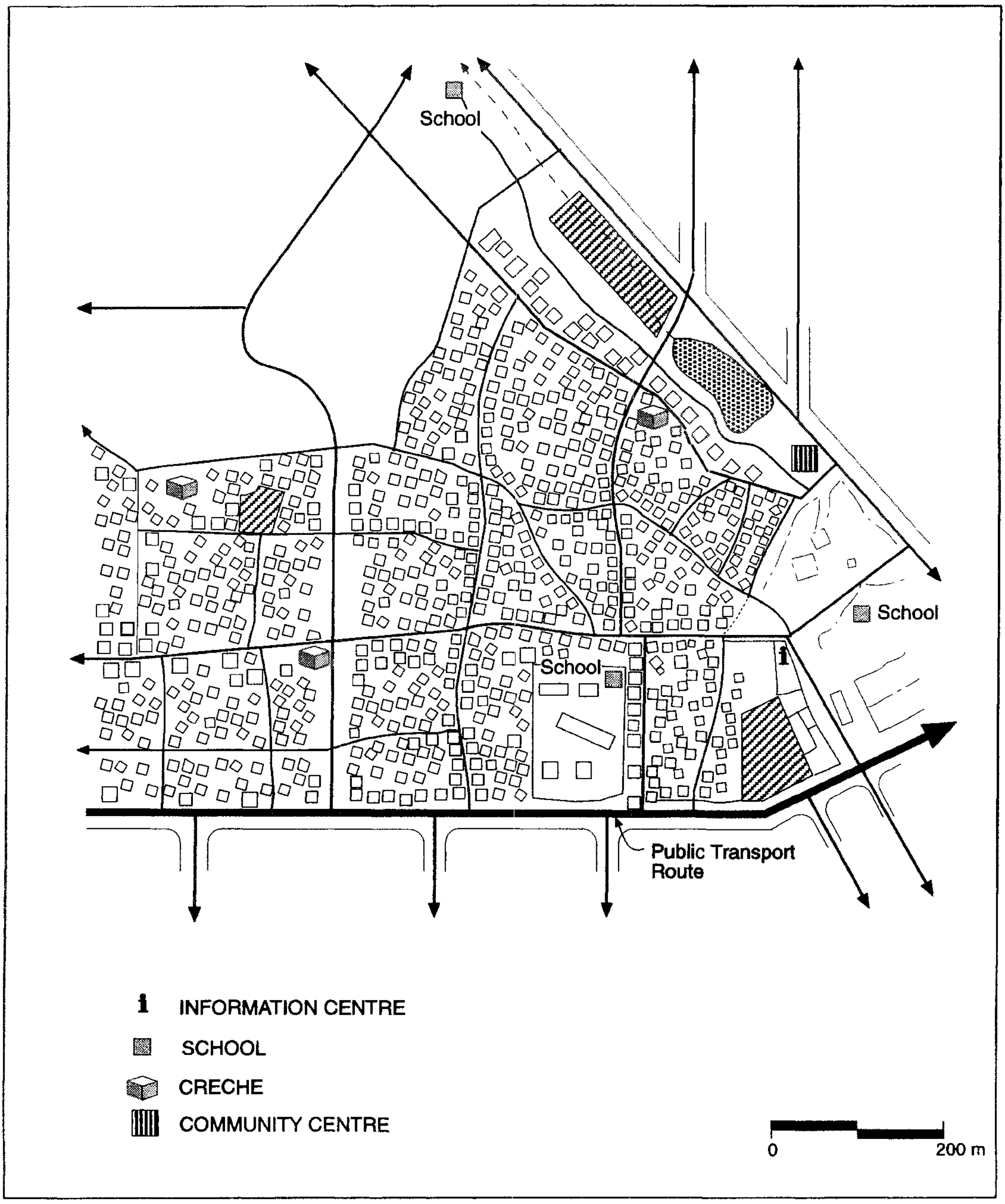


2.3.2 *Facilities*

* *Focus on public space as the main structuring element of urban settlements, and define hard open spaces* (see 1.1.1 and 1.2.1).
  Spatial implications include: (1) the location of larger public facilities around the larger hard public space, and (2) where possible, the location of public facility buildings to front directly onto hard spaces.

* *Cluster facilities to enable resource sharing* (see 1.5.1).
  Spatial implication: the clustering of the two schools and the community centre in order to facilitate the sharing of halls, teaching equipment, playing areas, and so on.

FIGURE 27: Conceptual Diagram of Key Spatial Relationships Relating to Facilities within 'Upgrade' Projects, at a Smaller Scale

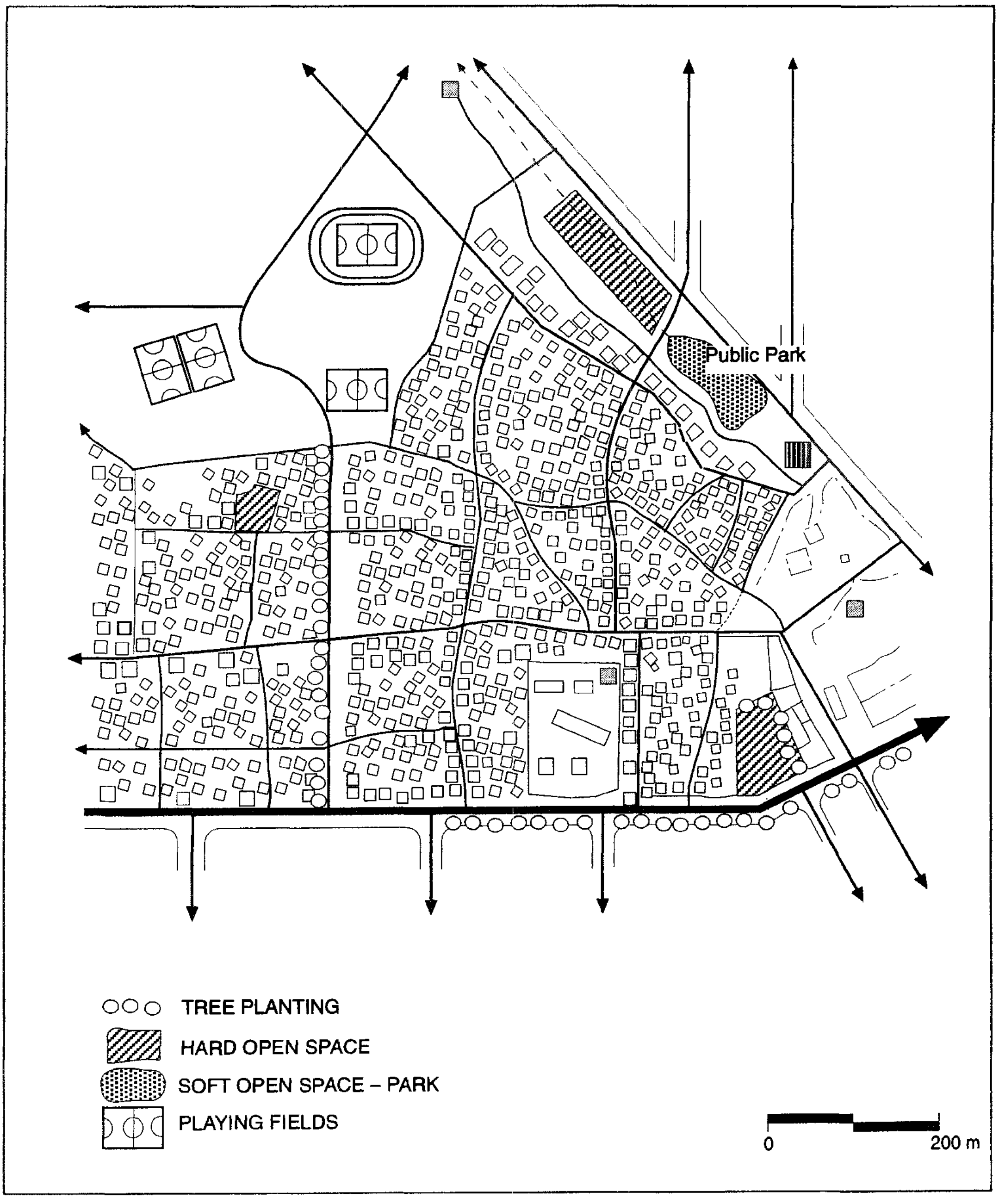


2.3.3 *Soft Spaces*

* *Define hard open spaces (see 1.2.1).*
Spatial implication: the use of treeplanting to create a sense of enclosure along the activity route, and around the public squares.

* *Provide contrasting spaces of intense activity and relief* (see 1.6.1).
Spatial implication: the location of the soft open space close to the largest public square, around which commercial activity is anticipated.

FIGURE 28: Conceptual Diagram of Key Spatial Relationships Relating to Soft Spaces within 'Upgrade' Projects, at a Smaller Scale



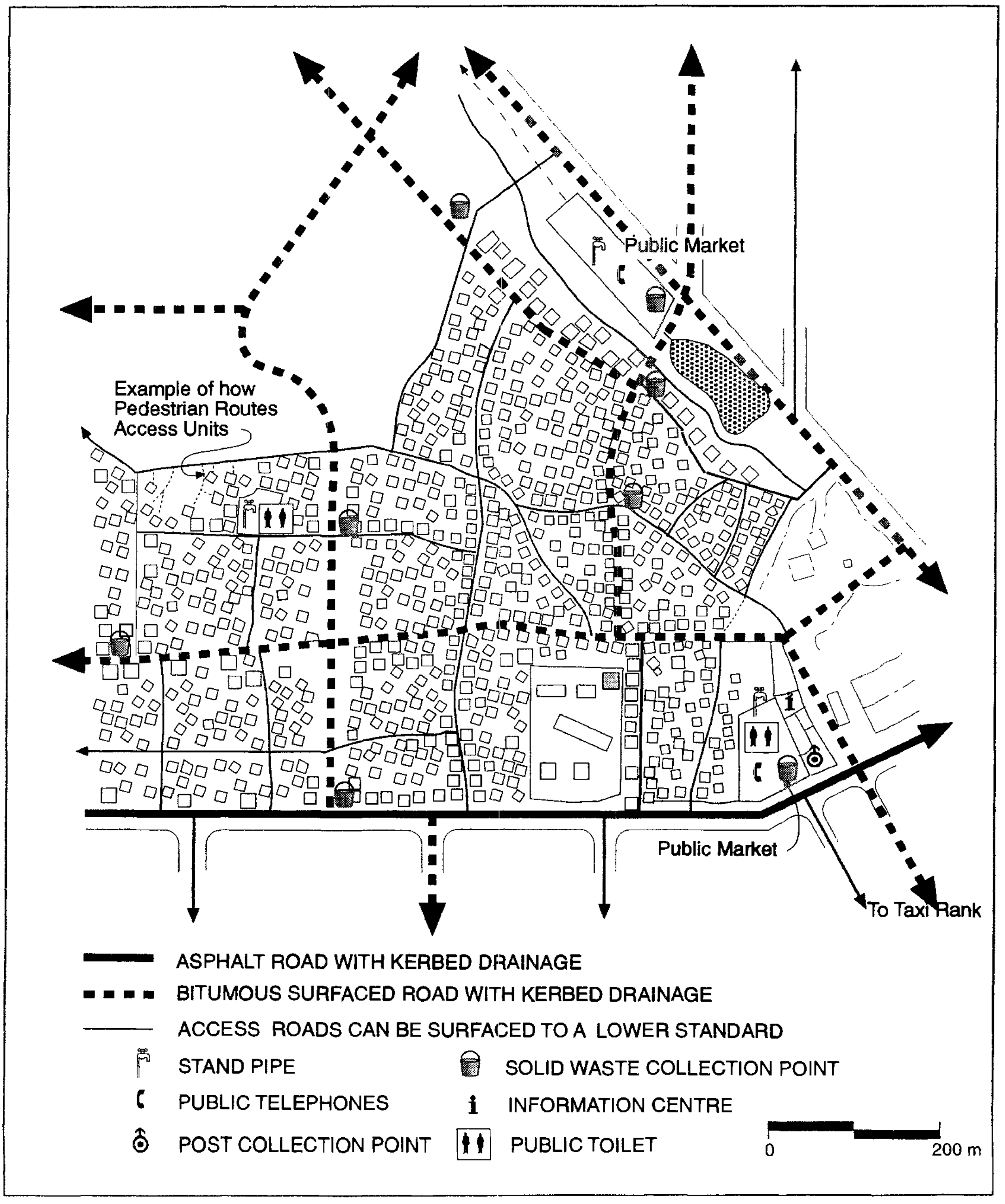
2.3.4 *Utilities*

* *Address the collective functions of services, and cluster collective services around public spaces* (see 1.5.5 and 1.4.3).
Spatial implications include: (1) the location of water standpipes, public telephones, solid waste bins, a public toilet and a post collection point around the public squares, and (2) the distribution of solid waste collection points throughout the area (erven are assumed to have a yard tap, on-site sanitation and an electronic prepayment electricity dispenser - for the purposes of reticulating water supply and sewerage, the need to relocate dwellings in order to rationalise subdivisions and servitudes is likely).

* *Incorporate public markets as an element of essential public infrastructure* (see 1.4.4).
Spatial implication: the use of the two larger public squares, located on the more intensive movement routes, as public markets.

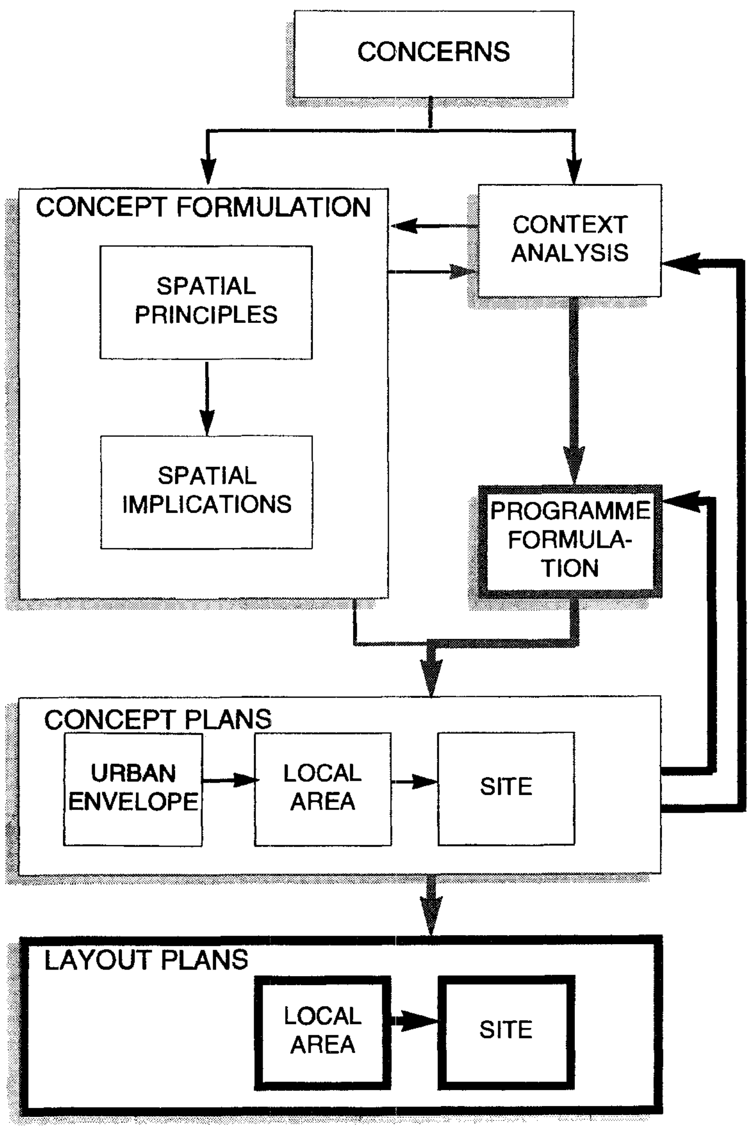
* *Facilitate efficient service provision and land utilisation* (see 1.5.3).
Spatial implications include: (1) the operation of regular road-based public services (eg. public transport, solid waste collection and postal delivery) on asphalt (eg. premix) or bituminous (eg. single seal) roads with kerbed and piped stormwater drainage, to ensure the minimum of disruption during wet seasons, and (2) the clustering of collective service points (ie. public standpipes, public telephones, post collection points and public toilets) so that, when serving a residential function, a single trip can satisfy numerous service needs.

FIGURE 29: Conceptual Diagram of Key Spatial Relationships Relating to Utilities within 'Upgrade' Projects, at a Smaller Scale



Section 4:

Layout Guidelines



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Section 4:
Layout Guidelines

This section translates the conceptual layout planning principles provided in the previous section, into a set of more technical layout planning guidelines.

The layout guidelines are intended to inform the latter part of the plan formation stage of the layout planning process (see 2.5 of section 2). They are intended to inform the task of converting local area and site concept plans into local area and site layout plans - in other words, attaching detailed dimensions to the elements of concept plans. Parts 1.1, 1.2, 2.1, 3.1 and 3.2 deal more with the preparation of local area layout plans, while parts 1.3, 1.4. 2.2, 4 and 5 deal more with site layout plans.

Guidelines are presented for the following elements of layout plans: (1) roads, (2) intersections, (3) facilities, (4) blocks, and (5) erven.

1. Roads

Design decisions regarding roads relate mainly to: (1) the functional hierarchy of roads within the layout plan, (2) the geometric configuration of these roads, (3) the cross-sectional dimensions of road reserves, and (4) the accommodation of parking within the road network. Each of these design decisions is discussed in turn.

1.1 Functional Road Hierarchy

As stated in the previous section, the general functions of a road are diverse. In general, a distinction can be drawn between the social, environmental and developmental functions of a road, and technical functions associated with the accommodation of motorised traffic.

In a conventional multi-functional road, these functions are in an approximate state of balance, with the requirements of no single function predominating. This condition characterises many older roads where there is a mix of abutting land uses and road users.

As traffic volumes increase however, the various functions of the road often come into conflict, with social, recreational and economic functions being threatened by increasing volumes of through-traffic. In addition, increasing volumes of through-traffic conflict with the needs of local and access-seeking traffic. The common design response has been to segregate the functions, thereby eliminating the conflict. The need for segregation is justified by the increasingly heavy traffic burden roads are expected to accommodate, and the invasive and intrusive nature of traffic, which results in environmental nuisance and degradation in sensitive areas.

This approach has formed the basis for the establishment of road distribution hierarchies, where specific traffic-related roles and functions are ascribed to the various levels of the hierarchy - a distinction is drawn between mobility (ie. longer distance, higher speed traffic) and access (ie. shorter distance, lower speed traffic), direct access to adjoining properties is prohibited for all but the lowest levels, and environmental, social and developmental functions are excluded at higher levels.

Problems have arisen in the universal application of the distribution hierarchy principle however - it is based upon a perspective that segregation is necessary in all cases and under all circumstances, even where a balance in functions is attainable, and where serious conflict between functions is unlikely to occur. Not all areas experience, or will experience, high levels of through-traffic.

There is a need for a relaxation of this rigid hierarchical perspective - particularly relating to lower-order roads where a more balanced approach could readily be adopted. In order to maintain the multi-functionality of roads, it is important to achieve a balance between those functions which the road should fulfil, and reconcile any competing demands which may exist between them, instead of simply segregating functions. The use of a formally articulated road hierarchy as input to layout planning should therefore be avoided.

There are certain routes however, used for regional and primary distribution, where the needs of longer distance traffic should predominate over those of other road users. These routes serve a predominantly mobility function - in other words, they are designed to provide limited access, uninterrupted vehicular channels which accommodate the needs and requirements of fast-moving motorised traffic. The need for uniform operating conditions and high levels of safety, requires the retention of standards relating to direct frontage access and interchange spacing. With other higher order roads however, there is a strong case for reconciling social and movement needs by relaxing standards, particularly those relating to intersection spacing, and resorting to more imaginative and innovative design solutions.

The recommended functional road hierarchy therefore includes the following broad classes of road[10]:

10. It is important to note that this does not imply that all levels of road should be present in a layout plan - many smaller scale layout plans are comprised only of multi-functional routes (1.1.3).

1.1.1 *Regional Distributors*

Regional distributors accommodate long-distance traffic within an urban settlement, and between a settlement and its surrounding regional hinterland. Regional distributors therefore accommodate inter-city, as well as intra-city, movement. Traffic moves at high operating speeds (ie. vehicles travelling at speeds greater than $\pm$ 60 km/hr). There is full restriction on frontage access, and grade separation is provided at intersections. General consistency in road design is required for efficient and safe operation.

1.1.2 *Primary Distributors*

Primary distributors accommodate the greater proportion of longer distance intra-city or inter-district traffic movements. The primary distributor network links the main business, industrial and residential districts of the urban settlement. There is full restriction on frontage access.

Longer distance traffic movements are normally characterised by heavy volumes of relatively fast moving traffic with a comparatively high proportion of heavy commercial traffic (> 10%) - road-based public transport services (other than express bus services) would not normally use such routes.

1.1.3 *Multi-Functional Routes*

Multi-functional routes accommodate a range of diverse road requirements - achieving a balance between access and local traffic mobility requirements, as well as between movement, environmental, social and developmental requirements.

A natural ordering of movement through a multi-functional road system should be anticipated, with certain routes designed to carry heavier volumes of local through-traffic, and others designed to carry mainly local and access-seeking traffic. The purpose of each route in the local road system should be well understood, enabling appropriate cross-sectional elements, surfacing, intersection configurations and spacings, and design speeds to be applied. Routes should range from those designed to accommodate relatively large volumes of mixed traffic (ie. activity streets), to those designed primarily for pedestrians in which vehicle behaviour is determined by a set of pedestrian rules (ie. *woonerven*).

DETERMINING A HIERARCHY OF MULTI-FUNCTIONAL ROADS

To determine an appropriate hierarchy of multi-functional roads, and to anticipate the demand for movement which may result, a number of factors should be taken into account:

* the function of the roads surrounding the site, the volume, type and destination of traffic using them and how these patterns may change in the future. In addition, the possibility of extraneous traffic wanting to use the site as a potential short-cut should be assessed.
* the volume and type of traffic likely to be generated and attracted by the development itself. An examination has to be made of the nature of road traffic, by private vehicles, by public transport, on foot etc., the proportion of such movement which is internal to the area, and the origins and destinations of all trips attracted and generated by the development.
* the location of public transport routes external to the site, and how such routes will be integrated into and through the site. The requirements for additional services should be established with current operators.
* the location of existing and proposed activities including shops, business areas, industrial sites, public facilities, markets etc.
* the degree of integration which is required with the surrounding area. To create economic opportunities, traffic should be encouraged to pass through an area.

1.1.4 *Pedestrian Routes*

Pedestrian routes accommodate the movement of pedestrians exclusively, with sufficient space provided for the movement of occasional emergency or service vehicles. The functions of pedestrian routes can vary significantly, from those routes abutting and accommodating intensive commercial activities (eg. pedestrianised roads in city centres), to routes performing a primarily access function in cases where car ownership is low and likely to remain so. Pedestrian routes are generally either roads converted for pedestrian only use, or narrow roads designed specifically for pedestrian movement only.

1.2. Geometric Road Layout

Guidelines for the geometric layout of roads are discussed in terms of: (1) road geometry, (2) traffic management, (3) road curvature, (4) road gradient and (5) intersection spacings.

1.2.1 *Road Geometry*

Road geometry refers to the pattern of a road network - as mentioned in section 1 of this handbook, open and closed (or limited-access) road networks are the two ends of a continuum of geometric network patterns.

TABLE 4: Main Advantages and Disadvantages of Through Streets and Cul-de-sacs

THROUGH STREET		
Characteristic:	*	Street is open at both ends
Advantages:	*	Minimises pedestrian walking distances
	*	Allows pedestrian and vehicular access in both directions
	*	Greater numbers of passersby create opportunities for opening shops and informal trade
Disadvantages:	*	Greater numbers of passing traffic and pedestrians increase the noise level
	*	Greater passing vehicular traffic increases the danger of road accidents
CUL-DE-SAC		
Characteristic:	*	Street is open at one end only
Advantages:	*	Smaller numbers of passing traffic and pedestrians decrease the noise level
	*	Less passing traffic decreases the danger of road accidents
	*	Creates semi-private space at the closed end of the street
Disadvantages:	*	Increases pedestrian walking distances
	*	Less safe from crime because of smaller numbers of passing traffic and pedestrians

Appropriate road geometries are distinct and context specific, depending on factors like topography, drainage requirements, surrounding movement patterns, and the modes promoted in transport policy (eg. the promotion of pedestrian and public transport modes in *verkehrsberuhigung*, or traffic calming, policies in Germany). Road geometries should reflect an understanding of needs, together with a detailed understanding of potential behaviour and operational performance.

KEY DIRECTIVES IN ROAD LAYOUT DESIGN

There are a number of key directives that can assist in the geometric design of appropriate, context specific road layouts. These are as follows:

* integrate the site into the surrounding area by extending all appropriate, externally-located, intermediate order roads into and through the site
* identify the location of public transport routes external to the site, and determine how such routes will be integrated into and through the site
* determine the need for locally generated public transport requirements, the form such provision should take, and the route structure which should be adopted

* determine the need to extend higher-order distributors through the site, and whether the scale of movement generated by the site itself warrants such provision - such distributor routes are identified at a city scale, and when they fall within a specific site, should be designed according to appropriate technical engineering standards, and managed to achieve convenient, efficient and safe operation.
* assess the resultant demand for movement which will occur on each route by all modes, based not only on locally generated traffic but through-traffic as well

As mentioned earlier however (see 1.3.4 of section 3), at the level of principle, open and flexible, public transport and pedestrian orientated road geometries are most appropriate in the South African context. It is useful therefore to discuss the geometric requirements of pedestrians and public transport services in greater detail.

Road-based public transport services are best facilitated by road geometries[11] that enable direct and unrestricted pedestrian movement to stops, offer public transport vehicles direct or unconvoluted routes in which the number of turns where right-of-way is yielded is kept to a minimum, and enable changes in service routing and the number and location of stops.

The mix of public transport services (eg. local-area, line-haul, limited stop, etc.) to be accommodated within a layout plan, and the particular routes that will carry these services, need to be identified. Provision should be made for a range of public transport routes within the road layout, and if all routes are not used, there should be an understanding of the implications this would have for the efficiency of service operation, facility location and pedestrian movement.

Public transport routes, as far as possible, should be planned to run through areas, rather than around areas. Accordingly, other than for express or limited stop services, local public transport services should be planned to operate on middle and lower order routes, rather than on higher order routes (ie. primary or regional distributors). Routing should be direct, but should also penetrate the area as much as possible. Changes of

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11. It should be noted however that given the attainment of appropriate operating conditions (eg. directness of route, stop spacings), both closed and open road layouts are theoretically able to accommodate public transport movement. Public transport services operate on middle order roads - in practice, only higher order and local roads tend to be provided. The absence of middle order routes has negatively affected connections between areas, forcing all local-area movements to utilise higher order roads, and has placed difficulties on public transport operations. The inherent problem in public transport viability is that of city structure and the density of the movement system, not necessarily road geometry at the local level.

right-of-way should be avoided, but reconciled with the need to broaden the potential service catchment as far as possible.

Where a number of alternative routes through an area are possible, it is preferable to concentrate public transport movement on fewer routes, where higher frequency can be maintained, rather than spread service provision over a number of routes with a commensurate drop in service frequency. Different bus services along a route should use the same stops, and provision should be made to accommodate the number of vehicles which could be expected at any one time.

The spacing of stops along a route is influenced by the type of service and the need to reconcile service access with journey speed. In the case of local bus services, stops are usually spaced every 300 to 500 m, depending on intensity of roadside development. Express bus services stop infrequently at principle generators and attractors of movement such as railway stations and major business centres. Mini-bus services usually have no formal provision for stopping, and stop when hailed.

For safety reasons, bus stops on opposite sides of single, two-way carriageways should be staggered so that buses stop 'tail-to-tail' and move off away from each other. It is desirable to stagger the stops by about 45 m, although this may be reduced if laybys are provided. For maximum convenience for passengers approaching from side roads, bus stops should be sited as close to intersections as possible but consistent with visibility and other safety standards.

At stops where routes terminate, buses may be standing for some time and may need to turn around. It is preferable to provide a turning area off the roadway, unless there is a suitable roundabout which can be used. In addition, holding areas need to be provided for mini-bus services - these needs are often diverse, particularly in predominantly residential areas. Ideally such holding areas need to be located adjacent to other facilities.

Where the scale of a development does not warrant or enable the provision of a public transport service within the area, direct pedestrian routes should be established to link the area into the surrounding public transport network.

Pedestrian movement is best facilitated by road geometries in which all routes are as straight and direct as practical, allowing generally unrestricted pedestrian movement to all principle activities. Pedestrian movement routes should be constantly overlooked by dwellings or passing traffic and should be well lit after dark.

Pedestrian-only routes which are not overlooked by buildings or passing traffic are often potentially dangerous, and should therefore be avoided as much as possible. Where such routes are unavoidable, they should be kept as short as possible. Stepped kerbing, bollards or other physical obstructions should be used at both ends of the pedestrian section to prevent the passage of vehicles. Visibility through the section should be maintained, and the creation of hidden refuges avoided.

In cases where rail line provision is an integral part of the layout, or where a site is being developed adjacent to an existing railway station, every opportunity should be taken to structure a set of road-based public transport routes to interchange or terminate at the railway station. The interchanging movements are a potentially strong instrument to initiate development and the planning of an appropriate layout should trade-off interchange efficiency with local economic development potential.

1.2.2 *Traffic Management*

Traffic management refers to the design of road networks to manage anticipated vehicular traffic, and to the subsequent use of legal and policy measures to respond to changes in traffic behaviour.

The volume and nature of traffic on a road network is directly affected by the form and nature of the geometric road layout.

With a strict functional road hierarchy it is possible to estimate with considerable reliability the volume and nature of traffic which will use each link of the road system. The layout is structured in such a way that the aggregate amount of traffic generated by the development does not exceed the practical capacity of the local distributor serving it.

With a multi-functional road network it is not possible to ascribe a specific role and function to each link of the system and forecast operational performance. It is possible however, to anticipate the possible range of traffic each link would be expected to carry. While less predictable, the routes which would be followed by local traffic and any longer distance through traffic can be deduced.

The use of multi-functional roads therefore requires greater insight into behaviour and performance, and greater detailed design effort. The direction, volume and mode of traffic generated and attracted by a proposed layout will be dependent upon variables like household size and composition, areas of employment, levels of car ownership, and use of public transport. It is important that an understanding is gained on the extent of change which is realistically possible so that the layout is designed to accommodate such changes.

ANTICIPATING TRAFFIC BEHAVIOUR

To anticipate probable traffic responses to a particular geometric road layout proposal, and to understand and evaluate the performance of the road system in the peak hour (normally taken as the morning peak hour), it is necessary to group an urban area into sub-areas. For a sensible grouping of the area (into blocks, zones or some other analytical unit), the following information is required:

* average number of workers (per household and per business unit)
* proportion of trips in the peak hour
* proportion of trips which occur by various modes
* proportion of trips where both the origin and destination is within the area
* proportion of trips which are outbound from the area and their principal destinations
* proportion of trips which are inbound to the area and their principal origins
* incidence of through traffic

The resultant pattern of movement can be anticipated by estimating the likely movements on each road within the proposed road network - in essence trying to realistically replicate probable behaviour. For instance, an unbroken stretch of road with 50 households abutting it (with an average of 1,5 workers/household and 30% of households owning a motor car) would result in 15 car movements and 50 pedestrian movements along the road during the morning peak hour. 50% of these movements are in one direction, while 50% are in the other - this of course depending on the points of destination in the surrounding area.

In this way link volumes and turning movements can be established, and an understanding gained of the adequacy and appropriateness of the road network.

This exercise should be repeated for the evening peak hour and an assessment made of off-peak conditions, particularly to identify the possible routes of commercial and service traffic which will influence intersection geometry.

On lower order, multi-functional roads the traffic management objective is essentially to encourage careful driving - to keep the speed of appropriate volumes of traffic low, and to make the road as safe for pedestrians as possible. Lower speeds improve the safety of urban environments for pedestrians. Dual carriageways, where provided, should have an operating speed of less than 60 km/hr while single carriageways should have operating speeds in the range of 30-50 km/hr. For residential access roads, where the principal functions are social and environmental, both traffic speeds and volumes should be constrained.

With regard to traffic speeds, to achieve low speeds, the overall configuration, geometry and edge conditions of roads should be compatible with low operating speeds.

The means to reduce speeds should be self-enforcing, and should take into account the probability that some drivers will travel at speeds in excess of those which suit prevailing conditions. It should also be recognised that conditions which restrict the speeds of small vehicles will inevitably cause some inconvenience to the drivers of large vehicles.

Within open, multi-functional networks, the design option most likely to be effective in reducing speeds on lower order roads, without signalised intersection controls, is the avoidance of long straight roads - shorter sections of road terminating in a T-junction is the preferred geometric form. On higher order roads, with intersections controls, road lengths should be as straight and continuous as possible in order to facilitate road-based public transport operations.

An advantage of open, multi-functional road geometries is the ability to introduce traffic calming policies in the form of diverters, road closures and *woonerven*, to overcome whatever problems (eg. 'rat running') may arise from any unexpected increases in private car ownership and greater traffic volumes.

MANAGING TRAFFIC SPEED

The two main determinants of operating speed are scale and parallelism. Scale relates to the overall dimension of the cross-section and the sense of containment. Parallelism relates to the perceived effect which various cross-sectional elements (eg. fences, sidewalks, verges, kerbs, roadway markings) have in leading the eye to the point of perspective.

It is these two conditions which explain the degree of variation in traffic speeds on a range of road types. Accordingly, the two main distinguishing factors for operating speeds are road width (ie. whether a road has a single or multi-lane carriageway), and the extent of forward visibility (ie. the degree and extent of horizontal curvature) - both relating to the geometry of the road rather than to any allocated role and function. For example, on straight dual-carriageways the perception of what constitutes a safe operating speed is much higher than on a comparatively narrow residential road.

In addition, various design variables play a major role in establishing a safe operating speed (eg. the degree of horizontal and vertical curvature, super-elevation, skid resistance, intersection visibility, forward visibility, etc.) - all of which must be reconciled before a safe operating speed for each route can be determined.

With regard to traffic volumes, in multi-functional networks the intention is to accept higher traffic volumes throughout the day, than in functional hierarchy networks. Intensity of movement, both private and public, has a direct bearing on the creation of economic opportunity and local economic development. Higher order multi-functional routes therefore have to be attractive not only to access-seeking traffic, and local traffic, but also to a certain amount of through-traffic - such through-traffic would be travelling shorter distances than that canalised onto the primary and regional distributor network.

On higher order multi-functional routes, it is inevitable that the practical capacity of the road will be exceeded during the morning and evening peak periods, when the incidence of both local and through-traffic increases. On these roads problems relating to traffic volumes become essentially a management issue, both at the local and at the city scale. At the local level, management action can be taken to increase the capability of the system during the peaks by local prohibitions on parking and stopping, particularly where the presence of stationary vehicles affects intersection capacity. At the city level, major efforts need to be made to reduce the incidence of longer distance vehicular traffic by promoting a more dense, integrated land use structure. Integrated land use activities not only produce shorter trip lengths but also influence modal split, with a higher incidence of non-motorised modes and increasing use made of public transport.

1.2.3 *Road Curvature*

Road curvature refers to the horizontal alignment of roads. (The vertical alignment of roads, which determines road gradients, is discussed in 1.2.4.) There are four main considerations in the design of appropriate road curvature.

The first is the place making function of road alignments, and their role in creating symbolic visual axes to important public buildings, cultural symbols or prominent topographical features.

The second consideration is the effect horizontal curvature has on the visibility of motorists and associated impacts on road safety. Determining appropriate visibility sight lines is a function of the role of the road in the network, and the speeds at which motorists are expected to travel. A higher order multi-functional route serving a collector function and carrying public transport services for instance, requires greater curve radii than a lower order route serving an access function.

The third consideration is the need to follow topographical contours in order to minimise earthworks, and to achieve acceptable and continuous grades that facilitate vehicular movement and the reticulation of gravity based services like sewerage and stormwater drainage. In hilly terrain therefore, road layouts should, where practical, be planned to follow the natural contours and drainage path of a site. On hilly sites high priority should be given to the drainage function of roads. Deep cuts and high fills should be avoided, for economic reasons - especially in hard or rocky ground. In the undulating terrain of Natal it has been found that a road running along a ridge, with long perpendicular cul-de-sacs (of reasonable gradients) ending at the floodline, is the most economical way of reducing cut-and-fill and maintaining adequate stormwater drainage.

The fourth consideration is the need to facilitate efficient service reticulation - specifically stormwater, sewerage, and above-ground electrical cabling. The ideal layout from a reticulated services point of view is a grid pattern with long straight road reserves - the advantage comes from having the shortest relative service line lengths per erf, straight trenches, and minimised manhole and poling requirements.

Manholes are used for the inspection of pipes, but their primary purpose is to get access to the pipe to clear blockages. It is normal practice to provide access to a gravity pipe, in the form of a sewer or stormwater manhole, at horizontal and vertical changes of direction, junctions between main and branch pipe lines (but not at junctions with erf connections in the case of sewerage), the head of a reticulation system, and at intervals on straight stretches of pipe.

Manhole spacing on straight stretches of pipe is normally restricted to the length of hand-operated cleaning rods - which are pushed along the pipe. Rods can pass around kinks in a pipe but, if the kink is too large, the rods tend to damage the wall of the pipe. In such cases the maximum spacing of manholes on straight stretches of road reserve is approximately 80-100 m. Therefore, in order to limit the number of manholes, which are relatively expensive items, curve radii should be selected to yield a tangent length of approximately 80-100 m.

Road curvature therefore influences manhole requirements. Changes in road direction also necessitate extra poles in above-ground public lighting and electricity supply systems, which increases costs.

As sewers do not necessarily have to be laid in the road reserve, and curvilinear sewers can negotiate gentle bends, road curvature need not be of direct consequence to sewer manhole requirements. Nevertheless, curved road reserves do bring sewer cleaning disadvantages, particularly if curve radii of less than 30 m are used.

1.2.4 *Road Gradient*

Road gradient refers to the vertical alignment of roads. Very steep or very flat road gradients present problems relating to the circulation of larger service vehicles and the self-cleansing flow velocities of gravity based services.

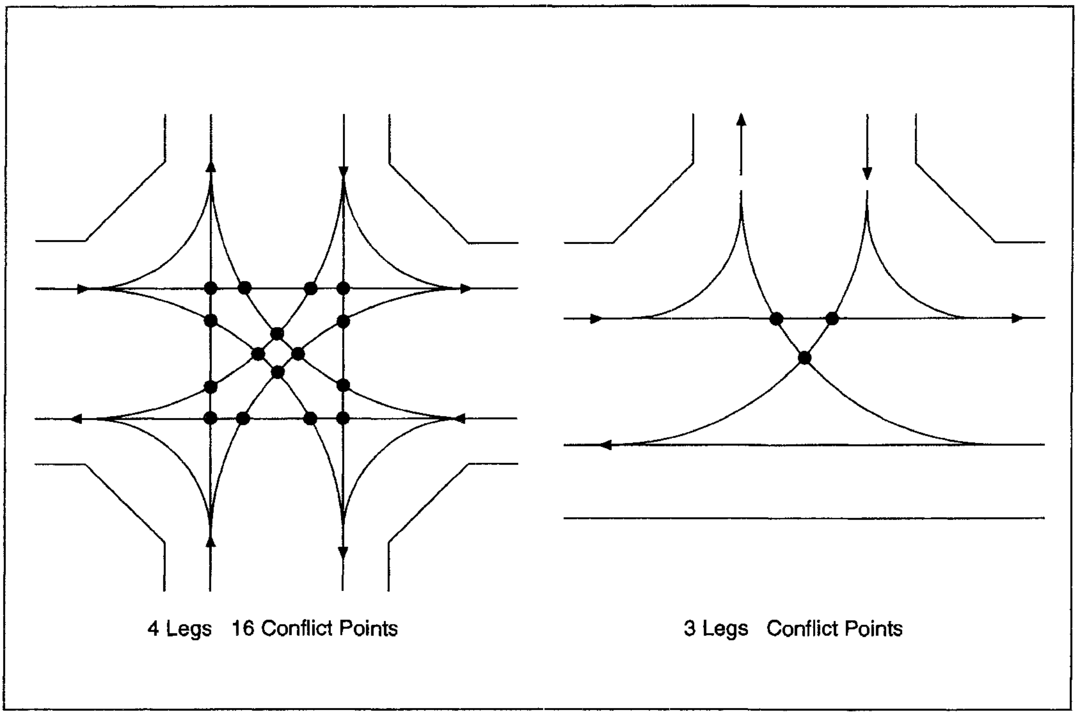
On the basis of vehicle usage, maximum grades should generally not exceed 5-6% (or 1:16-1:20) in flat terrain, 10-12% (or 1:8-1:10) in rolling terrain and 12-15% (or 1:7-1:8) in mountainous terrain. On roads which are to be used as bus routes, grades should generally not exceed 14% (or 1:7). On the basis of cleansing velocities, minimum grades should generally not be below 0,4% (or 1:250) in flat terrain.

These maximum and minimum gradients are only design guidelines - optimum layout design may require other gradients when taking other design factors into account.

1.2.5 *Intersection Spacings*

Intersections accommodate crossing and turning traffic, and as such are sites of increased potential conflict. Some intersection forms have more potential conflict points than others. In the case of uncontrolled intersections for instance, cross-intersections have sixteen points of potential conflict, whereas T-intersections have three.

FIGURE 30: Potential Conflict Points at T and Cross-Intersections



On higher order multi-functional routes, the number of intersections should be kept low, and their spacing should be as great as possible. Within an open road network, greater intersection spacings can be achieved by aligning blocks parallel to, as opposed to perpendicular to, higher order multi-functional routes. The normal minimum spacing for intersections on the same side of the road is 80-90 m, while a recommended minimum spacing of intersections on opposite sides of the road is 60 m - this can be increased to 80-90 m where intersecting roads lead to large traffic generators like schools or shopping centres however.

On less important multi-functional routes, intersection spacing is influenced more by considerations of economic use of land, than traffic circulation - intersections can actually be used to slow traffic down. Where traffic volumes are low, road layouts should favour off-set T-intersections in the form of a right-left stagger, as opposed to cross-intersections. Uncontrolled cross-intersections have greater potential conflict points and are perceived to have continuity in right of way through the intersection on all approaches. The normal minimum spacing for intersections on the same side of the road is 40 m, while the recommended minimum spacing of intersections on opposite sides of the road is 20 m - or even as low as 10 m in special high density cases[12]. There is however a trade-off between closer intersection spacing and the impact successive driver visibility triangles have on positioning fronting activities and the ability to provide on-street parking and loading facilities. The necessary compromise can only be made in each particular development.

1.3 Road Reserve Dimensions

The appropriate width of road reserves should be derived according to the range of functions particular roads are expected to perform. Road reserve dimensions are therefore planning output rather than input.

Width requirements are a planning, as well as an engineering, decision, incorporating social and environmental considerations as well as technical considerations. Road reserve space, and all its cross-sectional elements, should be fully justified - any space for which there is no specified use is wasted space, imposing avoidable costs for its provision and maintenance.

While minimising road reserve widths, consistent with planning and engineering requirements, remains an ideal for which to strive, a degree of flexibility must nevertheless be retained. Recognising that layout plans initiate a development process, it is to be expected that the functions of road reserves will change - this is especially the case in multi-functional road networks. In addition, depending upon the initial servicing strategy adopted, the introduction of new services or the upgrading of existing services may well occur. This flexibility however, in the form of additional width, is borne at the price of higher capital and maintenance costs.

Reserve width should be regarded as a variable, responding to specific design requirements and should not necessarily be regarded as continuous or fixed over a particular road length. Varying road reserve widths provide for variety and interest in the streetscape and allow for the incorporation of non-continuous elements like space for street trading, the provision of public transport embayments, and landscaping.

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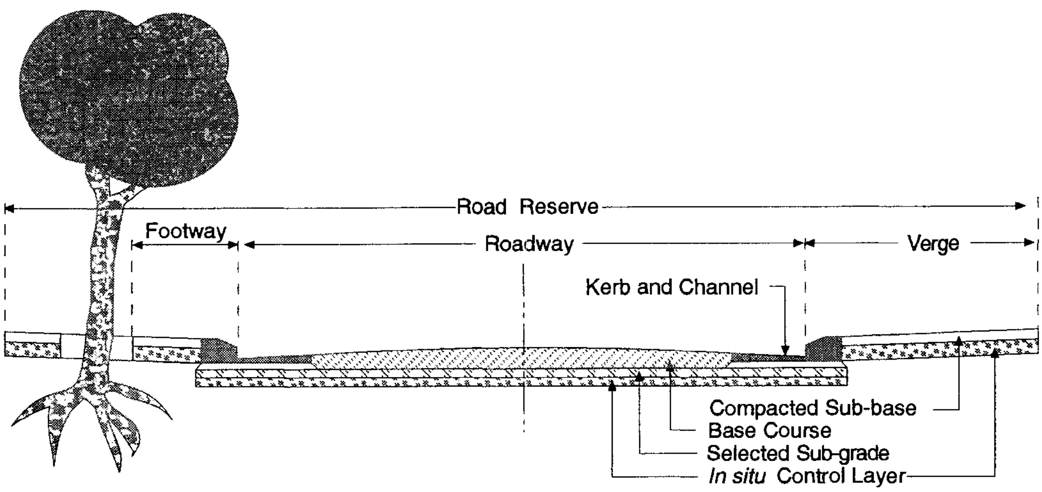
12. Wherever short intersection offsets are contemplated, it is important that possible intersection behaviour is anticipated and verified as appropriate. Narrow offsets are only appropriate with very specific design conditions.

FIGURE 31: Cross-Sectional Components of the Road Reserve



The elements which make up road reserve width include: roadways, footways, parking and loading space, public transport embayments, services reticulation and landscaping space.

A summary of the necessary widths for the various elements of the road reserve is provided in table 5. These widths should be used with caution, and only after rigorous assessment.

The table excludes a number of other cross-sectional elements like clearance to property boundaries, and clearance of services to the back of the kerb. In addition, in steep topography space should be allowed to accommodate cuts and fills within the road reserve. The exact space requirement for each element should therefore be established for each project.

TABLE 5: Width of Road Reserve Elements

ELEMENT	WIDTH (mm)
Single Lane	2 500 - 4 000
Footway	1 350 - 1 800
Trading Space	1 200
Parking Strips	1 800 - 2 500
Bus Bays	3 300 - 3 500
Sewer Trench	1 000
Water Pipe Trench	700
Stormwater Pipe Trench	1 100
Stormwater Channel	1 750
Electricity Cable Trench	1 000
Public Lighting Poles	330
Telecommunications Trench	1 000
Street Trees	500
Barrier Kerbs	400

1.3.1 *Roadways*

The roadway, or blacktop, is the part of the reserve that accommodates vehicular movement. Roadway widths vary according to the volume and type of traffic they are intended to accommodate, with lanes ranging from 2,5 metres to 4 metres depending on traffic volumes and composition, and the chosen design conditions, influenced by the proportion of larger vehicles in the traffic stream.

Lanes often require enlargement on curves, to facilitate the turning movements of larger vehicles. Roads carrying bus services for instance, with a roadway width of 7,4 m, should be widened to 8,0 m where horizontal curve radii are less than 150 m. Local roadway widenings at busier intersections, to incorporate turning lanes, are also sometimes necessary.

In a functional hierarchy road network, the strict segregation of movement and low incidence of conflicting traffic enables roadway widths on lower order roads to be reduced to a minimum. In a multi-functional road network however, the greater mix of vehicular traffic, while still enabling modest road widths, does not facilitate the very narrow widths associated with residential access roads within a functional hierarchy.

Where multi-lane roadways are provided, such as four-lane undivided carriageways, pedestrian refuges are often required to allow pedestrian crossing manoeuvres to be undertaken in two stages. Pedestrian refuges on traffic islands are the most common and generally the least costly type of crossing aid for pedestrians - permitting pedestrians to concentrate on crossing one stream of traffic at a time by creating a relatively safe waiting point, usually in the centre of the roadway. Either additional width is required to accommodate islands, or the width of roadway is reduced as a result of installing a refuge - this can reduce vehicle speeds, but sufficient width is still needed to permit safe passage of the largest vehicle anticipated to use the road.

The use of labour intensive construction methods can, where applicable, reduce certain roadway widths, since provision need not be made for construction vehicle turning movements.

1.3.2 *Footways*

The footway, or sidewalk, is the part of the reserve that accommodates pedestrian activity and street trading. Footway widths vary according to the anticipated volume of pedestrians at peak periods, the nature of social, recreational and economic activity expected to occur within the footway, and whether footways are required on both sides of the roadway.

Adequate space should be provided to enable pedestrians pass each other without having to step onto the roadway. The implications of providing footways on one side of a road only should be thoroughly explored, and should only be adopted if it can be demonstrated that longitudinal pedestrian flow will be light, or will be predominantly along one side of the road.

Minimum footway widths are approximately 1,35 m, and 1,8 m when heavier volumes of balanced bi-directional movement are anticipated. Where people can be expected to wait in the footway (eg. at bus stops), the footway width can be increased by a further 0,9 m. Footway trading would require an additional width of approximately 1,2 m.

Poorly sited street furniture which reduces effective footway width should be avoided, as they can create unnecessary inconvenience and hazard. Traffic signal controllers, street lighting columns, junction boxes, street name boards and so on should therefore where possible be provided at the back of the footway, rather than at the kerbside.

1.3.3 *Parking Strips*

On-street parking and loading spaces, provided on multi-functional roads require an additional width of between 1,8 m and 2,5 m to be added to the roadway - 2,2 m being a preferred figure. The nature of land uses abutting the road reserve, and their on-street parking requirements, will determine whether or not parking space is required on one or both sides of the roadway.

To scale roads for pedestrians, trees should be provided in planting islands within the parking strip, together with pedestrian platforms at the more important pedestrian crossing points to minimise crossing distances and improve safety.

1.3.4 *Bus Embayments*

Bus laybys, or embayments, reduce the delaying effects of a standing bus on heavily trafficked routes. Bus bays require an additional 3,3-3,5 m to be added to the roadway - the length of the bay is determined by traffic speed, ranging from 52 m to 83 m in length.

On roads where traffic volumes are low, bays will not normally be necessary as they are costly to provide and can increase journey times when buses have to wait to re-enter the traffic stream.

To operate safely, bus stops should be kept clear of parked vehicles - where relatively intensive use is made of adjoining land this can be difficult. Where a bay is justified, but the full width cannot be provided, then either a lesser bay width can be provided which will still allow a bus to pull over causing less disruption to traffic, or the footway can be partially extended by 1 m into the roadway to provide a 'bus boarder'. The boarder discourages parking and loading, but permits buses to pull up beside the kerb - having the added advantage of assisting people who have difficulty in stepping onto buses from the road surface. If used in conjunction with planting islands, kerb returns at intersections and 'narrowed' pedestrian crossing points, they do not present a hazard to moving vehicles when adjacent parking spaces are not occupied.

1.3.5 *Services Reticulation*

An important function of the road reserve is to accommodate reticulated utility services like sewers, watermains, stormwater pipes or channels, and electrical and telecommunication cables.

The space requirement of reticulated services within road reserves varies according to whether reticulation is mid-block or street in the case of water, sewerage and electricity, above or below-ground in the case of electricity, public lighting and telecommunications, beside or beneath the roadway in the case of sewerage, stormwater pipes and even watermains, and whether trenches can be shared. In addition, in cases where services are to be provided at different stages, the space requirements for realistic future service upgrades should be anticipated and accommodated within the road reserve in the initial design stage.

Sewers can be laid mid-block in lower density layouts and under the roadway in higher density layouts. Road reserve width is not therefore a critical factor. However, if there is a preference for sewers to be laid under the footway, for maintenance reasons, a trench width of 1 m is required on one side of the roadway. Similarly, if water supply mains are to be run in the road reserve, beneath the footway, a trench width of 0,7 m is required on one side of the roadway. In the case of stormwater, open channels require more space than underground pipes - 1,75 m as opposed to 1,1 m. As open channels are required to convey increased runoff as they progress downhill, a corresponding increase in channel width is required. For underground cabling systems, a trench width of 1 m is required, with an additional 0,33 m required for public lighting poles.

1.4 Parking

Decisions relating to the amount of parking to be provided in a layout, its location, and the relative proportion of different types of parking space, have wide-ranging impacts on the quality of an urban environment. Parking provisions influence the amount and cost of public land taken up by movement uses, the gross residential densities achievable in a development, the nature of road use in an area, and the safety of road-users.

To establish appropriate levels of parking provision within a layout plan, it is necessary to anticipate the quantity and variety of parking needs that are likely to occur. This can be done by establishing levels of car ownership amongst end-user households, or observing the parking requirements of similar income groups in cases where no end-user group is identifiable. It is important that parking provision is not based upon unrealistic assumptions regarding increases in household income, so that over-provision and the creation of sterile, unkept open spaces can be avoided. For reasons of economy, initial parking provision should be utilised within a fairly short period of time (ie. ± 5 years), with, in certain instances (ie. in areas where greater commercial activity is anticipated), sufficient space made available to meet further future demands.

There are two basic types of parking space provision: (1) off-street and (2) on-street parking space.

1.4.1 *Off-Street Parking*

Off-street parking refers to the accommodation of vehicles either on individual residential erven, or in areas provided specifically for parking purposes (ie. undercover parking garages or parking lots).

In residential developments, which consist of single units on an erf, erf sizes and the location of dwellings should generally enable households owning cars to accommodate their vehicles within the curtilages of erven. Similairly, in multi-unit housing, erf sizes and the location of units should accommodate any realistic resident vehicle parking requirements. This is the most equitable way of accommodating private motor vehicles - wealthier households pay the direct cost of parking their own vehicles, while poorer households, who do not own cars, are not forced to subsidise the cost of providing parking space (within road reserves) for wealthier, car-owning households.

In lower income developments, where it is unlikely that a large number of households will ever own a car, not all residential erven should contain on-site parking space. This is particularly the case in layout arrangements where numbers of small erven gain access through pedestrian routes only.

In non-residential developments, which attract long-term commuter parking, parking should be accommodated off the roadway - requirements for such parking are normally contained in the town planning or zoning scheme for a municipal area.

For those developments like supermarkets, which attract comparatively large volumes of short-term parking, or service parking, like garages and car body repair shops, off-street parking should also be provided. Once again, the provisions of the zoning scheme would normally apply. Similarly, the requirement for off-street loading facilities are also covered in the relevant zoning scheme.

1.4.2 *On-Street Parking*

On-street parking refers to the accommodation of vehicles within the road reserve, either within the roadway, or within embayments adjacent to the roadway.

In predominantly residential developments, visitor-parking can occur within the roadway in the case of predominantly access roads, or in embayed parking spaces in the case of roads performing a greater mobility function.

In predominantly non-residential developments, activities that require no more than two long-term parking bays, like single shops or any other one-person business, parking requirements can be accommodated on-street.

Provision for short-term parking and loading/off-loading requirements can also be made on-street in residential areas and on multi-functional routes. The necessary space should be embayed so that the area reserved for parking and loading is not seen as part of the travelled-way. Kerb returns at intersections should be provided to assist pedestrian crossing manoeuvres, and to improve intersection visibility.

Because parked cars present a potential safety hazard, with pedestrians unexpectedly appearing between parked vehicles, raised embayment breaks should be provided on more busier routes where it is safe for pedestrians to cross the road, to enable approaching traffic to see waiting pedestrians. Embayment breaks should be provided reasonably frequently to encourage pedestrians to make use of them.

2. Intersections

Design decisions regarding intersections relate mainly to: (1) the functional hierarchy of road intersections within the layout plan, and (2) the geometric dimensions of these road intersections. Each of these design decisions is discussed in turn.

2.1 Functional Intersection Hierarchy

Road intersections perform a variety of functions. As in the case of roads, a distinction can be drawn between the developmental functions of an intersection, and technical functions relating to the management of traffic movements. The carrying capacity of a road network is determined by intersection capacity, not by route capacity, and therefore it is the quality of intersection performance that determines the operational quality of the network as a whole.

Intersections are the loci of economic opportunity - each quadrant of an intersection being exposed to two adjacent traffic routes, and consequently being the site of maximum potential consumer exposure in the immediate area.

As well as being sites of potential economic opportunity, intersections are sites of potential traffic conflict and lack of safety. At intersections, traffic enters, crosses or leaves the main traffic stream - the degree of risk is a function of the number of points of potential conflict which exist, and the proportion of turning traffic. Problems arise as traffic volumes, operating speeds and the quantity of turning traffic increases. As the number of conflict points increases, so the complexity of decision-making involved in negotiating the intersection increases, and even limited volumes of turning traffic can present a real hazard.

Under these circumstances the response, in terms of the current hierarchical road system, is to simplify decision-making by allowing a number of simpler decisions to be made sequentially through separating out the points of conflict - or in other words, to use intersection types with fewest conflict points, and to reposition the activity for which access is required further from the intersection. The extent of such separation is determined by a number of factors relating to safe operating conditions. Where traffic volumes and operating speeds are high for instance, the prohibition on direct access is absolute. Within a conventional functional road hierarchy, the developmental functions of intersections therefore tend to be ignored.

There is a need therefore to reconcile the requirements of safe operating conditions, with the need to use intersections developmentally, as sites of potential economic opportunity. The recommended functional intersection hierarchy therefore includes the following broad types of intersection:

2.1.1 *Distributor Intersections*

Intersections between regional and primary distributors, as well as intersections between these distributor routes and higher order multi-functional routes, should be designed to facilitate safe and uniform operating conditions. These intersections perform a mobility function. This then, precludes locating any activities which require direct frontage access adjacent to regional or primary distributor intersections. This includes those activities which require rapid access to the mobility system (eg. fire and police stations) - access should be taken from a multi-functional road leading to a distributor route.

2.1.2 *Higher Order Intersections*

Intersections between multi-functional roads, that accommodate larger volumes of traffic, are points of greatest accessibility, and are therefore points where development opportunities are largest. The relative accessibility of a particular intersection is determined not only by the type and nature of passing traffic, but by the ability of traffic to stop. Consequently, in order to create economic opportunities, vehicles, including public transport vehicles, should be able to stop on the roadway - a requirement that should be incorporated in the layout plan.

Activities should not be prevented from locating, and gaining frontage access, fairly close to the intersection. Taking access at the site of an intersection nonetheless, increases the number of potential conflict points considerably and should generally be avoided.

The volume of traffic at higher order multi-functional route intersections necessitates some form of intersection control, which in turn, through eliminating potential conflict points, enables the use of cross-intersections. Where the dominant traffic movements are 'through' the intersection, with very little turning traffic, traffic signalisation is the most efficient form of intersection control. Where turning movements are heavy, particularly right-turning traffic, a roundabout is the most efficient form of intersection control.

2.1.3 *Lower Order Intersections*

Intersections between multi-functional roads, that accommodate smaller volumes of traffic, are less accessible and therefore provide opportunities for less intensive trade and collective servicing points. Activities should not therefore be prevented from locating, and gaining frontage access, fairly close to the intersection. If the frequency with which access is taken is low and operating speeds are low to moderate, such access is acceptable.

Low traffic volumes do not justify investment into intersection control, in the form of traffic signalisation or roundabouts however - necessitating the avoidance of cross-intersections. Cross-intersections are inherently dangerous because of the perceived continuity in right of way through the intersection on all approaches. For low side-road volume applications they should be avoided as far as possible - with off-set T-intersections being preferable in some, but not necessarily all, cases.

2.2. Intersection Dimensions

A wide range of intersection forms are possible. For any combination of intersecting road widths, the type of traffic and pedestrian activity the intersection is likely to accommodate should be anticipated, and an appropriate intersection form selected.

The dimensions of intersections are determined by traffic factors like the width of intersecting roadways and the volume and composition of anticipated turning traffic, and by non-traffic factors like pedestrian activity and street-corner trading. In order to minimize land take-up, the size of intersections should be kept as small as possible, consistent with its anticipated functions.

Intersections are points of increased potential conflict, which can result in delay or accidents. The extent to which potential conflict points need to be avoided, by the choice of intersection radii, largely depends upon the type of vehicles involved in conflicting movements and how frequently they meet at the intersection. When traffic volumes are light and tidal for instance, owing to the low incidence of conflicting traffic and the low duration of traffic delay, intersections can be sized to allow the full road width to be used by larger turning vehicles.

Where street-corner trading requirements predominate, and traffic speeds are limited by road geometry, a higher incidence of potentially conflicting turning manoeuvres can be tolerated - this yields smaller intersections which enable pedestrian crossing manoeuvres to be more readily and safely undertaken, and allows development to occur close to the intersection.

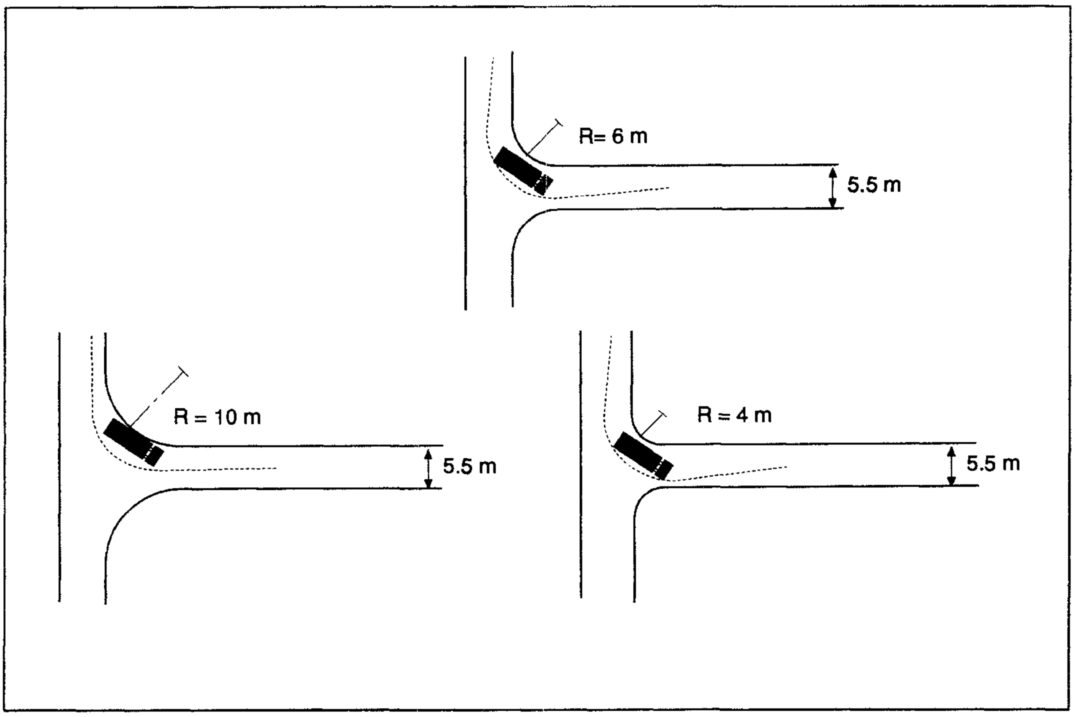
There are three key variables in determining appropriate intersection dimensions: kerb radii, splays and pedestrian activity.

2.2.1 *Kerb Radii*

Kerb, or bell-mouth, radii are determined by the turning requirements of anticipated vehicular traffic. Different kerb radii have an impact on the turning performance of certain types of vehicles - typical kerb radii for heavy vehicles are between 10 m and 12 m, with larger public transport buses requiring a greater radius of approximately 15 m.

The following three examples of kerb radii provide an indication of the impact of radii on vehicle turning movements:

FIGURE 32: Intersections Designed to a Radius of 10 m, 6 m and 4 m



Intersections designed with a kerb radius of 10 m allow both refuse vehicles and pantechnicons to turn without interfering with traffic on the through road. Pantechnicons may have difficulty in turning past vehicles on the stem however, and may have to wait until the intersection is clear. Where the stem road is a residential road however, the lightness of traffic volumes and the infrequency of vehicles of pantechnicon size mean that such delays will be very infrequent and of short duration. Radii of this order will therefore normally be sufficient for most intersections between residential and higher order roads.

Intersections designed with a kerb radius of 6 m allow pantechnicons to turn into or out of the intersection using most of the width of both carriageways, and allows refuse vehicles to turn without interfering with through-traffic. Radii of this order will therefore normally be sufficient for intersections within the primarily residential road network.

Intersections designed with a kerb radius of 4 m allow all vehicles to turn into or out of the intersection but require vehicles larger than private cars to use most of the width of both carriageways. Whilst this may not present problems where both roads are very lightly trafficked, the tightness of turn required for large vehicles may result in kerb mounting. Radii of this order should therefore normally be restricted to intersections carrying very low traffic volumes, situated well within the residential network, in places where speeds can be kept low and where drivers can be expected to proceed with care.

The minimum kerb radii which can be used is a function of the width of the intersecting roads and the anticipated turning behaviour. In many instances, the use of three-centred curves can substantially improve turning behaviour without a disproportional increase in intersection space.

2.2.2 *Splays*

Kerb radii necessitate the splaying of property boundaries, principally for the maintenance of pedestrian footways around a corner. Splay dimensions are derived from driver visibility sight lines, the space requirements of street-corner traders and collective service points, the width of the road reserve, and the position of the roadway in the reserve.

To enable vehicles to emerge from a side road and join the main traffic stream safely, a certain length of unrestricted visibility is required - to enable the emerging driver to identify suitable gaps in the traffic stream, and to enable approaching traffic to see side road traffic and take any precautionary or avoiding action necessary. This is termed the sight triangle and is based upon the distance back from the edge of the through carriageway of the driver's eye for side road traffic (the x dimension), and the stopping sight distance of the main road (the y dimension). The sight triangle influences the position of the splay.

The driver's eye position is considered to be some 2,4 m from the edge of the through carriageway. For approach speeds of 40 km/hr and less, sight distances of 45 m or less are acceptable. The higher the approach speed on the through road the more restrictive the sight triangle requirements become.

Providing an x dimension of 2,4 m however, allows only one vehicle at a time to exit safely - all following traffic is also required to stop and look. Therefore this type of sight triangle is only suitable where traffic volumes in the side road are low - when side road traffic volumes increase and speeds and volumes on the through road also increase, a different sight triangle is required.

FIGURE 33: Sight Triangles at Intersections

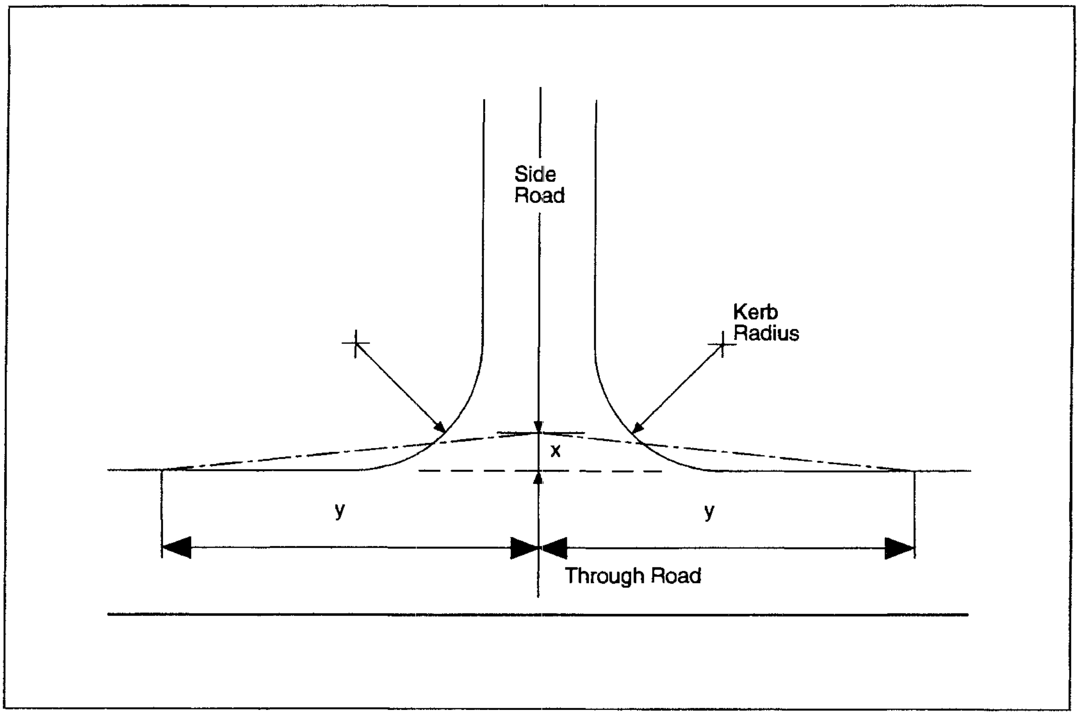


TABLE 6: Y Dimension for Sight Triangles at Varying Approach Speeds

APPROACH SPEED	Y DIMENSION
40 km/hr	45 m
50 km/hr	100 m
60 km/hr	120 m
70 km/hr	140 m
80 km/hr	160 m

Under such circumstances the sight triangle changes to avoid the need for through-traffic to change course, slow down or stop. To achieve this, drivers from the side road must be able to see far enough down the through road to be able to judge when to accept a gap without interrupting through-traffic movement. In this case the y dimension needs to be increased as approach speeds increase, and the x dimension needs to be increased to allow following vehicles to see down the through road while moving up to the intersection - thereby allowing two or more vehicles to select a particular gap. The distance is a function of the number of vehicles required to accept a particular gap and is easily deducible. In practice an increase of the x dimension to 4,5 m is commonly adopted, which is able to accommodate up to about 300 vehicles/hour exiting from the side road.

The requirements of the sight triangle constrains parking or stopping on the roadway. Parking and loading should be embayed and a kerb return provided - this facilitates pedestrian crossing by minimising crossing length, and provides a minimum distance over which side road traffic can see and be seen.

Within the sight triangle fixed objects like stationary cars or trees should be avoided. Where pedestrian volumes are relatively high and sustained, the footway should be positioned inside the sight triangle. Where corner-trading is likely to occur, additional space should be provided to accommodate this activity in order to reconcile safety standards with creating economic opportunities.

2.2.3 *Pedestrian Activity*

The quadrants of intersections are areas of greater accessibility, and as such are sites where many activities wish to locate, and which can be expected to generate pedestrian activity through the intersection. Where intense pedestrian activity is likely to occur, intersections should be designed to accommodate this activity in the safest and most responsive way possible.

Pedestrian activity at intersections relates mainly to street trading, collective servicing points like public water standpipes and solid waste collection points, and road crossing manoeuvres.

In situations where street-corner trading or collective service provision is likely to occur, as mentioned above, additional space in the form of either larger splays or left off corner erven, should be provided to facilitate this.

With regard to road crossing manoeuvres, pedestrian crossing width should be kept to a minimum, to ensure that the length of time pedestrians are exposed to risks is minimised. Consequently, pedestrian crossing should occur at the throat of the intersection, not across the mouth, and footways should lead pedestrians to the preferred crossing point.

To minimise exposure to risk on routes where, due to public transport, parking and loading activities, roadway width is considerable, kerb returns should be provided and parking and loading facilities embayed. When pedestrian crossing volumes are particularly high, it is often necessary to minimise the conflict between road crossing movements and turning traffic, by providing some form of assistance like pedestrian refuges or traffic signalisation.

3. Facilities

Design decisions regarding public facilities relate mainly to: (1) the space taken up by facilities and amenities on the layout plan, (2) the population thresholds they serve, and (3) the distance end-user households have to travel to gain access to them. Each of these design decisions is discussed in turn. (The locational requirements of facilities are discussed in 1.3.5 of section 3.)

A public facility system is made up of four broad categories of often interrelated facilities: educational, health, social, and public service facilities.

TABLE 7: Public Facilities

EDUCATIONAL FACILITIES	1.	pre-primary
	2.	primary
	3.	secondary
	4.	tertiary
HEALTH FACILITIES	1.	mobile clinics
	2.	clinics
	3.	day-hospitals
	4.	community hospitals
	5.	provincial or regional hospitals
	6.	academic hospitals
SOCIAL FACILITIES	1.	mobile libraries
	2.	libraries
	3.	community centres
	4.	sports stadiums
	5.	places of worship
PUBLIC SERVICE FAC.	1.	mobile post offices
	2.	post offices
	3.	mobile police stations
	4.	police stations
	5.	fire stations
	6.	community information centres
	7.	local business service centres

The specific demographic and socio-economic profile of communities should be used to plan and provide public facilities. For example, it is possible that a greater proportion of investment would be required for pre-school facilities within the first five years of a new settlement, than for secondary and tertiary education.

Planning standards are conventionally used to establish public facility improvement programmes and, where necessary, identify and reserve appropriate quantities of land to accommodate these investments. This spatial quantification of the needs of an urban population is sometimes referred to as a 'programme' (see 2.3 of section 2). Public facility needs are usually determined by the application of space and threshold standards, and time and distance standards.

3.1 Space and Threshold Standards

Government and parastatal agencies are generally responsible for determining space and user threshold standards for their respective public facilities and amenities. The spatial dimensions, rough locational arrangements and cumulative land requirements for the range of facilities and amenities in an urban development, are specified in local structure plans, with detailed locational planning occurring at the layout planning stage.

Standards for individual facilities and amenities are conventionally assessed by considering their 'optimal' spatial requirements in isolation of each other. This leads to a number of problems.

Firstly, when the range of 'optimal' facilities are brought together on a site, their combined land requirement is excessively large. This results in a reduction of residential land, and thus a reduction in gross residential densities - to a level often too low to maintain efficient facility use. Development at higher densities is difficult when space standards are large and inflexible. Developers wishing to build at densities higher than the current norm, are confronted with a situation in which more people necessitate more land for facilities and amenities. The effect is an even greater reduction of land for residential purposes. Any increase in net residential density is therefore countered by a reduction in residential land - resulting in gross densities that remain similar to the norm.

Secondly, the reduction in residential land that results from large and inflexible space standards, increases the per unit cost of public land acquisition. The smaller the proportion of residential land, the fewer the number of households that can be accommodated, and thus the less the potential to share costs between a greater number of households.

Thirdly, formulating space standards in isolation restricts the potential that resource sharing and multi-functional use, have to reduce land requirements. In conditions of resource scarcity this is essential - in cases where neither the local authority nor the relevant government department can afford to develop the planned facilities or maintain public open spaces, land remains vacant and unattended.

TABLE 8: Public Facility Space and Threshold Standards

	DU/FAC	POP/FAC	HA/FAC
EDUCATIONAL FACILITIES			
Creche***	900	5 000	0,013
Primary School**	600	3 300	0,500
Secondary School**	1 200	6 600	1,000
HEALTH FACILITIES			
Mobile Clinic*	900	5 000	NA
Clinic*	900	5 000	0,200
Day-Hospital*	1 800	10 000	0,500
Community Hospital*	14 500	80 000	1,500
SOCIAL FACILITIES			
Mobile Library*	350	2 000	NA
Library*	1 800	10 000	0,013
Community Centre*	4 000	22 000	0,500
Sports Stadium*	9 000	50 000	3,000
Place of Worship*	NA	NA	0,150
PUBLIC SERVICE FACILITIES			
Mobile Post Office*	2 000	11 000	NA
Post Office*	2 000	11 000	NA
Mobile Police Station*	4 500	25 000	NA
Police Station*	4 500	25 000	0,300
Fire Station*	11 000	60 000	1,200
Community Information Centre***	4 000	22 000	NA
AMENITIES			
Sports Field*	1 400	7 700	0,600
Public Open Space***	182	1 000	0,050
COLLECTIVE SERVICE POINTS			
Public Water Standpipe	25	140	NA
Communal Toilets	20	110	NA
Solid Waste Collection Point	250	1 400	NA
Public Telephones	3 000	16 500	NA
Post Collection Points	3 000	16 500	NA

Note: * = local *de jure* standard, ** = local *de facto* standard, *** = international standard

Space and threshold standards should therefore avoid over-provision or underutilisation. The most significant increases in gross residential density can in fact be achieved by reducing facility space standards to more realistic levels. Education and recreation facilities are particularly important in this regard. Reductions in space standards should however, not override the purpose of a land use programme, which is to ensure that adequate spatial provision is made for the necessary provision of public facilities and amenities.

It is suggested that public facility space standards be used with circumspection, and that in many instances standards should relate more to distance and facility performance, than to space. For example, instead of conventional space standards of 2,5 ha and 6,8 ha for primary and secondary schools respectively, standards should relate to the number of pupils per library or playing field, without prescribing the size of the school plot. In this way resource sharing between schools located in clusters is facilitated, and appropriate land requirements can be derived in each development.

The flexible application of space standards suggested above is based upon two premises. Firstly that quantity in facility provision is not equal to quality (eg. reduced school sites do not necessarily lead to reduced standards of education), and secondly that community needs vary from place to place (eg. open space requirements are different in the inner city than on the rural fringe). Space and threshold standards are therefore not universally applicable - the implication being that standards should not be rigidly applied.

Table 8 provides a set of space and user threshold standards that offer reasonable alternatives to those in current use. They are drawn from international and *de facto* local cases. These are rough guidelines, in the absence of detailed information regarding facility performance standards. It is beyond the scope of this handbook to make detailed recommendations regarding space, threshold and facility performance standards.

3.2 Time and Distance Standards

Time and distance standards are used to ensure that public facilities and amenities are as accessible to end-user households as possible. Depending on the supporting threshold population, some facilities should be sited in locations accessible to pedestrians, while others should be sited in locations accessible to public transport users as well as to a limited number of pedestrians in the local area. Time and distance standards are therefore more applicable to lower order, pedestrian orientated facilities - the locations of higher order facilities are determined more by the public transport system than by time and distance ranges.

Table 9 provides a set of time and distance standards - that, when used in conjunction with user threshold standards, can act as benchmarks to check the accessibility of facility locations. They are drawn from international cases and local *de jure* standards. For those facilities accessed primarily by pedestrians, the standards assume an average walking speed of 3 km/hr, or 50 m/min.

TABLE 9: Public Facility Time and Distance Standards

	DISTANCE (m)	WALKING TIME (min)
EDUCATIONAL FACILITIES		
Creche	1 000	20
Primary School	1 500	30
Secondary School	5 000	NA
HEALTH FACILITIES		
Mobile Clinic	1 000	20
Clinic	1 000	20
Day-Hospital	2 000	40
Community Hospital	5 000	NA
SOCIAL FACILITIES		
Mobile Library	1 000	20
Library	1 500	30
Community Centre	1 500	30
Place of Worship	1 500	30
PUBLIC SERVICE FACILITIES		
Mobile Post Office	1 000	20
Post Office	2 000	40
Mobile Police Station	1 500	30
Police Station	1 500	30
Community Information Centre	1 000	20
COLLECTIVE SERVICE POINTS		
Public Water Standpipe	100	2
Communal Toilets	75	1,5
Solid Waste Collection Point	150	3
Public Telephones	500	10
Post Collection Points	500	10

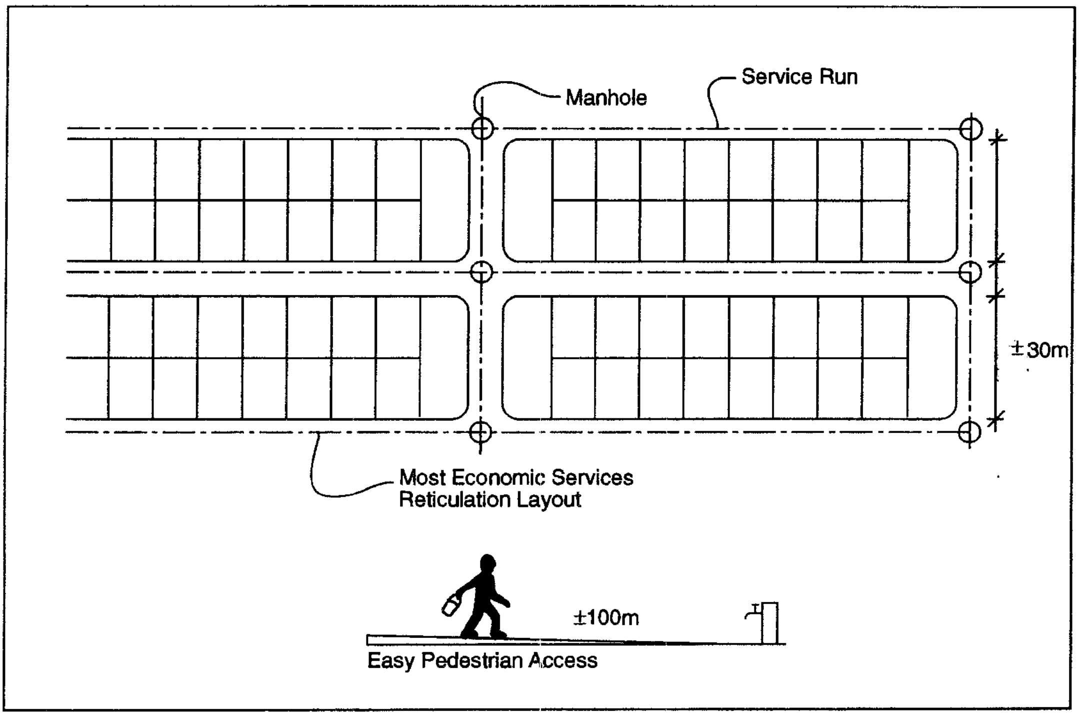
4. Blocks

Design decisions regarding block dimensions relate mainly to: (1) block width and length, and (2) subdivision patterns. Each of these design decisions is discussed in turn.

4.1 Block Width and Length

The primary concern in determining block dimensions should be the facilitation of easy pedestrian circulation. It should be noted that in this regard block lengths are of far greater importance than block widths. In practice residential block widths seldom exceed a maximum of ± 60 m - a dimension that does not significantly impede pedestrian movement. Block lengths, on the other hand, can reach up to ± 300 m, and sometimes longer, which can obviously significantly decrease levels of pedestrian access.

FIGURE 34: Diagram Illustrating Ideal Block Dimensions for Easy Pedestrian Access and Efficient Services Reticulation



Block widths are determined by the cumulative depth of erven within blocks. A consideration in establishing appropriate block widths is safe road intersection spacings. On lower order multi-functional roads in primarily residential neighbourhoods, minimum intersection spacings should be 30-40 m - necessitating block widths of a similar order. This minimum intersection spacing allows for adequate driver visibility and safe clearance intervals.

Block lengths are determined by the cumulative frontage of erven within blocks. Key considerations in establishing appropriate block lengths are pedestrian movement and service reticulation.

Pedestrian movement is best facilitated by fairly short blocks of approximately 100 m. Shorter blocks provide greater through connections for pedestrians and constrain vehicle speeds - 50 m allowing a spot speed of 40 km/hr to be attained, and 75 m allowing a speed of 50 km/hr.

For all reticulated services, from both a cost and maintenance point of view, straight blocks are most efficient. An optimum arrangement is a straight block length of 80-100 m - as stormwater and sewer manholes can then be located at either end of the block, where, because of pipe junctions, manholes are usually required anyway. Blocks of 100 m are particularly advantageous for mid-block reticulations, as access to manholes is possible within road reserves rather than on private erven. Block lengths of ± 100 m can therefore satisfy both pedestrian and servicing requirements - there is however a trade-off between shorter blocks and greater road length per erf which influences cost.

The most effective way of lowering servicing cost through layout planning, is to reduce the length of service runs relative to the number of erven served. There is a close relationship between the total length of roads in a development, and the total length and cost of service runs - in the form of pipes and cables. This is because road reserves either contain services, or, in the case of mid-block services, replicate reticulation. Minimising the length of roads therefore has the corollary of minimising the length of service runs.

LAYOUT EFFICIENCY INDICATORS

The following indicators provide a way of assessing the efficiency of a layout proposal. Suggested target values are drawn from international and local cases.

(1) *Network Length:Area Ratio*
A network length:area ratio measures the length of road network in relation to the area served. In general, the lower the value of the ratio the more efficient the network. A suggested target value is 150-230 m/ha.

(2) *Network Length:Dwelling Unit Ratio*
A network length:dwelling unit ratio measures the length of road network relative to the number of dwellings within a given area. In general, the lower the value of the ratio the more efficient the network. The area and dwelling unit ratios need to be considered in conjunction because ironically, the smaller the erven in a two erf-deep block, the longer the road network. A suggested target value is 5-10 m/du.

(3) *Frontage:Depth Ratio*
A frontage:depth ratio measures the width of an erf relative to length. In general, the greater the ratio (ie. the shorter the erf frontage) the more efficient the layout. Narrowing erf frontages and reducing plot sizes effectively reduces the network length per erf and increases erf densities. A suggested target value is between 1:5 and 1:3.

(4) *Residential Density*
Density measures have two interrelated components. The first is the density of residential dwellings. Gross residential density expresses the number of dwelling units divided by total site area, and net residential density expresses the number of dwelling units divided by that part of the site taken up by residential use only. The second is the density of population, expressed as the number of people divided by the site area. Appropriate densities are specific to a range of social, economic and environmental factors - with gross densities in the region of 50-100 du's/ha likely to be appropriate in most developing urban areas of South Africa - see 5.2 of this section for a discussion around this.

(5) *Land Utilisation Index*
A land utilisaton index, or land use budget, identifies the proportional use of land. Land uses are conventionally broken down into residence, commerce, industry, public facilities, public amenities and movement. Appropriate proportions of land uses, particularly commercial, industrial and public amenity uses are context specific. However as a rule of thumb, at the local area layout scale, residential, commercial and industrial uses should take up $\pm$ 55% of land, public facilities and amenities $\pm$ 25%, and movement $<$ 20%.

4.2 Subdivision Pattern

In those 'greenfield' developments where planners are responsible for determining erf boundaries, key considerations in establishing appropriate subdivision patterns include service reticulation, erf size, access requirements and housing consolidation.

The nature of service reticulation influences subdivision patterns. If services are reticulated in the middle of the block, then erven need to front the road reserves running on either side of its length. If rectangular erven are turned short end to face the transverse streets at the end of the block, this creates a detail problem regarding the connection of mid-block services.

The mid-block reticulation of sewerage, water supply, electricity and telecommunication cables is often favoured for cost reasons. As no allowance needs to be made for traffic loads and other services which may be located in the road reserve, mid-block pipes can be laid at shallower depths, and as a result are less expensive. House connections are also shorter, as roadways do not need to be crossed. Local authorities however often prefer street reticulation, as it is easier to carry out maintenance, and meter reading is easier with the meter at the front of the property. In the case of above-ground electrical cabling, while mid-block reticulation can make overhead wires less obtrusive from the street, this advantage is often neutralised by maintenance access difficulties and the need to provide additional poles in the road for streetlighting - giving the impression of a 'forest of poles'.

TABLE 10: Main Advantages and Disadvantages of Road and Mid-Block Service Reticulation

ROAD RETICULATION		
Characteristic:	*	Service lines located within the verge and footway, or beneath the roadway
Advantages:	*	Easier access to service lines and manholes for maintenance purposes
	*	Meter reading is easier
Disadvantages:	*	Connections to on-site wet core are longer
	*	Service lines tend to be deeper with consequent cost increases for excavation and manholes
	*	Heavier manhole covers are required
	*	Traffic loading increases pipe cover requirements when service lines are located under the roadway
	*	Roadway disruptions when new erf connections cross the roadway
MID-BLOCK RETICULATION		
Characteristic:	*	Service lines located between erven in the middle of the block
Advantages:	*	Poling is less visible from the street
	*	Reticulation costs are lower
Disadvantages:	*	Access for maintenance is difficult
	*	Backyard shacks are often built over service lines
	*	Privies are sometimes erected over mid-block manholes, and the manhole is then used as a toilet

In cases where a large block accommodates a public facility like a school, an attempt should be made to position residential erven on the perimeter of two or three sides of the block, so that surrounding service runs do not serve only one side of the road reserve and residential erven back onto the semi-private open space. Consideration should however be given to the avoidance of dangerous spaces behind residential erven, that are unlit and hidden from public surveillance. For this reason, in the case of public open spaces (as opposed to semi-private open spaces like school playing fields), residential erven should front onto the space wherever possible.

When erven are small, with a length of ± 10 m, it becomes inefficient to design conventional two-erf deep blocks, because excessive lengths of road reserve are required to provide every erf with road access. Numerous subdivision patterns, like pan-handle erven or blocks with dissecting pedestrian only routes, can increase the number of erven between road reserves. The latter assumes that erven within the centre of the block will never require private vehicular access. Four-erf deep subdivision patterns offer servicing advantages, as services can be run mid-block with two service runs per block. It should be noted however, that households often prefer erven with street frontage because of the trading opportunities they offer and the awkward toilet locations that can result on inner erven.

A further consideration is the nature of housing consolidation, and the form of housing. Subdivision patterns vary according to whether or not the housing is ground-related (ie. single dwellings vs. flats), and whether the development is a conventional greenfield project, an *in-situ* upgrade or a form of managed land settlement in which a group of households occupy an entire block and arrange their own internal subdivisions with survey and service connection to individual erven occurring later. In the case of *in-situ* upgrade, subdivision patterns should attempt to rationalise erf boundaries with the minimum of disruption, while in the case of managed land settlement, no internal erf boundaries are provided.

5. Erven

Design decisions regarding erf dimensions relate mainly to: (1) erf width and length, and (2) erf size. Each of these design decisions is discussed in turn.

5.1 Erf Width and Length

Key considerations in establishing appropriate erf widths, or frontages, include service provision, and housing type.

In the case of single-unit housing (ie. row housing or semi-detached housing where one house occupies a single erf), for both reticulated services and road-based services, greatest efficiency is achieved when erf widths are at a minimum. In the case of reticulated services, narrow erf widths increase the number of households per unit length of service run. Narrow, deep erven therefore minimise road length, and by implication, the cost of service provision per erf. In the case of road-based services like solid waste collection, narrow erf frontages enable kerbside servicing to take place without collection crews having to get on and off the vehicle - they can move from erf to erf on foot whilst the vehicle moves slowly alongside.

Housing type and the width requirements of attached dwellings also influence appropriate erf widths. Row housing conventionally requires a minimum width of ± 5 m, to enable acceptable room sizes. In the case of semi-detached housing where on-site vehicular access is required, a side space of ± 3 m should be allowed in addition to the width of the dwelling.

In the case of multi-unit housing (ie. where a number of dwelling units occupy a single, commonly owned or leased erf), erven are obviously wider and larger, sometimes even occupying the entire block. The most efficient and socially acceptable form of multi-unit housing is generally regarded as low-rise, three to four-storey walk-up accommodation, with fairly high erf coverage - the cost of high-rise accommodation increases significantly as lifts are required.

A consideration in establishing appropriate erf lengths, or depths, is safe road intersection spacing. As mentioned earlier, erf length is the basic building block of road layouts - with the length of two erven generally establishing the minimum spacing of intersecting roadways.

5.2 Erf Size

Key considerations in establishing appropriate erf sizes include residential density, servicing cost, land use mix, and housing processes.

In the case of single-unit housing (as opposed to multi-unit walk-ups or flats), erf size determines net residential density, which in turn is the primary informant of gross residential density. It should be noted however that erf size does not necessarily determine population density as, particularly in lower income areas, larger erven often result in higher levels of subletting and sharing which increase population densities considerably.

The achievement of higher residential densities in layout plans (ie. gross residential densities in the region of 50-100 du's/ha) is prerequisite in supporting numerous urban activities like commercial enterprises, the conservation of peripheral agricultural land, and service provision. Perhaps the most important of these activities is the operation of public transport services - passenger density, and by implication residential density, is particularly important for the financial viability of different public transport services. Different service types require different passenger densities for efficient and viable operation.

Residential density also has a significant impact on land and servicing costs.

With regard to the impact of residential density on the cost of land, density affects acquisition costs in two ways. Firstly, net residential density influences the unit cost of residential land acquisition - the smaller the land take-up per unit, the lower the unit acquisition cost. Secondly, gross residential density influences the unit cost of public land acquisition for road reserves and public open spaces. Developers are generally required to meet the space requirements of facilities and infrastructure, and transfer this land into public ownership. When public land costs are recovered in housing sales, the higher the proportion of residential land, the lower the unit cost.

With regard to the impact of residential density on the cost of service provision, there is a trade-off between greater servicing costs, and greater cost sharing in higher density environments. On the one hand, higher density developments often require more expensive 'internal' services than lower density developments. In particular, larger (and more expensive) water and sewer pipes are required to accommodate greater loads, and wider roadways are required to accommodate greater traffic volumes. On the other hand, some service costs (eg. streetlights, stormwater drains, road lengths) remain relatively constant irrespective of density. Therefore even though total internal servicing costs in higher density developments increase with population density, the ability to share costs between a greater number of home-buyers results in lower unit costs.

There is however, obviously a trade-off between the density and cost advantages of smaller erven (ie. in the region of 75-100 sq m), and the greater flexibility of site layout and plot use resulting from larger erven (ie. in the region of 200-300 sq m). The range of erf sizes provided in a layout plan have a significant impact on the mix of land use activities and the range of housing processes that can be initiated and facilitated.

By integrating larger erven with smaller erven, layout plans accommodate commercial and industrial activities that are compatible with residential uses, commercial and service enterprises that operate from residential erven, and a range of housing processes and housing types.

TABLE 11: Main Advantages and Disadvantages of Smaller and Larger Erven

SMALL ERF		
Characteristic:	*	Erven are about 100 square metres
Advantages:	*	Raw land costs are generally lower
	*	Smaller plots increase the supply of land for housing in an area
	*	Result in higher residential densities which make shops and public transport services more viable
	*	Reduce the cost of servicing because service runs per erf are shorter
Disadvantages:	*	Limited opportunity for the expansion of buildings
	*	Limited opportunity for the provision of cheaper on-site services like aqua-privies

LARGE PLOT		
Characteristic:	*	Plots are about 200 to 500 square metres
Advantages:	*	More open space available for playing, growing food or keeping pets
	*	More open space available for running home businesses
	*	Opportunity to provide additional rooms or backyard shacks for rental
	*	Wider range of house types can be built on the site
	*	Enables the provision of cheaper on-site services like VIP latrines
Disadvantages:	*	Land costs are higher
	*	Servicing cost are higher
	*	If subletting and sharing does not occur, can result in lower residential and population densities which are insufficient to support shops and efficient public transport services

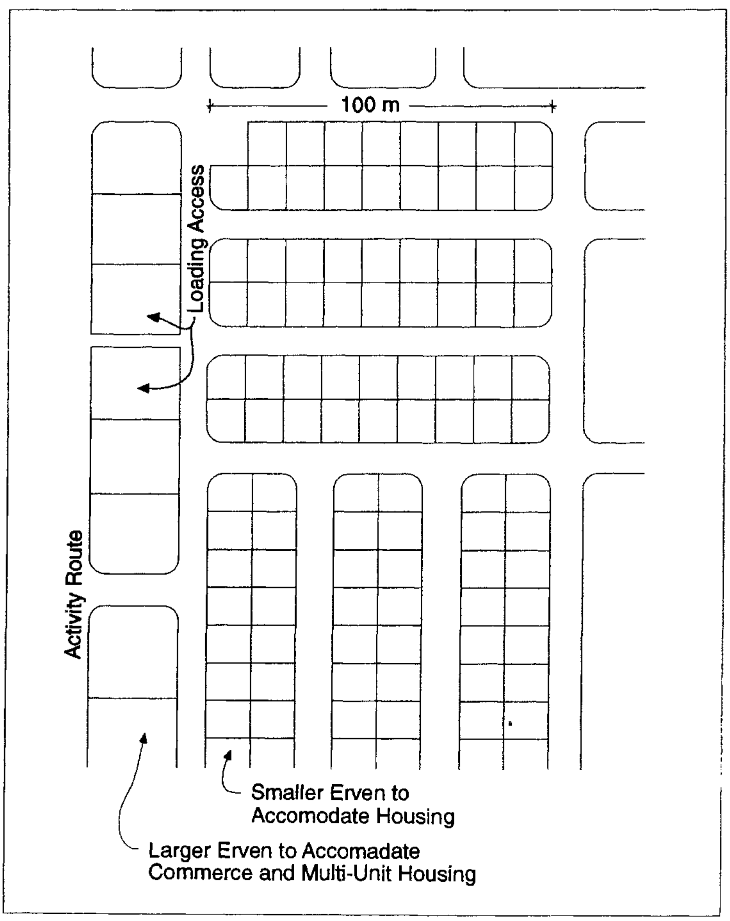


FIGURE 35: Diagram Illustrating the Integration of a Range of Erf Sizes Accommodating a Mix of Small-Scale Retail, Manufacturing and Residential Land Uses

In the case of erven accommodating commercial and industrial activities, the appropriate size and location of erven depends on the scale, nature and compatibility of the anticipated commercial and industrial activity, and their access and distribution requirements. For instance, larger scale commercial activity other than shopping centres, will generally require erven in central locations with direct frontage to higher order roads and convenient pedestrian access to public transport services. Larger industrial activity will generally require good access to rail infrastructure, distributor routes and public transport, and smaller scale manufacturing activities will generally require close proximity to each other.

In the case of erven accommodating a range of housing processes and housing types, the appropriate size and location of erven should reflect the diverse range of housing needs of the end-user community. Decisions regarding erf size are influenced by the number of people who will live on the erf and the type of housing that is to be built.

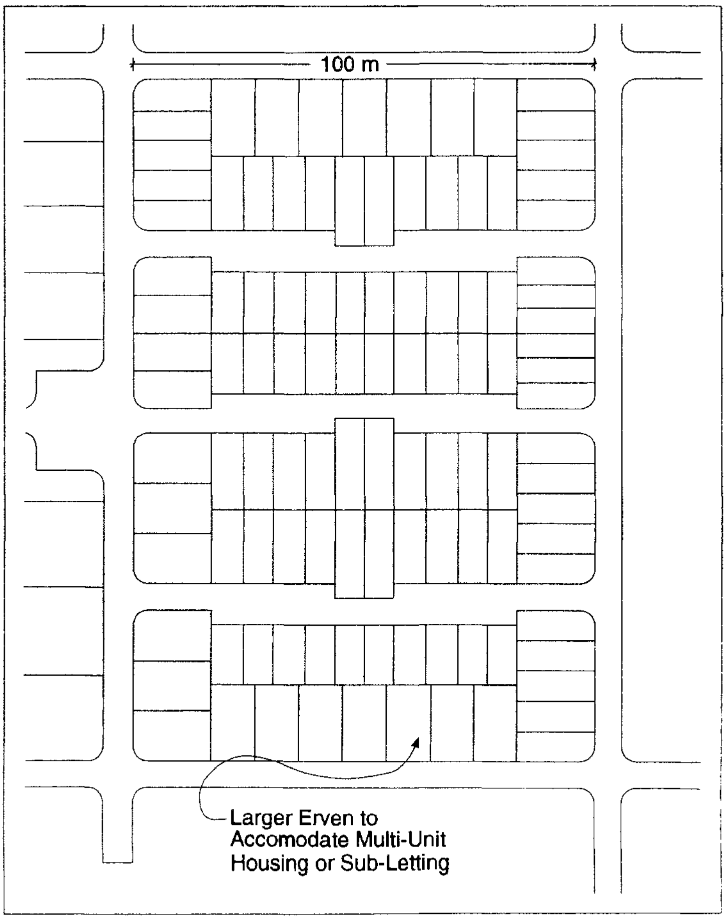


FIGURE 36: Diagram Illustrating the Integration of a Range of Erf Sizes Accommodating Different Housing Processes

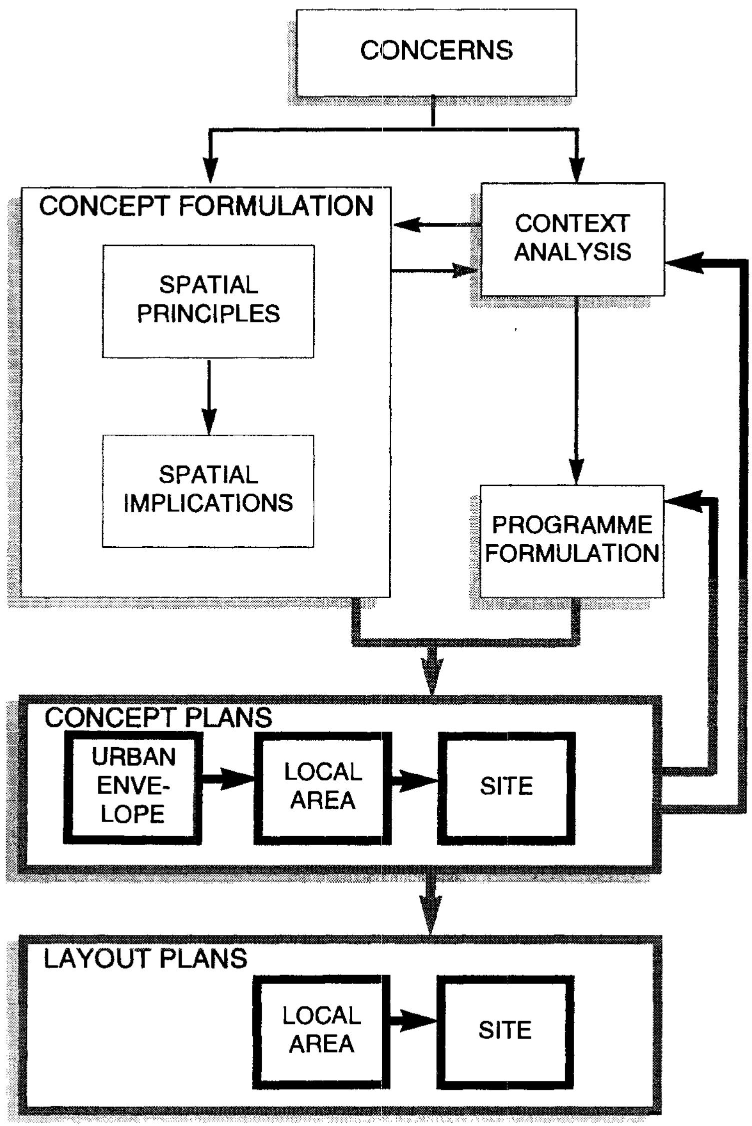
Erf size and shape should be designed in close coordination with the design of dwellings, and with paths for incremental building in the case of starter dwellings. A variety of housing forms and housing processes should be accommodated, ranging from multi-unit rental accommodation, to an individual household consolidating an erf with a basic level of services, to a household using a larger fully serviced erf as a source of income by subletting additional dwellings.

As it is difficult to predict with any level of accuracy what housing needs are likely to be, and housing forms in lower income environments in any event tend to change (eg. houses are expanded or sublet), flexibility in erf size and shape should be allowed in order to offer user households a choice.

A further determinant of erf size is the choice of sanitation service. When on-site sanitation services are provided, erf sizes should maintain adequate environmental and health conditions. On-site sanitation generally requires minimum erf sizes of 200 sq m.

Section 5:

Elements of Layout Infrastructure



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Section 5:
Elements of Layout Infrastructure

This section (1) identifies the range of infrastructural elements within the layout plan, and (2) discusses their functions, service options and implications for layout planning.

Whereas sections 3 and 4 of the handbook correspond closely to the stages of the layout planning process set out in section 2, this section is intended primarily as reference material for town planners. The purpose of the section is to discuss the implications that different engineering services have for layout planning in order to ensure that the provision of these services (either initially or over a period of time) is facilitated by the layout plan, and to assist the type of interaction between professionals called for in section 2. A concern for efficient service provision must be considered together with other social, economic and environmental concerns in layout planning. Parts 9 and 10 of this section, which discuss public spaces and markets, are intended to inform town planners' interactions with urban designers, and those involved in market provision.

Water supply, sanitation, roads, stormwater disposal, energy supply, public lighting, solid waste removal, communications, public spaces, and markets are identified as the elements of layout infrastructure. The service options identified for these elements are not exhaustive, but are sufficiently comprehensive to represent the broad range of service technologies available.

The term 'services' in South Africa is generally used to refer to water supply, sanitation, roads, stormwater drainage, solid waste removal, public lighting and electricity. A criticism of this interpretation of 'services', raised earlier, is however that the more collective functions of services, regarding street trading, small scale manufacturing, social interaction and recreation, tend to be ignored. For the purposes of this section therefore, the term 'services' is expanded to include the provision of communication systems, public spaces, and public markets, as well as the more conventional services mentioned above.

While elements within communication systems, public spaces, and public markets are sometimes either a combination of utility services, or more public facilities than utility services, they do form part of the basic infrastructure around which the consolidation of residential, commercial, industrial and public buildings occurs. These services are therefore considered essential in ensuring that the collective, as well as the residential, functions of basic infrastructure are facilitated.

1. Water Supply

1.1 Functions

The residential functions of a domestic (as opposed to agricultural or industrial) water supply service are essentially to provide a reliable and adequate supply of potable water for basic drinking, cooking, personal hygiene and clothes washing needs, as well as for less essential needs like garden watering, car washing, swimming pools, etc. At a minimum an amount of 25 litres of water per person per day is needed - at the other extreme, many South African households use 450 litres per person per day.

The collective functions of a domestic water supply service relate more to the provision of water in public places, like markets or squares abutting mosques, for washing, food cleansing, drinking and fire fighting purposes.

The main benefits of an effective water supply service are a reduction in health and safety risks, and a reduction in the time spent collecting water.

1.2 Service Options

Water supply services can be provided in the following ways:

TABLE 12: Summary of Water Supply Options

ON-SITE SUPPLY	1.	House Connection (High Consumption)
	2.	House Connection (Normal Consumption)
	3.	Yard Tap
	4.	Yard Tank
COMMUNAL SUPPLY	5.	Public Standpipe
	6.	Public Water Tanker
	7.	Water Kiosks

Notes:

1. The consultants who identified water supply service options (Palmer Development Group and Ulli Bleibaum Associates) felt that of the options presented, public water tankers and water kiosks were an inadequate form of provision.
2. Assumptions regarding consumption rates are as follows: house connection (HC) = 350 l/cap/day, house connection (NC) = 250 l/cap/day, yard tap = 120 l/cap/day, public standpipe = 50 l/cap/day.

1.2.1 *House Connection (High Consumption)*

House connections refer to the in-house supply of reticulated water. It is the conventional water supply service provided in the developed urban areas of South

Africa. House connections are normally metered. The amount of water that is used by households under this supply option is highly variable, the anticipated volume of which affects the designed capacity and the cost of the reticulation network - this option assumes high consumption (350 l/cap/day).

1.2.2 *House Connection (Normal Consumption)*

As in the above option (1.2.1), house connection refers to the metered in-house supply of reticulated water. The amount of water used by households in this option is assumed to be normal consumption (250 l/cap/day).

1.2.3 *Yard Tap*

Yard taps refer to a single tap on an erf, standing outside the house. In site and service schemes the tap is generally mounted on the outside wall of the toilet privy. This option requires full water reticulation, but the demand per erf can be relatively low (± 120 l/cap/day). Yard taps can be metered. Over time, average usage usually increases - there is generally no constraint on households making house connections which generally implies greater water use per person.

1.2.4 *Yard Tank*

Yard tanks refer to a tank on an erf into which water is delivered, and from which the household draws. Until recently yard tanks (± 200 l) were considered primarily as a way of reducing the peak flow provision for reticulation design. This concept implies that the flow rate into the tank is limited by some device and the tank therefore acts as a balancing tank. More recently, the option of a yard tank is being considered more from the point of view of cost recovery, where a water bailiff collects the charge per tank on a daily round and opens the valve to fill the tank.

1.2.5 *Public Standpipe*

Public standpipes refer to a water supply point shared by a number of households. The key issue in terms of level of service is the number of households (or erven) per standpipe, and the distance to be walked to the standpipe. In planning new supplies for urban areas, a generally recognized minimum is one standpipe per 25 households, with a maximum walking distance of 100 m. With standpipes at 1:25, expected use is ± 25-50 l/cap/day. The issue of cost recovery is problematic, as it is usually not possible to clearly identify who uses water and how much is used.

1.2.6 *Public Water Tanker*

Public water tankers refer to a supply agency delivering water to the erf by tanker, and discharging it into a drum or other container, on site. This is generally used as an interim or emergency service option only, with little or no cost recovery. Water tankers are applicable to situations where there is no reticulation and it is too far for people to walk to get water. The term 'water vending' is essentially a private sector equivalent of public water tankers.

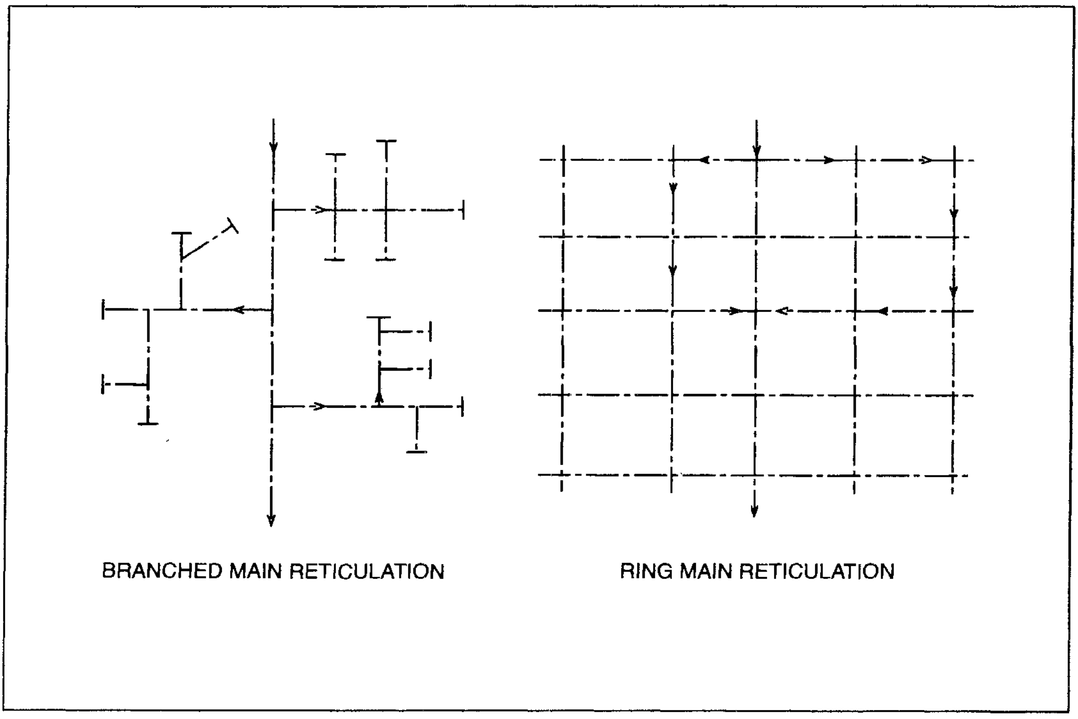
1.2.7 *Water Kiosks*

Water kiosks refer to the selling of small quantities of water in fixed locations. Kiosk systems are generally set up by supply agencies, which contract kiosk owners to sell water. This is a fairly low and expensive level of service, as the need for the kiosk owner to make a living dictates that the number of households per kiosk is about 100, and the price of water is high (± 5-8 c/25 l).

1.3 Reticulation Options

Road and block layouts define the basic pattern of a water reticulation network. The layout decisions that are taken by the design engineer relate to the choice of a branched or a ring main reticulation system, and the choice between street and mid-block locations for water pipes.

FIGURE 37: Water Reticulation Options



The advantages and disadvantages of mid-block and street reticulations have been discussed in section 4 of the handbook (part 4.2).

1.3.1 *Ring Main Reticulation*

In ring main water reticulation systems, all pipes are inter-connected into a network. In the event of pipe breakage, all households can therefore be supplied with water from either end of the road. For this reason ring main reticulations are generally considered best.

1.3.2 *Branched Main Reticulation*

In branched main water reticulation systems, the interconnection of pipelines at their ends is not required, and roads are therefore supplied with water from one end only. Valves need to be provided in the reticulation at intervals to allow a section where a break has occurred to be isolated. If a the pipe breaks, none of the users further up the line can be served. Due to the fact that branched networks require fewer valves and marginally shorter pipe lengths, this option is less costly (by $\pm$ 5%) than ring main networks.

1.4 Comparison

The main advantages and disadvantages of different water supply service options are presented in table 13. The options have been listed in terms of decreasing levels of costs - as a general rule, services become more convenient as the cost of provision increases.

TABLE 13: Main Advantages and Disadvantages of Water Supply Options

HOUSE CONNECTION		
Characteristics:	*	Piped water supply to taps inside the house
	*	Metered water use
Advantages:	*	Taps are inside the house
	*	More than one tap can be connected
	*	Appliances can be connected
Disadvantages:	*	High initial and ongoing costs - household must maintain on-site taps and pipes at own cost, which is expensive as skilled labour is required
	*	Requires wastewater disposal system
	*	Greater water use increases impact on environment - as more water is extracted from, and more wastewater absorbed by, the environment
YARD TAP		
Characteristics:	*	Piped water supply to a tap standing outside the house
	*	Metered water use
Advantages:	*	Generally uses less water than house connection

	*	Less water use reduces impact on environment
Disadvantages:	*	Water has to be carried into the house from outside for cleaning and cooking purposes, which is inconvenient
	*	Requires wastewater disposal system
YARD TANK		
Characteristic:	*	Water tank on site which is filled by a piped network
Advantages:	*	Generally uses less water than house connections
	*	Less water use reduces impact on environment
	*	Can reduce water demand during peak hours
Disadvantages:	*	Health risk if tank stands open for periods of time
	*	Inconvenient if tank is not filled regularly
	*	Water use is partially constrained as there is a limit to the amount of water that can be used at any one time
PUBLIC STANDPIPE		
Characteristics:	*	Piped water supply to a street tap which is shared by a number of households
	*	Non-metered water use
Advantages:	*	Low initial costs per household
	*	Easy to operate and maintain
	*	Low water use reduces impact on environment
Disadvantages:	*	Inconvenient as water has to be carried over long distances at times
	*	Time consuming if queuing is necessary
	*	Lack of individual ownership can lead to water wastage - can also lead to disputes regarding cost recovery, who uses water, and how much
PUBLIC WATER TANKER		
Characteristics:	*	Delivery of water by tanker
	*	Water delivered to on-site containers or collection points
Advantages:	*	Option in cases where there is no piped water network
Disadvantages:	*	Ongoing costs are high as water has to be transported in special vehicles
	*	Water can be expensive to buy because of high operating costs
	*	Water has to be carried into the house from outside or from the collection point - normally it is women and children who have to do this

1.5 Implications for Layout Planning

The main implications of domestic water supply services for layout planning, relate to road and block layout, the location of public standpipes, public facility location, and road reserve width.

(1) The ideal layout for water reticulation is a grid pattern with long straight blocks, in which narrow rectangular erven run perpendicular to the road - the positioning of valves can be arranged at the ends of blocks. This layout configuration yields relatively short pipeline lengths and straight trenches. The

slope of the road is not as critical for water reticulation, as with gravity services.

(2) Public standpipes tend to be meeting places and therefore adequate space is required around them. At a ratio of one standpipe per 25 erven this is less important as the numbers of people using the facility are insufficient to generate queues - in this situation standpipes are normally located on the edge of a road reserve. As standpipe density decreases however, the numbers of people using each standpipe increases, queuing increases and the probability of people washing at standpipes increases. Here more space is required and the standpipe as a meeting place needs to be considered - a safe location with shade and seating should be sought, and an arrangement with several draw-off points and washing slabs draining to a soakaway should be considered.

(3) The cost of water reticulation systems is substantially affected by fire fighting requirements. This is due to the fact that fire fighting draw-off is usually seen as an extra, over normal domestic demand, and the flow rates required at the point of extraction are high. If costs are to be minimised, the issue of water for fire fighting in low-income settlements is obviously an important one. Fires often occur in these areas as inflammable fuels are used and wooden building materials are common. In situations where reticulation to residential areas is not designed for additional fire fighting flows, public facility buildings like schools and community halls should be located along major routes where larger water supply ring mains are likely to be located. Generally watermains with a diameter of 90 mm or greater will have sufficient capacity to serve a fire hydrant. Residential areas are then served by smaller, more maneuverable fire vehicles, backed up by large fire vehicles - depending on the severity of the fire.

(4) If watermains are run in the road reserve, beneath the footway, a width of 0,7 m is needed on one side, to allow for a trench to be excavated without disturbing the roadway or the boundary wall of a property. In constrained situations pipes can be run under the roadway.

2. Sanitation

2.1 Functions

The residential functions of a sanitation service are essentially to remove sewage (ie. body wastes) and sullage (ie. liquid household wastes) from a site in a way which minimises health risks, to convey these wastes to a point where they can be treated, and to treat wastes so that they can be returned to the environment in a sustainable manner.

The collective functions of a sanitation service relate more to the provision of public toilets in public places like markets and public transport modal interchanges.

The main benefits of an effective sanitation service are convenient access to toilet facilities, and a reduction in health and pollution risks. Excreta related diseases are estimated to cause over 10 000 deaths in South Africa per year, most of which are caused by gastroenteritis (or diarrhoea) which is associated with faecal-oral bacterial transmission.

2.2 Service Options

Sanitation services can be provided in the following ways:

TABLE 14: Summary of Sanitation Service Options

OFF-SITE SANITATION	1.	Full Flush Toilets
	2.	Intermediate Flush Toilets
ON-SITE SANITATION	3.	Aqua-Privy (LOFLOS)
	4.	Pour-Flush Toilet
	5.	VIP Latrine
OTHER SYSTEMS	6.	Chemical Toilets
	7.	Bucket Collection
	8.	Communal Toilets

Note:

1. The consultants who identified sanitation service options (Palmer Development Group and Ulli Bleibaum Associates) felt that of the options presented, chemical toilets, bucket collection and communal toilets were an inadequate form of provision for permanent use, because they either provide inadequate heath protection or they are socially unacceptable.

2.2.1 *Full Flush Toilets*

Full flush toilets refer to 'water closets' generally connected to waterborne sewerage. The flush volume has conventionally been 12-20 l, but newer designs are available which use 8-12 l. A full flush toilet can be connected to a septic tank-soakaway, a septic tank-solids free (or small-bore) sewer and a conservancy tank, as well as to conventional waterborne sewerage. Waterborne sewerage can take the form of conventional street sewers, mid-block sewers, shallow or *condominiale* sewers, and curvilinear sewers.

2.2.2 *Intermediate Flush Toilets*

Intermediate flush toilets are essentially the same as full flush toilets above (2.2.1), only flush volumes are lower. The flush volume is 3-6 l. They have the obvious advantages that less water is used, and the toilet can be used in a house in the conventional way.

2.2.3 *Aqua-Privy (LOFLOS)*

Aqua-Privy (low flush, on-site) refers to an on-site digester and soakaway, with a pedestal and privy on top of it. An aqua-privy requires small volumes of water, to keep the digester full and maintain a water seal at the pedestal. Because of the low flush volume (1 l or less), a reticulated water connection is not necessarily required and the flushing tank can be filled with a bucket from a public standpipe once every one or two days.

2.2.4 *Pour-Flush Toilets*

Pour-flush toilets refer to a pedestal with a simple water seal connected to a closed on-site pit. After use, the pedestal is flushed either by hand with a bucket, or by a low volume flush arrangement similar to that used in aqua-privies above. The flow goes into the pit for treatment.

2.2.5 *Ventilated Improved Pit Latrine*

Ventilated improved pit (VIP) latrines refer to a pedestal within a privy, directly over a closed on-site pit. The key innovations of the VIP, over conventional pit latrines, are its ventilation and fly control arrangements. The pit is provided with a liner (where necessary), a properly constructed substructure, and a vent pipe with a fly screen at its outlet which rises to a point above the roof of the structure. The liner serves to prevent the collapse of the pit and is porous in order to allow liquids to pass into the ground. Some sullage can be thrown into the pit, but where larger volumes are expected (over ± 5 l/day) and soils are impermeable, a separate soakaway may be necessary. The volume of the pit is dependant on the length of time required between emptying, with 1,5 m^3 being commonly selected. In urban areas, the pumping of pits generally occurs at ± 5 year intervals.

2.2.6 *Chemical Toilets*

Chemical toilets refer to an off-site, non-reticulated sanitation service, normally used where temporary sanitation services are required for relatively short periods of time (eg. construction sites, carnivals etc.). They have also been used as 'emergency' sanitation in some low-income urban areas. Chemical toilets are not considered as a long term, permanent sanitation service, due mainly to their high cost.

2.2.7 *Bucket Collection*

Bucket collection refers to a bucket placed below a simple pedestal within a privy, with the bucket being emptied at regular intervals by a local authority (generally twice a week but sometimes once a week). In order to empty the buckets, they have to be removed and carried to a tanker truck into which they are emptied. Generally the bucket is then replaced with a clean one. The tanker then transports the waste to a treatment works. The disadvantages of bucket collection include no provision of an odour and fly access barriers, no capacity to deal with functions where numbers of people gather at a house, and the health risks associated with carrying full or near full buckets of excreta.

2.2.8 *Communal Toilets*

Communal toilets refer to flush toilets shared by a number of households, where either one toilet is shared between adjoining households or a toilet block is provided. The key issue in terms of level of service is the number of households (or erven) per toilet, and the distance to be walked to the toilet. Communal toilets are suitable for temporary use where it is not possible to provide anything else. Their disadvantages include social conflict between neighbours relating to freedom of access, privacy and responsibility for cleaning, and substantial reticulation and external services provision out of proportion with the convenience to users.

2.3 **Reticulation Options**

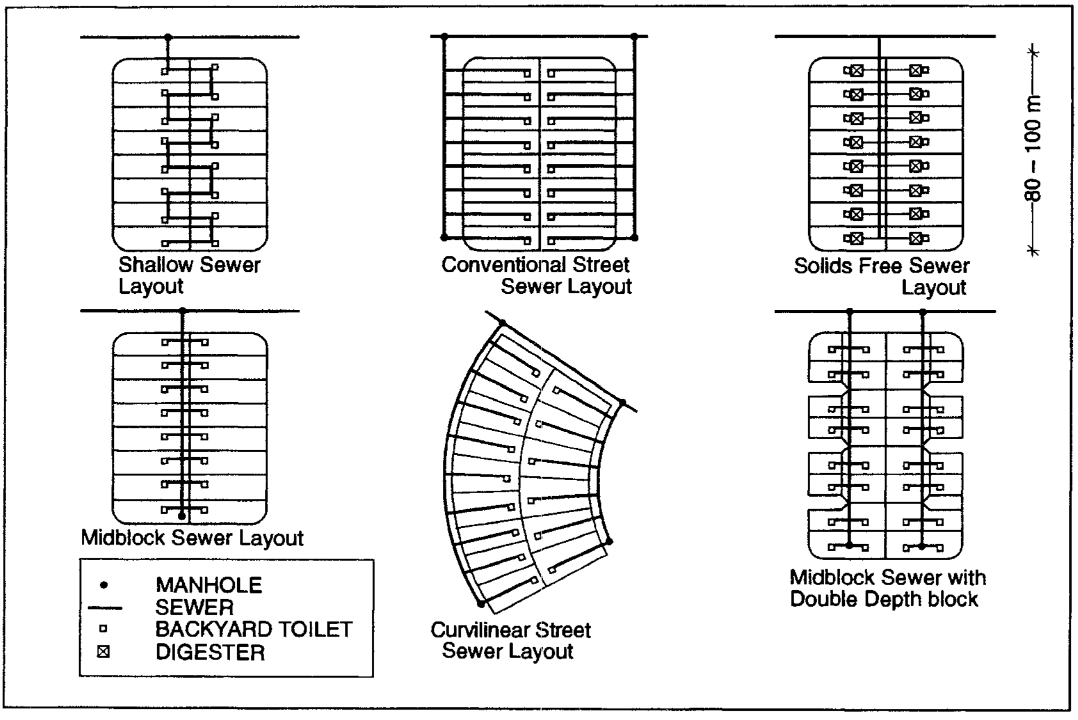
Sewers are not designed to flow under pressure, and conventionally, flow partially full with an open surface in the pipe. They are sized to take the necessary flow at the best gradient which can be achieved. Road and block layouts define the basic pattern of a sewerage network. The layout decisions that are taken by the design engineer relate to the choice of a either conventional street, mid-block, shallow, solids free or curvilinear sewer reticulations. Mid-block, shallow, solids free and curvilinear sewers all represent attempts to reduce the cost of a conventional street sewerage network.

2.3.1 *Conventional Street Sewers*

Conventional street reticulations are a hierarchical network of sewers in the road reserve. The system is made up of on-site sewers ($\pm$ 100 mm diameter), street sewers ($\pm$ 100-150 mm diameter) in the road reserve, collector sewers which do not take erf connections, and outfall sewers which convey sewage to a treatment works. Where it is not possible for flow to reach treatment works under gravity, pumping stations and rising mains (pressure pipes) are provided. Street sewers are provided with manholes for maintenance purposes.

Sewer reticulation in the road reserve is generally preferred by local authorities for maintenance reasons - it is easier to get access to street sewers and erf connections if blockages occur. This is outweighed to some extent by the need to run erf connections below streets. Although there are maintenance advantages with street sewers, the capital cost of a street sewer system is generally higher than a mid-block system. The advantages and disadvantages of mid-block and street reticulations are discussed in section 4 of the handbook (part 4.2).

FIGURE 38: Sewer Reticulation Options



2.3.2 *Mid-Block Sewers*

Mid-block reticulations run sewers between erven, in the middle of blocks, before connecting to collector and outfall sewers. Mid-block sewer reticulations, particularly in flat to undulating terrain, have often been favoured because excavation depth can be reduced, erf connections to the rear of erven are shorter, and lighter manhole construction is possible.

2.3.3 *Shallow Sewers*

Shallow sewer reticulations run from erf to erf within a block, and are generally laid at flatter grades and shallower depths than conventional sewers. Shallow sewers reduce costs by reducing cover over pipes, and thereby the depth of trenches and manholes -

they are particularly cost effective where intermediate and hard rock has to be excavated. Pipe integrity is maintained by using a higher class pipe or some external protection such as concrete slabs. This concept has not been used extensively in South Africa.

A form of shallow sewers, in Brazil, known as *condominiale* sewers, represent a community based approach to sanitation. A collector sewer is provided by the authority, and site connections are then made by groups of households who lay and maintain sewers themselves.

2.3.4 *Curvilinear Sewers*

Curvilinear sewer reticulations relate to the way a sewer is laid, rather than its location in relation to erf boundaries. Curvilinear sewers consist of either a series of straight pipes which are kinked at the joints, or a series of curved lengths of pipe. They reduce the need for manholes in situations where straight sewer runs are not possible - this generally occurs in steep terrain where sewers need to follow contours. Manholes are eliminated by introducing curvilinear sewers where changes in horizontal or vertical sewer direction would normally require a manhole. In general, a minimum curve radius is 30 m - this relates primarily to the extent to which pipes can be kinked at their joints.

2.3.5 *Solids Free Sewers*

A solids free, or small bore, sewer reticulation system has a digester tank on the erf. Only liquid effluent is carried in the reticulation system - hence pipes can flow full, reduced flow velocity requirements enable flatter and shallower pipes, the number of manholes for maintenance purposes can be reduced substantially, and peak flows are lower due to the attenuation effect of the digester tank. The solid effluent, remaining in the digester, is emptied periodically. This form of sewer reticulation is particularly suited to hilly or very flat areas.

2.4 Comparison

The main advantages and disadvantages of different sanitation options are presented in table 15. The options have been listed in terms of decreasing levels of costs - as a general rule, services become more convenient as the cost of provision increases.

TABLE 15: Main Advantages and Disadvantages of Sanitation Options

FULL-FLUSH TOILET		
Characteristics:	*	Toilet connected to sewer network
	*	Toilet flushed by cistern
Advantages:	*	Low health risks

	*	Water seal reduces smell
	*	No concern for waste after flushing
Disadvantages:	*	High initial and ongoing costs
	*	Requires piped water supply to site
	*	Requires expensive and sophisticated bulk and link infrastructure
	*	Increases water use
	*	Environmental impact is serious if wastewater is not properly treated
INTERMEDIATE FLUSH TOILET		
Characteristics:	*	Toilet connected to sewer network
	*	Toilet flushed by a cistern using less water
Advantages:	*	Low health risks
	*	Water seal reduces smell
	*	No concern for waste after flushing
	*	Less water used in flushing
Disadvantages:	*	High initial and ongoing costs
	*	Requires piped water supply to site
	*	Requires expensive and sophisticated bulk and link infrastructure
	*	Low flush volume has difficulties in dealing with heavier anal cleansing material
	*	Environmental impact is serious if wastewater is not properly treated
AQUA-PRIVY		
Characteristics:	*	Toilet connected to an on-site septic tank and either a soakaway or sewer
	*	Toilet flushed by a cistern using little water
Advantages:	*	Piped water connection is not necessary as water can be poured into cistern manually
	*	Uses little water which reduces ongoing costs
	*	Water seal reduces smell
Disadvantages:	*	Flush water has to be carried if no piped water supply
	*	Regular septic tank emptying is necessary
	*	Soakaway blockage can pollute groundwater and be a health risk
POUR-FLUSH TOILET		
Characteristics:	*	Toilet connected to a covered on-site pit
	*	Toilet flushed by bucket
Advantages:	*	Low initial cost to install
	*	Piped water connection is not necessary
	*	Water seal reduces smell
	*	No off-site sewers required
Disadvantages:	*	Flush water has to be carried
	*	Regular pit emptying by tanker is necessary
	*	Soakage from pit can pollute groundwater and be a health risk
VIP LATRINE		
Characteristics:	*	Toilet directly over an on-site pit outside the house

	*	Toilet is not flushed - once the pit is full it has to be emptied or a new pit must be dug
Advantages:	*	Low initial and ongoing cost
	*	Better ventilation and fly control than conventional pit latrines
	*	No off-site sewers required
Disadvantages:	*	Toilet has to be outside the house to enable the emptying process
	*	Regular pit emptying is necessary
	*	Soakage from pit can pollute groundwater and be a health risk
	*	Difficult to upgrade to a flush toilet as the pit has to be removed, a new pedestal installed, and a sewer system connected
BUCKET COLLECTION		
Characteristics:	*	Removable bucket provided by the local authority placed below a toilet seat, outside a house
	*	Buckets emptied into collection trucks by local authority on a regular basis
Advantages:	*	Low initial cost as no sewerage or piped water has to be connected
	*	Labour intensive - could therefore provide jobs
Disadvantages:	*	High ongoing cost - service charges and upgrading
	*	Requires regular truck collection at least twice a week which adds to service costs
	*	Potential health hazard to users and collectors as waste can be spilled from full buckets
	*	Has no control of smell or flies
	*	Cannot cope when numbers of people gather for a function

2.5 Implications for Layout Planning

The main implications of sanitation services for layout planning, relate to road and block layout, the location of sanitation facilities, road reserve width, and erf dimensions.

(1) The ideal layout for conventional sewer reticulation is a grid pattern with straight blocks of 80-100 m, in which narrow rectangular erven run perpendicular to the road - this minimises manhole requirements and pipe length per erf. In the case of curvilinear sewers, lengths of road with curve radii of less than 30 m should be avoided. Section 5 (part 1.2.3) of the handbook discusses the requirements for manholes within a reticulation network in greater detail.

In steep and undulating terrain, where normal sewer reticulation is difficult, solids free sewers and on-site sanitation become more viable. In these situations, road and block geometry have less impact on the provision of sanitation services.

(2) If communal toilets have to be used they are best located at the end of a block as this will allow sewer reticulation to be minimized, as sewers would not be needed in longitudinal streets. There is no recognized standard for walking distance, but 50 m would seem reasonable. This would be fairly consistent with 100 m block lengths and 20 erven per communal toilet block.

The location of treatment works is governed primarily by topography as, if pumping is to be minimized, the works needs to be downslope of the area being drained. Also the works needs to discharge to a river and therefore it is often placed close to the bank of a river, at the downstream side of the settlement. An important issue from a planning point of view is then the distance from the works to the nearest residential erven, taking odours into consideration - as a rule of thumb, residential erven should not be closer than 500 m from a treatment works.

(3) If sewers are run in the road reserve, beneath the footway, a width of 1,0 m is needed on one side, to allow for a trench to be excavated without disturbing the roadway or the boundary wall of a property. Sewers can be run under the roadway or in the mid-block.

(4) For on-site sanitation services, in the form of pit latrines and aqua-privies, minimum erf sizes are in the region of 200 sq m (or a somewhat higher figure if the sites are steep). VIP latrines can be used on smaller sites, but this brings substantial limitations for building on the site, and access for pit emptying becomes increasingly difficult. Soakaways and pits should ideally be located 2 m away from buildings.

In the case of solids free sewers, space requirements on site are not as severe as for pits and soakaways - an area of about 6 sq m should be left for the digester tank, and adequate access to this tank by a vacuum tanker should be provided for. Modern equipment will allow for a horizontal pumping distance of up to 60 m but this is strongly influenced by pumping (suction) head. The equipment can only deal with a suction head of about 6 m - this means that the level between the bottom of the pit or digester and the top of the vacuum tanker can not exceed 6 m. The lower the tanker can be in relation to the pit or digester, the greater the distance which can be pumped. On sloping sites the above constraint normally requires that the vacuum tanker positions itself on the street below a block and empties the pit or digester on both of the erven in the block above it and not the erven below it. This has implications for layout, as erven on the lowest edge of an area being planned may need special access.

3. Roads

3.1 Functions

Different types of roads perform different combinations of functions. The residential functions of roads are essentially to facilitate the access of people, goods and services to and from residential erven through a variety of modes (including foot and bicycle movement), and to provide space for utility services under the roadway and within the road reserve.

The collective functions of roads relate more to the facilitation of through-traffic circulation, the accommodation of economic activities, and the provision of open space for recreation and community interaction.

The main benefits of an effective road network are easy access throughout an urban area, the regular provision of road-based public services (eg. public transport, solid waste collection, etc.), and the provision of multi-functional urban space.

3.2 Service Options

TABLE 16: Summary of Road Options

PAVED SURFACES	1.	Concrete Paving
	2.	Brick Paving
	3.	Hyson-cells
ASPHALT SURFACING	4.	Premix
	5.	Sand Asphalt
SURFACE TREATMENTS	6.	Double Seal
	7.	Sealmac
	8.	Single Seal
	9.	Slurries
GRAVEL/EARTH ROADS	10.	Gravel Additives
	11.	Gravel Wearing Course
	12.	Soil-Cement
	13.	Earth Street

Note:

1. The following traffic volumes (measured in vehicles per day - v/d) are appropriate: earth and soil cement = 50 v/d; gravel wearing course = 500 v/d; gravel additives and slurries = 1 000 v/d; single seal, sealmac, sand asphalt, hyson cell and brick/concrete paving = 2 000 v/d; double seal and premix = 10 000 v/d.

Roads are made up of a combination of a surface and a structure - the particular combination depending primarily on anticipated vehicular traffic volumes (expressed in vehicles/day). High volumes of heavy traffic warrant a significant structure, while low traffic volumes can be accommodated on relatively thin or no structures. Of the two components, road surfacing has a lower capital cost but will require maintenance, while road structure has a higher capital cost and relatively less maintenance cost. Surfacings are fairly easily and quickly replaced while replacement of the structure is costlier, takes longer and therefore causes greater inconvenience.

Road surfaces on granular, waterbound macadam, bitumen treated or emulsion treated pavement structures, can be provided in the following ways:

3.2.1 *Concrete Paving*

Concrete paving refers to interlocking, 50-80 mm thick concrete paving blocks. The blocks form part of the road structure, and the underlying pavement layers may therefore be reduced. Concrete blocks do not provide a smooth, even ride, and are therefore suitable for slow moving low to medium volume traffic. Concrete paving lends itself to labour intensive construction, and blocks provide an opportunity for design variety through the use of different colours and textures.

3.2.2 *Brick Paving*

Brick paving has most of the features of concrete paving above, except the interlock. For a comparable concrete block pavement, brick paving may require a slight increase in structural layer thickness to compensate for the lack of interlock. Burnt clay bricks generally have a rougher surface than concrete blocks. However, since this type of surfacing is suitable only for slow moving traffic, the rougher surface is not of much consequence.

3.2.3 *Hyson-cells*

The Hyson-cells system uses a large 3-dimensional mat of rectangular hollow plastic geocells as in-situ formwork, to cast a matrix of closely nested, jointed interlocking blocks. The cells are filled with a stone and cement/sand grout. Pigments can be used for variety. The surface of the completed roadway must be brushed to provide adequate skid resistance. Cell depths of 50 mm and 75 mm are available for residential use and 100 mm and 150 mm for heavy duty use. The surfacing in this case contributes to the road structure and appropriate reductions in a conventional pavement structure can be made. The system is labour intensive and can use suitable local materials.

3.2.4 *Premix*

Premix refers to a mix of graded stone chips and a bituminous binder. The mix is applied hot to a prepared base in a 20-40 mm layer - when layers are 40 mm and thicker, the surfacing contributes to the structural strength of the pavement. Premix provides a smooth, dense finish with a good riding surface, suitable for high traffic volume applications in excess of 10 000 vehicles/day. While the initial capital cost is high, premix will generally outlast other types of surfacing on a traffic volume basis. The expected life is between 9-14 years and overlays can be applied with minimum inconvenience to the road user.

3.2.5 *Sand Asphalt*

Sand asphalt refers to a mix of graded sand and a bituminous binder. The mix is applied hot to a prepared base in a 20-30 mm layer. Sand asphalt provides a smooth, even finish with a smooth riding surface, suitable for low traffic volume situations. Edges require a positive edging or kerb to prevent the edge of the surfacing from breaking off under traffic action. The expected life of a sand asphalt is 2-8 years.

3.2.6 *Double Seal*

Double seals refer to two layers of stone chips with a bituminous binder. This form of treatment may be used for roads with traffic volumes of 4 000-10 000 vehicles/day. Larger aggregate is used for higher traffic volumes. Resealing with smaller stone chips can be carried out with minimum inconvenience to the road user. The expected life of a double seal is 8-13 years.

3.2.7 *Sealmac*

The Sealmac concept involves the strengthening of the pavement layers by a non-woven geotextile, laid in conjunction with a bitumen tack coat, and constructing a conventional seal over it. This method is particularly suited for upgrading of existing pavements, but may also be used for new work where only substandard granular material is available.

3.2.8 *Single Seal*

Single seals refer to a layer of stone chips with a bituminous binder. The purpose of the seal is to waterproof the underlying pavement layers and to provide an all weather, dust-proof surface. This form of treatment is suitable for low to moderate traffic volumes (± 2 000 vehicles/day). Provided the structural layers are adequate, the road can be resealed or even upgraded with an asphalt overlay, should this be required. The expected life of a single seal is 8-11 years.

3.2.9 *Slurries*

Slurries refer to a mixture of sand, cement, bitumen and water. They can be placed directly on a gravel base as a seal to protect the gravel in the form of a thick (10 mm) or thin (3-5 mm) slurry for low volume roads (2 000 vehicles/day), or they can be used to enhance the riding quality of other surfaces (eg. a thin slurry layer may be applied to a single seal to just cover the tops of the stones for a smooth surface, or to only partially fill the voids between the stones to provide better skid resistance). The expected life of a slurry is 2-8 years.

3.2.10 *Gravel Additives*

Gravel additives refer to dust palliatives (chemical or bituminous agents) mixed into the upper layer or sprayed onto the surface of the gravel wearing course to bind the finer particles of the gravel. This reduces dust. Sulphonated oils and other similar additives remove adsorbed water from clay materials, forming a very dense, relatively hard-wearing surface which will not be softened by water. It will however wear eventually, whereupon conventional maintenance becomes more difficult than with normal gravel, due to the hard surface.

3.2.11 *Gravel Wearing Course*

Where in-situ earth subgrades do not conform to wearing course standards, a 100 mm layer of gravel wearing course can be applied and compacted over the full width of the travelled way. A suitable wearing course is a gravel which binds the material in wet weather, while not producing excessive dust in dry weather. Gravelled surfaces are subject to maintenance such as repairing potholes, grading to remove ruts and corrugations, and occasional regravelling.

3.2.12 *Soil-Cement*

In-situ material (subgrade) or imported gravel may be used as a surfacing by mixing it with small quantities of cement (2-5%). Soil cement can be used as the initial surfacing, designed for future upgrading. This treatment is suitable for pedestrian traffic and very low volumes of light traffic.

3.2.13 *Earth Street*

Where the in-situ material conforms to wearing course standards, the vegetation and topsoil can be cleared over the width of the proposed street and the subgrade compacted. This street can carry low volumes of light, bicycle, and pedestrian traffic, with the occasional medium size service truck. Typical traffic volumes would be of the order of 50-100 vehicles/day.

3.3 Comparison

The main advantages and disadvantages of different road options are presented in table 17. The options have been listed in terms of decreasing levels of cost - as a general rule, services become more convenient as the cost of provision increases.

TABLE 17: Main Advantages and Disadvantages of Road Options

PAVED SURFACE		
Characteristics:	*	Interlocking concrete or clay paving blocks
	*	Blocks laid by hand
Advantages:	*	Low ongoing costs
	*	Suitable for moderate amounts of traffic
	*	Enables colour patterns
	*	Blocks can be made on-site and laid labour intensively which creates jobs
Disadvantages:	*	High initial costs
	*	Requires road edging
	*	Uneven surface not suitable for high speed traffic
ASPHALT SURFACE		
Characteristics:	*	Mix of sand or stone chips with bitumen
	*	Asphalt is mixed off-site and applied hot by a paver
Advantages:	*	Suitable for larger amounts of traffic
	*	Even road surface
	*	Road surface lasts for a long time which reduces maintenance costs
Disadvantages:	*	High initial costs
	*	Sand asphalt requires road edging
BITUMINOUS SURFACE		
Characteristics:	*	Layers of stone chips and bitumen
	*	Stone and bitumen compacted together on road
Advantages:	*	Suitable for moderate amounts of traffic
	*	Can be applied by hand - labour intensive, creates jobs
	*	Smoother surface than gravel
Disadvantages:	*	Relatively high initial costs
	*	Smoothness of surface depends on underlying layers
	*	Road surface does not last as long as asphalt, therefore has to be maintained regularly which adds to ongoing cost
GRAVEL SURFACE		
Characteristics:	*	Layer of compacted gravel
	*	Gravel can be mixed with additive
Advantages:	*	Low initial costs
	*	Can be applied by hand
	*	Additives can reduce dust
Disadvantages:	*	High ongoing costs as surface has to be maintained regularly
	*	Surface can erode quickly due to weather conditions and traffic use
	*	Suitable for small amounts of traffic
	*	Dust in dry season
	*	Mud in wet season
	*	Surface not suitable for street trading and playing

EARTH SURFACE		
Characteristic:	*	Existing earth, where suitable, is leveled and compacted
Advantages:	*	Low initial costs
	*	End-user community can maintain surface fairly easily - can lead to job creation
Disadvantages:	*	High ongoing costs as surface has to be maintained regularly
	*	Surface can erode quickly due to weather conditions and traffic use
	*	Suitable for small amounts of traffic such as bicycles, pedestrians and occasional service trucks
	*	Dust in dry season
	*	Mud in wet season
	*	Surface not suitable for street trading and playing

3.4 Implications for Layout Planning

The main implications of layout planning for road surfacings and structures, relate to functional road hierarchy, and intersection dimensions.

(1) Road surfacings and structures should match the anticipated functions of roads - in essence a network of road surfacings should reflect a functional network of movement routes.

Higher order multi-functional roads, that accommodate larger traffic volumes and regular road-based services like public transport and solid waste collection, should have a more substantial structure and surface. The road structure should be provided at the outset, and some form of all-weather surfacing applied - a minimum surfacing would be a single or double bituminous seal, with upgrading to a premix wearingcourse taking place at a later stage. Where staged road construction is envisaged, adequate provision should be made in the pavement structure to allow for subsequent upgrading.

Lower order multi-functional roads, that accommodate smaller traffic volumes, can have lighter structures and a hardened surface. While a paved, asphalt or bituminous surfacing on these roads is not essential from a traffic perspective, it is argued that a minimum surfacing of a single bituminous seal or slurry (or perhaps even a soil-cement surfacing) is required in urban areas. Earth and gravel surfacings do not accommodate the full range of non-movement road functions, and do not create a public environment conducive to private sector responses in the form of housing consolidation or commercial activity.

Roads subject to periodic closure, to enable the total road space to be used for trading purposes, should have an all-weather surface - the preferred surface being brick or concrete paving blocks, which enable a variety of colour and textural patterns to be incorporated into the roadway design.

(2) Where labour intensive road construction methods are used, intersection dimensions can sometimes be reduced as provision need not be made for the turning movements of road construction vehicles. The extent of the reduction in kerb radii, depends upon the particular turning circle requirements of the construction vehicles used.

4. Stormwater Disposal

4.1 Functions

The residential functions of a stormwater management network are essentially to remove unwanted water from roadways and residential erven in order to minimise inconvenience in more frequent storms, and to prevent loss of life and damage to property in the event of severe storms.

The collective functions of a stormwater management network relate more to preserving natural watercourses and their ecosystems, to minimising the pollution of receiving waters, and to minimising erosion and sedimentation.

The main benefits of effective stormwater management are reduced health risks resulting from stagnant pools, and reduced transportation problems resulting from flooded roadways.

4.2 Service Options

Stormwater management may be defined as the collection, conveyance, storage, treatment and disposal of stormwater runoff in order to limit flood damage and preserve water quality. A stormwater network is made up of two interrelated systems - a minor and a major system. The essential difference between the two is that the former is for drainage, while the latter is for flood control.

The minor system manages surface runoff from more frequent, minor storms (ie. storms that are likely to occur every two to four years). It consists of road edge channels, underground pipes and small channels which collect stormwater runoff and transport it to the major system.

The major system is the overland route which excess runoff will follow when the minor system's capacity is exceeded. This runoff will spread across flood plains, or flow along channels that become enlarged during the storm. A major system therefore consists of natural and artificial watercourses, large conduits, roads, stormwater storage facilities, and temporary ponding areas.

Stormwater disposal services, within the minor system, can be provided in the following ways:

TABLE 18: Summary of Stormwater Disposal Options

OFF SITE SYSTEMS	1.	Kerb Stormwater Drains
	2.	Lined Side Channel
	3.	On-Road Channel
	4.	Unlined Side Channel
ON-SITE SYSTEMS	5.	On-Site Disposal
	6.	No Provision

4.2.1 *Kerbed Stormwater Drains*

Kerbed stormwater drainage refers to the movement of stormwater along surfaced roads, kerb and channel, and pipe networks to an outfall point. The road cross-section may be cambered or provided with a cross slope. In the case of cross sloping roads, kerb barriers can be removed to integrate the side walk and roadway should this be desired. Runoff from roads is transferred to the pipe system through kerb inlets. Cross sloping roads result in fewer inlets than cambered roads, and are therefore more commonly used in lower income areas.

4.2.2 *Lined Side Channel*

Lined side channels refer to an open, lined drainage channel to the side of roads, which conveys stormwater to an outfall point. Side channels may be trapezoidal, rectangular or V-shaped, and are normally $\pm$ 250 mm below the edge of the road to ensure drainage off the road. The use of side channels is preferable where roads are unsurfaced, and silting problems can be expected due to the ingress of sand into pipes. Access to erven is provided by carrying channels across driveway intersections by means of pipes, or culverts.

4.2.3 *On-Road Channel (Dished Road)*

On-road channels, or dished roads, refer to roads constructed with an inverted camber in order to perform a drainage function. As the drainage function of dished roads conflicts with traffic-carrying functions, on-road channels are mainly used for stormwater drainage on surfaced lower order roads with low volumes of slow-moving traffic (eg. cul-de-sacs, *woonerven* and motorcourts).

4.2.4 *Unlined Side Channel*

Unlined side channels refer to an open, unlined drainage channel to the side of roads, which conveys stormwater to an outfall point. Unlined channels are similar to the lined channels discussed above (4.2.2).

4.2.5 *On-Site Disposal*

On-site disposal refers to the minimisation of direct stormwater discharge into the street, by surface or subsurface disposal on residential erven. Surface disposal involves either directing gutters and down pipes (or the use of gutterless roofs) to pervious areas on residential erven, or in cases where the entire property is paved or covered, the provision of holding basins, porous layers or restricted capacity stormwater discharge pipes. Such flow attenuation minimises soil erosion and may reduce the concentration of pollutants. Subsurface disposal involves the use of on-site recharge wells or trenches. The versatility of these installations allows them to be used to remove standing water in areas difficult to drain, both on-site and as part of the minor stormwater system.

4.2.6 *No Provision*

No provision of stormwater disposal is normally applied in the case of very low order roads and tracks where rainfall is very low. Stormwater finds its way along roads and discharges onto adjacent plots with permeable soils. During rain periods no provision can be problematic - polluting water resources, creating stagnant ponds which become a health hazard, and damaging the road structure.

4.3 Major System Elements

Major stormwater management systems can be made up of the following elements:

4.3.1 *Storage Facilities*

Storage facilities attenuate the rate of runoff, especially in situations where the existing downstream stormwater system is inadequate - they also often have pollution control and recreation functions. These facilities take the form of purpose-built ponds. The different types of attenuation ponds include retention, retarding, on-stream, off-stream, dry, wet or on-site ponds. The distinction between retention and retarding ponds is that whereas retarding ponds detain runoff for a relatively short period of time for controlled release during or after a storm, retention ponds retain run-off for future uses like groundwater recharge.

4.3.2 *Sub-Surface Disposal*

In pervious soils with low water tables, the sub-surface disposal of runoff can offer a short-term alternative to surface ponds. Sub-surface disposal facilities take the form of dry wells, trenches, or areas like parking lots and sportsfields which are adapted to attenuate stormwater as a secondary function. In order to absorb runoff, surfaced areas like parking lots can use a porous asphalt pavement (ie. an open graded asphalt-concrete mixture with a high proportion of larger aggregate), or occasional concrete grid openings filled with grass or porous material.

4.3.3 *Open Channels*

Open channels form part of a stormwater outfall. Ideal channels are those that have either been created naturally and have reached some degree of stability, or those that, when created artificially, correspond to natural drainage patterns. Open channels have low construction costs, large discharge and storage capacities, and can reduce the quantity of runoff as a result of infiltration, but require considerable maintenance.

Erosion and increased flooding of channels, as a result of increased urban development, have been overcome in the past by concrete linings, which stabilise and drain areas more rapidly. While concrete channels generally solve local flood problems, they can adversely affect aquatic ecosystems, public use of the river environment, and can increase flooding and erosion problems further downstream.

4.3.4 *Flood Plains*

A flood plain is an area, bordering a watercourse, which may be intermittently flooded - it provides storage for flood water and forms a safety barrier for adjoining properties. An artificial flood plain should be several times wider than the average width of the top of the watercourse. It should be grassed and planted with trees and shrubs to prevent erosion - particularly on steeper slopes where the velocity of the flood water is greatest. Land uses that will not be seriously affected by occasional flooding, like recreational areas, can be located on the flood plain.

4.4 Comparison

The main advantages and disadvantages of different minor stormwater disposal options are presented in table 19. The options have been listed in terms of decreasing levels of costs - as a general rule, services become more convenient as the cost of provision increases.

TABLE 19: Main Advantages and Disadvantages of Minor Stormwater Disposal Options

KERBED STORMWATER DRAIN		
Characteristic:	*	Rainwater moves from the site, along gutters, into underground pipes
Advantages:	*	Underground pipes minimize road flooding
	*	Gutters provide road edging
Disadvantages:	*	High initial costs
	*	Underground pipes are difficult to clean
	*	Can only be provided with roads that have a hard surface
LINED SIDE-CHANNEL		
Characteristic:	*	Rainwater moves from the side into a lined open channel on the side of the road
Advantages:	*	Lower initial costs
	*	Easier to clean than underground pipes
Disadvantages:	*	Can be a health risk if rainwater remains undrained for a long time
	*	Rubbish is sometimes dumped in the channel
	*	Restricts pedestrian and car movement from footway to roadway
ON-ROAD CHANNEL		
Characteristic:	*	Rainwater travels in a depression on the roadway
Advantages:	*	Lower initial costs
	*	Easier to clean than underground pipes
	*	Favours pedestrian movement by not separating footway and roadway
Disadvantages:	*	Suitable for slow-moving traffic
	*	Can only be provided on roads with a hard surface
	*	Water on the road can create skidding and splashing problems for vehicular traffic
UNLINED SIDE-CHANNEL		
Characteristic:	*	Rainwater moves from the site into a unlined open channel on the side of the road
Advantages:	*	Low initial costs
	*	Easier to clean than underground pipes
	*	Reduces flow by enabling some water to seep into the ground
Disadvantages:	*	More difficult to clean than lined channels
	*	Can be a health risk if rainwater remains undrained for a long time
	*	Rubbish is sometimes dumped in the channel
	*	Restricts pedestrian and car movement from footway to roadway
ON-SITE DISPOSAL		
Characteristic:	*	Rainwater drains into wells, trenches or soft surfaces on the site
Advantages:	*	Can have low initial and ongoing costs
	*	Reduces the need for rainwater disposal in the larger area
	*	Reduces the concentration of pollutants in the rainwater

	*	Can dispose of rainwater in areas that are difficult to drain
Disadvantages:	*	Can be a health risk if rainwater remains undrained on the site for a long time
	*	Site can be flooded in heavy storms

4.5 Implications for Layout Planning

The main implications of a stormwater disposal network for layout planning, relate to road and block layout, open space networks, and road reserve width.

(1) As in the case of sewer reticulation, the ideal layout for stormwater pipes is a grid pattern with straight blocks of 80-100 m, in which narrow rectangular erven run perpendicular to the road - this minimises manhole requirements and pipe length per erf. Section 4 (part 4.2) of the handbook discusses the requirements for manholes within a reticulation network in greater detail.

The drainage function of roads, and there role in the major stormwater system, should be given high priority in the planning of road layouts in hilly terrain. Road layout should be planned to ensure positive drainage - pipes and channels should follow contours at low and continuous gradients. In order to reduce sedimentation, the gradient of road edge channels should not be less than 0,4% (1:250). The road layout should avoid T-junctions at the bottom of hills where stormwater in the road could flow across the intersection, locate cul-de-sacs or loops downstream of a higher order road where stormwater will accumulate at the closed end, and avoid curves on steep roads where runoff in channels may not be able to negotiate the curves.

(2) The preferred land use for flood plains along a water course is linear open space, in the form of public parks, sportsfields, golf courses, etc. Where practical, major stormwater facilities should be incorporated into this open space network. Retention ponds should be designed and operated to provide aesthetic and recreational amenities, while sub-surface disposal facilities should double up as sportsfields and parks.

Stormwater should therefore be viewed as a resource. Stormwater storage facilities perform a pollution control, as well as a flood control function. Provided runoff has sufficient opportunity to travel over unsurfaced areas in order for water pollutants to percolate onto the soil, water quality does not present a major obstacle to the recreational use of stormwater.

(3) If stormwater pipes are run in the road reserve, beneath the footway, a width of 1,1 m is required for trench excavation. Open channels require a wider reserve, in the region of 1,75 m. As open channels are required to convey increased

runoff as they progress downhill, a corresponding increase in channel width is often required.

5. Energy Supply

5.1 Functions

The residential functions of a domestic energy supply service are essentially to provide a reliable and adequate supply of energy for basic cooking, house lighting, space heating and refrigeration needs, as well as less essential needs like water heating, the operation of various appliances (eg. irons, sewing machines, power tools, etc.) and entertainment in the from of radio and television.

The collective functions of a domestic energy supply service relate more to the operation of public lighting and traffic signalisation systems, and to the provision of metered energy services in public markets for small scale manufacturing.

The main benefits of an effective energy supply service are reduced health, safety and pollution risks, increased home business and education opportunities, greater home comfort, and a reduction in the time spend collecting fuels.

5.2 Service Options

Energy supply service options are unlike other utility services in that a combination of services, as opposed to one particular service, is selected by the end-user. The only fuel that can satisfy all energy needs is in-house electricity connection. Even in the case of electricity however, household energy supply needs are likely to be satisfied through the use of a variety of different fuels.

Energy supply services can be provided in the following ways:

5.2.1 *In-House Electricity Supply*

In-house electricity can take the form of credit metered house connections or electronic prepayment electricity dispensers. Credit metered connections require a substantial meter reading and billing infrastructure. Due to increasing electricity arrears in lower income areas, suppliers currently prefer prepayment metering to credit metering, as a way of reducing non-payment. Electronic pre-payment metering requires households to pay for their electricity consumption in advance - as little as R5 of electricity can be purchased at a time. The dispenser usually includes a light fitting, 1-3 plug sockets, and is designed to facilitate the future extension of in-house reticulation.

TABLE 20: Summary of Energy Supply Service Options

ELECTRICITY SUPPLY	1.	Prepayment Dispenser (Below-Ground Cabling, 4kVA)
	2.	Prepayment Dispenser (Below-Ground Cabling, 1kVA)
	3.	Prepayment Dispenser (Above-Ground Cabling, 4kVA)
	4.	Prepayment Dispenser (Above-Ground Cabling, 1kVA)
GAS SUPPLY	5.	Polyflow Plastic Gas Pipes
	6.	High Density Poly Ethylene Gas Pipes
	7.	Steel Gas Pipes
	8.	Bottled Gas
COMBUSTIBLE FUELS	9.	Paraffin
	10.	Coal
	11.	Candles
	12.	Wood
OTHER SYSTEMS	13.	Photovoltaic Systems
	14.	Wet Batteries
	15.	Passive Solar

Note:
1. The values, 1 kVA and 4 kVA, refer to the After Diversity Maximum Demand (ADMD) which has a significant influence on the size of cabling and the capacity of transformers, which in turn effects the cost of reticulation.

5.2.2 *Gas Supply*

Gas is supplied in two main ways. Liquid petroleum gas is supplied in portable bottled form (up to 200 kg), while coal (or town) gas is supplied through a piped reticulation network. Existing piped networks are limited in extent, serving the older areas of Cape Town, Port Elizabeth and the PWV. Gas can satisfy energy needs for cooking, lighting, space heating, water heating and refrigeration.

5.2.3 *Paraffin*

Paraffin is a fuel that can be sold in small quantities, making it affordable to households with irregular incomes. Hence it is widely used in South Africa. Although households will often pay high prices per unit of volume, paraffin maintains its popularity because unlike most commercial fuels it is locally available from spaza shops at anytime of day or night. Paraffin can satisfy energy needs for cooking, lighting, space heating, water heating and refrigeration.

5.2.4 *Coal*

Coal for domestic use is an affordable fuel. Coal stoves however represent a substantial investment to low-income households, who are therefore, often reluctant to part with them in the event of electrification. Coal stoves are a primary contributor to air pollution - low smoke coals are however being developed. Coal can satisfy energy needs for cooking, space heating and water heating.

5.2.5 *Candles*

Candles are widely used either as a source of night light, or as a standby in the event of electricity blackouts. Candles present fire safety risks however, and the low luminescence of the light produced limits the range of activities that can be undertaken at night (eg. reading).

5.2.6 *Wood*

Fuelwood provides a 'safety net' fuel for the poorest households in the urban areas of South Africa. Wood is a cheap and renewable source of energy, if planted and cropped sustainably. The collection and burning of wood can however result in long walking distances and the emission of high levels of particulates and other volatile hydrocarbons which can be harmful to health. Wood can satisfy energy needs for cooking, lighting, space heating and water heating.

5.2.7 *Photovoltaic Lighting Systems*

Photovoltaic (PV) lighting is a form of electrical lighting in which solar radiation is converted into electricity, and stored in a battery during the day. When lighting is required, electrical current is drawn from the battery and converted to a current and voltage adequate to power a light bulb. PV lighting can satisfy energy needs for lighting, refrigeration and appliances. These systems have been limited to areas without access to grid electricity, as this method of lighting is relatively expensive in capital cost terms.

5.2.8 *Wet Batteries*

Wet batteries, such as car and truck batteries, are often used in areas which have no access to other sources of electricity. Households using car batteries pay prices of R3-6/charge - this is one of the most expensive forms of energy provision per unit of energy. Wet batteries can satisfy energy needs for lighting and appliances.

5.2.9 *Passive Solar*

The utilisation of solar energy often requires costly apparatus, while the source of energy is obviously free - on average 4,5-6 kWh equivalent of insolation is incident per square metre in South Africa. Passive solar can satisfy energy needs for space heating and water heating. These two energy services are largely responsible for excessive loading of the electricity network in residential areas. Solar energy can therefore compliment electricity supply.

5.3 Reticulation Options

Road and block layouts define the basic pattern of a electricity reticulation network. The layout decisions that are taken by the design engineer relate to the choice of above or below-ground cabling, and the choice between street and mid-block locations for cables. The advantages and disadvantages of mid-block and street reticulations have been discussed in section 4 of the handbook (part 4.2).

5.3.1 *Above-Ground Cabling*

Above-ground cabling is the most popular way of providing an electricity reticulation, as it allows for the rapid stringing of cables from pole to pole. These poles can be made of a variety of materials including creosoted natural wood poles, carbon steel, or precast concrete. They are placed at regular intervals, and should be of sufficient height and strength to provide support for public lighting and telecommunications infrastructure.

5.3.2 *Below-Ground Cabling*

Cabling for below-ground applications is typically designed with armour plating, which is impervious to water. It is placed underground at a depth of 1 m, and is suitable for labour-based or labour intensive contracting. Below-ground cabling is neater than above-ground reticulation, and results in less aerial clutter. If street lighting is desired however, poles will have to be erected in any event to so carry streetlamps - which could have partially facilitated above-ground electricity reticulation.

5.4 Comparison

The main advantages and disadvantages of different energy supply service options are presented in table 21. The options have been listed in terms of decreasing levels of costs - as a general rule, services become more convenient as the cost of provision increases.

TABLE 21: Main Advantages and Disadvantages of Energy Supply Options

ELECTRICITY - BELOW-GROUND		
Characteristics:	*	Prepayment electricity dispenser in the house
	*	Below-ground cabling
Advantages:	*	Electricity can satisfy all energy needs
	*	Little impact on the environment relative to other fuels

	*	Below-ground cabling is less visible and improves safety
	*	Prepayment enables household budgeting
	*	Appliances can be connected - improves quality of life
Disadvantages:	*	High initial costs
	*	Faults are difficult to find under ground
	*	New connections require digging up cable
ELECTRICITY - ABOVE-GROUND		
Characteristics:	*	Prepayment electricity dispenser in the house
	*	Above-ground cabling
Advantages:	*	Electricity can satisfy all energy needs
	*	Less impact on the environment than other fuels
	*	Prepayment enables household budgeting
	*	New connections are easily installed
	*	Appliances can be connected - improves quality of life
	*	Above-ground cabling can be coordinated with public lighting and telecommunication reticulation
Disadvantages:	*	Above-ground cabling is aesthetically unattractive in areas without trees
	*	Danger of falling live wires
GAS SUPPLY		
Characteristic:	*	Piped gas supply in the house
Advantages:	*	Efficient cooking fuel
Disadvantages:	*	High initial costs
	*	Supply restricted to small areas with gas pipe networks
	*	Not all energy needs can be satisfied
	*	Danger of gas leakage in the house which could lead to accidents
PHOTOVOLTAIC SYSTEMS		
Characteristic:	*	Sun energy is stored in a battery during the day, and then used as electrical power
Advantages:	*	Low ongoing costs
	*	No danger of live wires
	*	Not harmful to the environment
	*	Can be used in remote areas without cabled electricity
Disadvantages:	*	High initial costs
	*	Not all energy needs can be satisfied
	*	Power dependant on adequate sunshine
OTHER SOURCES		
Characteristic:	*	Other energy sources like paraffin, bottled gas, wood, wet batteries, candles and coal
Advantages:	*	Supplementary energy services
	*	Fuels can be purchased in small amounts
	*	Can be cheap and readily available
	*	Most services can be used in areas without cabled electricity

Disadvantages:	*	Can cause pollution, fire and injuries
	*	Not all energy needs can be satisfied by individual energy sources

5.5 Implications for Layout Planning

The main implications of energy supply services for layout planning, relate to road and block layout, public facility location, and road reserve width.

(1) With regard to road and block layout, only electricity supply is of concern to layout planners as electricity, unlike other fuels (with the exception of piped gas), requires a reticulation network. The remaining fuels are either transported by road, or by foot. Electricity supply is however, one of the most flexible services to reticulate (particularly in the case of above-ground reticulation) and its impact on road and block layout design is therefore not as great as other services. Nevertheless, a rectilinear grid layout with rectangular plots and a minimum of cul-de-sacs, or very short cul-de-sacs, is most efficient, as it results in shorter service length per erf and straight service runs minimise poling requirements in above-ground systems.

(2) In situations where all erven do not have reticulated electricity supply, and only streetlighting is provided, public facility buildings like schools and clinics should be located in relative proximity to one another, so that as a minimum these facilities are electrified. Household electricity reticulation normally follows public lighting reticulation, unless it is predetermined that electricity is provided from the outset.

Electrification normally involves finding the closest contact to HV (high voltage - 11 or 22 kV) reticulation and reticulating this to the centre of the site (or leading it around the outside of the site), at which point substations which house transformers and switches are situated. It is around these substations that 'load centres', in the form public facility buildings and shops, should be located. The substations catering for these loads should be sited so that any spare transformer capacity can also serve nearby residential consumers.

Where HV is stepped down to LV (low voltage), using a transformer, feeders are taken to provide typically from 70 to 150 erven on a circuit. LV distribution to residential erven should start as soon as possible after leaving the substation. It is desirable therefore that a substation is sited where distributor cables can radiate outwards without obstruction.

(3) If electricity cables are run in the road reserve, below-ground reticulation requires a width of 0,5-1 m, while above-ground reticulation requires a pole's width of space - 0,33 m. Substations and transformers also require space, but

transformers can be mounted on poles above ground which avoids any further claim on road reserve.

Street tree planting is not a problem for above-ground and below-ground reticulation, provided they are pruned below overhead cables, and are not planted over underground cables.

6. Public Lighting

6.1 Functions

The functions of a public lighting service are essentially, by improving visibility, to increase the safety of urban areas from crime, to improve nighttime traffic safety, and to enable outdoor activities to be extended into the evening. Whereas the primary function of street lighting is to provide nighttime lighting for pedestrians and traffic using public roads, the primary function of area lighting is to provide a low level of general lighting for the entire urban settlement.

The main benefits of an effective public lighting service are reduced crime and road accident risks, and an increased aesthetic quality to the urban environment.

6.2 Service Options

Public lighting services can be provided in the following ways:

TABLE 22: Summary of Public Lighting Service Options

STREET LIGHTING	1.	Streetlights
	2.	Photovoltaic Lights
AREA LIGHTING	3.	Mast Security Lights

6.2.1 *Streetlights*

Streetlights refer to lamps and luminaires along roadways and public spaces, mounted on 3,5-9 m high poles at 30-50 m intervals - depending on the level of service being delivered. Streetlights can be placed on one side, or on both sides of the roadway. Residential streetlighting usually provides a minimum recognition distance of $\pm$ 10 m - the measurement of illuminance is a contentious issue however, as recognition distance is difficult to measure. Streetlights are susceptible to vandalism and require consistent maintenance. It is generally more cost effective, and makes sense in terms of the construction process (eg. pole or trench sharing), to combine the provision of streetlighting with household electrical reticulation.

6.2.2 *Photovoltaic Streetlights*

Photovoltaic or solar lights are powered by sun energy and are therefore self contained. They provide an alternative source of street or area lighting for areas where grid electricity is not available. It is a relatively expensive form of lighting (in January 1994 the capital cost of a photovoltaic streetlight was ± R4 000, as opposed to ± R2 250 for a conventional streetlight).

6.2.3 *Mast Security Lights*

Medium and high mast lights refer to clusters of lamps mounted on poles of 20-40 m in height. High mast lights of 40 m typically serve about 140 residential erven. Mast lighting usually provides a minimum recognition distance of ± 4 m. High and medium mast security lights are not designed to provide residential street lighting - they provide area lighting in which both public and private spaces are illuminated. The installation and maintenance of mast lighting requires specialised maintenance and installation capabilities. Compared to streetlighting, the maintenance and energy costs of mast lights are therefore high (in January 1994, ± R3 622/annum for a high mast light vs. ± R1 030/annum for an equivalent area served by streetlights). Mast lighting runs off a separate reticulation system to domestic electricity reticulation, which means that a separate system with its attendant costs has to be installed.

6.3. Reticulation Options

Road and block layouts define the basic pattern of a public lighting network. The layout decisions that are taken by the design engineer relate to the choice of above or below-ground cabling.

6.3.1 *Above-Ground Cabling*

The above-ground cabling of streetlights is generally coordinated with above-ground electricity cabling. A variety of materials can be used for streetlighting poles, including treated wood, steel and concrete - which vary markedly in initial cost, life expectancy and susceptibility of vandalism.

6.3.2 *Below-Ground Cabling*

Street and mast lights can be reticulated using below-ground cabling in the road reserve. The construction of underground systems is more labour intensive than overhead systems, but has greater overall costs and presents difficulties for maintenance and upgrade.

6.4 Comparison

The main advantages and disadvantages of different public lighting service options are presented in table 23.

TABLE 23: Main Advantages and Disadvantages of Public Lighting Options

STREETLIGHTS - BELOW-GROUND		
Characteristics:	*	Lamps and poles are provided along roads
	*	Cabling is below-ground
Advantages:	*	Electricity connections can be made at the same time as streetlighting
	*	Below-ground cabling is less visible and improves safety
	*	Lights selected areas only
Disadvantages:	*	High initial cost
	*	Faults are difficult to find under ground
	*	Streetlights can be vandalised
STREETLIGHTS - ABOVE-GROUND		
Characteristics:	*	Lamps and poles are provided along roads
	*	Cabling is above-ground
Advantages:	*	Electricity connections can be made at the same time as streetlighting
	*	Lights selected areas only
Disadvantages:	*	Above-ground cabling is aesthetically unattractive in areas without trees
	*	Danger of falling live wires
	*	Streetlights can be vandalised
	*	In curving layouts, like *in-situ* upgrades, additional poles are required at every change in cable direction
MAST LIGHTS		
Characteristics:	*	Group of lamps mounted on high poles
	*	Cabling is below-ground
Advantages:	*	By lighting a large area is effective for policing and security
	*	Mast lights are difficult to vandalize
Disadvantages:	*	High initial costs
	*	Electricity connections have to be provided separately
	*	Causes light pollution (ie. unwanted light)
PHOTOVOLTAIC STREETLIGHTS		
Characteristics:	*	Sun energy is stored in a battery during the day, and then used as electrical power for lighting at night
Advantages:	*	Low ongoing costs
	*	No danger of falling live wires
	*	Can be used in remote areas without cabled electricity
	*	Not harmful to the environment
Disadvantages:	*	High initial costs
	*	Lighting dependant on adequate sunshine

6.5 Implications for Layout Planning

The main implications of public lighting services for layout planning, relate to public facility location, and road reserve width.

(1) The design and installation of public lighting and electricity supply networks should be coordinated. There are a two basic approaches which can be followed in installation. The first is to install a complete power supply system for public lighting and household electricity which will be able to cope with all future power demands. The second is to install the system in stages.

Staged installation can take the form of either servicing a portion of the development area and progressively extending it to other areas, or servicing the entire area with a minimum level of service and upgrading it as a whole (eg. a streetlighting system could be provided first, followed by household electrical connection at a later stage).

If installation occurs in portions, then in order to maximise the lighting intensity, and therefore safety, of public spaces, public facilities and hard open spaces should be clustered and become those portions of the development area that are serviced first.

(2) The road reserve requirements of public lighting systems depend on the particular lighting requirements of the roadway, and the degree of coordination between streetlighting, electricity supply, and telecommunication design.

The degree to which electricity reticulation can be integrated with public lighting and telecommunication services, should be considered. Above-ground cabling has the benefit of providing both public lighting and telecommunications poles, which reduces space requirements. The frequency of poles for LV reticulation however is greater than that required for streetlighting. The space necessary for poles is 0,33 m.

Single side public lighting (as opposed to an opposite, alternate or central arrangement) is the most common form of streetlighting. In this case, poles can be shared with above-ground electricity and telephone reticulation, and trees can be planted on the opposite side of the roadway. Higher illuminance levels should generally be provided at intersections, important public places (ie. public telephones, public squares) and more important roads.

7. Solid Waste Removal

7.1 Functions

The residential functions of a domestic solid waste removal service are essentially to store household solid wastes, to collect wastes, and to transport wastes from collection points to disposal sites at regular time intervals.

The collective functions of a solid waste removal service relate more to the provision, and collection of, solid waste bins in public places, like markets and squares.

The main benefits of an effective solid waste removal service are reduced health and pollution risks, an aesthetically clean environment, and in some cases economic opportunities arising from entrepreneurial collection services and recycling.

7.2 Service Options

All steps in solid waste management are related. Consequently the effectiveness of removal options is closely related to the method of household or communal storage selected, as well as the method of transportation and disposal. Solid waste removal services, can be provided in the following basic ways:

TABLE 24: Summary of Solid Waste Removal Service Options

KERBSIDE COLLECTION	1.	Screw Compactor Kerbside Collection
	2.	Rear Loading Hydraulic Kerbside Collection
	3.	Open Truck Kerbside Collection
	4.	Tractor and Trailer Kerbside Collection
LOCAL COLLECTION	5.	Local Entrepreneurial Kerbside Collection
	6.	Communal Collection
	7.	No Collection

7.2.1 *Screw Compactor Kerbside Collection*

Screw compactor kerbside collection refers to the collection of refuse bags deposited by households at the kerbside, by a screw compactor vehicle, with a load capacity of 7 500 kg, that can be tipped conventionally for the purposes of discharging. Collection occurs at fixed intervals - all options discussed here are assumed to occur once a week.

7.2.2 *Rear Loading Hydraulic Kerbside Collection*

Rear loading hydraulic kerbside collection refers to the collection of refuse bags by a rear loading hydraulic compactor vehicle, with a load capacity of 6 500 kg. This vehicle uses rear-mounted compaction systems which sweep refuse into the truck body, and compress it against a movable barrier which is pushed forward along the body by the waste. This barrier is subsequently used to discharge the collected waste by pushing it rearwards, after lifting the compaction mechanism clear of the body.

7.2.3 *Open Truck Kerbside Collection*

Open truck kerbside collection refers to the collection of refuse by an open-topped high sided non-compaction truck, with a load capacity of 3 000 kg. Waste is passed up from ground level to a worker inside the truck who packs the load, or alternatively, wastes are loaded with the use of forks.

7.2.4 *Tractor and Trailer Kerbside Collection*

Tractor and trailer kerbside collection refers to the collection of refuse by tractor and trailed-containers, with a load capacity of 1 000 kg or 10 m^3. The main advantage of the system is the ready availability of tractors and thus of maintenance facilities, while disadvantages include low speed and a poor braking system.

7.2.5 *Local Entrepreneurial Kerbside Collection*

Local entrepreneurial kerbside collection refers to the collection of kerbside refuse by a local 'entrepreneur' using a hand or animal-cart, with a load capacity of 100-500 kg. Waste is transported to a collection point in the form of a 6 m^3 skip, from where it is transported by the service agency to the disposal site. Payment to the entrepreneur can take place either at the collection point by the service agency, or by householders at the time of collection.

7.2.6 *Communal Collection*

Communal collection refers to individual households carrying their refuse to predetermined locations providing a communal storage facility, in the form of a 6 m^3 skip. Once the skip is full, it is removed by a container hoist vehicle and transported to a disposal site. Container hoist vehicles are equipped with hydraulically-operated hoisting arms to lift skips between the floor of the vehicle and the ground. Waste delivered by households, to collection points, can be exchanged for food coupons, transport coupons, money or even food.

7.2.7 *No Collection*

No collection refers to the disposal of waste on residential sites. The local authority provides no planned removal service, but promotes correct reducing, reusing and recycling practice on site through education programmes and the provision of necessary equipment like compost bins. Waste is separated into different types (eg. ash, putrescibles and inorganic material). Each waste type can then be put to different uses (eg. ash and matured compost from putrescible waste can be worked into the soil for gardening purposes, paper/wood/cardboard can be used as fuel, and cans/plastic bottles can be used as containers). Non-collection is only viable if there are favourable physical conditions and there is adequate public awareness of how to handle waste.

7.3 Collection Options

Solid waste collection options refer to the method used to collect household waste. The type of collection vehicle used is linked to the household or communal storage method. Collection vehicles can take the following forms:

7.3.1 *Non-motorized collection*

Non-motorized collection tends to occur in conjunction with the local entrepreneurial removal option. The method of waste collection tends to be in vehicles with relatively small load capacities (100-500 kg). Non-motorised vehicles can take the form of handcarts (operating radius of $\pm$ 1 km), animal carts (operating radius of $\pm$ 3 km), and pedal tricycles (operating radius of $\pm$ 3 km).

7.3.2 *Motorized Communal Storage Collection*

Motorized collection of communal storage containers occurs in conjunction with either local entrepreneurial removal or communal removal options. The method of waste collection tends to be in vehicles that can load and off-load containers, or skips, at solid waste transfer stations. Collection containers and transfer stations can take various forms, ranging from large collection vehicles which remain located at a certain point till full, to permanent compaction-transfer stations where a fixed hydraulic compacting unit is used to compress waste into large containers. Motorised communal collection vehicles can take the form of container-hoist, tractor and trailed-container, truck-mounted front-loading, and truck-mounted rear-loading vehicles.

7.3.3 *Motorized Kerbside Storage*

Motorized collection of kerbside storage containers occurs in conjunction with local removal options. The method of waste collection tends to be in vehicles with relatively large load capacities. Motorised kerbside collection does not usually need transfer stations, with vehicles transporting waste direct to the disposal site.

Motorized vehicles can be categorized into non-compactor and compactor vehicles. Compactor vehicles are designed specifically for purposes of compacting low-density compressible wastes. Non-compaction vehicle bodies therefore require a larger load space than a compactor body, to carry the same amount of waste. Non-compactors vehicles are however lighter and can therefore carry greater loads. Non-compactor vehicles can take the form of high-sided open-top, side loading 'roll-top', tractor and open trailer, and front-loading high-sided enclosed vehicles. Compactor vehicles can take the form of rear-loading hydraulic, screw, side-loading hydraulic, rotating drum and paddle compactor vehicles.

7.4 Comparison

The main advantages and disadvantages of different solid waste removal options are presented in table 25. The options have been listed in terms of decreasing levels of costs - as a general rule, services become more convenient as the cost of provision increases.

TABLE 25: Main Advantages and Disadvantages of Solid Waste Removal Options

KERB-SIDE COLLECTION		
Characteristics:	*	Household leaves rubbish bags on the footway next to the house
	*	Rubbish bags collected by waste collection vehicles
Advantages:	*	Household does not have to carry waste far
	*	No concern for rubbish after collection
	*	Can cope with large amounts of waste
Disadvantages:	*	High ongoing costs
	*	If not collected, waste is often scattered in streets
LOCAL COLLECTION		
Characteristics:	*	Household leaves rubbish on the footway for collection by a person using a cart
	*	Waste taken to central storage point to be collected by waste vehicle
Advantages:	*	Household does not have to carry waste far
	*	Creates job opportunities
	*	No concern for rubbish after collection
Disadvantages:	*	If not collected, waste becomes scattered in streets
	*	Cart can only transport small loads of rubbish
COMMUNAL COLLECTION		
Characteristics:	*	Households take rubbish to a collection point
	*	Rubbish is collected by a waste vehicle
Advantage:	*	Low ongoing costs
Disadvantages:	*	Waste has to be carried by household over distances
	*	If collection points are far, rubbish is often left in the street
	*	Delays in collection can be a health risk
ON-SITE DISPOSAL		
Characteristic:	*	Rubbish is reused or recycled on the site
Advantages:	*	Low ongoing cost
	*	No transport of rubbish is required
	*	Amounts of rubbish are reduced

Disadvantages:	*	Waste that cannot be reused or recycled pollutes the environment
	*	Delays in handling wastes on the site can be a health risk

7.5 Implications for Layout Planning

The main implications of solid waste removal services for layout planning, relate to road and block layout, the location of collection points, and intersection dimensions.

(1) As solid waste removal is a road-based, as opposed to a reticulated service, removal services are able to adapt to most road networks. Nevertheless, as in the case of reticulated services, an open road network with narrow rectangular erven is most efficient. Open road networks facilitate greatest flexibility in service routing and pedestrian access to collection points, while narrow erven enable collection crews to move alongside vehicles on foot without constantly having to get on and off the vehicle.

The regular movement of solid waste vehicles necessitates roads with adequate structure, surfacing and drainage. In cases where surfacing and drainage standards are lowered for affordability reasons, those routes carrying solid waste vehicles on a regular basis should be structured, surfaced and drained to a higher standard.

(2) Solid waste collection points should be located near intersections, on widened footways or left-off corner erven. The space requirement depends on the size and number of containers needed, which is determined by the number of households served, the waste generated per household, and the load capacity of the collection vehicle. The choice of location is influenced by the access requirements of collection vehicles to load and transport waste to disposal sites, and the walking distance limits between end-user dwellings and collection points.

The distance between end-user dwellings and collection points is central to an effective service - the greater the distance, the more likely it is that households will dump their waste in the road or another public space. Maximum walking distance recommendations in developing countries have ranged from 100 m to 250 m, depending on topography and user density. A reasonable guideline would seem to be ± 150 m.

Locating the collection point alongside other collective services, like water standpipes and public telephones, may serve to encourage households to take their waste to the point. Solid waste is potentially unhygienic and has unpleasant odours however, which makes it difficult for collection points to be located too close to other collective services, especially those related to the sale of foodstuffs or water consumption.

(3) Adequate intersection dimensions vary according to the turning requirements of the type of collection vehicle used - the larger the turning circle of the vehicle, the longer the required kerb radii. Typical kerb radii for heavy vehicles are between 10 m and 12 m.

In the case of communal collection, it is only those intersections, at which collection vehicle turning is necessary, that require dimensions large enough to facilitate the turning movements of these vehicles.

8. Communications

8.1 Functions

The function of a communications network is essentially to facilitate the exchange of information at various levels - between individuals, between individuals and the community within which they reside and between individuals and the broader external environment. The ease with which people can communicate is a vital component in the development process and social and economic enrichment - without access to information, communities remain isolated, with limited access to the opportunities city environments offer.

The residential functions of a communications network are essentially to satisfy the need for households to summon emergency assistance, and for individuals, families and communities to maintain regular contact.

The collective functions of a communications network relate more to the provision of public telephones, information centres and postal services in public places, like markets or squares, and to satisfying the need for businesses and traders to communicate rapidly with suppliers and potential consumers.
The main benefits of an effective communications network are increased access to information, favourable economic development conditions, access to correspondence education opportunities, and a reduced demand for physical movement.

8.2 Elements

The elements of communication networks include:

TABLE 26: Summary of Communication Elements

TELECOMMUNICATIONS	1.	Telephone Connection
	2.	Public Telephones
	3.	Telephone Bureaus
POSTAL COMMUNICATIONS	4.	Site Postal Delivery
	5.	Post Collection Points
	6.	Post Offices
	7.	Mobile Post Offices
	8.	Poste Restante
INFORMATION POINTS	9.	Public Information Centres
	10.	Local Libraries

8.2.1 *Telecommunications*

Telecommunications take the form of in-house telephone connections, public telephones, and telephone bureaus.

In-house telephone connections refer to the provision and rental of reticulated metered telephones within dwellings - from core housing upwards. On request for service in reticulated areas, the household is connected to the nearest distribution point.

Public telephones refer to pay or card-phones usually covering a 1 500 m to 500 m radius. Pay-phones are generally sited in pairs in an attempt to reduce the possible impact of vandalism on availability. In cases where a coupon vendor is located nearby, one card-phone is usually provided for every two pay-phones.

Private or public telephone bureaus refer to a group of about eight telephones in an existing shop or a refurbished container. Private bureaus have a meter for each telephone - the number of call units required being paid in advance to the bureau operator. The charge is higher than the Telkom charge, the difference accruing as profit to the bureau operator. Private bureaus often provide a message service, whereby telephone messages are recorded by the bureau operator and released to the recipient upon payment of a fixed fee.

8.2.2 *Postal Communications*

Postal communications take the form of site postal delivery, post collection points, post offices, mobile post offices and *poste restante* services.

Site postal delivery refers to the delivery of letters to individual erven by hand.

Post collection points refer to a group of post boxes at an accessible location within a residential area. Individual households are each allocated a post box. An alternative is the provision of pre-manufactured, transportable private box lobbies containing 800 private boxes - typically serving about 1 000 households. The lobby can be relocated as patterns of demand change and additional lobbies become necessary.
Larger parcels are collected by addressees at post offices. Post offices also collect post from post boxes for transportation, and provide a number of other post office services.

Mobile post offices, offering periodic post office services at various locations, are used to service old age homes, universities, etc. Because of security reasons they are not currently used in low-income areas. Were security to improve, this service would be offered where demand warranted the provision of such a service.

Poste restante refers to post delivered to, and kept by, a post office, and its sorting and collection by addressees.

8.2.3 *Information Points*

Information points take the form of public information centres and local libraries.

Public information centres refer to a public facility fulfilling a number of communication functions - the mix of services being dependent on local need and the extent of services provided by other agencies. Typically, public information centres provide access to resources, support services and entitlements by the community, as well as a referral service to other specialised services. The range of services offered can be extensive, ranging from technical advice regarding self-building, access to credit and development controls to legal advice, employment opportunities and crime prevention.

Local municipal libraries provide free access to newspapers, magazines and books.

8.3 Implications for Layout Planning

The main implications of communication networks for layout planning, relate to the location of public telephones, the location of post collection points, and road reserve width. The location of public information centres and libraries is discussed in section 4 (part 3.1).

(1) It is Telkom national policy to site public telephones with a 1 500 m service area radius, which results in a maximum walking time of ± 30 minutes. In some low-income areas however public telephones are installed with a service area of 500 m radius, which results in a maximum walking time of ± 10 minutes. The performance of public telephones is monitored through coin box receipts, and where revenue is considered high additional phones are

provided - which are located anywhere along the line of route of the service cable.

There is little information available on optimum walking distances to a public telephone, or about current utilisation of public telephones in low-income areas. A reasonable guideline would seem to be a service radius of ± 500 m - greater distances are likely to have a negative effect on user convenience and potential demand.

Public markets, public squares and modal interchanges should be the main locational informants of public telephones. Telephones should be located on major pedestrian movement routes, and be well lit and exposed to passersby for safety reasons.

(2) It is Post Office policy that postal delivery services will be extended to low-income areas through the provision of private box lobbies. Private box lobbies should be sited at points of high pedestrian access like modal interchanges and commercial centres. A reasonable guideline would seem to be a service radius of ± 500 m, which would result in a maximum walking time of ± 10 minutes. They should be located next to a post box for postal collections, and where possible, close to public telephones.

(3) Telephone cables can be reticulated above and below-ground. Above-ground reticulations are a more flexible system, and less affected by layout planning considerations - there are no fixed positions for telephone poles within the road reserve and poles are located on site at any suitable position. In the case of below-ground reticulation, within the road reserve, a trench space of 1 m wide is required.

9. Public Spaces

9.1 Functions

The functions of public spaces are essentially to facilitate social interaction and collective social events, to act as extensions of overcrowded individual dwellings by providing opportunities for privacy, recreation and rest, to facilitate informal trade, and to provide a spatial framework for the consolidation of public facilities and commercial activities.

9.2 Elements

The term 'space' refers to all unbuilt spaces, and encompasses more specialist areas like roadways and footways. Perceptions of space are created by the interrelationship between the vertical plane (ie. trees, walls, buildings) and horizontal plane (ie. surfaces). The nature of this relationship in terms of height and size, and the quality of design and materials used, will to a large extent determine the nature of the space and how it could be utilised. There are a number of useful categorisations of space.

Firstly, space can be viewed as a continuum ranging from private to public space, with gradations of semi-private to semi-public space in between. The distinction refers to the degree to which the use and control of space is exclusive to specific individuals or organisations. 'Public' spaces are therefore spaces for use by the general public.

Secondly, space can be categorised in terms of appearance and surfacing - there is a continuum ranging from hard space to soft (or green) space, with many variations between.

TABLE 27: Summary of Public Space Elements

VERTICAL EDGES	1.	Trees
	2.	Low Walls
	3.	Colonnades
	4.	Terraces
HARD SURFACES	5.	Paved Surfaces
	6.	Asphalt Surfaces
	7.	Surface Treatments
	8.	Gravel Surfaces
	9.	Gravel Additive
SOFT SURFACES	10.	Roll-On Grass
	11.	Seedling Grass
PUBLIC FURNITURE	12.	Benches
	13.	Play Equipment
	14.	Public Art
	15.	Bollards

The basic design elements of public space include:

9.2.1 *Vertical Edges*

Vertical edges refer to the physical barriers that define a public space, the form of which profoundly effects the quality and character of the space. The best public spaces are usually defined by vertical edges that provide a sense of enclosure and greater security through public surveillance. Edges can be made by a combination of treeplanting, low walls, colonnades, terraces and abutting buildings. The degree of enclosure and access to the public space affects the way in which surrounding uses relate to it, and defines areas with varying degrees of privacy.

9.2.2 *Hard Surfaces*

Hard (horizontal) surfaces refer to public squares, roadways, and footways that perform an open space function in addition to a circulation function. Hard public space can be surfaced by a range of treatments including gravel, bituminous, asphalt and paved surfaces. The quality and type of surfacing affects the use of the public space (eg. defining a gradation of emphasis from primarily vehicular to primarily pedestrian use), its character and its cost.

9.2.3 *Soft Surfaces*

Soft (horizontal) surfaces refer to a variety of sizes of public parks. Soft public open space is usually landscaped with trees and plants, and surfaced with grass. Gravelled or paved cycle and footpaths are often provided within the soft surfaces. The nature of the landscaping and surfacing affects the use of the space, its character and its cost.

9.2.5 *Public Furniture*

Public furniture refers to the physical objects within public spaces, used for rest, recreation and aesthetic improvement. Public furniture typically takes the form of benches, playground equipment, bollards, etc. The nature and arrangement of public furniture affects, and can limit, the use of the space and the degree to which it can accommodate a range of different activities.

9.3 Public Space Design

While there is no standardised way of designing public spaces, there are a number of factors which affect spatial quality, relating to multi-functionality, scale, clarity of role, enclosure, and comfort.

(1) One of the central issues in the making of public spaces is multi-functionality. In terms of their social role, almost all public spaces are required to perform a variety of functions, although the emphasis of function will vary. The best spaces are those which allow a variety of activities to occur within them, and accommodate these activities by recognising the needs of the people engaged in them. In so doing, the spaces seldom accommodate any one activity optimally - *in toto* however, their performance is superior. Conversely, the more space is geared to a single function (eg. a road designed for vehicular movement only), the more its flexibility and overall performance is reduced.

(2) There is a relationship between the scale and intensity of use. Large and underutilised spaces are neither pleasant nor safe. Conversely, small overcrowded spaces are stressful. The size and character of a space should therefore be informed by its locational significance and the uses that will abut it

(eg. if a school site is to be placed next to a square, it should be recognised that the square will become an important play space for the school children and the space should be made accordingly).

Scale is also affected by the height of abutting buildings. Building height affects the pattern of sunlight and shadow and may create a 'dwarfing' effect. The most comfortably-scaled spaces are those flanked by buildings not exceeding walk-up height.

(3) The role of, and access to, space should be made clear through design. Where the role and utilisation of space is unclear (ie. where it is unclear whether a space is for public or private use), problems frequently arise with regard to responsibility and maintenance. When responsibility is blurred, spaces are often poorly maintained, and as a result become ineffective.

(4) Urban spaces should have a sense of enclosure and surveillance - essentially creating 'outdoor rooms'. The nature, quality and safety of a space is significantly affected by the way in which the defining edges are made (eg. by planting, by buildings, by walls, by colonnades, and by combinations of these).

(5) The comfort a space offers is affected by the degree to which it provides protection from, or the possibility of enjoying, the natural elements (ie. sun, wind, rain). Comfort is also affected by surfacing and public furniture. The way in which a public space is surfaced not only affects its character and cost but is also an important function-defining element (eg. defining a gradation of emphasis from primarily vehicular to primarily pedestrian use). Similarly, the activities within public spaces, and the character of the space, can be enhanced by the provision of public furniture (eg. benches, lighting, play equipment), which can also be used as space-defining elements. Appropriate combinations of vertical edges, hard and soft surfaces, public furniture and landscaping, and vary according to context - as a general rule maximum user choice should be generated.

10. Public Markets

10.1 Functions

Small scale enterprises can play a significant role in terms of poverty alleviation. Public authorities can play numerous roles in facilitating this kind of economic activity - the focus here is on one such facilitating mechanism, in the form of the provision of basic services and infrastructure, which, provided in an agglomerated form, are public markets.

The functions of public markets are essentially to provide assistance to informal sector manufacturers and traders, to improve the access of lower income consumers to commercial services, to provide a space for community interaction, and in some cases to provide a tourist attraction. Public markets enable many unemployed to generate income through a variety of small scale manufacturing, service and retail activities.

The main benefits of public markets are the provision of central trading locations for small operators, the creation of agglomerations of small traders capable of competing effectively with larger commercial establishments, and the management of many of the problems often associated with individual street hawkers or home-operators in the form of traffic and pedestrian disruption, litter and health hazards. Market trading plays an important role in the distribution of goods in lower income areas - providing high levels of access, selling in smaller more affordable units, and sometimes extending credit.

10.2 Elements

Markets can be classified according to what, how and when they function. They can be categorised according to their level in the retail chain, the type of activities accommodated, the nature of purpose-built infrastructure provided, periodicity, and ownership. As a result, markets can take numerous forms, including wholesale food markets, farmers markets, street markets, small retail markets, weekend markets, and so on.

TABLE 28: Summary of Levels of Public Market Provision

1.	Lock-Up Stalls
2.	Market Buildings
3.	Shelter and Stall Infrastructure
4.	Basic Level of Market Infrastructure

The levels of market infrastructure identified are in no way mutually exclusive options. Some of the most successful markets are in fact systems of markets which contain combinations of market infrastructure. The different levels of public market provision typically include:

10.2.1 *Lock-Up Stalls*

Lock-up stalls refer to small rooms, sometimes located within market buildings, which are physically divided from each other, and can be closed and locked. Some fittings inside the stall (eg. shelving or surfaces) may be publicly provided, although this can easily be provided by the stall-holder. Stalls are usually provided with metered electricity connections, while taps and toilets are provided communally, within the market building itself. Lock-up stalls can be used for selling, small-scale manufacturing or service outlets.

10.2.2 *Market Buildings*

A market building refers to a building containing a group of stall spaces, which offers shelter and relative security to traders. Market buildings can vary greatly in terms of size, form and level of service provision and finish (eg. shelving and surfaces), and can provide within them a range of different levels of stall infrastructure.

10.2.3 *Shelter and Stall Infrastructure*

Shelter and stall infrastructure refers to publicly constructed individual trading spaces. Stalls are usually provided in the cheapest buildings materials - either timber and corrugated iron or concrete block. Basic stall infrastructure of this kind can be upgraded by the stallholder by expanding the selling surface and creating storage space.

10.2.4 *Basic Level of Market Infrastructure*

The minimum necessary elements of public market infrastructure are a hardened surface which does not absorb fallen foods or liquids and prevents dust and mud formation, rubbish bins, public standpipes, and trees. Trading space can either be provided within public spaces or within road reserves. Individual stall-holders provide their own stall infrastructure and shelter. This kind of infrastructure can be used at intermittent times without a serious loss of revenue or the sterilisation of large pieces of public space.

10.3 Public Market Design

There is no standard hierarchy of market provision - rather informal selling, manufacturing and services can be regarded as operating on a size continuum, from large agglomerations of permanently located operators, to scattered hawkers in public spaces and individuals operating from their homes. The level of public investment in market infrastructure generally reflects this continuum. Guidelines for the layout of varying levels of public market infrastructure and market size, are as follows:

(1) With regard to larger scale market activity (eg. decentralised wholesale markets), more formal, permanent market infrastructure is likely to be required, in the form of market buildings or lock up kiosks. In the case of market buildings, the relationship of the building to pedestrian movement outside the building is critical. A market building will operate best when it is closely aligned with street-based pedestrian flows, and there are entrances which can allow passersby to penetrate the market easily. These markets can generate heavy vehicles which load and off-load goods - if they are to maintain a close

interface with passing pedestrian flows, then loading and off-loading should occur at the rear of the market.

The interrelationship between stalls and passing pedestrians requires that stall configuration takes on a linear pattern. This linearity can be most easily maintained when the stalls relate directly to passing pedestrian flows, but can also be maintained where the site is square or rectangular, where the inside circulation space is organized in linear elements.

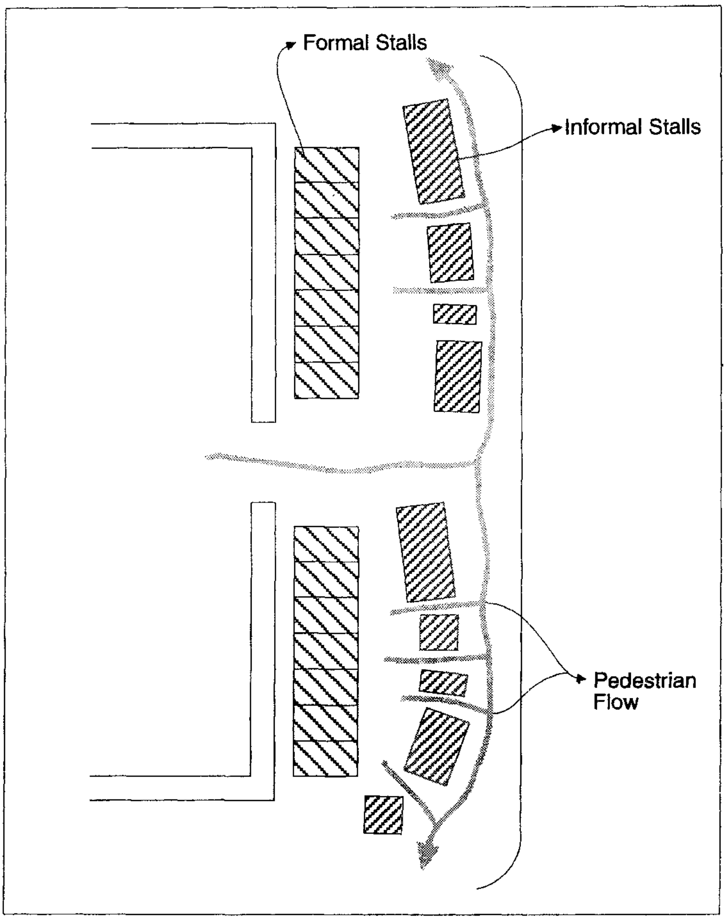


FIGURE 39: Diagram Illustrating Linear Stall Configurations

The success of a market is affected by stall orientation and entrance location, as this affects the stalls which are exposed to passersby. Stall orientation and entrance location should distribute pedestrians evenly past all stalls, and marginalised or 'dead' areas should be avoided. The length of stalls is also important - when allowed to create contiguous rows of stalls spontaneously, stallholders generally create runs of some 18-22 m before allowing a break for through passage. This can be used as a guideline in designing new market infrastructure. Where the length of run is much longer, shoppers tend to avoid penetrating to central stalls, and these become marginalised. Where rows of stalls are organized in parallel rows it is important that the space between them is not too great, or the intensity of a desirable shopping environment is lost. The width of circulation space should not be more than 1,5 m.

FIGURE 40: Diagram Illustrating Appropriate and Inappropriate Lengths of Linear Stall Runs

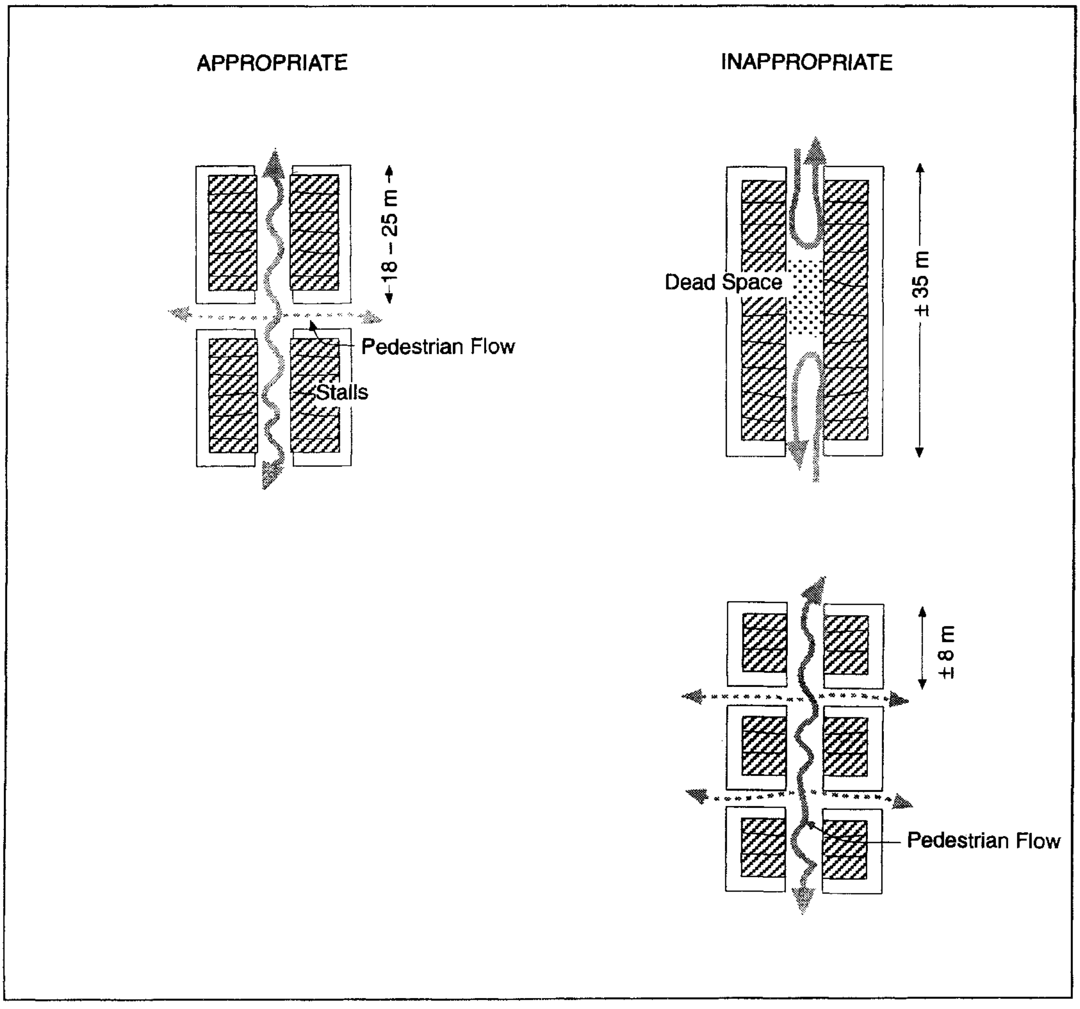
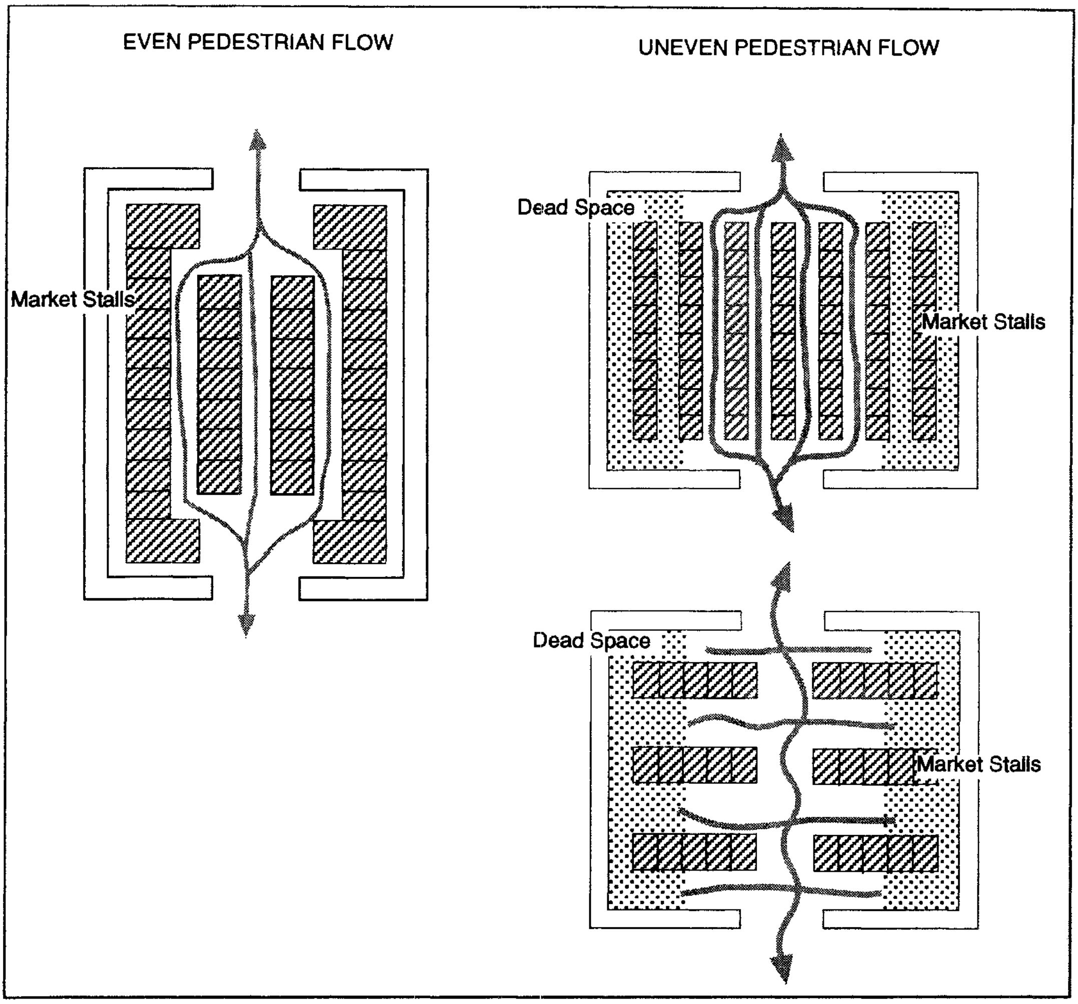


FIGURE 41: Diagram Illustrating Even and Uneven Distributions of Pedestrian Flows Past Stalls



(2) With regard to smaller scale market activity, less formal market infrastructure is required, in the form of public spaces. It is important that these public spaces are designed to be multi-functional as market activity may be intermittent. They could take on different forms.

One form is that of widened and hardened footways. A footway width of 5 m will be sufficient to accommodate a row of stalls (± 1,5-2 m deep) and still allow for pedestrian circulation. Footway widening should occur along routes with the largest volumes of pedestrians, often leading to a more formal public market or a public transport modal interchange. The higher and more concentrated the volumes of pedestrian movement, the greater should be the length along which widening occurs.

Another form is that of hardened urban squares with either the central area of the square or the edges demarcated as non-vehicular space. The square may be fully occupied at peak periods, but there will be a tendency for traders to gravitate towards the outer edges of a square at quieter times so as to be closer to passersby.

(3) With regard to market size, it is a general rule that larger markets are more successful than smaller ones. This is because they offer greater choice and diversity, parts of them tend to be more permanent, and other attractions (eg. restaurants, entertainment) tend to be associated with the market. It is extremely difficult to gage the number of traders that can be supported by a particular volume of pedestrian flow, and there is therefore no predictable relationship between pedestrian volumes and numbers of stalls or trading spaces. It can be assumed however that the greater and more consistent the volumes of passersby, the greater the potential to support traders. From a design perspective three points are important.

The first point is that markets which are designed to be small, and have no capacity to expand, very often fail as they are too small to attract consumers. A rough guideline is that markets should accommodate at least 70 operators (preferably more) and that expansion should be allowed for.

The second point is that the size of a market will rarely be exactly the same over the period of a week or a month. There will inevitably be periods of expansion and periods of contraction, and planning for a market must be flexible enough to accommodate these changes. It can be expected that market activity which has concentrated on a dominant activity route will, at peak periods, expand into lesser intersecting routes, which converge on the main point of access. This should be accommodated in the layout through footway widening short distances down these routes.

The third point is that any extensive public investment in market infrastructure should respond to market development, rather than precede it. The growth of a market should be planned in a phased way, so that it can operate as a totality at each stage of its development. Initially some space should be made available in locations where higher concentrations of pedestrian flows are likely to occur and small businesses are likely to emerge, perhaps in the form of widened footways or squares. If traders respond to this space, then basic public support in the form of rubbish bins, standpipes and possibly the demarcation of selling space, should occur. If the number of sellers increases and appear to become permanent, then further forms of investment into purpose-built shelter and stall infrastructure can be considered.

Appendix A:
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Appendix B:
Working Papers

The following working papers were prepared as background to the preparation of the handbook:

Stage 1 Working Paper:

1. Layout Design in South Africa: Origins, Approach and Critique
Roger Behrens
Urban Problems Research Unit (UCT)

Stage 2 Working Papers:

1. Water Supply
Ian Palmer, Rolfe Eberhardt, Ulli Bleibaum
Palmer Development Group

2. Sanitation
Ian Palmer, Rolfe Eberhardt, Ulli Bleibaum
Palmer Development Group

3. Roads
Ralph Cameron-Williger
Liebenberg and Stander Consulting Engineers

4. Stormwater Management
Jeff de Wet, Alastair Bishop
Liebenberg and Stander Consulting Engineers

5. Energy Supply
Steve Thorne
Energy for Development Research Centre (UCT)

6. Public Lighting
Sarah Ward
Energy for Development Research Centre (UCT)

7. Solid Waste Removal

Rob MacDonald
Palmer Development Group

8. Public Spaces

Craig Baynham, Jac Theron
Baynham Theron Urban Design Consultants

9. Public Markets

Vanessa Watson
School of Architecture and Planning (UCT)

10. Communications

Paul Mann
Liebenberg and Stander Consulting Engineers

Stage 3 Working Papers:

1. Place Making

Professor Dave Dewar
School of Architecture and Planning (UCT)

2. Public Spaces

Professor Dave Dewar
School of Architecture and Planning (UCT)

3. Infrastructure Development

Simon Nicks
Chittenden Nicks Partnership

4. Geometric Road Hierarchy and Movement

Paul Mann
Liebenberg and Stander Consulting Engineers

5. Service Costs and Affordability

Professor Bruce Boaden, Professor Alan Stevens, Bruce Brooker
Department of Construction Economics and Management

Appendix C:
Service Costs

This appendix (1) provides an indication of the costs of the service options identified in section 5 of the handbook, and (2) discusses those factors that would cause typical service costs to vary.

Service costs account for approximately 50% of the cost of a serviced site (ie. 6 sq m wet core), 30% of a starter house (ie. 29 sq m house), and 20% of a basic house (ie. 42 sq m house).

Typical Percentage Breakdown of Housing Costs

COST ELEMENT	SMALL WET CORE 6 SQ M	STARTER HOUSE 29 SQ M	BASIC HOUSE 42 SQ M
Land Acquisition	9	6	4
Indirect Costs	12	13	13
Professional Fees	4	3	2
Water Supply (Yard Tap)	10	6	4
Sanitation (Aqua-Privy)	12	8	5
Roads (Double Bitumen Seal)	14	9	5
Stormwater (Lined Side-Channel)	5	3	2
Energy Supply (Electricity Dispenser)	12	8	5
Public Lighting (Streetlights)	1	1	1
House Costs	15	39	59
TOTAL HOUSING COST	100%	100%	100%

Notes:

1. Indirect costs include local authority charges, legal fees and bond costs, capitalised interest, escalation (18 months), and marketing and sales costs.
2. Professional fees include town planning, civil engineering, electrical engineering and land surveying fees.

The methods used by consultants to arrive at the costs presented in this handbook were as follows:

Roads, stormwater disposal, electricity supply, public lighting, and solid waste disposal costs were calculated using eight hypothetical layouts at varying densities. The basic design characteristics of these layouts are illustrated on the following two pages.

Water and sanitation costs are based on a review, conducted by the Palmer Development Group, of 22 *de facto* lower income development projects across South Africa. In the case of off-site reticulated systems, the eight hypothetical layouts were used to assess the impact of residential density on reticulation cost.

Public spaces costs are based on a review of *de facto* development projects in Cape Town.

Public market costs are based on the costing of *de facto* international cases.

Stormwater disposal operating and maintenance costs are based on local authority records.

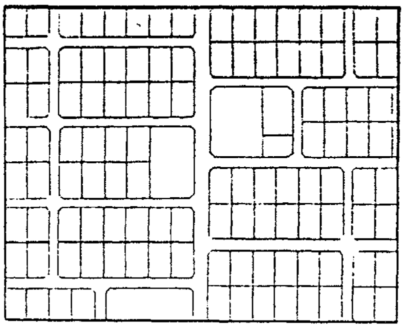
The servicing cost calculations of the eight hypothetical layouts, made as many simplifying assumptions as possible. Cost estimations were based on general assumptions regarding ideal site conditions, as well as specific assumptions regarding individual services. The general assumptions were as follows:

(1) a gentle sloping site
(2) no particular problems associated with soil conditions
(3) a 3 metre deep water table
(4) a watershed running to the one side of the layout
(5) a development project of 1 000 plots
(6) that the example layouts at different densities should be consistent - distorted rectilinear grid layouts with a similar road pattern.

Gross residential densities in the hypothetical layouts ranged between 14 du's/ha and 215 du's/ha, and average erf sizes ranged between 504 sq m and 66 sq m. The costs presented in this report are based on the 36-57 du's/gross ha, and the 111-191 sq m erf size, range.

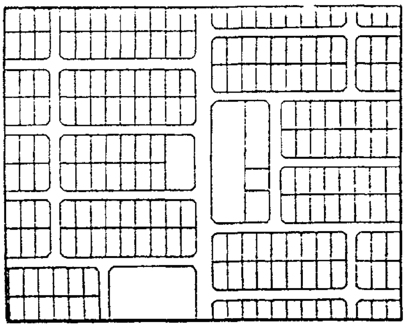
GROSS RESIDENTIAL DENSITY: 14 du's/ha

Area	: 7,98 ha
Number of Residential Erven	: 114
Number of Dwelling Units	: 114 du's
Total Road Length	: 1 865 m
Net Residential Density	: 20 du's/ha
Population Density	: 77 p/ha
Average Erf Size	: 504 sq m



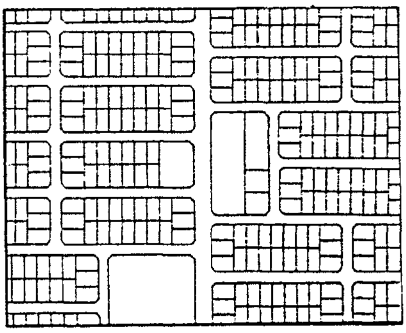
GROSS RESIDENTIAL DENSITY: 26 du's/ha

Area	: 7,98 ha
Number of Residential Erven	: 210
Number of Dwelling Units	: 210 du's
Total Road Length	: 1 875 m
Net Residential Density	: 38 du's/ha
Population Density	: 143 p/ha
Average Erf Size	: 264 sq m



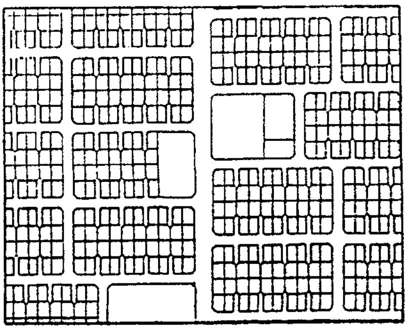
GROSS RESIDENTIAL DENSITY: 36 du's/ha

Area	: 7,98 ha
Number of Residential Erven	: 285
Number of Dwelling Units	: 285 du's
Total Road Length	: 2 369 m
Net Residential Density	: 52 du's/ha
Population Density	: 198 p/ha
Average Erf Size	: 191 sq m



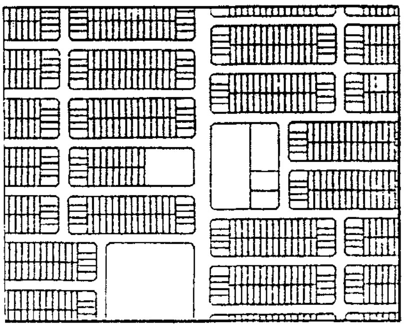
GROSS RESIDENTIAL DENSITY: 57 du's/ha

Area	: 8,0069 ha
Number of Residential Erven	: 456
Number of Dwelling Units	: 456 du's
Total Road Length	: 2 187 m
Total Cul-de-Sac Length	: 1 275 m
Net Residential Density	: 90 du's/ha
Population Density	: 313 p/ha
Average Erf Size	: 111 sq m



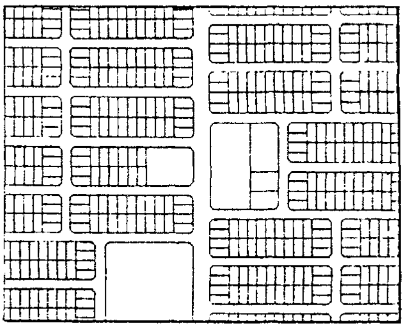
GROSS RESIDENTIAL DENSITY: 77 du's/ha

Area	: 8,032 ha
Number of Residential Erven	: 618
Number of Dwelling Units	: 618 du's
Total Road Length	: 2 654 m
Net Residential Density	: 126 du's/ha
Population Density	: 423 p/ha
Average Erf Size	: 79 sq m



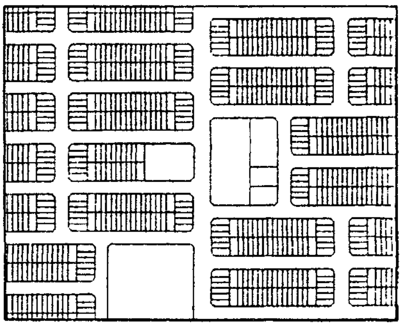
GROSS RESIDENTIAL DENSITY: 111 du's/ha

Area	: 8,0069 ha
Number of Residential Erven	: 446
Number of Dwelling Units	: 892 du's
Total Road Length	: 2 519 m
Net Residential Density	: 179 du's/ha
Population Density	: 610 p/ha
Average Erf Size	: 112 sq m



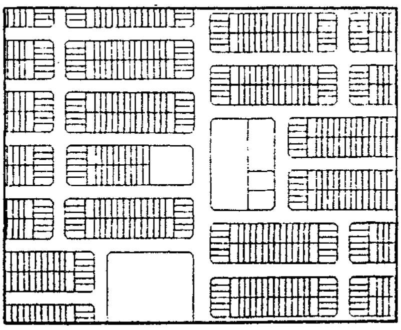
GROSS RESIDENTIAL DENSITY: 160 du's/ha

Area	: 8,032 ha
Number of Residential Erven	: 641
Number of Dwelling Units	: 1 282 du's
Total Road Length	: 2 523 m
Net Residential Density	: 303 du's/ha
Population Density	: 880 p/ha
Average Erf Size	: 66 sq m



GROSS RESIDENTIAL DENSITY: 215 du's/ha

Area	: 8,032 ha
Number of Residential Erven	: 575
Number of Dwelling Units	: 1 725 du's
Total Road Length	: 2 525 m
Net Residential Density	: 380 du's/ha
Population Density	: 1 182 p/ha
Average Erf Size	: 79 sq m



Water Supply

	SERVICE OPTION[1]	CAP. COST[2] (Rands)	O+M COST[3] (Rands)
1.	House Connection (HC[4])	1 200-2 200 (2 000)	570,48
2.	House Connection (NC)	1 000-1 800 (1 500)	387,96
3.	Yard Tap	800-1 400 (1 100)	342,36
4.	Yard Tank	no information	no information
5.	Public Standpipe	650- 900 (750)	296,64
6.	Public Water Tanker	no information	no information
7.	Water Kiosks	no information	no information

Notes:

1. The consultants who identified water supply service options (Palmer Development Group and Ulli Bleibaum Associates) felt that of the options presented, public water tankers and water kiosks were an inadequate form of provision.
2. Per erf capital costs (in 1994 Rands) refer to on-site and internal reticulation (where applicable) costs, and exclude connector and treatment costs. In the case of some service options insufficient examples exist in South Africa to enable costs to be provided. The costs represent medium costs in South African urban areas.
3. Operating/maintenance costs (in 1994 Rands) refer to per erf costs per annum. Costs include bulk supply, distribution and billing, and exclude interest and redemption costs.
4. HC and NC refer to high consumption and normal consumption respectively. Assumptions regarding consumption rates are as follows: house connection (HC) = 350 l/cap/day, house connection (NC) = 250 l/cap/day, yard tap = 120 l/cap/day, public standpipe = 50 l/cap/day.

Sanitation

	SERVICE OPTION[1]	CAP. COST[2] (Rands)	O+M COST[3] (Rands)
1.	Full Flush Toilets	1 800-5 600 (3 200)	160-696 (379)
2.	Intermed Flush Toilets[4]	1 800-5 600 (3 200)	160-696 (379)
3.	Aqua-Privy (LOFLOS)	1 000-3 900 (1 500)	61-219 (128)
4.	Pour-Flush Toilet	no information	no information
5.	VIP Latrine	800-3 800 (1 900)	25-125 (72)
6.	Chemical Toilets	no information	no information
7.	Bucket Collection	600-1 400 (800)	219-481 (335)
8.	Communal Toilets	no information	no information

Notes:

1. The consultants who identified sanitation service options (Palmer Development Group and Ulli Bleibaum Associates) felt that of the options presented, chemical toilets, bucket collection and communal toilets were an inadequate form of provision for permanent use, because they either provide inadequate heath protection or they are socially unacceptable.
2. Per erf capital costs (in 1994 Rands) refer to on-site and internal reticulation (where applicable) costs, and exclude connector and treatment costs. In the case of some service options insufficient examples exist in South Africa to enable costs to be provided.
3. Operating/maintenance costs (in 1994 Rands) refer to per erf costs per annum. Costs include on-site maintenance, water, reticulation, collection/emptying, connector service and treatment costs.
4. There is insufficient information regarding the cost of intermediate flush toilets relative to full flush toilets to provide accurate estimates. While the infrastructure is similar, intermediate flush toilets may be less expensive (± 85%).

Roads

	SERVICE OPTION	CAP. COST[1] (Rands)	O+M COST[2] (Rands)
1.	Concrete Paving	2 890-2 910 (2 900)	8,50
2.	Brick Paving	2 890-2 910 (2 900)	8,50
3.	Hyson-cells	980-1 120 (1 050)	9,80
4.	Premix	2 180-2 480 (2 330)	21,80
5.	Sand Asphalt	810-1 160 (985)	16,20
6.	Double Seal	1 880-2 230 (2 055)	26,30
7.	Sealmac	900-1 360 (1 130)	15,20
8.	Single Seal	760- 975 (867)	15,20
9.	Slurries	730- 900 (815)	22,00
10.	Gravel Additives	470- 630 (550)	18,50
11.	Gravel Wearing Course	400- 560 (480)	40,00
12.	Soil-Cement	215- 375 (295)	17,20
13.	Earth Street	120- 155 (137)	6,00

Notes:

1. Per erf capital costs (in 1994 Rands) are calculated at a gross residential density of 57 du's/ha. Costs exclude P&G costs, contingencies, fees, disbursements, testing and VAT - only direct plant, labour and material costs have been costed. Carriageway widths for local access streets are 6,2 m for service options 1 to 8, and 5 m for service options 9 to 13. Sand asphalts, slurries, and block and brick paving require edge constraints to prevent disintegration from traffic - allowance has therefore been made for sunken concrete edgings in these cases.
2. Operating/maintenance costs (in 1994 Rands) refer to per erf costs per annum, and are calculated at a gross residential density of 57 du's/ha. The following assumptions are made regarding traffic volumes (measured in vehicles per day - v/d): earth and soil cement = 50 v/d; gravel wearing course = 500 v/d; gravel additives and slurries = 1 000 v/d; single seal, sealmac, sand asphalt, hyson cell and brick/concrete paving = 2 000 v/d; double seal and premix = 10 000 v/d.

Stormwater Disposal

	SERVICE OPTION	CAP. COST[1] (Rands)	O+M COST[2] (Rands)
1.	Kerb Stormwater Drains	1 550	30-70 (50)
2.	Lined Side Channel	770	no information
3.	On-Road Channel	660	no information
4.	Unlined Side Channel	300	no information
5.	On-Site Disposal	no information	no information
6.	No Provision	0	0

Notes:

1. Per erf capital costs (in 1994 Rands) refer to internal reticulation costs, and are calculated at a gross residential density of 50 du's/ha. Costs exclude P&G costs, contingencies, VAT, and indirect costs (ie. fees, supervision, disbursements and tests) - only direct plant, labour and material costs have been costed. The costs shown are based on projects in the Cape Town area.
2. Operating/maintenance costs (in 1994 Rands) refer to per erf costs per annum, and are calculated at a gross residential density of 25 du's/ha. Costs are based on local authority records in Cape Town. Existing local authority records do not separate stormwater operating/maintenance costs into different levels of service, therefore reliable cost records for maintenance are not available.

Energy Supply

	SERVICE OPTION	*CAP. COST* (Rands)	*O+M COST*[1] (Rands)
1.	Prepay Disp[2] (BG, 4kVA)	2 917	756,85
2.	Prepay Disp (BG, 1kVA)	2 312	756,85
3.	Prepay Disp (AG, 4kVA)	1 871	756,85
4.	Prepay Disp (AG, 1kVA)	1 562	756,85
5.	Polyflow Plastic Pipes[3]	3 410	no information
6.	HDPE Pipes	3 097	no information
7.	Steel Pipes	2 378	no information
8.	Paraffin	not applicable	not applicable
9.	Coal	not applicable	not applicable
10	Candles	not applicable	not applicable
11	Wood	not applicable	not applicable
12	Photovoltaic Systems	1 500[4]	no information
13	Wet Batteries	not applicable	not applicable
14	Passive Solar	no information	no information

Notes:

1. Operating/maintenance costs (in 1994 Rands) for electricity supply refer to per domestic supply point (erf) costs per annum. Costs are drawn from the price build-up of the Eskom S1 tariff, and assume a breakeven of 537 kWh/month at 21,75 c/kWh.
2. Per erf capital costs (in 1994 Rands) for electricity supply refer to high/medium voltage reticulation, low voltage reticulation and service connection. Preliminary and general costs (± R90-190) and streetlighting costs (see section 3.6) are excluded. Costs are calculated at a gross residential density of 36 du's/ha. AG and BG refer to above-ground and below-ground electricity cable reticulation. The following values (1 kVA or 4 kVA) refer to the After Diversity Maximum Demand (ADMD) which has a significant influence on the size of cabling and the capacity of transformers, which in turn effects the cost of reticulation.
3. Per erf capital costs (in 1994 Rands) for reticulated gas supply refer to direct and indirect field costs (eg. plant, labour, materials). Home office costs (± R249), VAT (± R368) and contingency costs (± R567) are excluded. Costs are calculated at a gross residential density of 35 du's/ha. HDPE refers to high density poly ethylene pipes.
4. No information has been obtained on the capital cost of PV lighting systems. However a call for tenders for PV lighting systems, that could provide some lighting and provide for radio and television at costs less than R1 500, was recently placed. Several manufacturers and suppliers bid for the tender.

Public Lighting

	SERVICE OPTION	CAP. COST[1] (Rands)	O+M COST[2] (Rands)
1.	Streetlights[3] (BG,% exv)	180	10,32
2.	Streetlights (BG,excl exv)	119	10,32
3.	Streetlights (AG,incl pl)	100	11,88
4.	Streetlights (AG,excl pl)	40	11,88
5.	Med Mast Security Lights[4]	210	15,24
6.	Photovoltaic Lights[5]	no information	no information

Notes:

1. Per erf capital costs (in 1994 Rands) are calculated at a gross residential density of 36 du's/ha.
2. Operating/maintenance costs (in 1994 Rands) refer to per erf costs per annum, and are calculated at a gross residential density of 36 du's/ha.
3. Streetlights refer to 70 W lamps at 50 m intervals. AG and BG refer to above-ground and below-ground cable reticulation. The first below-ground streetlight option includes 44% (R61/erf) of total excavation costs (R139/erf), on the assumption that the remainder is attached to electricity reticulations costs. The second below-ground streetlight option excludes excavation costs. The first above-ground streetlight option includes pole costs, on the assumption that pole costs are not included in above-ground electricity reticulation costs (eg. in the case of mid-block reticulation). The second above-ground streetlight option excludes pole costs.
4. Medium mast security lights refer to 20 m masts carrying 4 X 400 W lamps.
5. No information has been obtained on the capital cost of PV streetlighting. However it is estimated that PV streetlights cost significantly more than conventional streetlights - ± R4 000 as opposed to ± R2 250.

Solid Waste Removal

	SERVICE OPTION	VEH. COST[1] (Rands)	O+M COST[2] (Rands)
1.	Screw Compactor	750 000	153,40
2.	Rear Loading Hydraulic	650 000	154,44
3.	Open Truck	250 000	153,40
4.	Tractor and Trailer	100 000	224,12
5.	Local Entrepreneurial KC	300 000	209,56
6.	Communal Collection	300 000	107,12
7.	No Collection	not applicable	no information

Notes:

1. Vehicle cost (in 1994 Rands) refers to the vehicle purchase price. The cost does not include the cost of skips, containers, bins and bags.
2. Operating and maintenance costs (in 1994 Rands) are presented on a per erf per annum basis, and include storage, collection and disposal costs. All collections are assumed to occur on a once weekly basis. Costs are calculated at a gross residential density of 56 du's/ha.

Public Spaces

	ELEMENT	CAP. COST[1] (Rands)	O+M COST[2] (Rands)
1.	Trees[3]	250	no information
2.	Low Walls	160- 230 (195)	4,00
3.	Colonnades	100- 300 (225)	30,00
4.	Terraces	not applicable	not applicable
5.	Paved Surfaces	73- 76 (74)	0,20
6.	Asphalt Surfaces	21- 65 (43)	0,43-0,56 (,49)
7.	Surface Treatments	19- 59 (39)	0,40-0,69 (,54)
8.	Gravel Surfaces	8- 12 (10)	0,84
9.	Gravel Additive	10- 13 (11)	0,40
10.	Paved Side Walks	73- 76 (74)	0,10
11.	Asphalt Side Walks	21- 65 (43)	0,25
12.	Gravel Side Walks	8- 12 (10)	0,42
13.	Roll-On Grass	12- 40 (31)	7,50
14.	Seedling Grass	5- 10 (7)	7,50
15.	Benches[4]	500-1 000 (750)	85,00

Notes:

1. Capital costs (in 1994 Rands) for vertical edges, hard surfaces, side walks and soft surfaces refer to square metre costs. Costs do not include overheads of 15% and VAT of 14%.
2. Operating/maintenance costs (in 1994 Rands) for vertical edges, hard surfaces, side walks and soft surfaces refer to per square metre costs per annum.
3. The capital cost of treeplanting (per tree) includes labour, compost and the sapling.
4. The capital and operating/maintenance costs for public benches refer to costs per bench. Benches can be made from timber, asbestos cement, precast concrete, steel, or combinations of these materials. Low walls and terraces can also be designed as seating within public spaces.

Public Markets

ELEMENT		*CAP. COST*[1] (Rands)	*MAIN. COST*[2] (Rands)
1.	Lock-Up Stalls	8 727-9 845 (9 286)	186
2.	Market Buildings	3 428-5 695 (4 561)	91
3.	Shelter and Stall	944-1 843 (1 393)	28
4.	Basic Level	313	6

Notes:

1. Capital costs (in 1994 Rands) refer to costs per stall space. Costs are derived from *de facto* examples of public markets in Sri Lanka, Zimbabwe, Taiwan, Thailand, and India. Cost estimates include an allowance for preliminaries (establishment and overhead charges) at 8% and for VAT at 14%, calculated on the full cost of labour, materials, overheads and profit.
2. Maintenance costs per annum (in 1994 Rands) are assumed to be 2% of the capital cost of the market infrastructure. No information on operating costs (eg. market management and administration) is available

Numerous factors influence the relative cost of internal service provision, making it impossible to provide exact costs. The following discussion is on those factors which would cause the typical internal service provision costs provided, to vary.

While the factors that influence cost are often specific to individual service technologies, at a general level, the following would seem to have the greatest effect on servicing costs: (1) site conditions, (2) delivery system, (3) design standards, (4) geometric layout, and (5) a number of miscellaneous factors. These are discussed in turn.

1. SITE CONDITIONS

Firstly, context specific site conditions have a significant influence on the cost of service provision. The following factors are of particular importance:

1.1 Topography

Flat or gently sloping terrain, which facilitates shallow grades and drainage, is easier to develop than steeply sloping terrain. This is of greatest importance in road, sewerage and stormwater networks. In the case of roads, steep slopes often require substantial earthworks in hard or rock material to achieve acceptable road widths and grades, which increase costs. In the case of stormwater pipes and sewerage, steep slopes increase the cost of excavating and laying pipes.

1.2 Soil Type

Rock, which is expensive to excavate, and very sandy or very clayey soils increase servicing costs. This is of greatest importance in road and sewerage networks. In the case of roads, the higher the bearing capacity of the in-situ material, the fewer structural layers are required in the pavement structure. In the case of on-site sanitation systems, sandy soils require pit liners, while less permeable soils require longer soakaways.

1.3 Water Table

Areas with high or variable water tables and marshy, silty or clayey conditions, are costlier to develop than areas with low water tables and sandy or gravelly conditions. When water tables are high, it is often necessary to dewater trench excavations, and the risk of ground water contamination restricts the use of on-site sanitation disposal systems which necessitates more expensive off-site sanitation systems.

1.4 Climate

Climatic conditions can have an important impact on costs in that poor climatic conditions can result in lengthy delays which add to the contractor's overheads and therefore are allowed for in the pricing of the work. The time of year during which the work has to be carried out is therefore also important.

1.5 Vegetation

Site clearance costs could add significantly to overall costs if the vegetation is particularly intensive. Alternatively, the cost of stabilising loose soil could also be costly.

2. DELIVERY SYSTEM

Secondly, the way in which services are delivered influences the cost of provision. The following factors are of particular importance:

2.1 Construction Method

The choice of technology, the period of construction, and access to labour, influence capital cost. In particular, choices between the use of capital intensive, labour intensive, labour-based or community-based construction systems influence the relative cost of labour, on-site training and construction.

2.2 Project Size

The size of the development project influences the cost of consultants fees, plant hire and materials transportation. Due to economies of scale in implementing large developments, larger projects tend to be more economical than smaller projects.

3. DESIGN STANDARDS

Thirdly, the specifications and standards applied in infrastructure design have a significant influence on the cost of service provision. The following factors are of particular importance:

3.1 Design Capacity

The capacity to which service networks are designed determines pipe sizes, cable sizes, the capacity of transformers, road structure, the volume of solid waste collection vehicles, and so on, all of which effect the capital cost of provision. This is particularly important in the case of roads, where the volume, type and composition of anticipated traffic affects the required pavement structure and its associated costs - heavy vehicles cause substantially greater damage to a pavement than light vehicles.

3.2 Lifespan

The design philosophy regarding the lifespan of a service has an influence on cost. Life cycle cost estimates are often used to determine the designed lifespan of a service. Generally, services designed with longer lifespans will incur higher construction, but lower maintenance costs, and vice versa. The design lifespan of a street for instance, is generally taken as 15-20 years. Design periods less than this will result in lighter pavements with lower construction cost, but higher maintenance costs.

3.3 Materials

The choice and availability of materials effects costs. This is particularly important in the case of roads where the availability of suitable pavement materials from nearby commercial sources, or borrow pits, often determines the choice and cost of pavement constructed.

4. GEOMETRIC LAYOUT

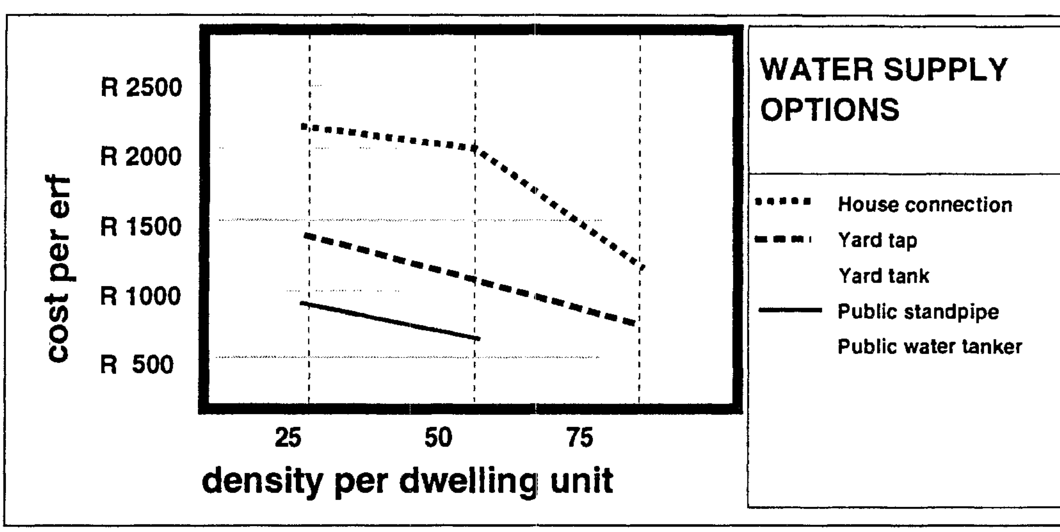
Fourthly, the geometric layout of an urban settlement influences the cost of service provision. The following factors are of particular importance:

4.1 Residential Density

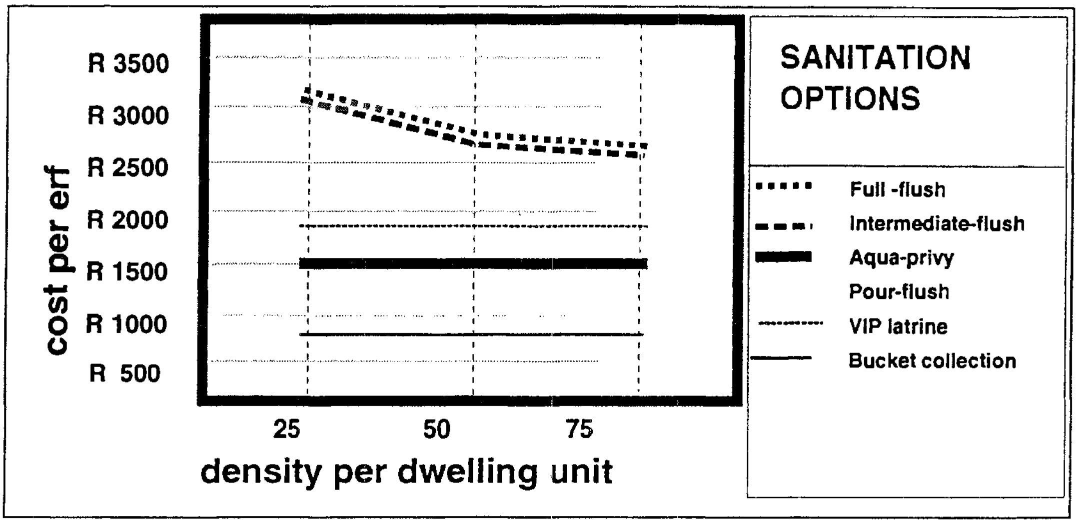
Erf size, erf frontage and gross residential density have a significant influence in the length and cost of reticulation per erf. There is a trade-off between greater servicing costs, and greater cost sharing, in higher density environments. On the one hand, higher density developments often require more expensive 'internal' services than lower density developments to accommodate greater loads. While on the other hand, some service costs (eg. streetlights) remain relatively constant irrespective of density. Therefore even though total internal servicing costs increase with density, the ability to share costs between a greater number of home-buyers results in lower unit costs.

The following six graphs illustrate the impact of increasing gross residential densities on the capital cost of service provision.

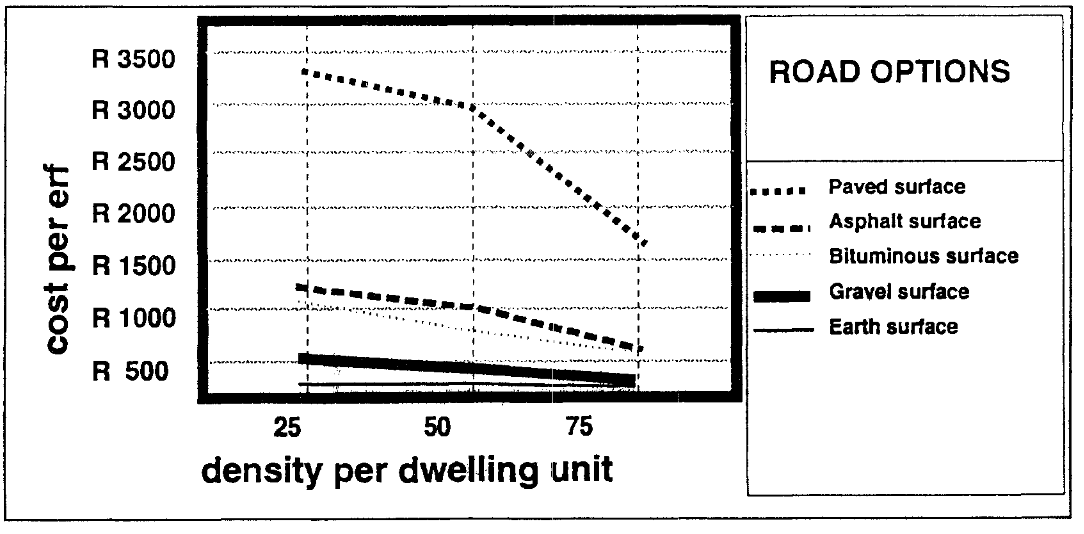
The Impact of Density on the Capital Cost of Water Supply



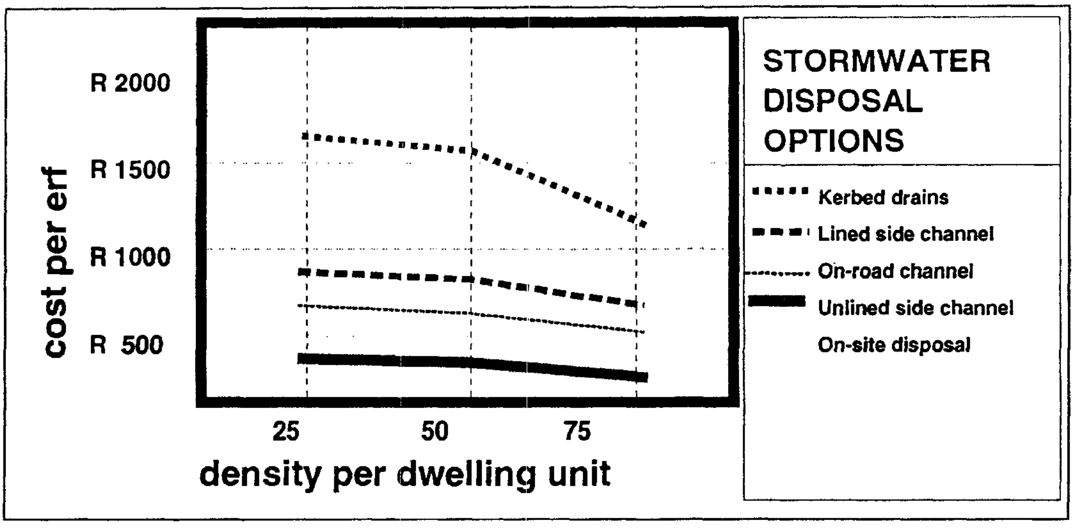
The Impact of Density on the Capital Cost of Sanitation



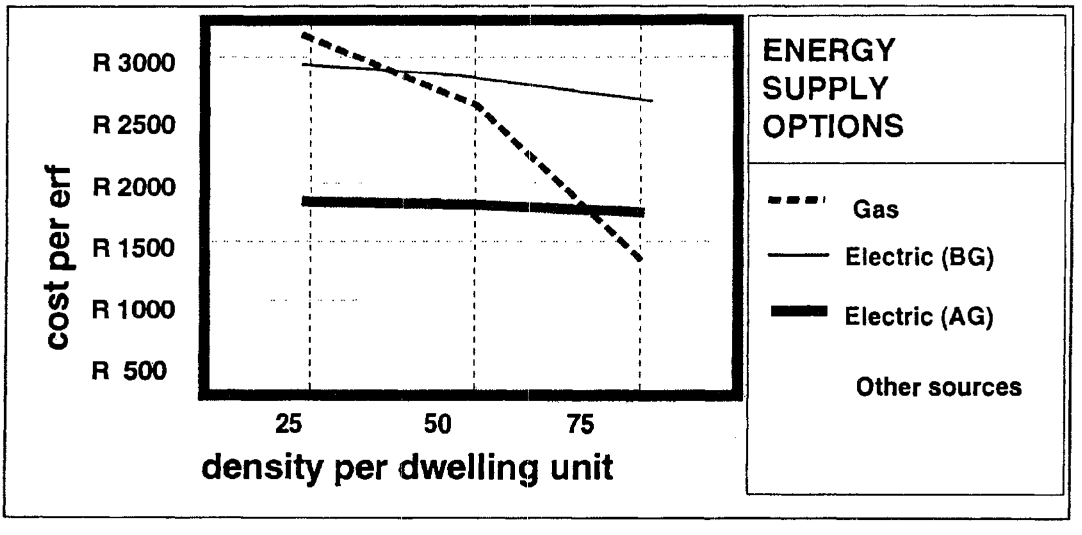
The Impact of Density on the Capital Cost of Roads



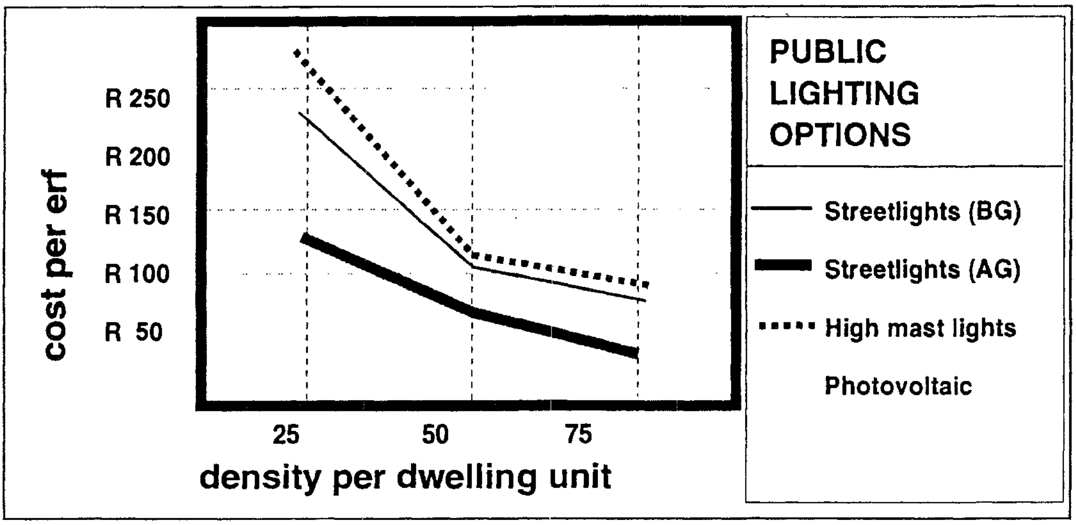
The Impact of Density on the Capital Cost of Stormwater Disposal



The Impact of Density on the Capital Cost of Energy Supply



The Impact of Density on the Capital Cost of Public Lighting



4.2 Road and Block Alignment

Road curvature and block length influence the number and spacing of manholes in sewer and stormwater reticulation, and the quantity of poles in above-ground electricity and streetlight reticulation. As the road layout changes from a rectilinear grid pattern, to more complex curvilinear patterns, manhole and pole requirements generally increase and reticulation costs rise.

4.3 Reticulation Networks

The form of reticulation in sewerage, water supply, telecommunication, electricity and streetlight services, influences costs. In the case of sewerage and water supply, mid-block reticulation generally enables shorter erf connections and less land take-up in the road reserve, than conventional street reticulation. In the case of telecommunication, electricity and streetlighting, above-ground reticulation is generally less expensive than below-ground cabling.

5. MISCELLANEOUS FACTORS

5.1 Economic and Business Climate

The economic and business climate has a profound effect upon the construction industry and the costs at which products in this industry are delivered. Typically when the economy is strong, construction costs are high, with increases usually exceeding the rate of inflation. Prices or costs of service provision at the present time, however, are relatively low as a result of the long depression in the industry. This situation can, however, be expected to change rapidly with an upturn in the economy when competition for work will decrease and costs will escalate.

In the likely event of an upturn in the economy and with increased state spending in the housing sector, substantial cost increases can be expected with respect to labour, materials, overheads and profits. This increase is likely to be less for the labour cost component since there is considerable capacity presently unemployed. One can expect, however, a much higher increase in the price of materials where there is little capacity for short-term expansion in production. This factor could favour labour intensive approaches to service provision.

5.2 Security and Other Risks

An important factor affecting tender prices and the cost of service provision is the perceived risk of additional costs being incurred by the contractor in carrying out work at a particular location. This usually results in a substantially higher tender being submitted than would normally be the case. These additional costs would include factors such as materials theft, delays due to social and political unrest and vandalism to completed work. Tenderers for the work normally allow a contingency amount of up to 50% to cover these 'unknowns'.

5.3 Monopoly Conditions

Monopoly conditions in the materials supply industry will affect the costs of service provision. This is particularly true with respect to the types of materials used in the construction of services where entry for small manufacturers is difficult. Examples of these materials would be cement and PVC and concrete piping.

Although it is not the case at the present time, a monopoly or shortage situation could develop with regard skilled and unskilled labour which could have a major impact on the costs of labour inputs.