URBAN ECOLOGY:

TOWARDS A MODEL FOR SUSTAINABLE DEVELOPMENT

By

Phillipus Johannes Barnard

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Supervisor:
Professor Ron Kirby

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This thesis is dedicated to those who taught me about nature.

FOREWORD

......"the man-made environment where a man lives is not all the result of arbitrary happenings. It has structure and embodies meaning. These meanings and structures are reflections of man's understanding of the natural environment and existential situation in general. A study of man-made place, therefore, ought to have a natural bias. It should take the relationship of the natural environment as its point of departure." Norburg Schultz, 1980.

This discourse propose an alternative to urban development in South Africa which would fix open space in functional landscapes and not only by avenues of green trees on urban development proposals. A rational base must be developed to integrate the "natural" and the "urban" which are inherent of human settlement, as well as the social and economic processes which would manage, maintain and sustain the plans.

Many of the ideas expressed came from Micheal Hough's push for a "urban vernacular" (1989, 1991, 1992) and McHarg's principles of "design with nature" (1971) in assessing site conditions to determine sensitivity, carry capacity and ultimately the type of land use. In addition to this the social aspects and economic conc (after Jacobs, 1977 and Van der Ryn and Calthorpe, 1991) was incorporated into a framework, as these factors would ultimately sustain human settlement on earth. Urban ecology as a theoretical model thus set out to prove the importance of ecological principles in the holistic approach all Urban Designers should adapt in understanding, structuring, planning and ultimately designing the total Urban Environment.

The concept of urban ecology was first clinched by Lawrence Halprin (Museum of Modern Art, 1991) in his search for design resolves drawn form nature during the late sixties. Halprin then developed this approach further by incorporating it into his theatrical exploration of earth-inspired solutions to a range of urban design related projects. The term is still used in a loose way, but there is a general consensus that it refers to the incorporation of ecological principles appropriate to the urban settlements into the creation of a sustainable environment, meeting human needs within the parameters set by Nature.

The focus for this discourse will not only be so called landscape solutions, but the fundamental ecological principles which should guide the design of urban environments, including social and economic concerns relevant to urban design. As in the animal kingdom, the interaction between animals and their environment is part of their social structure. Thus a social response is required to enable environments to be sustainable. Urban ecology therefore calls for a holistic and integrated approach.

Johan Barnard
October 1993

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PART 1:

THEORETICAL FRAMEWORK

1.0 INTRODUCTION TO URBAN ECOLOGY

The importance of the ecological environment in the sustaining of human health and habitability on Earth has been getting alot of publicity, funding and attention from the media and scientific research alike.

Earth as a biosphere is a closed system - except for the penetration of sun light energy, through gaseous filtering layers, an evolutionary and dynamic interactive co-existence of living, organic and anorganic components sustain life within a closed system on Earth. This fact makes humans, as part of this interaction, an important link within the existence and future sustainability of our global ecosystem. By definition all human creations and interactions must fundamentally not be to the detriment of this closed system. But it is - " Man in space is enabled to look upon the distant earth, a celestial orb, a revolving sphere. He sees it to be green from the verdure on the land, algae greening the oceans, a green celestial fruit. Looking closer at the earth's crust, he perceives blotches - black, brown, grey, extending dynamic tentacles upon the green epidermis. These blemishes he recognizes as the cities and works of man and he asks: "Is man but a planetary disease?"

It seems that society at large is realizing that this is not the case. We have lost the genetic link to the ecological principles, interactions and forces that created the biosphere that we know in modern times: a polluted, threatened habitat. (Research are now deemed necessary to establish the degree of risk which is involved in space programmes travelling through space rubble which are already in orbit around the earth's atmosphere, generated in the first 24 years since the global space programme have been operational - Earth Works Group, 1990)

In the creation (planning, design and management) of our settlements it seems that humans have forgotten that the *forces of nature* are still at work, forming and eroding the thin crust we live on. It must be possible to accommodate these devastating forces in the process of city building.

The processes which shaped the prehistory of a landscape on which man has settled, still have an impact on the environment. Would it not make sense to first understand these processes and then acknowledge and incorporate them in creating pleasant environments for people to settle, life and work in? This, by no means excludes the other major information clusters of social, economic and form related aspects as part of a comprehensive system of definition analysis, synthesis and evaluation of conclusion. The environmental aspects underpin social interaction and structure as well as the economics or feasibility and the form relationships of our city environments. Urban design was defined by Lucien Kroll as "...neither a work of art, nor an intellectual achievement, but a *living process*; an opened dynamic activity in which each generation adds new meaning and enriches it with its contractions." (in Harris, 1992).

The discourse was born from the growing awareness and the growing concern for the environment as has been firmly established through the media by ways of the ozone problem, the build-up of greenhouse gases and even environmental disasters like mud slides, floods, etc. The technology in the hands of modern man seems to have transformed, integrated and complicated ecosystems and environments to what could be called biological sterile landscapes lacking the resilience of natural systems. In addition to these designs, many do not even consider the social aspects of the design they generate, but is solely driven by economic and engineering parameters and planning regulations.

The laws of Nature are actually an integrated, yet effective structuring device - ordering compatible uses together and still pulling the thin thread through linking diversity into a complex, sustainable hole. The main reason for investigating the importance of the total environment on the urban system is to establish the difference between the *price* we pay and the true *cost* to the total environment. The ecosystem approach could act as a barometer indicating the difference between the input and the discharge of energy - and that is what the ecosystem revolves around: the flow of energy to sustain the system.

To conclude another phrase from Design with Nature (McHarg, 1971) *"If we could abandon the sad arrogance of ignorance and introduce a mood of reasonable inquiry, then circumspection will temper our indictment and we can reinterpret the stories. If we assume that man is a beneficent and constructive agent in the world, we could imagine the green celestial fruit as a great epidermis indeed, but we could consider the green film as cytoplasm and the black, brown and grey centre not as blemish, but as nuclei and plastids - directing, producing, storing and circulating material for the cytoplasm: the creative centres of life."*

1.1 URBAN DESIGN: THE EVOLUTION OF THE DESIGN GENERALIST

In the evolution of man and his settlements and technology the notion of a *generalist* has made way for the modern *specialist*. The idea of the Renaissance Architect has diversified into many professions and experts needed to plan, design and implement human settlements. This approach is now known as "interdisciplinary".

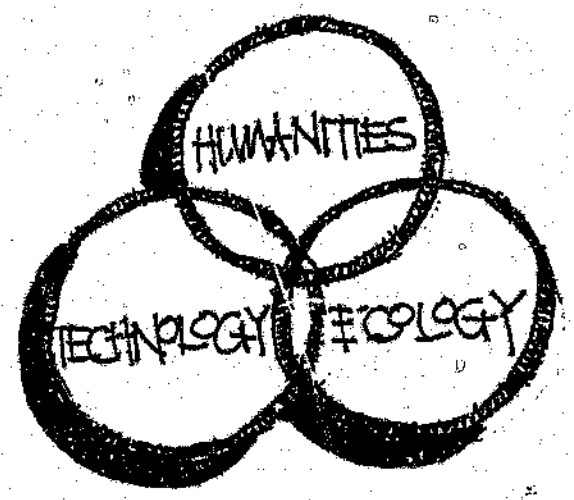

Fig 1.1 - The position of Urban Ecology relative to the other fields of expertise closely associated with urban design, after Dr Roger Boden and course notes.

See Fig.1.1

It is proposed in this thesis that what is needed more than specialists is the generalist and that the urban designer could be that facilitator. Amongst the Architect, Planner, Engineer, Landscape Architect, Geographer and Environmental Designer the design expertise of the urban generalist is required - for every specialist a larger generalist framework would be required.

In the study and defining of urban design as a field of expertise the notion of generalist becomes clear: the possibility of the rebirth of the facilitating modern urban generalist. The urban generalist would provide the structuring spacial and environmental framework for the settlement of a "1000 designers" (Senior, 1988). The theoretical framework of the urban designer should therefore include the principles of urban ecology as a sustainable community is one of his primary goals.

The urban designer is required to have a range of skills, expertise, knowledge and creativeness. The fields drawn from are quite theoretical but often very practical, allowing the approach to be open, focusing on both the process and product and never forgetting the importance of space, scale and human activity within an environmental framework.

1.2 HISTORICAL OVER VIEW

Since the time of the hunter-gatherer only three significant transitions can be noted: the transition to commercial agriculture and settlement, the industrialization which introduced the modern urban patterns and the electronic stage where communication to all corners of the earth brought high technology within reach of all dwellers who are connected, while man has already explored outer space. These developments were manifested in the settlement patterns through history (see Bacon, Mumford and others). The early settlements were compact, dense towns and this phenomenon persisted through the Dark Ages. Because of a lack of transport technology, cities remained relatively compact till the 1800's.

The invention of the coal fired steam engines, lead to industrialization which it brought about enormous health risks in the densely populated cities. Modern city planning include land use zoning for industries, commerce, housing and park land. The invention of the motor car, made commuting easy and quick so that people settled far from the problems of the overcrowded city centres, suburbia was born in the early 1900's.

Urban sprawl, and the enormous waste of resources which have been associated with it, was the result.

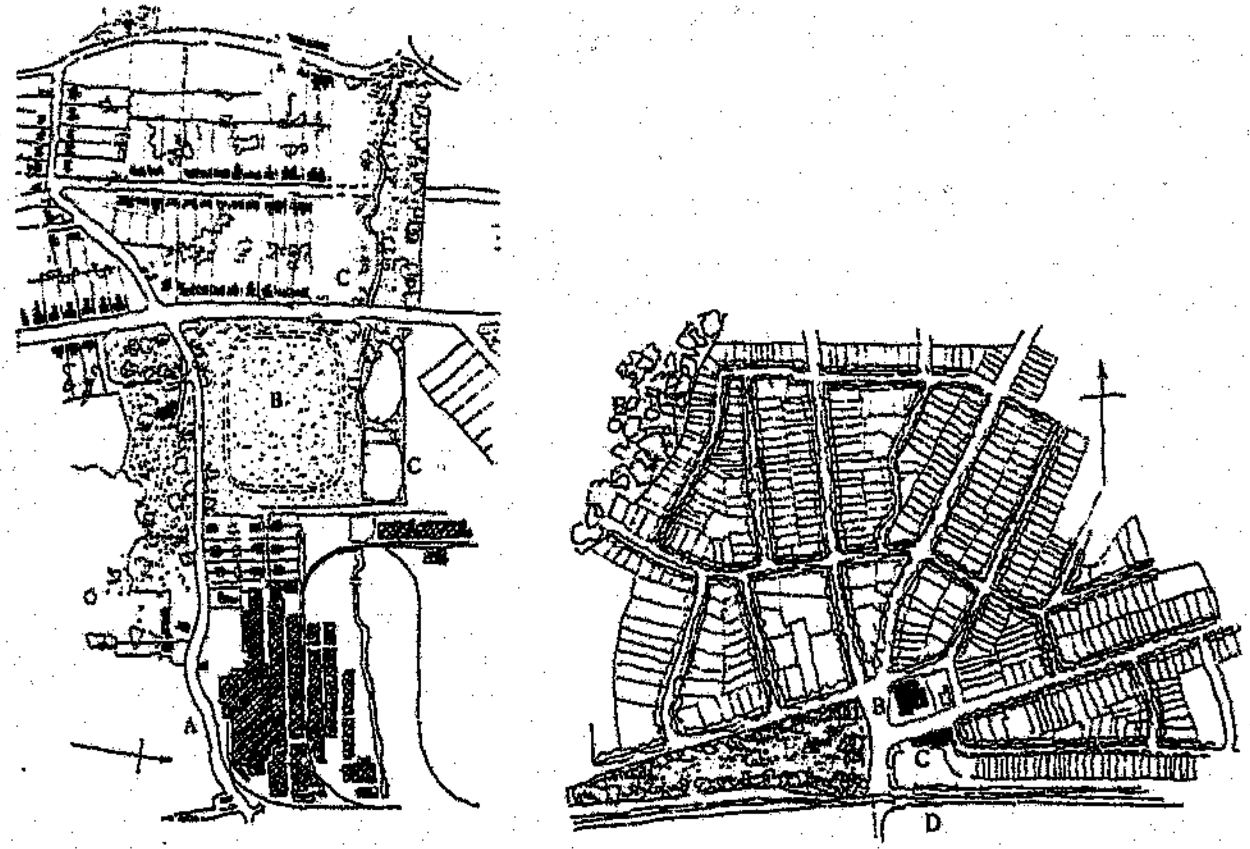

Fig 1.2 and Fig 1.3 - Bedford Park, Chiswick and Bournville, Birmingham (Cadbury brothers, 1898) clearly show the principle
s of grouping public facilities to create activity nodes, integrating functional open space into the community, as well as providing housing close to work opportunity. (Jellicoe, 1975)

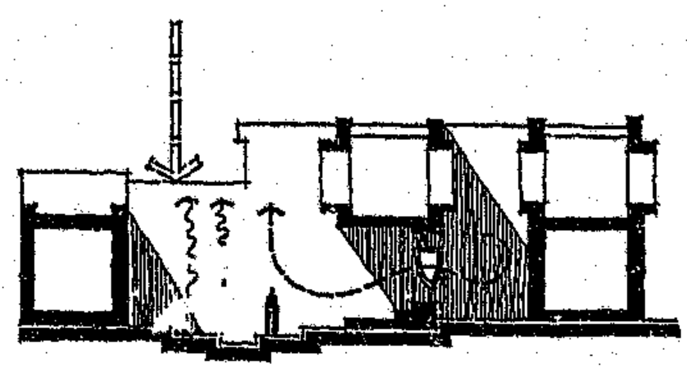

Fig 1.4 - The two court yard house, traditional, rural Egyptian design, with a deeply shaded and cool courtyard and a larger, warmer courtyard. The difference in air pressure induces a convection draught from cool to warm. Mazlara cooling jars are placed in passageways to add to the cooling effect because of evaporation. (After Cain, 1976 in Hough, 1991)

Technology, and particular the development of computers and modern telecommunication enabled not only the horizontal expansion of the residential components, but also the decentralization of business, retail and industrial sectors. In studying the reasons for these transitions in the basic urban structure, the possibility for an new transition becomes more and more of a reality. Among all these evolutionary transitions there is a larger whole - a more encompassing system of forces governing the shape, functioning and life of our urban settlements. A paradigm shift towards ecological planning, resource management, nature and sustainability was noted both in theory and in practical works.

The foundation for the changing paradigm (after Ahern and Fabel, 1988) thus was laid even before Ebenezer Howard and the Garden City Movement. (Jellicoe, 1975) The shift in emphasis towards a more integrated society and settlement pattern was already evident in Norman Shaw's Bedford Park Estate, Chiswick (1870) and the work of William Morris. See Fig 1.2 and Fig 1.3.

Early cities where inhabitants struggled for survival, they were less aware of their environment, because of their restrictive technology and access to energy. Electricity and the internal combustion engine changed man's impact on his environment for ever. In older cities and settlements the framework for compact and efficient settlements were dictated by technology. Access to energy, natural light and ventilation with clearly defined zones of transition between public and private was common knowledge. Not only livable spaces, but environmentally friendly settlements were the result of these basic environmental principles.

The reason why the design of urban environments in historical settlements were successful could be seen in the way built form related to the environment. See Fig 1.4. These patterns were born from local climate and site specifics, growing incremental and organizationally - thus continuing adapting to address social and community needs. The natural system can also provide clues as to how and where a human settlement should take place. Topography formed the boundaries of settlements, it defines space and divides communities. Rivers on the other hand, converge space and unify communities, it offers water transport, water for industries and human consumption. See Fig 1.5.

In the classic civilizations of the Ancient Greeks and Romans, going one step further than just environment and people, ecology and sociology. Their cities had also a bearing on the cosmos, on the universe and on its forces upon human beings. This could explain the *genus loci* of classical creations, classical cities and classical buildings, in Egypt, Greece and Italy.

There are limitations to non-renewable resources, like land, coal and oil, as well as the costs of infrastructure, maintenance and environmental degradation, and have finally convinced politicians that the present urban form, present more than just socio-economic problems. In the words of Peter Calthorpe (1991) "The current social, environmental and psychological pressures can produce a new philosophy of design and planning: replacing

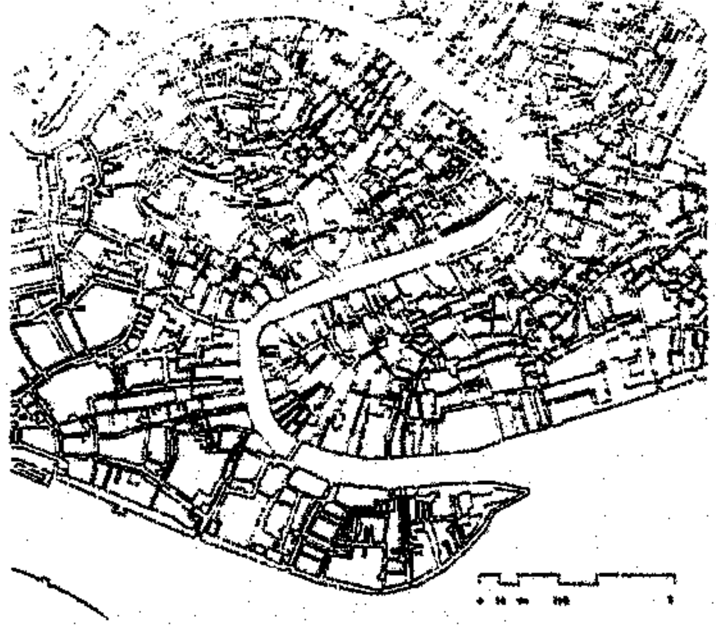

Fig 1.5 - Rivers, the availability of water and the ques it gives to the landscape have dictated many settlement through the ages. Venice is a case in point - the meandering river indicate a river not prone to flooding, the bend defines a "place" and the permanent water supply and harbour activity made the settlement sustain. (Dewar and Uytenbogaardt, 1984)

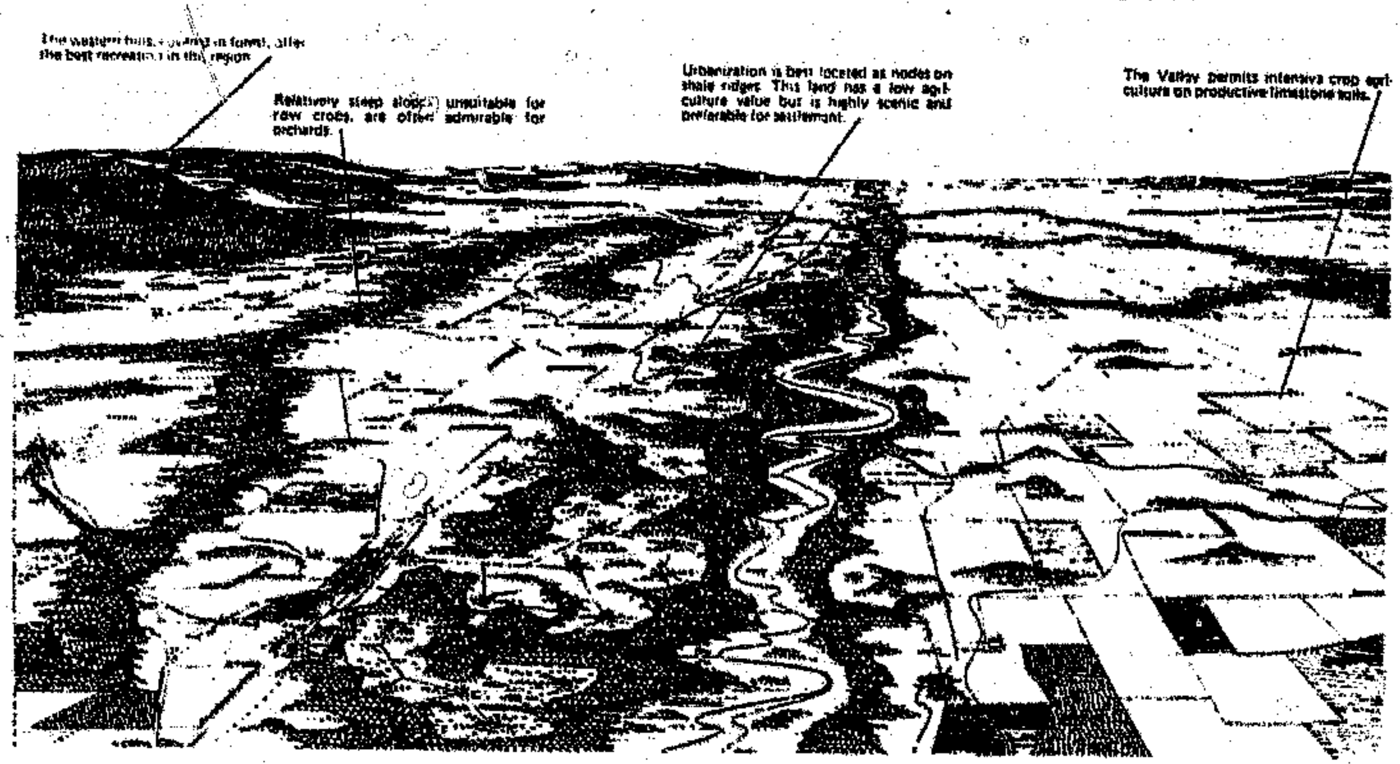

Fig 1.6 - The Great Valley, east of the Rockies - a broad and flat valley with rich limestone soils, spread over dolomite aquifers. McHarg used the "overlay" method of all the environmental data to establish development guidelines.

symbolic gestures and trendy styles with purposeful forms which honour ecology and history; replacing short-term market forces with long-term stability; and ultimately amplifying the unique quality of each place, rather than standardizing the built environment."

Urban Ecology, as well as principles of sustainability could help in developing a new model of holistic understanding in urban design. The emphasis is on the environmental factors pertaining to the city, but as is the case with natural communities the social realm should also be incorporated. In an effort to promote urban ecology from a implementation point of view economical concerns should also be addressed. The total re-evaluation of the modern city form, was already clear with the publishing, in 1959 of *The Death and Life of Great American Cities* (Van der Ryn, 1991). The oil crisis of the 1970's showed us how expensive our city form actually was. The destruction required to maintain these growing mechanisms led to the public outcry against the use of Chloro-Fluoro-Carbons's (CFC's) environmental pollution and global warming, have suddenly made environmental issues a public concern.

As a result of the intense public campaign for the protection of the environment and for the threats that we as developed world, pose for our total environment, ecological factors are becoming more and more important in planning decisions. The world's attention has been drawn towards the serious damage that uncontrolled exploitation of natural resources could have. Suddenly everybody was willing to pay more for an "ozone-friendly" fridge, biodegradable detergent and recycled paper. But as the argument will show, the change must be more fundamental - it must be incorporated in the way in which we occupy the land. Planning must start with a clear understanding of the virgin landscape as was called for in *Design with Nature* (McHarg, 1971). Design should incorporate ecological principles in all projects. See Fig 1.6.

According to Michael Hough (1989) the resource potential of material, including waste should be advocated - thus sewerage is actually not a urban waste product, but an under utilized resource of nutrients. The same applies to irrigation water and wildlife habitats. He calls for the natural ecosystem to remain intact in urban environments, to enable the recycling and utilization of a region's biomass, as well as assist in mitigation environmental problems in urban areas. The industrial/technological approach of resource exploitation and waste disposal could not be afforded any longer, due to the environmental cost - not the price - we are paying. An urban framework which could accommodate these ecological processes which would make cities more viable and sustainable.

Ann Winston Spirn (1984) in *The Granite Garden* also calls for an urban form responding three-dimensionally to the ideas first put forward by McHarg (1971). Trees should not only be planted for aesthetic reasons (i.e. avenues etc.), but to reduce turbulence around tall buildings, create a more suited micro-climate, recycle nutrients leached from the top soil layers and reduce the atmosphere's increasing carbon-dioxide content. Trees are in the first instance biological factories, habitat indicators and very functional mechanisms.

South African cities have to become more responsive to current social needs and problems. Without "designing with nature and following a holistic approach," the pressing environmental concerns will ultimately occur leading to serious economic, as well as social costs. An attempt will be made in this presentation to set guidelines along which urban design frameworks would develop into sustainable communities - by acknowledging the site specific opportunities, social needs and ecological principles, as well as taking the long term costs of cities into account.

1.3 URBAN ECOLOGY AS A SOURCE FOR URBAN DESIGN

The model of urban ecology calls for an urban designer with a holistic view of the present urban problems. His ideas must be creative and allow for minimal intervention, for maximum freedom of choice, change and growth. He should therefore interpret the site, human needs and activities, culture, history, politics, economic feasibilities, and the functions of the city, both from an ecological and social point of view. Urban design must therefore act in both a facilitating capacity, as well as in an interpretive capacity - enabling and generating meaningful opportunity and choice, but guiding decision-making, space, form and nature.

Contamination of groundwater bodies, air pollution and the obliteration of sensitive ecosystems are also issues not always addressed. The modern tradition of city design has contributed little to environmental health, sustainable development and ecological principles in man-made environments. Michael Hough (1992) describes urban design as being the art and science dictated to enhance the quality of life in cities, the provision of civilising and enriching places for people to live in. If his views serve as the basis or definition of urban design, that basis will have to be re-examined.

The principles which guided the shaping of the earth over millions of years have now globally been replaced with a manifestation of "symbolic capital" (after David Harvey) The limiting approach, as a result of the successful industrialization of the planet, is that of mono-functional utilization of city space, as well as the landscape and its resources. McHarg, Spirn and Hough (1991) argues that, resources are being squandered because of the way cities are being developed, exploited and cropped for mono-functional uses with only an economic concern, and no long term environmental understanding or concern. This argument also applies to the South African approach to the management and maintenance of our environments. The landscapes and the settlements we create are all highly maintenance intensive, maintained by others and not those who have developed and exploited the resource in the first instance.

In a practical way ecology can provide a basis for design. It could enable a long term workable framework for facilitating the linkages between sociology, science, technology, economy and the environment as an approach

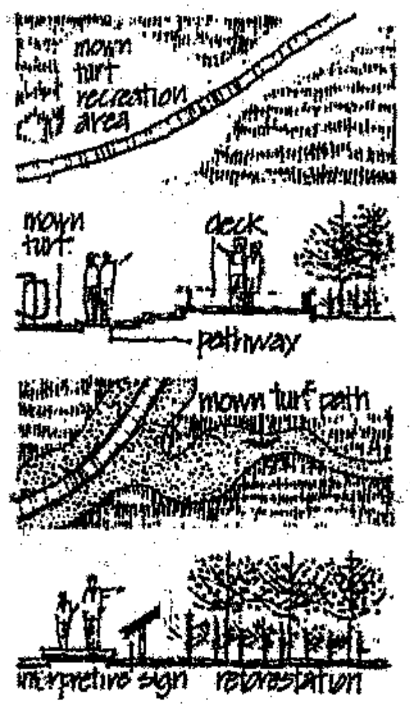

Fig 1.7 - The learning experience in allotment gardens - an environmental and social resource.

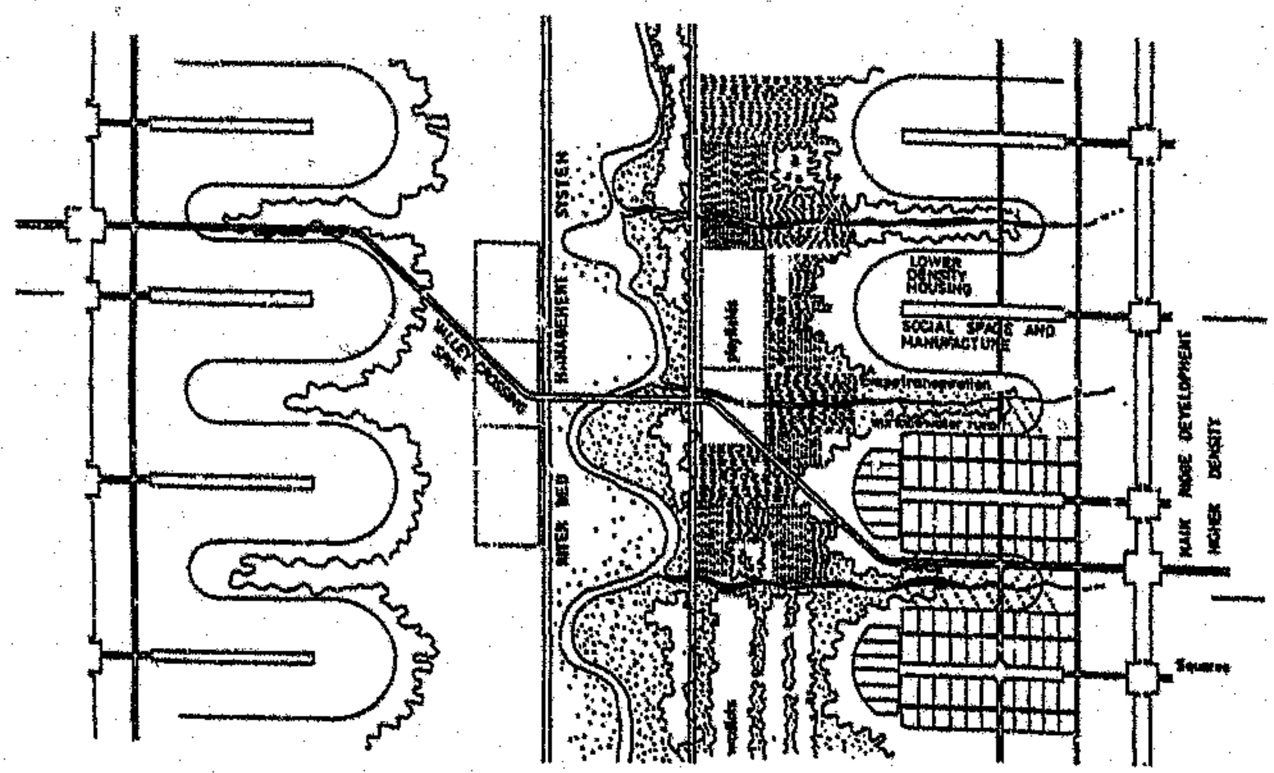

Fig 1.8 - Marianhill Structure Plan indicate some of the environmental concerns required in structuring a sustainable development. (Dewar, Uytenbogaardt and Rozendal, 1991)

to the design of human settlements. Nature compresses centuries of evolution in the patterns and interrelationships of the natural environment. "The integrity of nature can guide us, for in broadest, truest sense, nature is the only creation that has proven adaptive and successful in the long run" (David Morris, 1991).

The contribution therefore is locked into the understanding of the environment and how the landscape respond to certain interventions. It is the establishment of an urban structure, facilitation human settlement within a system of functional landscapes, which would accommodate densification, urban agriculture, surface run-off and waste recycling. It acknowledges time as an integral partner in shaping urban environments for sustainable human settlements. See Fig 1.7.

1.4 A PHILOSOPHY OF URBAN ECOLOGY

1.4.1 What is a City?

A city is not just a settlement - a place for people to stay - a city is a manifesto of human life and achievement. A city consist of layers of history, a sequence of cultural clues, it is space for ritual interaction, it is a functional symbiosis. It has got dimension, structure, pattern and meaning for its inhabitants as well as its visitors. It is a living, growing "thing" that should be treated as such.

"The places of greatest interest in cities are the places of greatest opportunity for activity. The way in which urban environments are built can either promote or retard formal interaction and communication." In South African Cities (Dewar 1991) a city is defined as a generator of opportunity, a generator of activity which is called urbanity. But that also refers to a place of complexity, of diversity, of intensity and of freedom. According to Dewar & Uytenbogaardt the limiting factor is access. Easy access to the opportunities it generates should be available to all people. See Fig 1.8

The reason for existence of urban settlements is the activity. This is generated through opportunity and access to activity which makes people immigrate to urban settlements. If we are going to accept nature as an equal partner in the system, there should also be opportunity for nature to sustain, and nature to co-exist with the social need for opportunity and activity. See Fig 1.9

The word "balance" explains the former statements. Dewar & Uytenbogaardt (1991) identify the key balances needed for sustainable living. The balance between society and the cosmos, the balance between society and

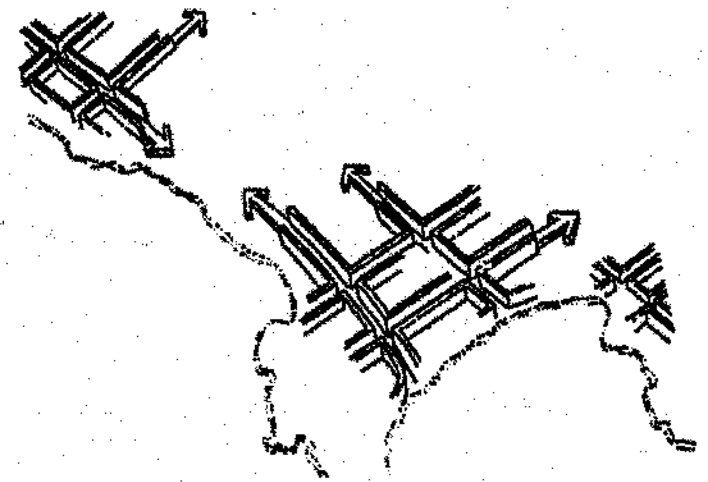

Fig 1.9 - An activity node is the result of facilities enriching human activity and access enabling the communication. (Dewar, Uytenbogaardt and Rozendal, 1991)

nature, and the balance between society itself - the interrelationships of people and their activities. (Man-cosmos, man-nature, man-man) Barry Gasson (1993) added the parameters of contextual "fit" and environmental "harmony". This would, when put together ultimately result in a sense of place - a celebration of natural, cultural and temporal uniqueness of a particular place.

The environment, and especially the natural environment, has always been a communication device. The hunter/gatherer obtained enough information from his natural environment (in clues and cues) to survive depending on nature alone. In the urban environment, the modern man reads signs in the urban space which formulate his understanding and ability to use the space. This refers to legibility and imageability as advocated by Kevin Lynch *Image of the City*. Often lacking in the sp...es between the "fast track", international style and functionalistic urban form.

Sustainable settlements must therefore achieve a dynamic balance or equilibrium between man's activities and needs and nature's resources and carrying capacity. Dewar & Uytenbogaardt (1991) describe it as follows: "Successful performing environments are necessarily complex. They contain a variety of overlapping conditions and activities. They provide the opportunity for the spontaneous and unexpected to occur. They accept conflict." Rappoport once said that cities require clarity at a larger scale, and at a smaller scale, complexity.

1.4.2 Can Urban be Ecological?

Ecology in the broadest sense of the word is the science of the relationship between living things, as well as the interaction between living organisms and their physical and chemical environments (after Holmila, 1986). It is actually searching for the patterns which connect them. Urban ecology attempts to do exactly that - finding those patterns which can connect the urban form to the environment and which could sustain living ecologically, socially and economically.

We can go further and see the city as a "living organism", in the same manner James Lovelock (1987) saw Mother Earth. The city, as in the case of the earth, actually do act in a manner resembling a living organism (after Le Corbusier). The earth is generating the bio-physical and chemical conditions necessary for man's survival. The city is the physical manifestation of how man has survived and flourished. It generates the economic and social activity which seems to has been the reason for man's success (It has only been since man have settled in cities that the population drastically increased).

Urban ecology poses the wonderful opportunity for the designer and the design process, because of the whole new set of restrictions focusing on the designer creativity. This, as most restrictions do, focuses on the functionality of the design and will ultimately also influence the creativity of the design. Khosla (1986) states:

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Urban ecology poses the wonderful opportunity for the designer and the design process, because of the whole new set of restrictions focusing on the designer creativity. This, as most restrictions do, focuses on the functionality of the design and will ultimately also influence the creativity of the design. Khosla (1986) states: "To meet the concerns of human well-being, the practice of design must now also be the goal, if incorporating a broader set of social objectives, including sustainability and the other criteria it implies such as equity, ecological resilience and development." (Holmila, 1986)

Sustainability could be defined by Hough (1991) as "... the use of energy and material in an urban area be in balance with what the region can supply continuously through natural processes such as photosynthesis, biological decomposition and the biochemical processes that support life". Thus a sustainable community or settlement requires less of its inhabitants in cost, effort and maintenance, and, at the same time, demands less of its environmental resources (land, soil, water, etc) to maintain a dynamic equilibrium. The sustainable environment moves towards the balancing of the amount of imported energy, the energy locally produced and the energy used, lost or wasted and recycled.

Urban ecology therefore addresses not only the ecological sound utilization of an environment, but also the holistic economical feasibility ("price" and "cost") and social benefit of a specific settlement form. Urban ecology thus promotes passive solar design whereby thermal comfort is derived from climate responsive design (design that utilizes solar energy is building construction) rather than costly fossil fuel driven heating options.

The words "Sustainable development" were first popularised in 1972 at the Stockholm UN Conference on the human environment. The concept has its roots in the natural resource conservation movement. However, the paradigm shifts towards sustainable development represents an effort to move beyond the reactory responses of early conservation movements towards developing a holistic, constructive and proscriptive alternative to growth based ecological, social and economic development approaches. The formation of the International Union for the Conservation of Nature and Natural Resources, IUCN, in 1948, was the first step towards recognising the connection between the processes of economic development and environmental concerns, and the development of a holistic concept of sustainable development. Sustainable design should strive to make development more efficient in the use of energy and resource material, as well as the re-use of waste, rather than simply trying to minimise its impact.

IUCN (1980) proposed that the World Conservation Strategy (W.C.S.) should provide a global framework for the essential integration of conservation and development efforts. The concept of sustainable development thereby expands into three traditions of conservation thought.

(i) The need to preserve the biosphere from growth based economic processes that consider living resources as external to the development process.

(ii) Historically adversary relationships between development, conservation and preservation are recast as a potentially mutually beneficial one.

(iii) It reaffirms the moral imperative to act as stewards, working as keepers and not exploiters of the biosphere, so that the development of a new social environmental ethic is possible.

Monoculture, "blob" zoning, energy-intensive machinery and waste disposal is out, and compact diverse and biological stable settlements are in. Mixed use, small site specific enterprises and community is important. The imbalance split of eight hour "producer" work day and the rest as "consumer" should be integrated. The home could also produce - food, cheap solar energy and a cleaner environment because of less waste production through recycling.

By re-establishing the notion of re-use, the urban designer must, according to Calthorpe (1991) "relearn many of the traditions and disciplines lost to modern architecture and planning." It is imperative that issues such as maximum solar access, protection of environmental features and social principles of community and privacy be considered in developing design frame works for urban settlements.

Thus, the ultimate goal of urban ecology as a basis for urban design, could be the following: *That the city, as environmental, social, economic and spatial resource, will be developed in such a way that it would create an integrated, multi-functional diverse resource framework which will not only consume but also produce, and not only have waste which have to be disposed of, but produce usable by-products stimulating an ever-increasing diversity of users and thus, opportunities.*

These views will be demonstrated by way of searching through the basic elements of nature (being water, climate, soil, vegetation, wildlife, as well as the social, economic and agricultural aspects within the urban ecological framework) to an alternative approach which would contribute to the theory of urban design.

1.4.3 Local Knowledge and Context

The idea of local knowledge as a valuable contextual reference (Ahern and Fabel, 1988) re-enforces the importance of local culture, socio-economic needs and environmental problems. To gain local knowledge is important, because through the perceptions of local people, one is acquainted with their subtle nuances of the local environment and social values. Through management, knowledge should be extended and principles adapted to become a tight knit, interactive system.

Local knowledge is specially important when it comes to the aesthetic quality and value of the environment. The interplay of human aspiration and ecological integrity is an underlying theme of sustainable development. At times technology has provided breakthroughs in sustainable social development whereas it could also become environmental constraints which caused social stagnation and human suffering. Urban development must be able to accommodate changes, even radical changes, within specific spatial units to be sustainable. According to Forman (1988), sustainable development includes four key characteristics:

(i) A time period of several human generations,

(ii) Adaptability and change in ecological and human systems,

(iii) Slowly changing variables with irregular cycles, and lastly,

(iv) Mosaic stability permitting ongoing and rapid fluctuations within component spatial units.

Just as in ecosystems the interrelationship with soil and the erosion processes and water as well as the water cycle and nitrate cycle are important, just so are the specifics under the social systems, the culture, the ethics, the ethnic groups, language and communication, all are integral parts in a sustainable environment.

1.5 CENTRAL IDEAS TO URBAN ECOLOGY

Although notion of urban ecology developed out of a strong concern for the urban setting, the central ideas were taken from the field of ecology. A few ecological terms will be discussed to show the connection.

1.5.1 Process and Product

The landscape is the result of both natural and human processes. The forces of water, wind and geological upliftment are all processes which have formed, and are still modifying, the landscape we settle on. Natural phenomena should therefore be perceived in terms of a continuous process. The processes of erosion, micro-climate and the subsequent change of the landscape should have some impact on the decision process which form our urban environments. The dynamics of the natural force at work will have an important impact on the upkeep of urban landscapes. Human and natural processes are constantly at work modifying the land and the landscape. To quote Michael Hough (1989), "The nature of urban design is one of initiating purposeful and beneficial change with ecology and man as its indispensable base."

The importance of process is stressed by both the ecologists as well as the urban design theorists. It is important to understand and apply some patience when engaging these two dynamic occurrences with procedural qualities. This clearly shows the correlation of ecological principles with that of accepted planning theory.

1.5.2 Natural Economy

The basic issue here is that complete knowledge and understanding of the natural system and way that it functions and maintains itself, could reduce financial inputs into development and maintenance of urban environments. By designing for the optimal site conditions, selecting the appropriate vegetation and implementing an appropriate maintenance procedure, the landscape will be improved at an affordable cost.

Cities have become major consumers of resources. If the momentum of this notion could be reversed and waste could be utilised optimally as resources (as is the case in nature) a natural economy would be in place (Jacobs, 1977) said that the used and unwanted materials such as energy, garbage and stormwater could be incorporated into a useful system of renewable resources with less environmental degradation and economic cost when the right linkages are established.

1.5.3 Carrying Capacity and Threshold

Carrying capacity is a term indicating population limits. In ecology the carrying capacity of the land is extracted from a range of environmental data. The weather, micro-climate, geology, soils, vegetation composition (quality and quantity) as well as wildlife utilising it is carefully studied to be understood prior to

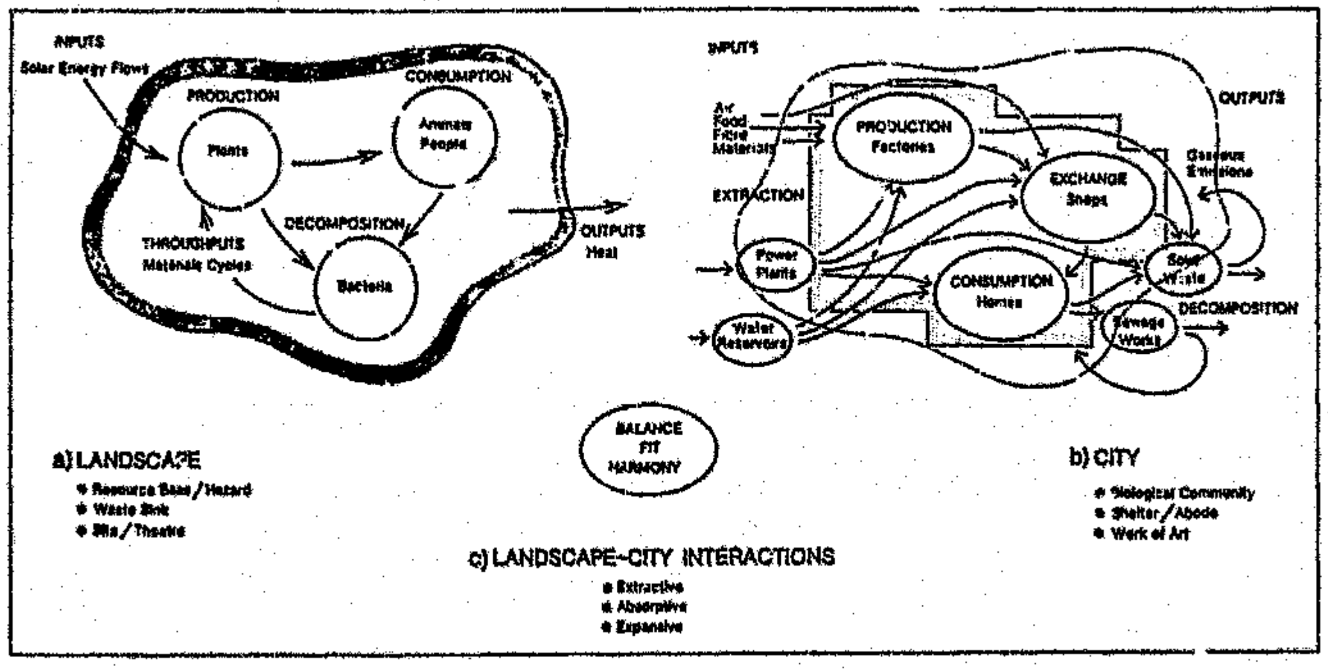

Fig 1.10 - The environmental viable city: A performance diagram. (Gasson, 1989)

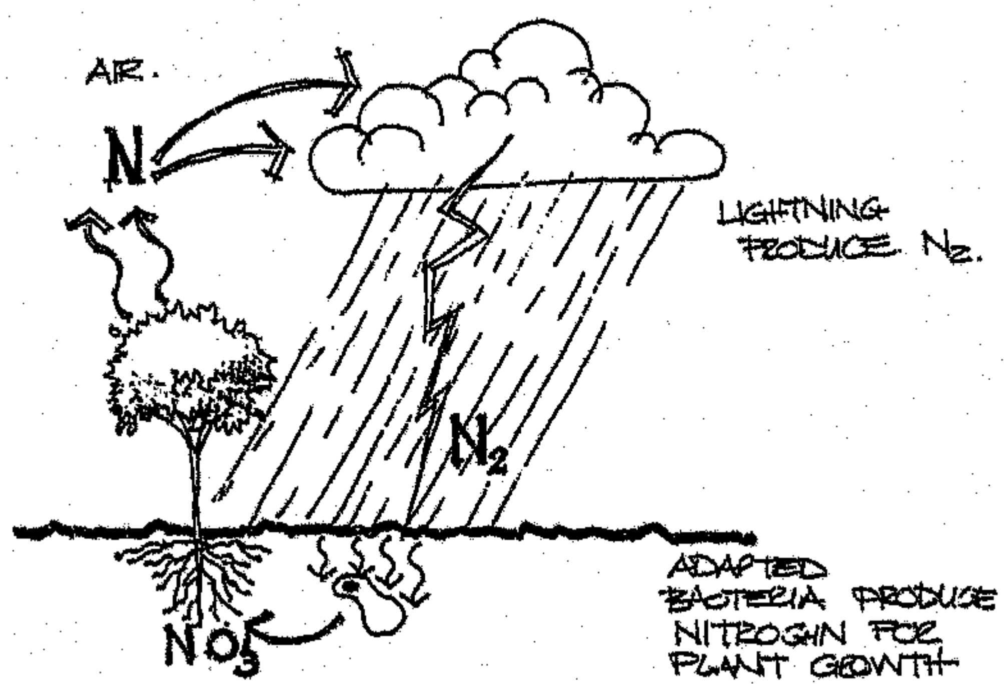

Fig 1.11 - The flow of Nitrogen through a natural, self-sustaining cycle. Nitrogen-gas forms a substantial part of atmospheric air (80%), but is of no use to higher organism in this state. Through lightning, rhizobium and free living bacteria in soil, nitrogen can be fixed in nitrate and organic forms. Nitrogen is an essential element promoting vegetative growth of plants. This facilitate the production of chlorophyll which enable plants to photosynthesise. This process converts energ, of the sun into basic building block of the food chain.

determining the carrying capacity. It must be accepted that all systems have limits to utilisation, exploitation and consumption.

In promulgating the World Conservation Strategy, the idea of carrying capacity was linked to human systems through analogy. The concept of carrying capacity include human population as part of the natural process. The availability of essential environmental resources becomes a primary limitation of carrying capacity and has been used to provide insight into population-food relationships, particularly in developing countries. The optimum carrying capacity involves the maintenance of a scattered population allowing a buffer against disturbances and disasters which is potentially more sustainable in the long term. See Fig 1.10.

In the urban milieu, it is of paramount importance to comprehend, evaluate and respond to the carrying capacity, with regard to: (i) total environment, (ii) local setting and (iii) available resources, to develop the critical framework enabling sustainable development. The environmental, social and economic interests, all must be integrated to the mutual benefit to man and his resources. The result would lead to a more cost effective method of utilising natural and financial resources. This approach has been emphasised by the Integrated Environmental Management procedure and documentation. (Department of Environmental Affairs, 1992)

1.5.4 Natural Flow of Energy, Elements and Chemicals

The notion of the flow of energy and circulation of organic matter, through controlled mechanisms in a natural system or ecosystem, is the basis for "stable" environments (dynamic stability). The circulation of elements in the natural and also a man-made environment is decisive to form natural geomorphological and biological structures (habitats, living conditions and food). The principle of the creation of life of all organisms, the birth or the formation thereof, death and decomposition of the remains and also the food chain are incorporated in the organic matter, nitrogen and hydrological cycles. Cycles should be continuous, as breaks can cause instability.

If ecosystems are interrupted, boxed in and confined, as is the case in the urban milieu, the robustness and functioning of ecological landscapes are severely affected. Ecosystems require a reasonable connection to its natural habitat as can be explained in the following example: Nitrogen-gas forms a substantial part of atmospheric air (80%), but is of no use to higher organism in this state. Through lightning, rhizobium and free living bacteria in soil, nitrogen can be fixed in nitrate and organic forms. Nitrogen is an essential element promoting vegetative growth of plants. This facilitate the production of chlorophyll which enable plants to photosynthesise. This process converts energ, of the sun into basic building block of the food chain. See Fig 1.11.

Fig 1.12 - Older buildings with less technology to their disposal related the people that move around them (scale) and respond to the climate and environment they were placed in.

Evolution →

primitive state	advanced state
simplicity	complexity
uniformity	diversity
instability	stability (steady state)
low number of species	high number of species
low number of symbioses	high number of symbioses
high entropy	low entropy

Retrogression ←

Fig 1.13 - Choice and Diversity (McHarg, 1971)

One of the most concerning problems of the urban system is the excessive consumption of energy rich materials. It is not only the enormous burden of financial expense or to nature, it also does not comply to the natural laws of systems replenishing the resources. Energy rich materials flow out by means of solid waste disposal, organic refuse dumps, sewage water, which are all separated and contained. Because of the high concentrations of certain hazardous elements, which accumulate, could lead to polluted and toxic environments. The natural chain of replenishment of resources are broken which in turn results in high accumulated cost of maintenance and disposal.

Steadman (in Van der Ryn, 1991), pointed out that the exterior appearance of a building becomes the consequence of the internal organisation, as well as the material structure of the building, which relates directly to cost, economics and the financial benefit to the developer or the owner. Whereas the older buildings with less technology to their disposal related the people that move around them (scale) and respond to the climate and environment they were placed in. See Fig 1.12.

1.5.5 Choice and Diversity

Species diversity in natural environments are of the utmost importance. The complexity of habitat structure makes a community or habitat stable, robust and thus sustainable - able to respond productively to change in habitat conditions and characteristics. The more diverse an environment, the more stable it becomes. It is because of species diversity that the rainforests must be saved and protected - the tropical rain forest is certainly the most complex and diverse ecosystem - having more than 1500 flowering planting per 20 square kilometres. (The Earth Works Group, 1990)

Diversity allows greater choice, greater environmental interest and greater adaptability to change. Hough (1989) said: "If health can be described as the ability to withstand stress, then diversity can also imply health". Therefore species' diversity from a biological sense, implies a healthy environment, implies a secure system and stable equilibrium. Because of a greater variety of habitats, it could sustain a larger selection of consumers/animals which again could improve the stability of the communities. The variety of animal species, the plant communities and habitat are maintained through a process of natural feeding, maintenance and regeneration. See Fig 1.13

The same principle can be applied in urban design. The common environmental solution found in our cities today move towards the monoculture, simplicity and predictability. This fact poses serious environmental threats as it is not based on sound principles, such as when a broad section of different habitats, conditions and activities are incorporated which will inevitably be more sustainable. Vertical zoning, mixed use the use of different options when implementing design proposals have been used with great success to create social diversity. After studying nature's example we could understand why diverse environments, economic strategies, activities etc. focus on a more complex structure, more stable, more interesting and enjoyable settlement which is also one which will adapt to change and therefore sustain.

1.5.6 Dynamics and Stability

Ecology should be seen as an interactive process - one organism affecting the other surrounding it; environmental factors dictating habitat types and changes are never ruled out. Ecology refers to an extremely dynamic, complex and integrated association of a few or a magnitude of organisms and elements. It is in this dynamic association that we have to look for the stability - the reason why the earth has survived for a 100 million years. This diverse interaction make the system more stable, more sustainable - a dynamic progression towards an equilibrium.

The urban environment certainly is dynamic, but does the stability and sustainability of our cities develop from its complexity? Are our attempts, to make cities, economies and communities more stable, developed from a dynamic complex base?

1.5.7 Horticulture *versus* Ecology

The horticultural science has become the symbolic remnants of the ecological, functional landscapes which existed before settlement. Horticultural landscapes are a costly struggle to maintain man's order and control, as opposed to ecology as a delicate equilibrium between a complex interaction self maintaining system. These two contrasting landscapes, the pedigree and the natural, the cultural vernacular symbolises the inherent conflicts of environmental values as a product of modern urban design. The first has little connection to the dynamics of natural processes, yet it has high value in the public mind as an expression of care, aesthetic value and civic spirit. The second being the natural, represents the vitality of altered but nonetheless functioning natural and social process at work in the city. It is regarded as a derelict wasteland in need of rehabilitation, unredeemed blight on the urban landscape.

Attitudes towards and perceptions of the environment expressed in town and city planning since the Renaissance have, with some exceptions, been more concerned with the Utopian and aesthetic ideals rather than with the (functional) natural process, as determinants of city form. Michael Hough (1991) said: "... responses to nature over the past two centuries have shifted from the Arcadian view of peaceful co-existence to one that expresses the utilitarian view of nature as a resource." The argument in this discourse agrees with this statement and is quite applicable to South Africa.

When we evaluate the history of green and open spaces in cities and its function in urban design, we should not turn to the history books describing the wonderful piazzas and squares and architecture of the pre-industrial age. We should review the social description of towns and cities, of houses arranged around courtyards to save on energy, conserve heat, minimize wind and provide access to sunlight and space. The tradition of the artistic philosophy ignores the so called working indigenous landscape of towns and countryside, created from the productivity of the natural landscape. This was not only an environmental reaction, this was a cultural and social reaction for the survival of man, of urban man, of settled man.

Just after the industrial revolution, public parks were developed in the expanding cities of Europe and America out of the romantic movement, to create a type of nature to improve the health of the city environment and the people, providing space for exercise and relaxation in a crowded, unhealthy, polluted environment.

In the post-industrial city, the connection between the green of the city and the surrounding countryside has been completely ignored. Parks are now exclusively seen as recreational areas with no relation to their previous use of urban agriculture and environmental reasons as was envisaged by Olmstead and others. Compare a modern central park to the central park that was initially proposed by Olmstead (in Jellicoe, 1975).

Through the planning convention of zoning for a separation of work and play, home and shopping, have become totally separate and distinct activities. Greater mobility, wealth and ability of implementing engineering technology totally changed the scale of the city. The environmental effects are often destructive on mainly streams, soils, vegetation and wildlife. Because there is no long term interest or dependence on the land for man's livelihood, his place of work and his living environment, the artificial leisure activity has no regard for the long term sustainability of the space it is occupying or using for its activities. As leisure has become the prime function of urban parks, the ecological and productive functions of the land have largely been forgotten. Michael Hough (1989) states that the essential creativity of nature, is dependent on the processes that continue to modify and often degrade nature, but will continue to function.

1.5.8 Succession and Stability

Succession in ecosystems are important in understanding sustainable environments. Take the forest, for instance: every forest goes through an infancy stage of establishment, a youth stage, when your pioneering species reach maturity, the adult stage when climax species reach maturity, and finally the old age, when the forest starts regenerating because of increased sunlight reaching the forest floor. The whole cycle starts over with the rebirth, when fast growing pioneering species geminate to reinstate the mature leaf canopy.

This natural occurrence reiterates ecology as a process of action and response - then nature follows a predetermined cycle of birth, maturity, decay and rebirth. This sequential cycle, whereby different stages follow a predetermined and robust cycle, makes it a sustainable process. Succession is an orderly process whereby the organisms re-act to the change in the habitat characteristics - which is predictable. By its reaction to the changing habitat it modifies the physical environment in which the community lives. This in return adjust the habitat - making it richer - and enabling a whole new range of species to establish and proliferate. A stable ecosystem, in a biological sense, is never static - it is always in a state of flux.

The principles of succession, taken from the natural environment, could be implemented in our cities, reducing costs and maintenance in our green spaces. By introducing the correct pioneering species, an ecological cycle will be enriched, and over time, alter the physical environment. The hostile urban environment will, through natural processes be made more conducive to plant growth by retaining the soil, introducing humus and support soil organisms, which immobilize nitrates to increase the soil fertility, which in turn would feed the climax species to follow.

As the pioneer plants are growing, more seeds are accumulated in the shade, and the subsequent micro-climate which will only germinate once the conditions are favourable - reducing the need for watering, fertilizing and other costly maintenance practices. The soil is protected from wind and transpiration, animals, feeding and living in the area, are depositing seeds for the plant rotation to follow.

1.5.9 Ecological Structure

The forest is also a good example of plant community structure. Forest communities grow and develop layers of which the so called canopy is the first layer. The leaf canopy provides the shade and subsequent micro-climate for forest conditions, high relative humidity, shade and low light conditions - keeping the roots cool and moist. The dropping of leaves also reintroduce nutrients into the soil, as well as humus after their decomposition.

The under-stories that follow each contributes to the growth habitat required to sustain the forest. These layers add diversity, micro-habitats and the possibility of symbiotic associations. Up to nine layers can be counted in a northern deciduous forest, and up to 27 groups in tropical rain forests of Brazil. (Hough, 1991) See Fig 1.14.

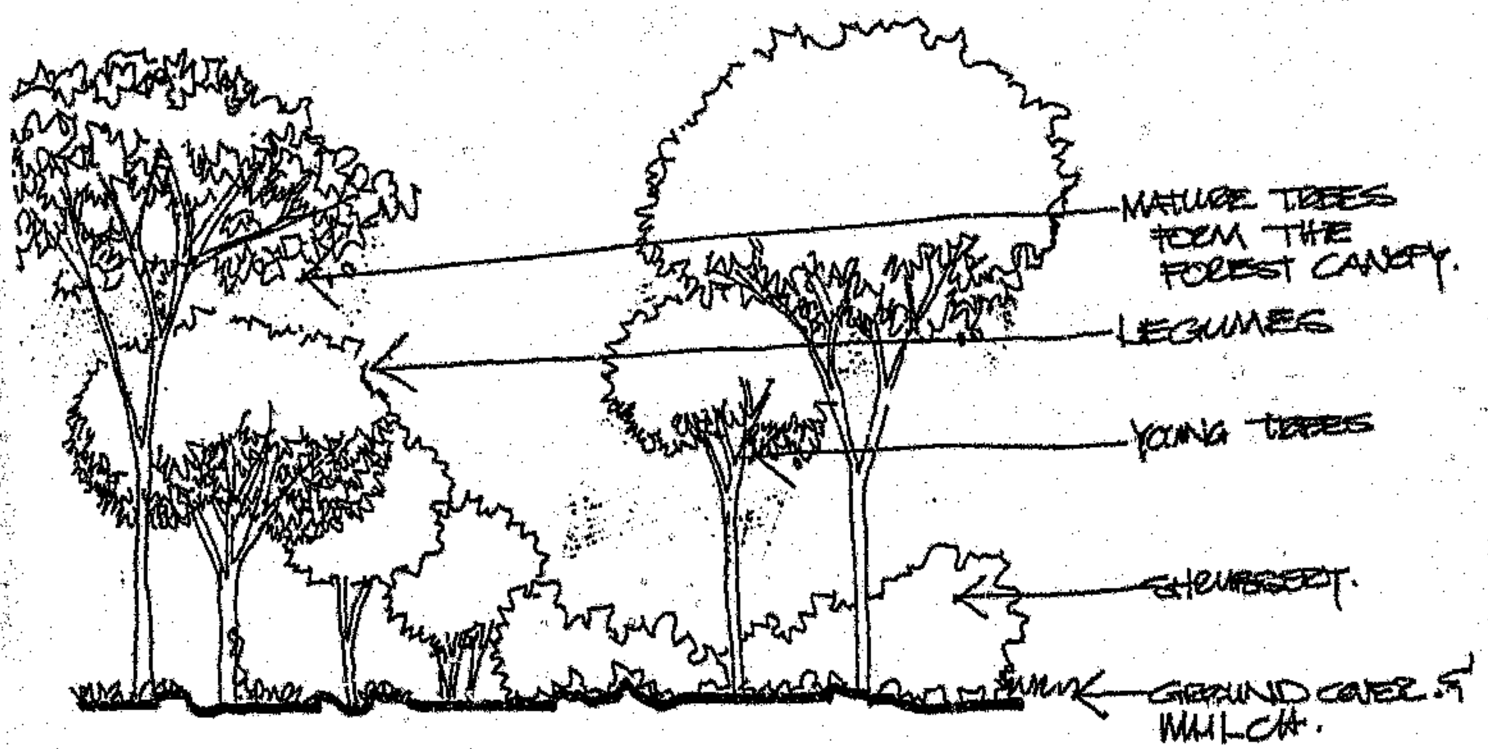

Fig 1.14 - Ecological structure in a typical forest indicating the different layers. (After Hough, 1991)

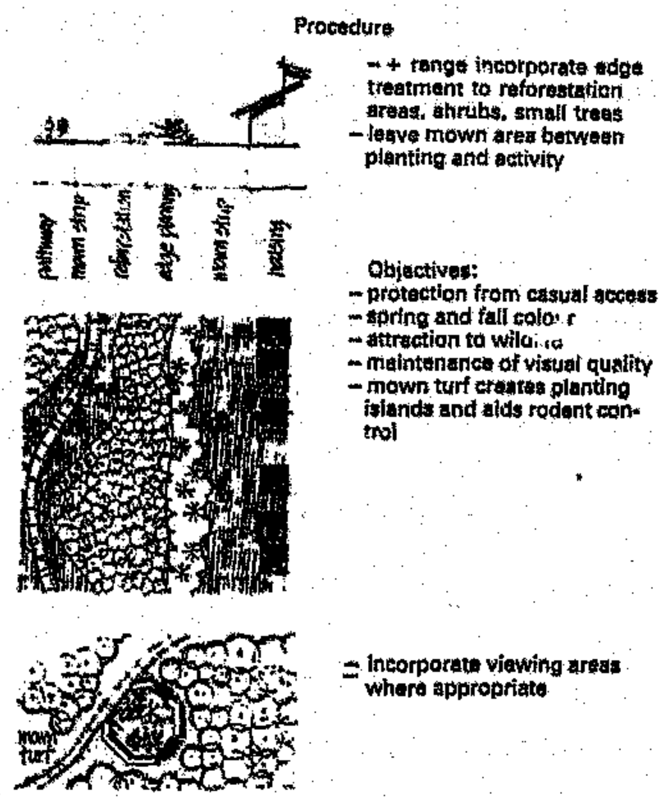

Fig 1.15 - The forest edge as a integration of habitats.

when one moves from one environment to the next, from one ecosystem to the next where certain animal and bird species would nest in the forest fringe, but feed in the meadows adjacent to the forest, and vice versa. Edge of the river is also very important because that is the friction zone of the moving water and the stable soil of the river bank. The same analogy can be drawn to humans (after Geddes). Settlements are made on the edge of the forest to have the view across the plains for security and to hunt, and forests behind them for food and building material. See fig 1.15

1.5.11 Ecology for Survival

Prior to industrialisation and modern technology man was dependant on nature, and his inter-action with nature for his existence and survival, had a much better understanding of nature, the natural process and the eco-system, the system of equilibrium, than modern man, who no longer needs to live in harmony with the processes of nature but has developed ways and means of overcoming all the forces of nature. He can shelter himself against storms, rain, wind and cold. He can move earth, he can change climate, he can alter ecosystems, he can introduce new plant communities and has led himself to believe there is no need to negotiate with nature for his own future.

"Man has viewed his physical environment as isotropic and has planned accordingly, while technology has enabled him to divorce himself from the natural constraints imposed on him by the natural environment. The realisation of technological constraints has effectively dislocated man from nature. We should restore balance between man and his natural environment." (Harris, 1992)

1.6 CONCLUSION

A more interactive urban environment must therefore be envisaged - a plan where agriculture, natural habitats, conservation sanctuaries; water, recreational and leisure are interactively associated with urban living in "fit", "harmony" and "balance" (Casson, 19..). By implementing these principles sensitive areas can, at an early stage, be zoned as sensitive, so that wetlands, water systems and recharge areas for aquifers are not damaged. Arable soil should be excluded from industrial and other cost intensive developments, so that this soil can be put to fertile and productive use.

The functional separation in the modern city of dwelling, work and recreation should be abolished and a new interactive function division should be implemented. The other aspect that must be addressed is the strong surface extension of these fringe expansion zones. Again for sound planning, these areas should not fall into the category of urban sprawl, but appropriate densities should be determined. The design of the urban fringe should also seriously consider the impact of such developments on the urban climate, especially the movement of polluted air, and the situation or positioning of industrial areas which could have serious polluted concentrations. (Spirn, 1986)

Ecology shows us that within the carry capacity of our environment and the diversity it allows, through the cyclical flow of energy, we would find a dynamic stability and a sustainable system. Urban ecology pushes for inclusion, holism, and sensitivity - a understanding who you are, who we are and how we fit in harmony, not to upset the balance of evolution.

"... man lives not as a result of arbitrary happenings. It has structure and embodies meaning. These meanings and structures are reflections of man's understanding of the natural environment and existential situation in general. A study of man-made place, therefore, ought to have a natural bias. It should take the relationship of the natural environment as its point of departure." (Norburg Schultz, 1980).

This thesis is in essence dealing with the holistic paradigm, a model for sustainability, from an environmental perspective. Urban ecology and urban ecosystems acknowledge the interaction of natural, social and economic processes which makes the urban environment so totally different from the natural or rural agricultural one.

Finally, we must recognize that design is an evolutionary integrative process and that sustainability is the ultimate goal. The critical questions therefore become the needs of the people on the one hand, and the potential resources inherent in the landscape. The social and economic needs of the people, and the capacity of the land, places the physical, biological and environmental criteria into a single system of investigation, understanding, planning, design, maintenance and management.

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2.0 WATER AND THE CITY

2.1 INTRODUCTION

Water has always been an important resource allowing human settlement, city growth and development. Port cities, cities on lakes and at river crossings have through the ages proved to be more sustainable cities. Water in moderate climatic areas, supports the potential for food production. It has also been more than a resource permitting survival, its been utilized as a means of defence, providing power and provided a means of communication and transport. Water also has symbolic connections to recreation, leisure and place with scenic beauty.

Connections must be made between urban and natural processes to establish a holistic approach to problems related to water. If we examine conditions within the context of an urban environment, the city open space resource becomes a fundamental factor in establishing not only hydrological balance but also a functional use for these areas. The ecological basis for urban design suggests that water resources in cities should be recycled back into the system. This would reduce costs and increase social and environmental spin-offs.

Water, is a precious natural resource and for too long taken for granted. South Africa is no exception. The exorbitant costs spent on the Tugela-Vaal water scheme and the Lesotho-Highlands scheme proves the point. Not withstanding the high cost to provide water we in South Africa probably have the cheapest drinkable quality water in the world. The reason for these capital intensive schemes are mainly to supply the demand of the PWV area. The Cape Peninsula is another example of expanding beyond the available water resources. The Cape Provincial Administration are committed to building dams in, amongst others, nature reserves, submerging sensitive and precious ecosystems never to be seen again, to allow the survival of our so called "accumulated capital". (after Harvey)

It has been poor planning to segregate the race and ethnic groups - to build Kayalesha on the largest aquifer in the South Eastern Cape (Gasson, 1989). It is poor planning to sacrifice endemic environments because of segregation rules implemented by politicians and vested interest/capital. But water has a significance beyond the transportation, economic and recreational assets we usually attribute to it.

The largest consumers of water are the large industries such as the steel and metal works, generating of electricity and the agricultural sector. Substantial subsidies from central government have kept water prices low which made good quality, cheap water available to them and to the broad public. Unfortunately it is true that something that is cheap is wasted so easily!

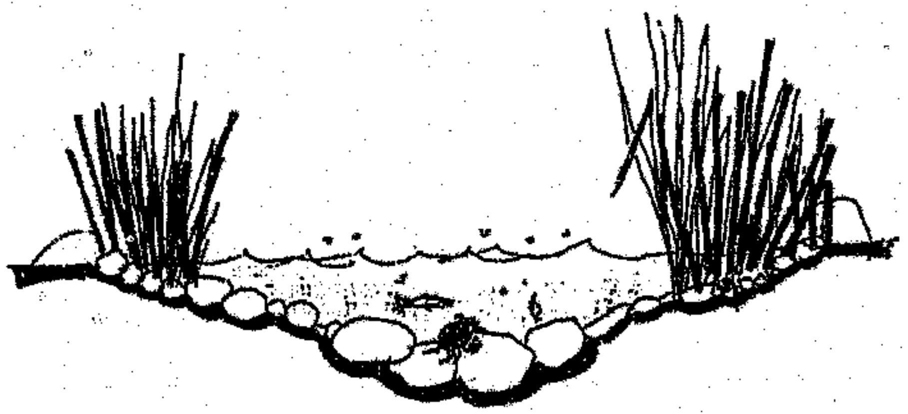


Fig 2.1 - A section through a naturally functioning stream. (After Simmonds, 1978)

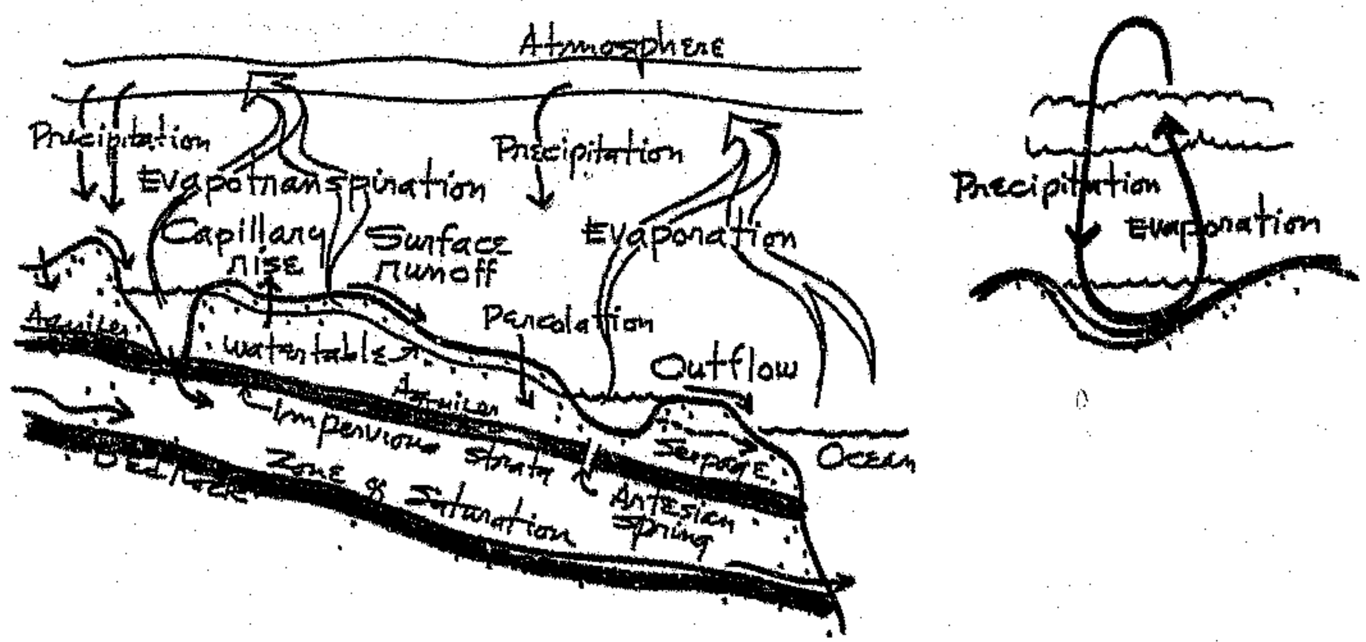


Fig 2.2 - A diagrammatic description of the hydrological cycle. (After Hough, 1991)

The approach advocated by urban ecologists is the opportunities locked in the present urban problem of waste management. Effluent is irrigation, agricultural and leisure resources, if aerated and appropriately treated. Solid sewerage waste has potential of also fertilizing agricultural land, increasing the organic component of the soil. In short waste products should be seen as resources. Advanced treatment and disposal of effluent may be accomplished by returning water and its nutrients back into the environment in such a way that it does not disturb the existing system. See Fig 2.1.

2.1.1 The Hydrological Cycle as a Basis for Design

The ecological role of water as a continuous system is not always realized. The hydrological cycle for instance, emphasizes the fact that water is constantly being replenished - being a renewable resource. It is continuously evaporating from the oceans, circulating over land mass in large clouds and fall to the land as rain or snow. Penetrate far below the surface of the soil and returns to the oceans via rivers, lakes and marshes. At every point in its cycle, some of the water is constantly being returned to the atmosphere as vapour to re-enter into the system. See Fig 2.2.

This process takes place around the continent as a whole, and the annual precipitation of the earth averages out and varies between 675 mm and 1000 mm per annum - very much the same as that of Johannesburg. Although the source, being the ocean, is widely dispersed over the earth's surface, the distribution of rainfall varies enormously. There are desert areas that receive very little rain (50 mm or less per anum), and then the rain forests of Africa and South America up to 10000 mm a year. (Earth Works Group, 1990) At any given time an average of 9% more moisture is evaporated from the oceans than that which flows back and falls back into the oceans via rain. This percentage amounts to the water falling on the land and is retained in rivers, dams and ground water. (Hough, 1991)

The hydrological cycle sustains the vegetative cover which protects drainage basins against erosion and improve water quality. The plant communities sustaining in a drainage basin is particularly adapted the hydrological regime of the specific ecosystem. Trees with their extensive root systems usually protect the edges of rivers and streams, as well as areas with high annual rainfall. They stabilize the slope, minimize erosion and reduce sediment inputs into streams while maintaining the water quality by extracting large amounts of nutrients.

2.1.2 Water: The Life of Cities

Whole cultures have evolved around the ritual of water, the use of water, especially washing. Special moments in Engineering and Architecture have been celebrated by water. The Roman baths, the aqueducts as well as the Roman's favourite sewer, the *cloaca maxima*, built in 600 BC. (Jellicoe, 1975) As in nature, water is of paramount importance to the survival of cities and man. It is therefore important to not only understand these processes but to be able to wisely manage these essential resources.

The catchment basins or watersheds have now been replaced by a stormwater sewer and chemical treatment facilities. Most of these surfaces are non-porous the problem of flash flooding and erosion become more critical and more visible during thunderstorms. Urban rivers are known to have flow peaks considerably higher than that of their normal flow. This places stress on the banks and floor of the river, constantly keeping the river in flux, of silting and eroding. Engineering systems have been used to try and rectify the problem, but they are usually costly and because it does not address the cause of the problem it is only a mitigating factor.

The actual supply from where water is plentiful in rivers, lakes and underground reservoirs to where it is needed has become a challenging engineering problem. The local water supply to the PWV through its storage dams and reservoirs are now being supplemented through hundreds of kilometres of pipes from Lesotho and the Tugela catchments. This certainly does not seem to be a sustainable situation.

In the South African context, the pollution threat of heavy metals and other chemicals are also issues for concern. Strict enforcement of the regulations controlling effluent should be introduced. Industries must be held responsible for the contamination of water used by them - a new social culture of water as a re-usable environmental resource must be communicated. The pollution of high quality water bodies through pollutant seepage, eutrophication and waste spills are increasing the problem. (After Gasson, 1989)

The engineering solutions to storm water drainage design is not the only problem. Planning without considering the natural resources required in dense urban settlements calls for an alternative approach. The establishment of a functional landscape framework to address the re-use of water, both from sewerage and storm water run-off.

Open space, too often ends up being just "SLOAP": space left over after planning. All types of open space can be functional, providing recreational and leisure opportunity, but also acting as storm water retention systems. (In this regard South Africa can learn from Hong Kong where drinking water is a matter of great concern and storm water is collected for industrial an domestic use.)

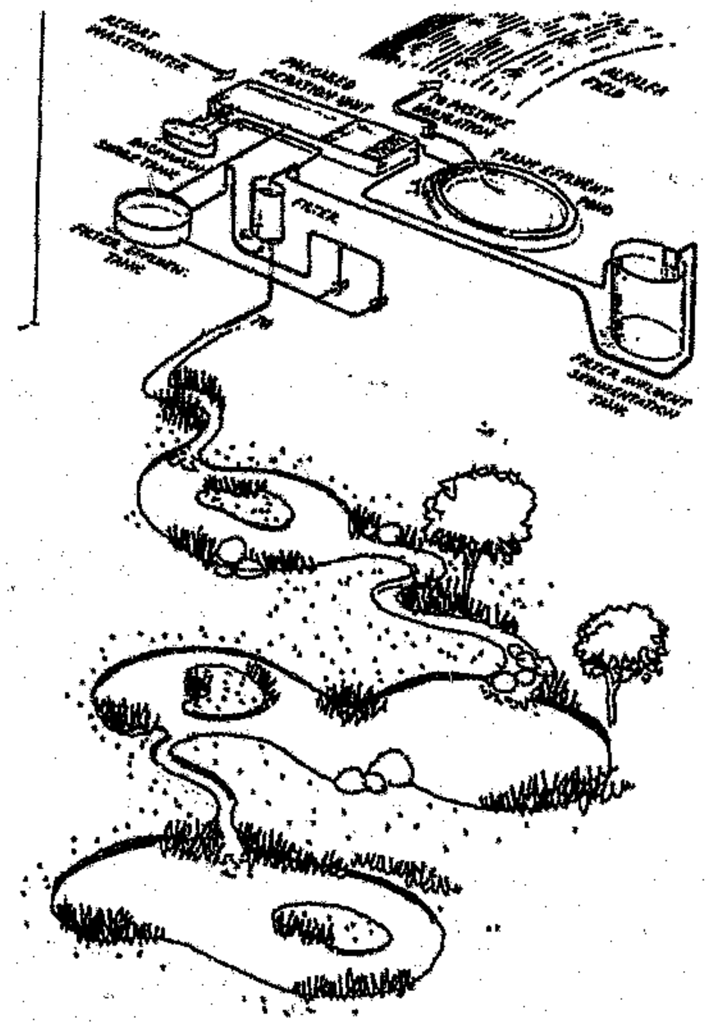


Fig 2.3 - A localized sewerage treatment facility, incorporating ecological principle s. The Bishop's Lodge, Santa Fe, Mexico. (Larry Spiller, 1985)

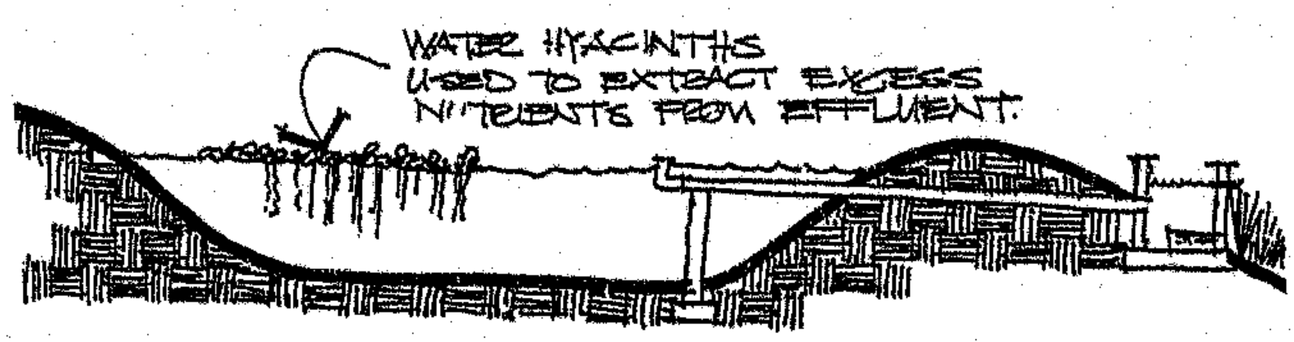


Fig 2.4 - Waste water Treatment Plants and its use in treatment facilities. (After Thurman, 1985)

2.2 WASTE WATER AS URBAN RESOURCE

2.2.1 Water and waste

It has been mentioned that all waste sources must be seen as useful resources. The same is true of waste water. Domestic grey water could successfully be used for irrigation, the soap fat floats and can be removed or will break down when exposed to sunlight, while the phosphates are useful additives to soil. But urban sewage could become an important resource.

The water separated from the solids are being used to irrigate pastures and to produce meat and milk. Such a purification strategy would produce protein rich food products. The solids are composted for use as organic fertilizer and the effluent from the primary treatment is used for irrigation. Technology already exists to purify the primary treated water to drinkable quality via flocculation, sedimentation, aeration and biological treatment, followed by maturation and chemical treatment. The majority of land resources surrounding present sewage treatment facilities have been totally under utilized. The presence of the solid waste (as a potential fertilizer) and the abundance of eutrified water (for irrigation, water features etc) should add value to the land if it is approached holistically. See Fig 2.3

The primary treatment works are the smallest section of the sewerage treatment facility. The solid waste derived from primary process can, through decomposition and additives, be transformed into an odourless mulch, extremely rich in the basic nutrients of nitrogen, phosphate, potash and calcium. It has been proved in Pennsylvania State that this would be equal to a fertilizer ratio of 1:1:1, as opposed to a normal, South African commercial fertilizer such as 2:3:2. The yields of corn, red clover and other agricultural products have been improved by up to 300%. (Hough, 1991) See Fig 2.

Secondary treatment could be accomplished by designing a natural-like system of cascades, oxidation ponds, with water hyacinthes, and reed beds - all actively, but biologically purifying the effluent. The presence of reed beds and other vegetation cope with the abundance of nutrients, especially nitrates and phosphates in sewerage water. This area could also double up as a stormwater detention zone. See Fig 2.

A first world strategy would also call for at least two waste water systems, as well as two water supply systems, which makes it extremely expensive on a city scale. But in the developing countries an alternative is to localize the treatment facility. It could become a community based facility - operated and maintained by the community - sustaining communal allotment gardens. Grey water could be used straight from the bath and zinc onto a vegetable patch. Sewerage should be collected to a basic treatment facility, surrounded by allotment gardens, sport fields and pastures.

2.2.2 Improving the Water Quality

The most fundamental step usually taken to improve water quality is to reinstate oxygen into especially the upper layers of water bodies. This can be done through aerator mechanisms or by allowing the water to flow over rapids, cascades or small waterfalls. The increase in oxygen not only allows aquatic life to proliferate, but also speeds up decomposition of organic matter. This enables sun light to penetrate deeper into the water freeing a larger zone of aquatic life. See Fig 2.3.

Aquatic plants can also contribute as a filter as well as a system of removing excess nutrients. The use of water hyacinth, duck weed and other fresh water invertebrates (contained in a series of oxidation ponds) has been highly successful in improving the water quality. This system becomes more sustainable because of larger water-land habitat greater variety of animals and organisms. See Fig 2.4

The aeration is also very important to allow for the aerobic environment to sustain. This not only enables the presence of organisms, but also assist in the breaking down of organic material. Studies of the University of Pennsylvania have proven that natural systems could be more effective in treating effluent, than our engineering and chemical solutions. Soil having the components to act as a filter of water, has been closely studied to develop the rapid transpiration bed, a system of treating waste water which evaporates partly and drains partly through layers of graded sands and soils. See Fig 2.5.

Another commonly used practice is the utilisation of sewerage effluent to irrigate highly productive crops. Forest, orchard or woodlot agriculture has been found to be very effective absorbing large quantities of the nutrients and other chemicals in the water. See Fig 2.6

By incorporating solar energy as a "energiser" to speed up the biological cycles, as is proposed in the Solar Sewerage Treatment Cell, is another localized alternative. The incorporation of a diverse ecosystem of feeders, fish and water plants, the effluent is purified in a total natural proces optimising energy, resources and finances. See Fig 2.7.

2.2.3 Urban Design Guidelines

- Localize sewerage treatment facilities to be installed, used and maintained by the local community - especially in developing communities.

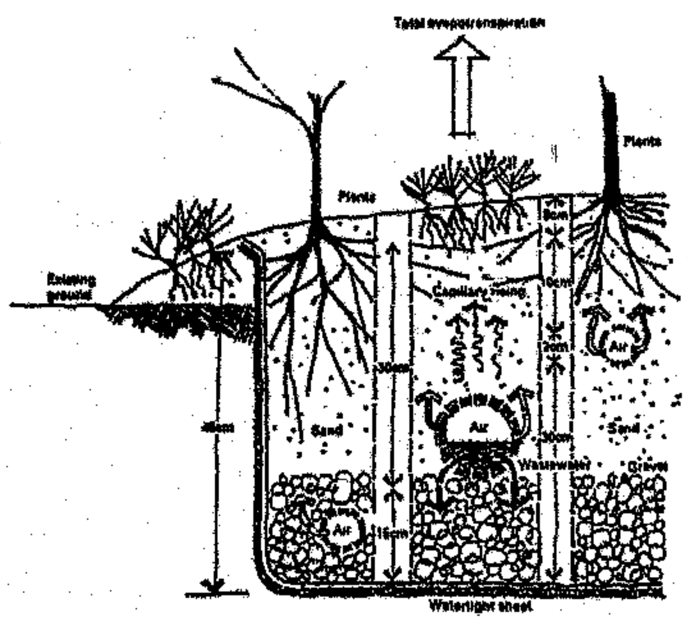


Fig 2. - The evaporation bed as proposed by Bernhart, 1974. An intense planting container is created by lining a bed with a watertight liner. This is then planted with appropriate plant species to extract and , through evaporation and growth, improve the effluent. A large drainage layer, with agricultural drain pipes is required to maintain a aerobic soil environment. (Spirn, 1984)

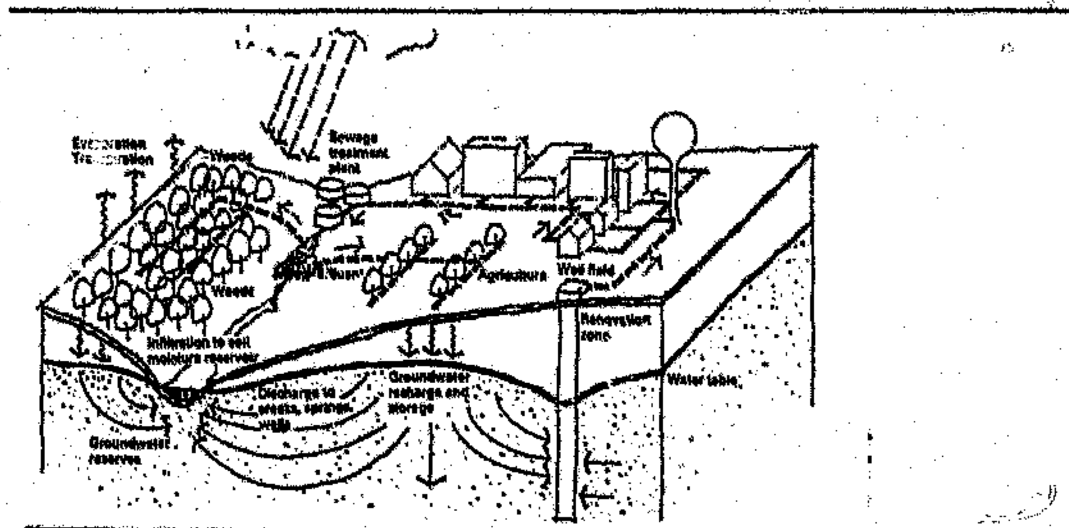


Fig 2.6 - An ecologically sensitive sewerage treatment facility. (Baylin, 1979 in Hough, 1991)

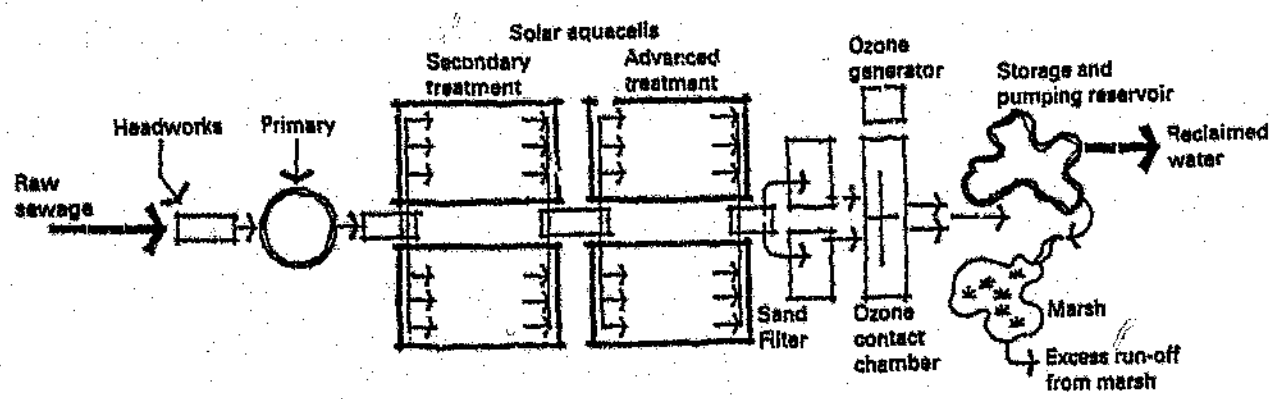


Fig 2.7 - A proposed waste water conservation cycle, by using "living filters" during the advanced treatment stage of the effluent. The nutrients in the effluent is being utilised as a resource. (Sopper, 1979 in Spirn, 1984)

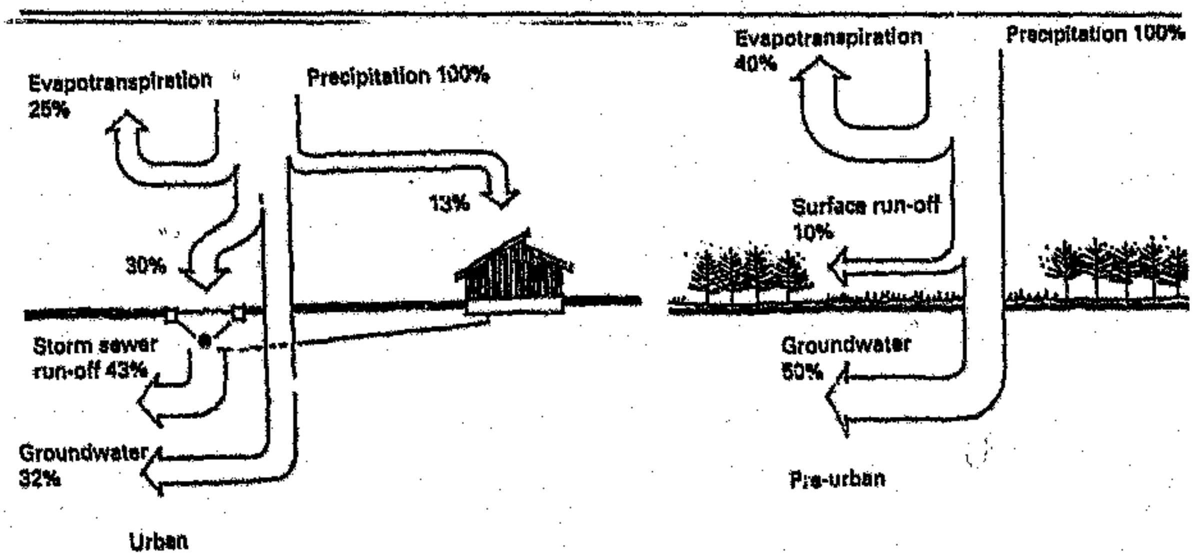


Fig 2.8 - A diagrammatic breakdown of the hydrological changes as a result from urbanisation. (The Ministry of the Environment, 1978, in Hough 1991)

- Utilize the resource locked into effluent by placing such facilities within the open space system and by surrounding it be agricultural and sport facilities. These activities could benefit from irrigation with treated effluent. The solids could be composed and utilised in allotment gardens.

- Introduce functional landscapes into open space systems of developing communities, which could accommodate secondary, biological treatment of effluent, by aerated maturation ponds, oxidation ponds and reed beds.

- Introduce an environmental education programme to teach the users of such appropriate technology how to maximize its potential, by using grey water on site to grow gardens and vegetables.

2.3 STORM WATER AS RESOURCE

2.3.1 Stormwater as Recharge System

In the building of modern cities, impermeable surfaces cover large percentages of the previously porous earth. Natural drainage ways and rivers are channelled, bridged and dammed. Precious wetland systems and marshes are filled for further development. Associated vegetation communities are removed and replaced with nothing. See Fig 2.8.

The channelling not only denudes the banks of natural vegetation cover, it also eliminates the crucial process of infiltration to replenish the groundwater systems. This single action results in two major urban problems. One is the serious erosion of riverbanks (especially in the down stream area), contributing to silting up of major dams and which would require additional capital for erosion protection. The present system of collecting storm water as close to the source and piping it to our fragile rivers as quick as possible, is not a sustainable solution. This system is capital intensive with large financial and environmental costs involved.

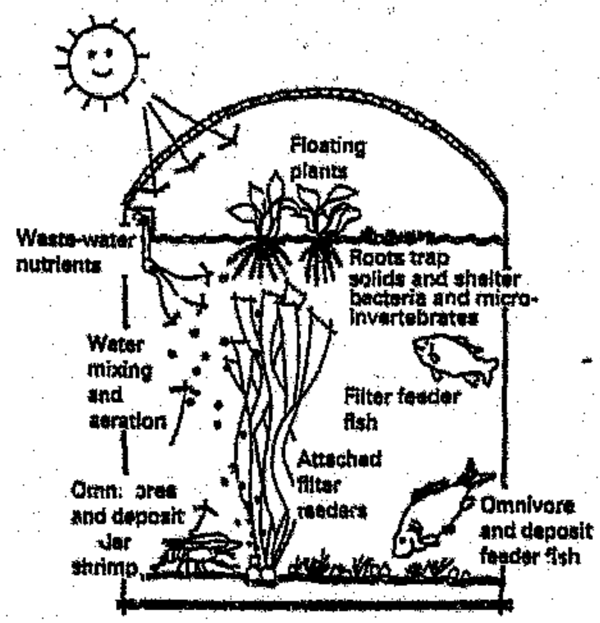


Fig 2. - Solar sewerage treatment in greenhouse type facilities. (Hough, 1991)

The natural drainage systems developed over millennia - creating balance between carving and depositing of the stream bed. When this equilibrium is under stress, enormous pressure is placed on the surrounding land, stream banks and developments within the flood plain during storm conditions. Thus, after society had filled the marshes, canalised the streams and add additional underground stormwater systems - all at enormous cost - it is impossible for nature to assist in reducing the stress on the environment because of human settlements.

Secondly precious groundwater resources are being over exploited and little replenishing takes place. Large amounts of water are now being stored outside the hydrological cycle. All the water which do find its way into the natural drainage system is poluted, killing the organisms critical for natural water purification. In addition flash flooding becomes more regular because of the lower surface resistance which results in fast flowing stormwater entering the underground piped drainage systems posing a threat at the outlets where it frequently causes flooding and damage.

The conservation of recharged groundwater sources should incorporated in the land use planning of an area. It is preferable that wildlife sanctuaries, agricultural and pending areas become the type of uses designated to these sensitive areas, rather than emergency housing developments and industrial sites. Groundwater resources will become more and more important sources of potable water. This confronts us with three problems:

(i) The conservation or sensitive utilisation of groundwater sources.

(ii) The elimination of groundwater pollution through over utilisation.

(iii) The constant re-charging of these groundwater aquifers to ensure their future existence.

2.3.2 Look to Nature

The disposal of the water polluted through city processes could be mitigated if natural principles are applied. The natural hydrological cycle cannot cope with the type, concentration and volume of polluted water produced by modern cities. Mechanisms should be implemented to mitigate the volume and concentration of polluted storm water run-off associated with our urban storm water systems.

The efficient way (through pipes and channels) of presently disposing of urban storm, and sewerage water not only results in flash flooding, erosion and river pollution, but also higher temperatures in cities, lower relative humidity and harsh micro-climates. This effects the whole biophysical component of the environment which is the result of these engineering driven solutions. There must be environmental sensitive solutions to alleviate the stresses these systems and waste is placing on the total environment. The increasing quantities of pure water

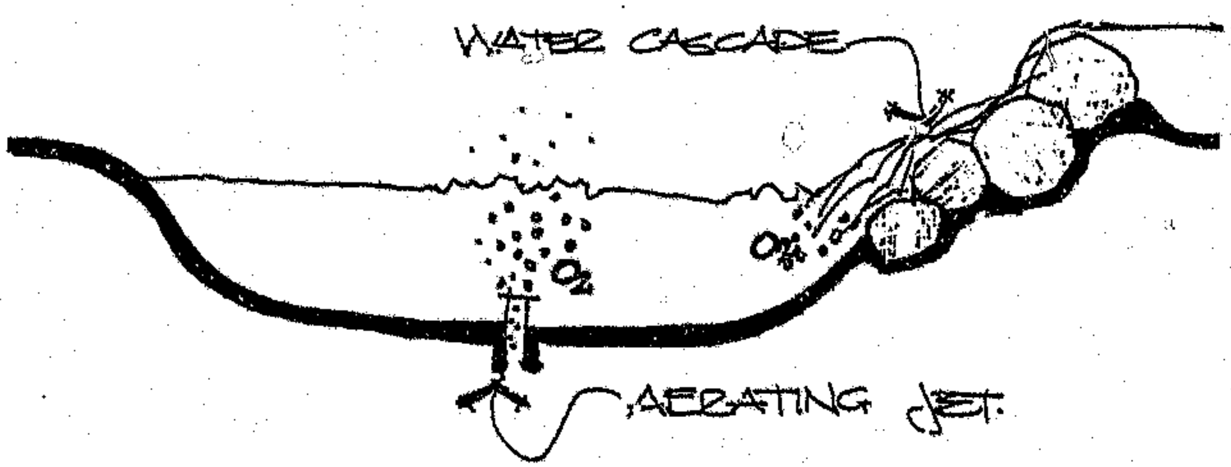


Fig 2. - Improving water quality by aerating the water. This could be done by industrial aerators, water jets or water cascading over rapids.

being extracted out of nature and returned into the natural system contaminated especially by the first world component of our cities (on average developed population use 150 ℓ per person per day - Gasson, 1989) is unacceptable. The same goes for the stormwater as a result of the impermeability of the city floor in general.

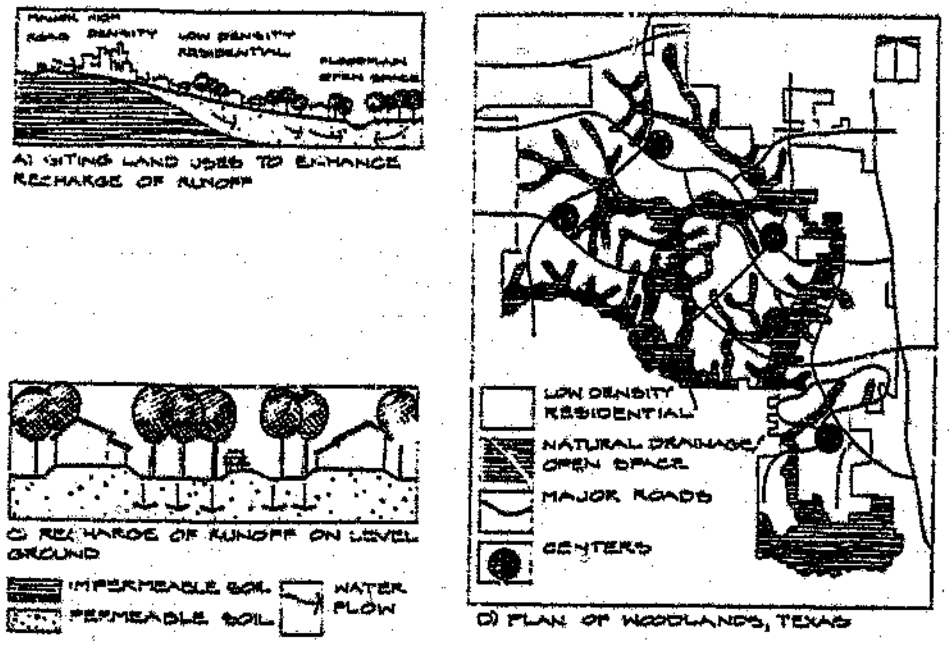
Problems are being solved very short-sightedly, never considering the larger environmental problems which are caused through these disposal systems. The benefits of well-drained street and civic spaces are paid for by sacrificing and accepting eroded stream banks, flash flooding, poor water quality and the disappearance of aquatic life. The traditional role of water features as being an expression of water supply and social interaction of the well in the market place of mid-evil villages. Aerated stormwater catchments and detention ponds could be the water features of a sustainable city. See Fig 2.9

Stormwater drainage should be designed to correspond closely with natural patterns of drainage to allow water to be detained, absorbed, filtered, aerated and improved in a natural way. This allows for a more environmental-friendly approach to disposing of stormwater, as well as replenishing the groundwater resources - a critical resource in a dry country like South Africa. The few shallow dams, few constant flowing rivers, no winter replenishment of our water resources, extensive use for irrigation of crop agriculture, as well as the poor siting of our major urban centres makes water extremely precious.

On the Transvaal Highveld, where 90% of the precipitation comes down in the form of quick thunderstorms, the planning of stormwater use should always receive serious consideration. In America costly artificial wetlands are being constructed to counter act the results of urban sprawl and efficient stormwater systems. The importance of small water reservoirs or detention ponds as an environmental barrier against the damage of storm water, which remains the fundamental problem with stormwater.

These environmental sensitive practices could become effective instruments to circulate, control and re-use water. For instance, sedimentary silt which settles on the bottom of water reservoirs contains nutrients washed out from adjacent soils, cultivated lands and urban settlement areas. This resource could be excavated during the dry season and be used for top soil - this is being done in America.

Vegetation greatly influences the movement of the water between earth and the atmosphere. Forests, grass plains and marches performs vital functions in maintaining stream flows, reducing peaks and potential flooding, but sustaining flow through dry periods. Through logging and destroying of our rain forests, peak or maximum flow may increase by as much as 20% and the low flow could be reduced by as much as 90%. The raise in flow is due to a higher run-off peak, which not only reduces the soils but also erodes productive land. The production of sediment increases by 17 fold, compared to what it was prior to logging. The same applies for the sprawl of urban areas. (Hough, 1992)



Fig's 2.10 to 2.13 - To mitigate the present problem of little infiltration in our urban areas Woodland, outside Houston was designed to enable infiltration in its green space system. The "natural drainage system" at Woodlands, Texas, exploits well-drained soils to absorb rainfall, in wooded swales, which also accommodates stormwater. (After Mcharg, 1971 in Spirn, 1984)

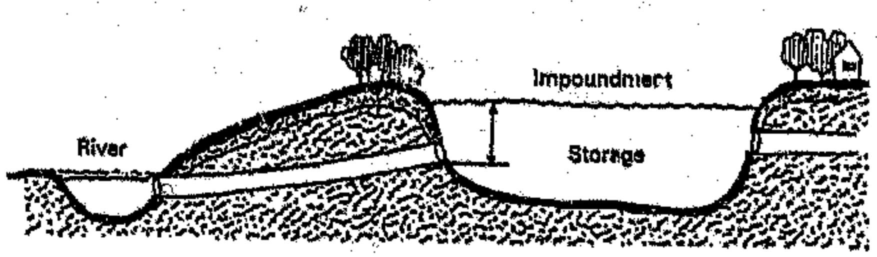


Fig 2.14 - Stormwater detention ponds must be incorporated into the urban fabric to mitigate flash flooding along the natural water courses, due to the velocity and the level of efficiency of our present stormwater pipe system. (Hough, 1991)

Although forests utilize enormous amounts of water to sustain the growth of trees (any one tree can utilize up to 600 and even 800 litres of water per day - Earth Works Group, 1990) these humus filled porous soils act as sponges and temporary storage in addition to the groundwater, lakes and the ocean, which all functions as temporary, but natural storage basins. Urban areas allows little infiltration, resulting in high surface run-off, the principles of forests in high rainfall areas could be implemented as a means of curbing the present problem of flash flooding down stream. In addition to the channelisation and thus concentration of run-off, detention ponding, marshes and "vleis" could be incorporated in the modification of natural drainage basins. This would reduce the need for expensive engineering solutions, as well as present the opportunity of functional open space systems and scenic leisure spaces. See Fig's 2.10 to Fig 2.13.

As water percolates through the soil it fulfils the purpose of purifying water before it reaches the underground sources. Minerals are being absorbed by the vegetation cover. The soil also reacts chemically with the water by oxidising pollutants and thus neutralises it. The underground water quality, under natural vegetation is also improved because grass and woodlands absorb large quantities - especially nitrates from soils and thus eliminating pollution of groundwater reservoirs. It must be stressed that these natural phenomena only improves groundwater pollution and does not eliminate it.

2.3.3 Managing Peak Flows

The most important aspect which needs attention in the urban drainage system, as we know it, is the principle of moderating peak flows. The impact thereof is usually felt much more severely further downstream in the rural agricultural areas than it is felt in the channelised urban drainage systems. It regulates the concentration of water run-off, and controls the velocity associated with concrete channels and pipes. These traditional engineering solution to urban stormwater problems creates significant hydrological problems when seen from a holistic environmental perspective. The idea of temporary storage in open spaces: on roofs, in parking lots and on pavements, is thus an integral part of managing urban stormwater as a resource, recharging the groundwater basins, as well as allowing our existing natural drainage systems, our rivers, streams and marshes to cope with the increased run-off. See Fig 2.14.

Because of their geological composition and the natural process which replenishes aquifers, recharging these basins are of utmost importance. The objective is thus to achieve a rate of water run-off that is equivalent to the pre-development levels. See Fig 2.15. This will also minimise flood and erosion damage, as well as contribute to the conservation of our precious top soil - in South Africa we lose 1 billion tons of topsoil to erosion every year. (Gasson, 1989) Again woodlands could play an important part in developing a natural mechanism for drainage protection, in association with undergrowth, grass, marshes and reed beds. This

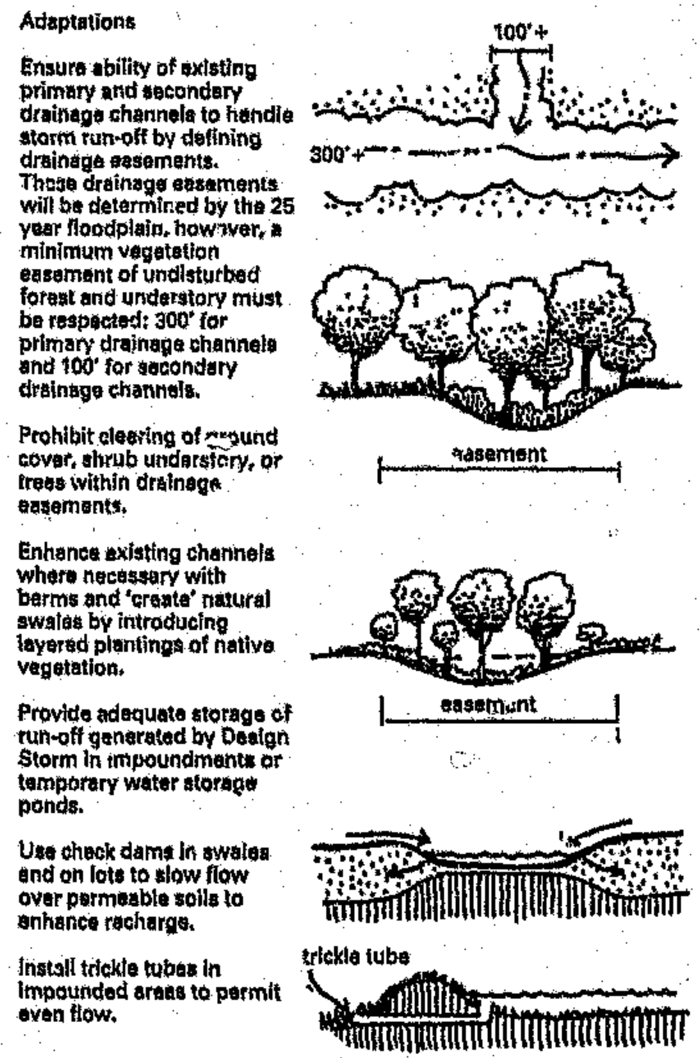


Fig 2.15 - A urban ecological design strategy for water relative to site planning can be summarised by the following example for Woodlands, Houston. (McHarg, Wallace et al, 1971)

lessens the danger of silting, erosion and pollution of our water resources. Thus storm water can be managed and recycled within the urban system.

2.3.4 Urban Design Guidelines

- Protect natural drainage ways, rivers and the associated storage areas such as vleis, marshes and lakes. Natural drainage systems are of extreme importance to sustain a hydrological balance.

- Understand the effect of changes in run-off patterns caused by urban development - the reduced infiltration increased surface run-off and removal of vegetation cover.

- Open space systems must form the backbone of urban stormwater drainage systems and incorporate all natural drainage ways and marshlands to allow undisturbed flow of water. The scenic quality of the water would add to the recreation and leisure potential of the system; the motivations for the development, maintenance and management of the drainage system as a whole would now have functional, economical and environmental clout.

- Reduce the channelisation of stormwater. Introduce detention ponds, permeable stormwater channels and erosion protection measures, in addition to existing natural drainage ways.

- The opportunity of retaining a large portion of the natural (and indigenous) vegetative cover still intact would also contribute to the mitigation of erosion. The usually impressive and aesthetically pleasing river bank woodland would now be retained - the root systems of these trees is imperative to the protection of the flood plain, which was once denuded of vegetation as a result of serious soil erosion.

- Protect natural aquifer recharge and storage basins. Compensate for the significant reduction of water infiltration in urban areas by designing parks, parking lots, paving and open space systems accordingly.

- Conservation practices can now be implied, such as conservation of productive wildlife habitats, habitat linkage, water purification through inexpensive wetland systems, contour planting etc.

- The limited use of underground stormwater piped systems. It should only be piped in extreme cases. Permeable drainage channelling will allow groundwater infiltration and replenishment.

- The implementation of perforated paved surfaces, to allow infiltration and ground water replenishment is imperative. All paved or engineered surfaces should allow for temporary detention of stormwater, reduce surface run-off speed, eliminate stormwater concentration and mitigate the possibility of flash flooding.

- The insistence of implementing erosion protective measures on all disturbed areas, where soil is exposed. Mulching, hydro-seeding, the use of plantable retaining systems and artificial erosion protection systems such as "GeoGute" or "Hysoncells" should become standard practice in all developments.

- The importance of water bodies in controlling climate in the city must also not be neglected. After rainstorms the ponding effect in parking lots, other paved areas, as well as low-lying curved areas and open spaces, could become a very important feature in controlling the urban temperature in specific. The process of transpiration in combination with evaporation from these temporary impoundments result in a significant reduction in air temperature.

2.4 CONCLUSION

By adopting the approach of seeing the resource potential of the city, its land and its process, we would not only utilize our resources better, but also establish a more environmentally friendly settlement. This would enable a urban settlement pattern conducive to natural system contributing to a much richer environment - a more sustainable system.

The treatment of sewage is a case in point. By acknowledging it as a resource instead of something that has to be treated and disposed of, the full potential of this can be realized. The concept of improving soil quality and practising urban agriculture to assist the secondary and tertiary treatment of sewage, has been investigated in the USA and Canada. Urban woodlands irrigated by partially treated sewage water, have shown a growth of up to 1,5 times that of the control woodland. The same can be said of agriculture, where in contained intensive allotments, very high yields were possible by drip irrigation with primary treated sewerage water.

The enormous advantage of an ecosystem or resources driven approach is twofold:

(i) There is now a yield, in monetary terms, from a practice which usually was associated with a financial burden.

(ii) The capital outlay could be reduced to a sixth of the cost of developing and managing a present day sewage treatment works. (Hough, 1991)

The principle of temporarily detaining surface run-off and retention ponds are also becoming more and more important in the process of stormwater management. These ponds are modelled from nature as a cost-effective and efficient way of controlling stormwater run-off. They modify the flows, moderating peak flows and allowing continuous infiltration for groundwater replenishment. The process of stormwater management can enhance the aesthetic appeal of urban developments, as well as managing the impacts of these developments in an environmental way.

As these practices are optimizing space/land, adding value to it and reduce the cost of water supply the system as a whole becomes more sustainable, associated with a saving in cost. These functional landscapes could be designed to allow limited human access and thus be incorporated in the open space system of the area. This will add to the diversity of green space types, as well as the recreational and leisure potential. Through the holistic understanding and careful modification of existing drainage basins, the present problem of bank erosion, flash flooding and the associated damage could be eliminated.

Element	Compared to Rural Environs
Contaminants:	
Condensation nuclei	10 times more
Particulates	10 times more
Gaseous admixtures	5–25 times more
Radiation:	
Total on horizontal surface	0–20% less
Ultraviolet, winter	30% less
Ultraviolet, summer	5% less
Sunshine duration	5–15% less
Cloudiness:	
Clouds	5–10% more
Fog, winter	100% more
Fog, summer	30% more
Precipitation:	
Amounts	5–15% more
Days with less than 5mm	10% more
Snowfall, inner city	5–10% less
Snowfall, lee of city	10% more
Thunderstorms	10–15% more
Temperature:	
Annual mean	0.5–3°C more
Winter minima (average)	1–2°C more
Summer maxima	1–3°C more
Heating degree days	10% less
Relative humidity:	
Annual mean	6% less
Winter	2% less
Summer	8% less
Wind speed:	
Annual mean	20–30% less
Extreme gusts	10–20% less
Calm	5–20% more

Fig 3.1 - Characteristics of Urban Climates (from Landsberg, 1981 in Spirn, 1984)

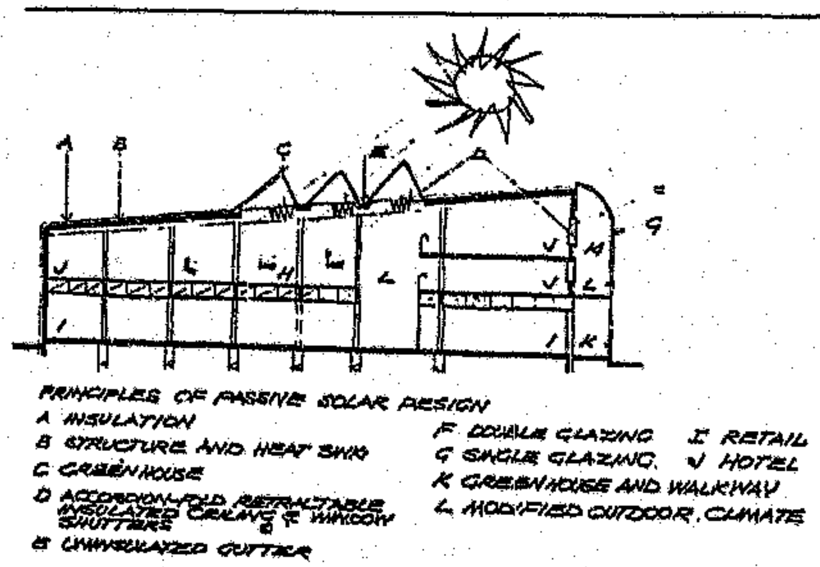


Fig 3.2 - Principles of passive solar design which could be incorporated in a building typology to reduce the use of petroleum energy.

3.0 CLIMATE

3.1 INTRODUCTION

The concept climate, refers to wind, precipitation, temperature, humidity, solar radiation, and is one of the main agents which has shaped the landscape. Human settlements, have modified the climate to their comfort, developing several micro-climates to suit our particular needs, within the limits of the local conditions. The modern city has an enormous impact on the climate and the environment. Living conditions, attitudes and the human comfort are important in creating space and buildings. See Fig 3.1.

"To be able to delve between heaven and earth, man has to understand the elements as well as their interaction. Therefore any general understanding of natural environment grows out of a primeval experience of nature as a multitude of living forces." Norburg Schultz, 1980. Climate is a wonderful example of showing how nature and its elements, interact and should therefore never be dealt with separately. Compare the solar effect of southern and northern slopes of a mountain range with regard to its temperature, humidity, as well as its habitat. In the modern city, the micro-climatic influence has gone further than just the local, it has an impact on the region. Climate control and air pollution has become a serious problem limiting the designing of efficient, but enjoyable city environments. The urban ecological solution calls for solutions at the source on a macro-urban scale.

The industries, motor vehicles and the other pollution causing practices all developed vested interests in our city economy, which makes it very difficult to modify attitudes towards their impacts. Therefore a holistic environmental strategy should be incorporated in urban settlements, as a means to mitigating the problems relating to climate. Design directives, therefore, inspired by ecological principles could provide solutions at reduced cost, and by taking into account the total environment, the sustainability of the micro-environment would be addressed as well.

Whereas the macro-climate, modified by landform, vegetation, water or other environmental factors, was an important influencing factor in locating human settlements in the past, the technology of the air conditioner has completely eliminated the need to look at climate. The ability to modify the climate makes the Equator and the Arctic just as hospitable as anywhere else in the world. Previously, in hot dry climates, the presence of wind was used, not only for ventilation, but also for cooling, where a series of courtyards were developed in houses and other public buildings which were connected via hallways. In these hallways pots of water were placed, the theory behind it being that the larger, sunnier courtyards heat up and because hot air rises, it sucks air through these courtyards from the cooler, shaded courtyards, resulting in a cooling effect throughout the building.

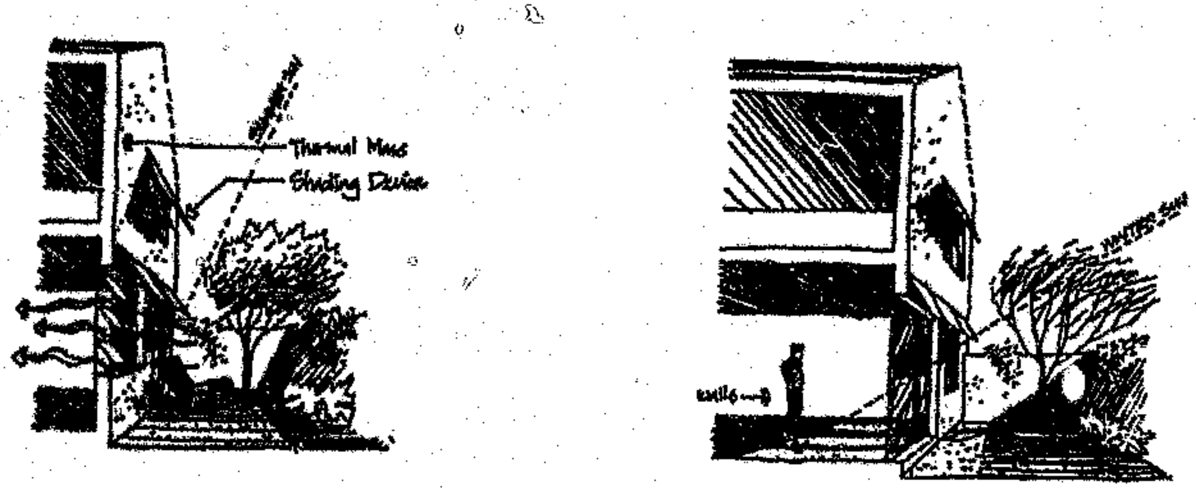


Fig 3.3 - Climate control through passive solar design, courtyards and deciduous trees. (Van der Ryr, Calthorpe, et al, 1991)

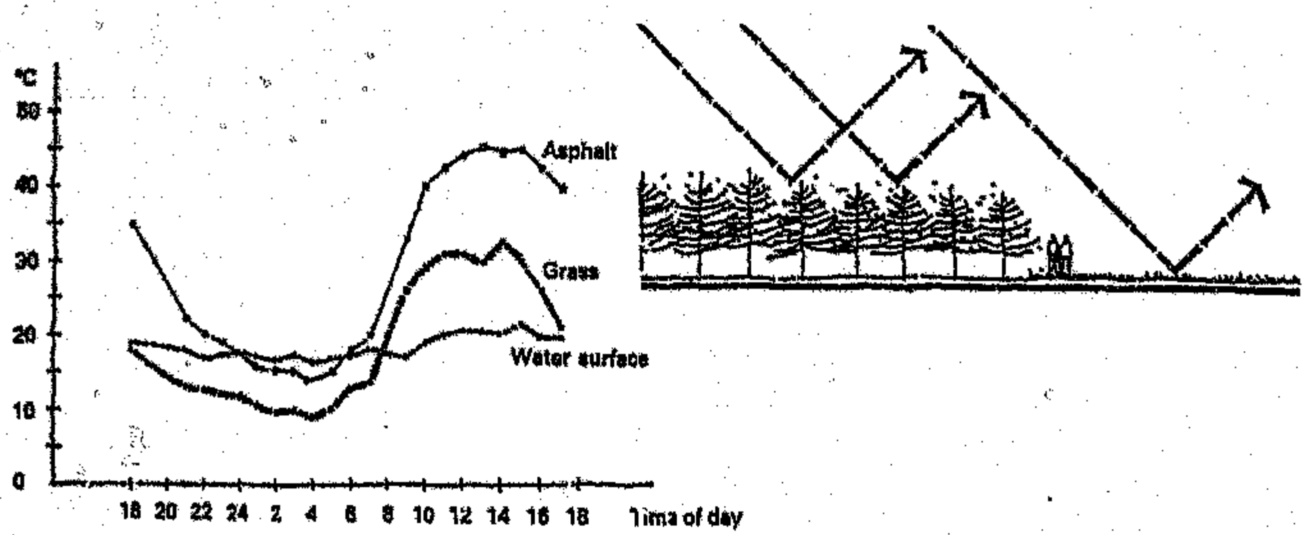


Fig 3.4 - Surface temperature of materials associated with urban environments, resulting in heat build-up in our cities. The introduction of water and vegetation could significantly influence the urban climate. (Miess, 1979 in Hough 1991)

The principle of urban ecology again calls for successful climate control through siting and organization of built elements and spaces, as well as the use of landform, orientation, water and plants as natural means to condition and adapt the micro-climate to ensure more hospitable environments for human interaction. Associated with this should be the use of strategically placed open space systems to improve the climatic conditions associated with the city and urban heat islands, but also to improve and filter the polluted air via natural means. See Fig 3.2.

Plants and water have always been associated with these city courtyards and gardens, to provide a basic measure of air conditioning and places of delight. The gardens of the Alhambra, done in the Moorish style, are practical adaptations to the hot climate of Spain, where evaporation off tiled surfaces, combined with the dappled shade of planting, cool the arcades, courtyards and internal spaces of these palaces. (Jellicoe, 1975) See Fig 3.3.

3.2 CLIMATIC INFLUENCES OF URBAN SETTLEMENTS

There is a distinct difference between the climate of a city and the climate of the adjacen* countryside. This can be attributed to a few specific aspects:

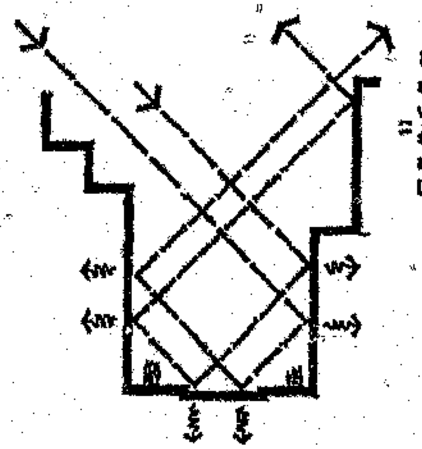
3.2.1 Heat Absorbtion and Radiation

The materials of which the urban environment is made, mainly asphalt, concrete and tar. These materials are highly absorbent of heat energy which is released during the cooler times of the day and night. This phenomena causes relatively higher temperatures in the city than in the adjacent countryside. See Fig 3.4.

When the surface temperature of forests, grass, asphalt and concrete are compe..d (with that of water as a reference) the following was noted. It was found that the temperature variation of asphalt can be up to 30 degrees, grass between 17 and 20 degrees, and for water only 3 to 4 degrees. (Spirn, 1984)

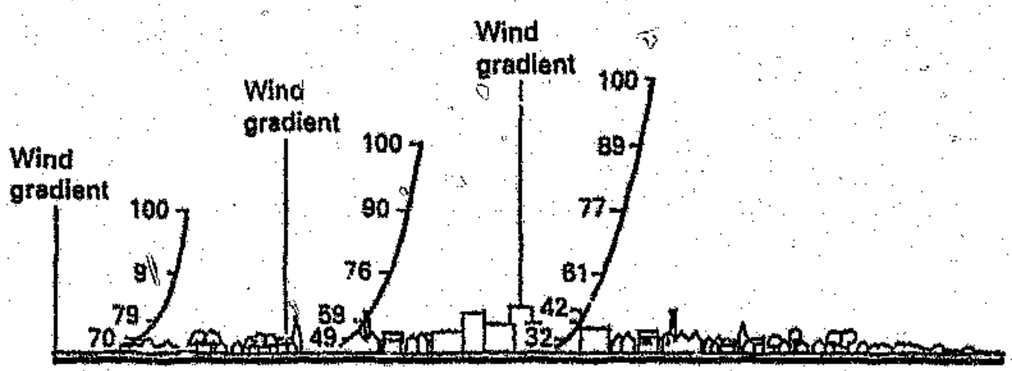
3.2.2 Surface Friction

The second aspect is related to the physical shape of the urban environment. Built-up areas reduce wind speeds because of its aerodynamic roughness but causes increased turbulence, as well as localised gusts of wind around street corners and tall buildings. See Fig 3.6.



In the city, vertical walls reflect solar radiation to the floor and walls of buildings. Impervious surfaces in walls and floors accept and store heat (from Lowry, 1967)

Fig 3.5 - The reflection of heat in cities amplifies the radiation problems and the associated retention of heat. (Lowry, 1967 in Hough, 1991)



Typical wind profiles over built-up area, urban fringe and open sea Increased aerodynamic roughness of built-up areas causes rapid deceleration of wind compared with open countryside. It has been calculated that wind velocity within a town is half of what it is over open water. At the town edge it is reduced by a third (from Miess, 1979)

Fig 3.6 - Surface retention, as a result of aerodynamic roughness of built-up areas causes rapid deceleration of general air movement. (Miess, 1979 in Hough, 1991)

3.2.3 Generated Energy

The city consumes enormous amounts of energy for heating and cooling purposes, industrial processes and the use of motor vehicles. The cumulative effect of energy loss from these sources add to the wetland energy retained in the heat absorbing materials in our towns and cities. See Fig 3.5.

3.2.4 Precipitation

Although higher temperatures are recorded in cities, as well as the recurrent occurrence of cloud formation, it seldom develops into rain. It was observed that certain localized areas and the countryside in the vicinity of cities usually receive higher rainfall than the city centre itself. The reason for clouds being formed could be explained by the abundance of hydroscopic particles suspended in the air. These particles act as nucleus, around which water vapour condensates which becomes visible as clouds. The relative high temperatures usually vaporize these clouds before the individual particles become too heavy and precipitates. When these clouds actually produce rain, the low relative humidity often results that the drops evaporate before it reaches the earth.

3.2.5 Run-off and Infiltration

As large areas are paved or covered by impermeable materials infiltration of water cannot take place. This results in large volumes of water accumulation on these surfaces, which is referred to as stormwater. Well engineered stormwater systems always channels the run-off and ensures the removal of water from point sources. These extremely effective stormwater systems does not only perpetuate flash flooding, but prohibits the important natural process of evaporation and infiltration to supplement the groundwater resources.

As rain water is quickly carried away by effective stormwater systems and less soil is exposed, available to absorb moisture, the process of evaporation is reduced. The significance hereof is that evaporation converts radiant energy into latent energy, thus cooling the air. These above-mentioned problems relating to heat exchange contribute to the phenomenon that is commonly known as the urban heat island.

3.2.6 The Urban Heat Island

This phenomenon which has been studied by several climatologists is the result of the complex effect of a city's presence in the environment. The presence of a city fundamentally change the climate of an area in the above mentioned ways. The urban heat island can be described as a mushroom developing over a large city situated on a flat piece of land. From the first rays of the sun in the morning striking the buildings and the paved areas, quite a large percentage of the heat energy is being absorbed. In the adjacent countryside, however, the

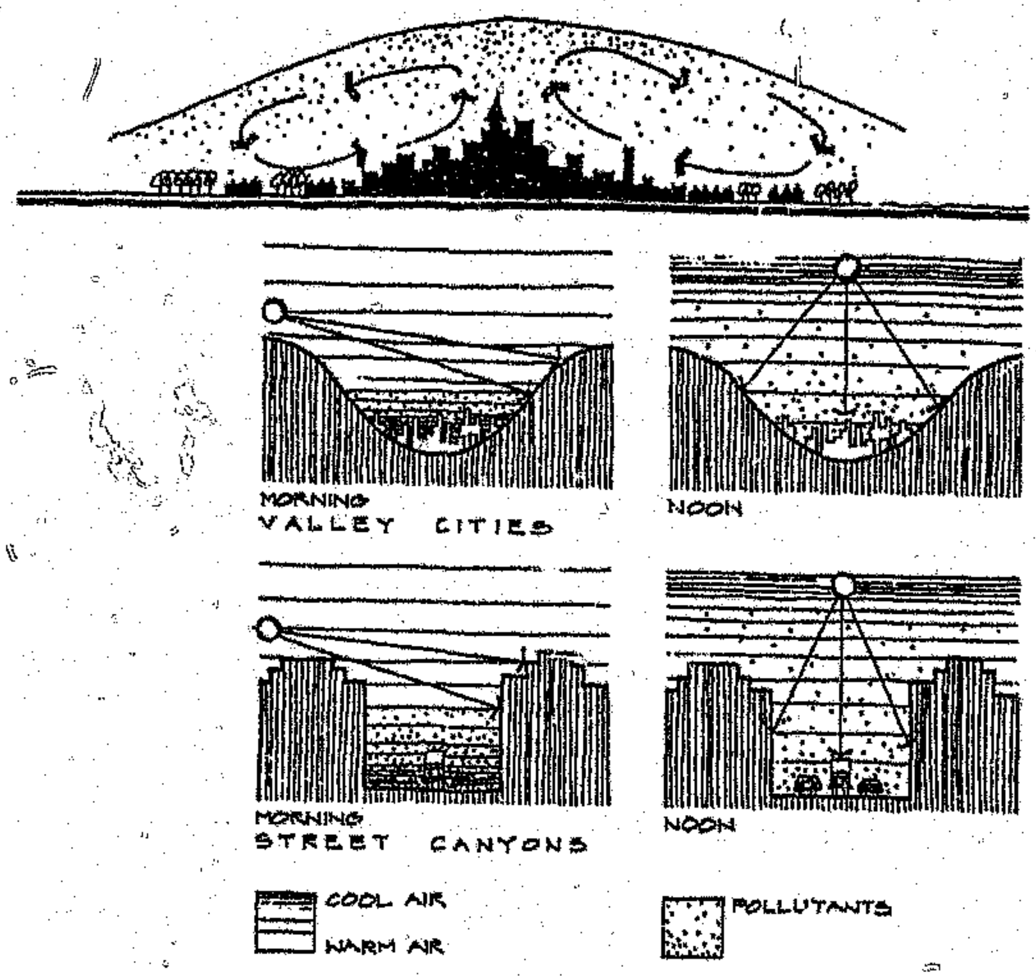


Fig 3.7 and Fig 3.8 - The urban heat island, as a direct result of the heat build-up in cities also result in inversion layers developing. Only strong persistent winds or rain would disperse it. (Hough, 1986 and Spirn 1984)

vegetation consumes the light energy through the process of photosynthesis and cover the soil surface whereby it significantly reduces the earth's ability to absorb radiant energy and therefore the surface temperature remains significantly cooler than in the city. See Fig 3.7.

As mentioned above the heat, which had been absorbed and stored very effectively in the built-up areas, is radiated to warm the air during the cooler periods of the day and the night. As soon as the radiation process starts, a stratification in the air develops because of the upper air layers cooling down faster than the air surrounding the buildings. This is not the case in the adjacent countryside. In the rural areas, however, the air cools quite rapidly during the night, and light winds which are unobstructed eliminate any stratification because of radiation. See Fig 3.8.

The above effect is likely to ensure that cities usually remain 4 to 5 degrees warmer than the adjacent countryside. The problem of pollution, smoke and other gases present in the atmosphere of cities reinforces this stratification and actually creates an inversion layer separating the cooler upper air and the warmer lower strata. During the night this inversion layer is compressed to form a fog-like presence, whereas during the day time the inversion layer expands because of the abundance of energy and becomes less visible.

3.2.7 Heat Insulation

The problem of the inversion effect of polluted air and the heavy load of solid particles in the gases normally surrounding the urban environment. It has been proven that there is about ten times more particles in city air than is found in the adjacent countryside. (Spirn, 1984) This reflects some of the energy radiating out from the city itself - i.e. the large tarmac areas, the concrete buildings, and so forth. In addition to this, the heat emitted from engines and factories and other industrial plants are insulated by this layer of polluted air - known as an inversion layer.

3.2.8 Air Conditioning Technology

Technology has gone a step further in modifying the city climate with the invention of the modern air conditioner. First invented by Gory in Charleston, Southern Carolina to alleviate the problematic side effects of malaria, this process of compressing air, which, once it decompresses, cools down significantly, and therefore cools the air around it. This process is commonly used in refrigeration, and also in the making of beer, food and cold drinks. The common side effects of mechanical ventilation are the following :

(i) Because the insides of the buildings are being cooled down, the heat exchanger needs to get rid of energy, usually on the outside of the building.

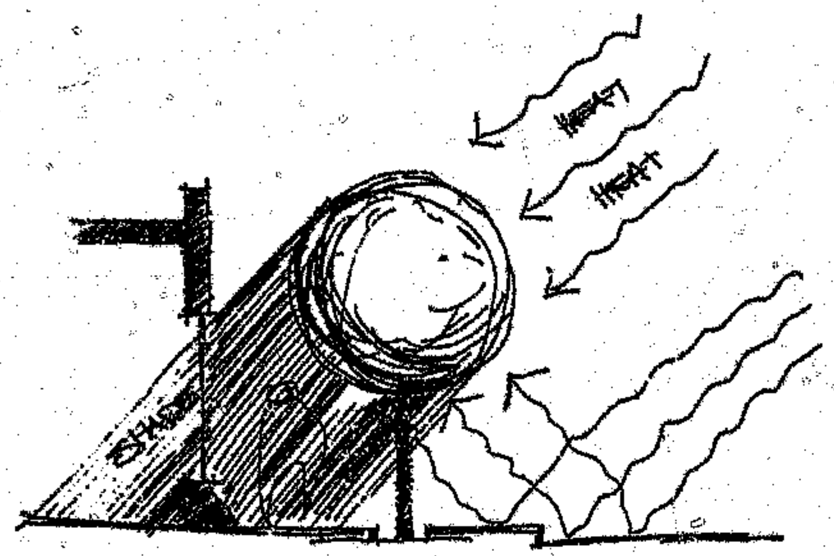


Fig 3.9 - The most important influence of vegetation on urban climates is its shading effect and the absorption of heat energy.

(ii) These mechanical air conditioning systems take in air of a poor quality and circulates it through an intense environment full of pollutants and poor in oxygen. This air is then again re-introduced into already polluted city environment, which adds to the problem.

(iii) Mechanical air conditioners also emphasize the preoccupation with internal climate and deny, in a way, the climatic role of exterior space. Air conditioning seems to screen out the products of industrial process, the smog, the soot, the chemical pollution, dust and other particles associated with air pollution. Unhealthy outdoor climates are generated, but go past unnoticed as we reorganize our lives to focus on the indoor climate.

3.2.9 Vegetation as Climate Control

The amount of incoming radiation can be controlled via the siting of buildings, as well as the orientation of buildings, streets, vegetation and open spaces. Vegetation therefore plays an important role in the basic climate control of exterior space. Vegetation has for centuries been utilized in the modification of the micro-climates in urban settings. Urban planting schemes should be able to ameliorate the air temperature, by shielding and controlling solar radiation. The leaves and branches intercept, reflect, absorb and defuse sunlight and thus provide welcoming shade in summer. The contrary is also true - trees protect the space below them from severe frost by retaining some of the heat radiation. See Fig 3.9.

Deciduous trees are useful in the moderate climates and the regions south and north of the solstice by allowing winter sun to penetrate and thus heating below the tree. In summer the heat is controlled as the trees leaves create shade. Therefore deciduous trees should be planted on the southern side of the street to shade the northern windows of these buildings against the hot summer sun, but would permit solar access during our short, but cold Highveld winters. The same principle could be implemented on the eastern side of a north-south running street - this would shade the buildings from the western exposures, but will still allow sunlight to warm the building during the winter.

In larger open plazas, large courtyards and wide streets, solar radiation penetrates right to the floor where it can be absorbed, retained and accumulated to heat up the environment. If this is not the climatic effect required, the design and construction of buildings could be altered or vegetation, particularly, trees, can be used very successfully to alleviate the problem. The capacity of forest canopy to absorb a large amount of solar energy has been researched, and was found to be considerable. Short-wave radiation in a closed canopy of a maple tree, for instance, can be reduced by up to 80% in midsummer, which calculates to 3,5 degree reduction in the temperature below this canopy. (Hough 1991).

Effects of wall climbing vines and the effect other plants have on the climate inside buildings have also been

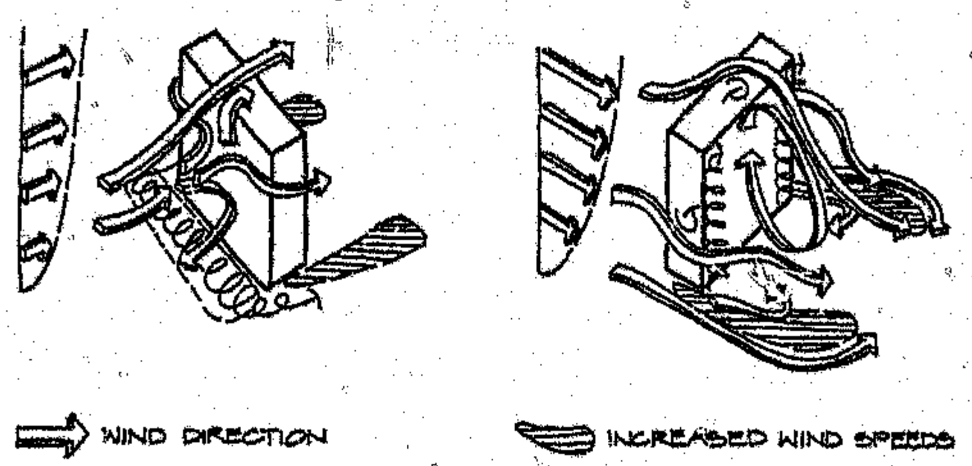


Fig 3.10 - Vegetation also reduce the present problem of turbulence around the basis of tall buildings. (Spirn, 1984)

studied by Prof. Dieter Holm (in Scheffler, 1993) and others, and have been found to be a much more effective and efficient means of controlling building climates. The basic thinking being that this planting forms an insulation layer acting very much the same as a cavity wall, to eliminate the transfer of heat energy from outside to inside during summer months. The opposite is true for the winter months when a large amount of the internal generated heat could be retained.

These effects become quite important if one considers the vast areas of vertical surfaces which are found in modern cities. Biologically, the leaves of these vines act as an effective solar energy collector. During the sunny summer months, leaves are raised to take advantage of the solar radiation and in doing so, permitting air to circulate between the plant and the building. This is the so-called chimney effect, which in addition to transpiration of these leaves, cools down the internal spaces as well as eliminating the radiated heat to affect the indoor spaces of the building.

Planted surfaces not only absorb heat slower than adjacent paved surfaces but it also cools the air. The microclimate is moderated through evapotranspiration of the vegetation. This life supporting function of plants cools down the air around them as the transpiration process of water to vapour, absorbs latent heat from the environment and therefore cools the plant and the air. A large tree can transpire up to 450-600 litres per day. (Earth Works Group, 1990) The potential cooling effect could be compared with five average room air conditioners - using up to 2 400 Watt per hour for 24 hours - thus saving 29 kilowatts. (Hough, 1991) It must then be noted that these air conditioners only shift the heat from indoors to outdoors, actually not alleviating the problem.

One large tree could therefore save enough energy per day to heat an average geyser for two days! Open spaces, parks wooded lots and vegetable gardens would not only absorb the carbon dioxide and replace it with oxygen, it could also cool the urban heat island and reduce the need for expensive energy to cool it down. (This advantage could be made redundant with the wrong choice of tree species as an evergreen tree would result in additional energy needed to heat the shaded house during winter time.)

Vegetation is often used to reduce high wind velocities so often associated with urban climates. The permeable nature of tree avenues and planted hedges produce better results in reducing wind speed and eliminates turbulence, than rigid and impermeable structures. It costs less to install and add to the scenic beauty, as well as purifying the air. See Fig 3.10

Green, vegetated corridors reduce absorbtion and retention of heat within the city macro-climate zone, and by doing so, alleviating the most important problem associated with urban heat islands through the insulation of heat. It also substantially reduce dust and other pollutants associated with city air. See Fig 3.11. In Stuttgart parks and green areas were strategically placed in the way of prevailing winds and in association with normal

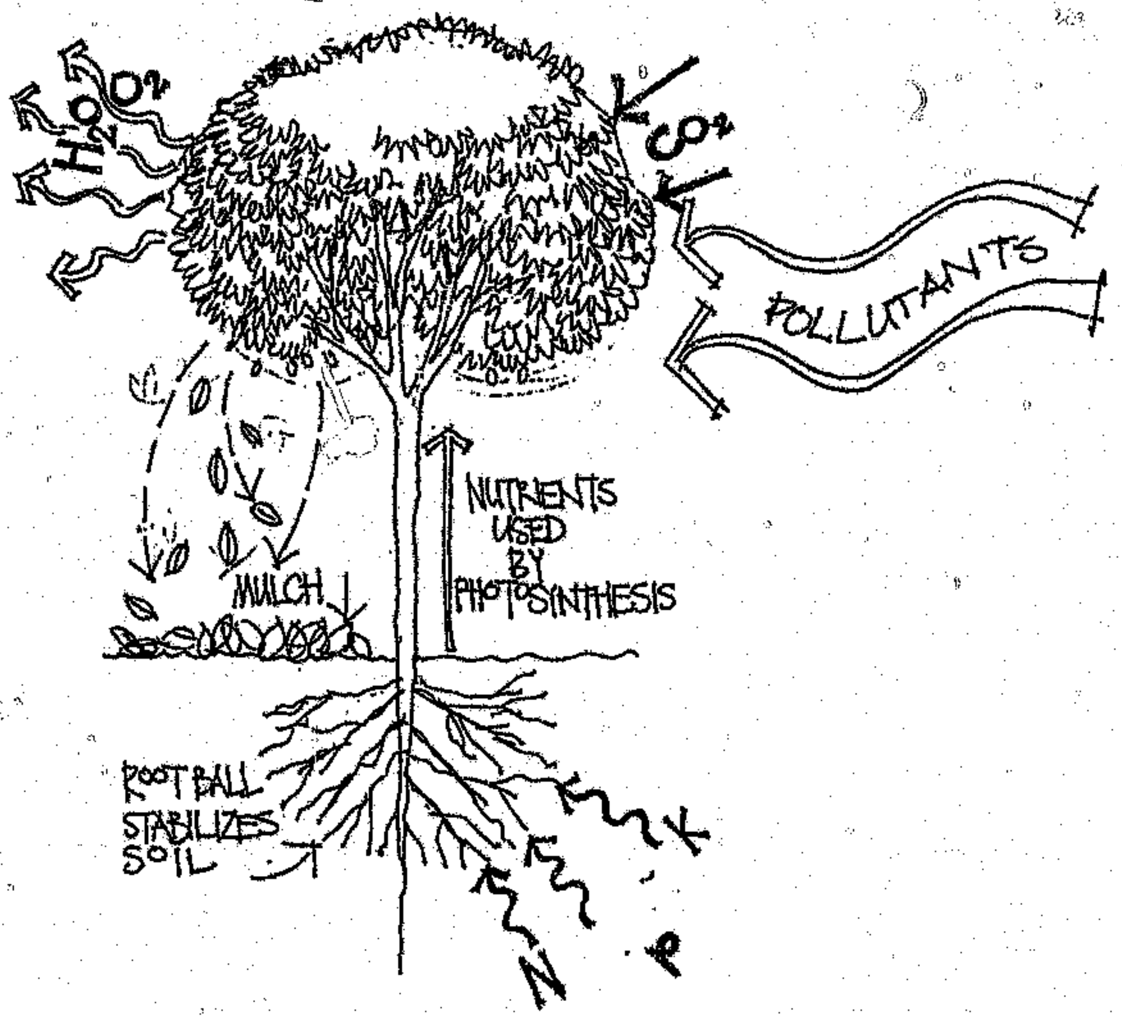


Fig 3.11 - Vegetation also improve the air temperature (through evapotranspiration) and the air quality (by absorbing some of the nutrients.

day/night airflows. These open systems had ameliorated air quality and reduced air temperature within the city boundaries. In Chicago, air flow modelling concluded that a finger pattern of green corridors and wedges of open space would have a most positive effect on the air quality.

3.2.10 Urban Design Guidelines

- The principle of courtyard development should be promoted, not only for reasons of effective land utilisation, but also for climatical reasons. The creation of small, well-defined and protected courtyards allow for a much more controlled solar and heat exchange ratio.

- The evaluation of land forms, not only for its slope restrictions, but as a way of channelling cool air down the valleys into the city centres. Planting, especially forest types, should be associated with these airways to filter and humidify the air. This would counter act the effect of heat retention and urban heat islands.

- The use of landform and windbreaks (preferably conifer type plants) in association with the designed urban fabric and natural elements such as water bodies, would not only reduce the turbulence of urban winds, but would also improve the air quality and remove heavier particles from the air.

- Structured planting against buildings would also improve the air quality on both inside and outside the building. It would reduce wind turbulence and micro-climate of the surrounding environment. Glare and heat radiation from the paved surfaces and glazed surfaces, would also be filtered and dampened. It would also assist in humanizing the scale of most city buildings.

- The use of deciduous and evergreen planting would control summer and winter climates efficiently.

- The positioning of substantial green space, fingers, or wedges again in the way of prevailing winds separating polluting industries and other urban users. The substantial open spaces would not remove the problem in its totality, but would definitely alleviate the specific effect of these pollutants.

- The study of sun angles and the design of buildings in such a way as to reduce the harmful summer sun, but allowing winter sun to penetrate into small protected courtyards.

Source	Source Type	Percentage of Emissions from Each Source by Pollutant[a]					Percentage of All Emissions
		CO	SO_2	TSP	HC	NO_2	
Transportation	Mobile (line)	83.5	3.0	8.8	40.7	39.6[b]	55.8
Road vehicles alone	Line	(75.2)	(1.3)	(6.6)	(34.9)	(29.0)	(49.0)
Fuel combustion	Stationary (point, area)	1.1	81.8	38.7	5.4	56.1	22.1
Electric utilities alone	Stationary (point)	—	(64.2)	(27.0)	(0.3)	(30.6)	(14.6)
Industrial processes	Stationary (point)	8.0	15.2	43.8	35.6	3.1	14.8
Solid waste disposal	Stationary (point)	2.6	—	2.9	2.6	0.4	2.0
Miscellaneous		4.8	—	5.8[c]	16.0	0.4	5.3

Fig 3.12 - Sources of Major Air Pollutants. (U.S.Environmental Protection Agency, 1977 in Hough 1991)

3.2 AIR QUALITY

3.3.1 Oxygen for Survival

Air, and oxygen in particular, is paramount of human survival on earth. It is the presence of air and sunlight (energy) which probably makes earth the only habitable planet in our solar system. Because air is so precious - it is difficult to comprehend the nonchalant attitude with which this precious resource is being polluted. Air quality and air pollution is not the result of urban settlements *per se*. The deforestation of the Canadian forer for wood and the Brazilian forests for agricultural land is contributing towards out present atmospheric pollution.

Oxygen is a renewable resource, but our present air quality suggests a sharp increase in the concentration of gases usually found in very small quantities. Parallel to this we as denuding the earth from its vegetative cover and thus limiting the earth's ability to sustain the critical oxygen level naturally found in our atmosphere.

The unhealthy environmental conditions of London and Glasgow during the late 1800's and the Industrial Revolution, as well as the "smog" of Los Angeles and Pretoria, are the result of poor siting, planning and design of industrial plants, the extensive use of the internal combustion engine as a mode of transport and the non existence of filtering and cleaning measures. The ISCOR plant in Pretoria is a case in point - the whole of Pretoria has to carry the cost of ISCOR's toxic emissions, because of ISCOR's vested interest which is classified "of national importance".

Technology has advanced far beyond its limited scope in the 1800 and still air pollution is becoming a threat to health and human existence. The major reason for this situation, according to the authors of *Sustainable Communities* (1991), is the persistence of private transport by means of the internal combustion engine - "... responsible for 60% of all urban pollutants" - and the elimination of the private motor vehicle in the future will be no easy task. See Fig 3.12.

The vested interest of the large petroleum, motor car and support industries make it almost inevitable that they would likely stay. Large portions of countries' economies are built on the motor industry. Even in South Africa the motor industries and the support functions are important employment sectors. The whole world is still seeing industrial developments (which also produces a fair share of the urban pollution) as the road to economic success.

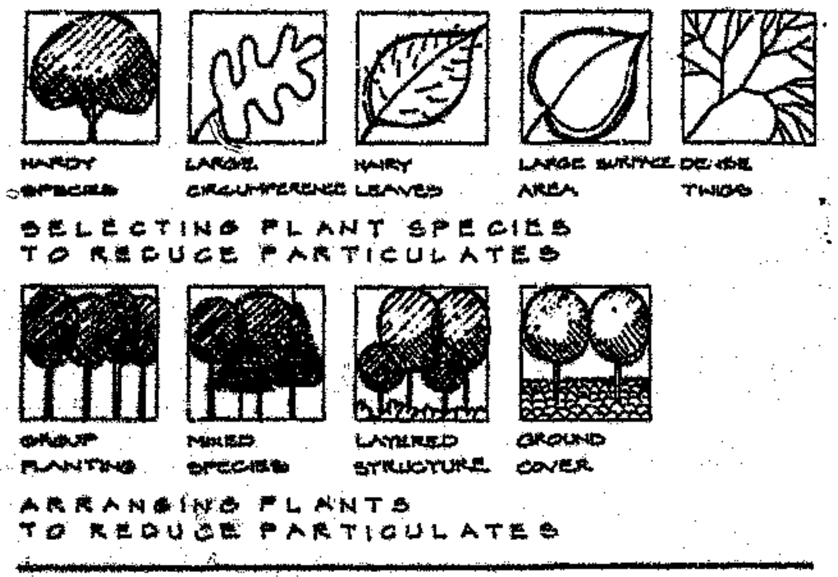
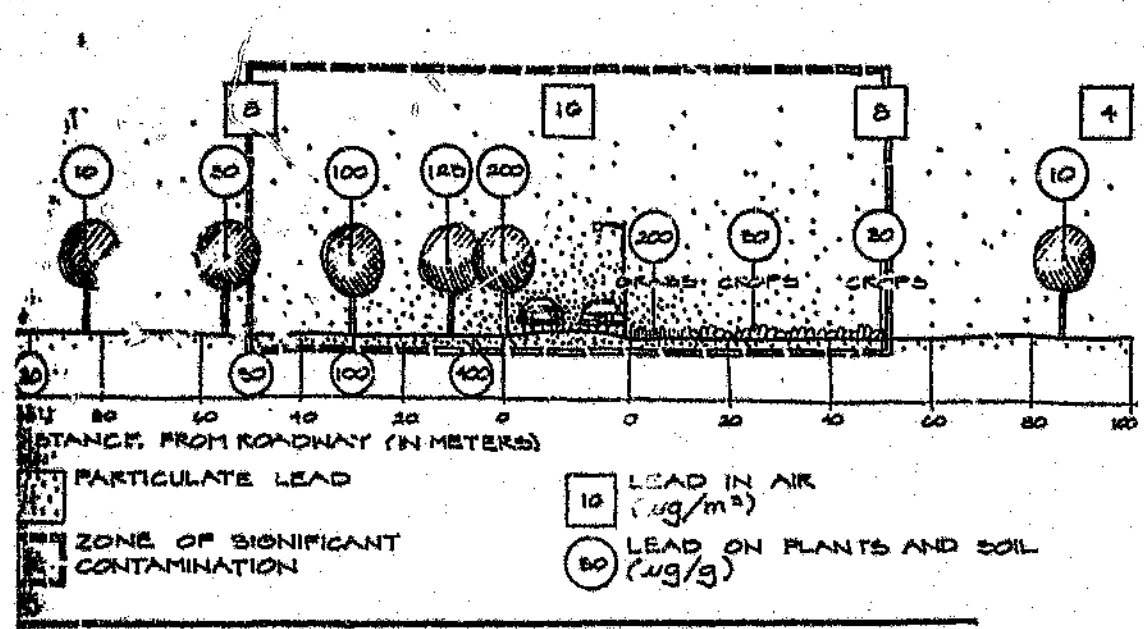


Fig 3.13 and Fig 3.14 - Using plants to reduce air pollution - certain species and arrangements create effective air filters. Affective planting arrangements allong roads mitigate the effects of pollution.



3.3.2 Plants to Improve Air Quality

Vegetation produces oxygen as a byproduct of photosynthesis - one tree could easily produce enough oxygen to satisfy all the requirements of 40 adult people per day. (Earth Works Group, 1990) On the issue of alleviation of urban pollution problems, plants again can play an important role. It was found that the leaves of a fir tree could absorb in the region of 25 kg of sulphur-dioxide per year. (NASA, 1989) Soil organisms are actually even more effective that the plants themselves to improve air quality. They are not only able to collect heavy metals, but also reduce carbon monoxide levels, nitrogen oxide levels, and in association with trees, reintroducing oxygen and nitrogen into the atmosphere.

The idea of "green lungs" and the whole notion of open space systems becoming effective, means not only to reintroduce oxygen into the air by absorbing carbon dioxide, as well as other pollutants from the air. In addition to this, these vegetated open spaces could also filter heavier particles like dust, out of the air and improve the level of humidity in the air by reintroducing moisture through the process of transpiration. See Fig 3.13 and Fig 3.14.

3.3.3 Dissolving our Earth

Acid rain has become a world wide problem - degrading total habitats which are sensitive to a change in pH. In Germany and Canada whole lake systems have been sterilized due to acidified precipitation, run off and soil. Large, mature forests are dying, plant communities are threatened and groundwater resources are being polluted. South Africa is now also being struck by these phenomenons.

Our extensive use of coal in the generation of electricity has suddenly turned into a possible environmental disaster. The reason for this is the fact that the Transvaal Highveld and Natal Midlands, areas known for its coal deposits and large power generation plants, are also extensively used for a wide spectrum of agricultural activities.

The relatively high rainfall of the Transvaal Highveld - above the South African average of 450 mm - is a complicating factor. The fact that it is a predominant summer rainfall area and that precipitation usually is associated with short thunderstorms resulting in the rain becoming increasingly acidic. In addition to the season and type of precipitation, the relatively long periods between thunderstorms, particularly during the winter periods results in large quantities of sulphur dioxide accumulating in the atmosphere - concentrated by the persistence of the Kalahari high pressure system during the winter months. (Botha, 1993)

The life bringing rain is quickly becoming a threat to the life it supports - the soil, the plants, the lakes and water bodies, the animals and finally man. As the rest of South Africa is arid, and therefore not suited for dry land agriculture, this could result in a complete collapse of our agricultural production with devastating consequences to the economy. The answer is quite clear - sulphur emissions into the South African atmosphere must be controlled and reduced.

3.3.4 Urban Design Guidelines

- Reduce the dependence on coal generated electricity, by developing so called "clean energy alternatives" such as passive solar energy and hydro-electricity. As our rivers are relatively small for conventional hydro-electrical schemes, smaller hydro plants could be considered.

- Reduce the carbon monoxide emissions resulting from the burning of fossil fuel in the internal combustion engine by using platinum catalysts in the exhaust systems. This would be made possible through denser, mixed use communities (as will be discussed later), the development of viable public transport options and the investment into electrically driven private transport.

- The responsible siting of industries which produces unhealthy atmospheric emissions. The social and environmental cost of poor siting of these industries cannot be dumped on communities.

- The implementation of extensive planting (especially trees) to filter and purifying the polluted air. (See *4.0 Planting for Environmental Effect*)

3.4 CONCLUSION

It is therefore imperative to realise the interrelationship and the links between open space distribution and climatic phenomena generated by topography to improve the city environment and make it more healthy and habitable to people. This re-iterates the whole notion of landscape as a functional part of urban environments, and not only as aesthetic improvement or horticultural exercise. These individual landscape elements therefore not only save costs and capital outlay, but also would produce a more balanced and varied improvement of city climates. It must be stressed again that the search for an ecological basis in urban design to understand the essential nature of these environmental elements can only reveal other opportunities and benefits resulting from retaining an ecological bias.

The above climate related problems can effectively be alleviated by the presence of strategically placed open spaces, channelling cool air in from the country side (see Stuttgardt case study in Spirn, 1984), large water bodies (to humidify and cool the air) and effective planting of vegetative screens and canopies (to cool and improve the air quality as well as reduce wind turbulence). This thesis thus supports Professor Mallows' argument to decide on open spaces first in planning and there after designing urban settlements.

4.0 PLANTING FOR ENVIRONMENTAL EFFECT

4.1 INTRODUCTION

In our modern age plants are taken for granted. The bulldozing or cutting of a tree, which had been growing for 50 years is not seen as an environmental tragedy. The important role of plants in the ecosystems - and even more so in the urban ecosystem - is usually over looked. In developing an urban design framework the understanding of vegetation and its functions goes far beyond the avenues of green circles shown on plans.

In recent years plants in the city were evaluated on merit of their horticultural and aesthetic performance. Landscapes have become artificial and design was only concentrated on form, colour, texture and then also functional aspects of shade, screening, etc. But urban ecology calls for another perspective. There is a valid basis for ecological approach to aesthetics and the use of plants for aesthetic, functional and ecological reasons. This, however, requires a shift in paradigm. (Ahern and Fabel, 1983) Plants are actually important pro-active participants in the environment. Their aesthetic appeal reveals only a fraction of their full impact on the landscape as we know it.

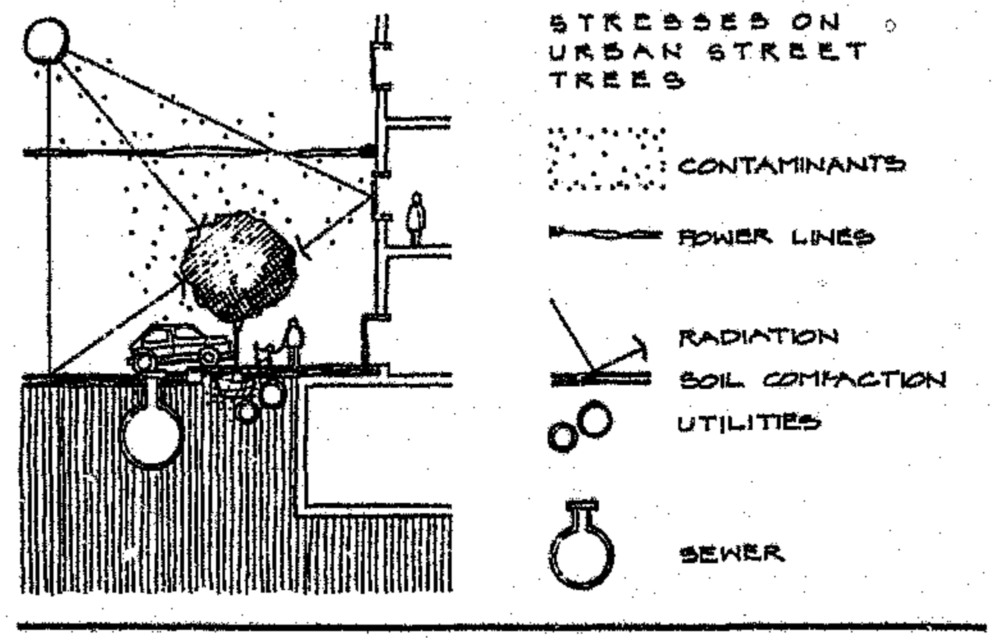


Fig 4.1 - Urban trees contend with great stress - Intense heat, air pollution, damage by vehicles and vandals, compacted, infertile soil, little air and water and limited root space. (Spirn, 1984)

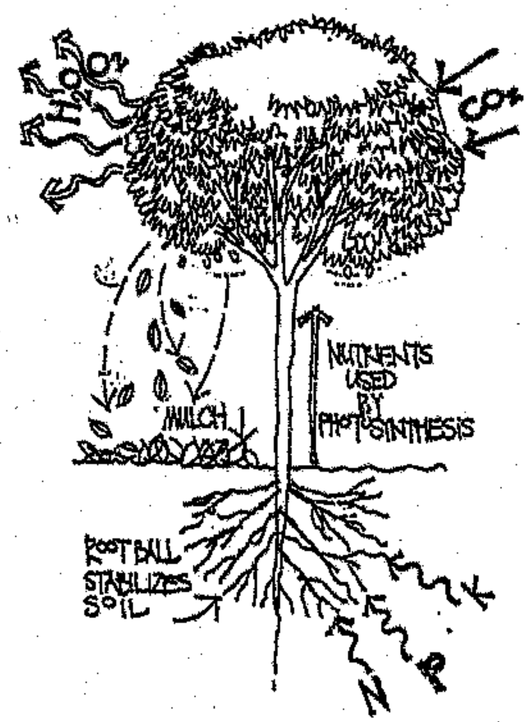


Fig 4.2 - Trees as retention mechanisms in ecology. Trees can be seen as the pump of nature. Because of their extensive root systems, they actually absorb and filters the movement of nitrates and other minerals through the soil, as well as water, pump it up and eventually reach the soil surface where it can re-enter with the added benefit of increasing the humus content of the top soil.

4.2 CITIES AND PLANTS

4.2.1 The Importance of Vegetation

Urban environments present by no means ideal growth conditions for plants. The process of photosynthesis requires an osmotic gas exchange between the green leaves and the air around it. Thus plants release oxygen and absorbs carbon dioxide. But other, of the toxic gasses are also absorbed. The high concentration of pollutants in urban areas are to the determent of plants. See Fig 4.1.

The pollutants are not the only stress imposed on plants by our cities. Compacted soils, frequent trenching for services and disturbance of soils, as well as the pollution of soils, all affect the growth and development of root systems and therefore also the plants' growth. Soil contamination with oil, salts and other chemicals also create difficult growing conditions. Lowering groundwater levels, reduced water penetration, as well as interference in the transfer of air and gases into the soils, adversely affect the growth of urban plant communities.

One of the major restrictive factors are that of the extreme climatic conditions which are associated with urban environments. Extremely hot and dry or cold and windy periods occur as a result of tall buildings, reflective glass and large exposures of paving, tar and concrete, wind turbulence. Soils could be waterlogging after rainstorms, but also excessively dry in between. Continuous disturbances of the soil because of construction and maintenance - all add to the factors that should be considered in designing for urban plant communities.

4.2.2 Trees as Retention Mechanisms

Trees can be seen as the pump of nature. Because of their extensive root systems, they actually absorb and filters the movement of nitrates and other minerals through the soil, as well as water, pump it up and eventually reach the soil surface where it can re-enter with the added benefit of increasing the humus content of the top soil. See Fig 4.2.

As previously stated trees absorb enonnous amounts of water, large amounts of carbon dioxide and also nutrients - thus retaining valuable resources. These resources are not only stored for its own use, but would benefit the habitat which develops in the vicinity of a tree. Trees like people cannot forcefully be removed from its position, without eradicating a symbiosis of organic and anorganic matter.

Tree planting in naturally occurring bushy areas or woodlands, as well as close to water courses or small ravines, are beneficial because it prevents silting and counteracts the excessive water evaporation because of

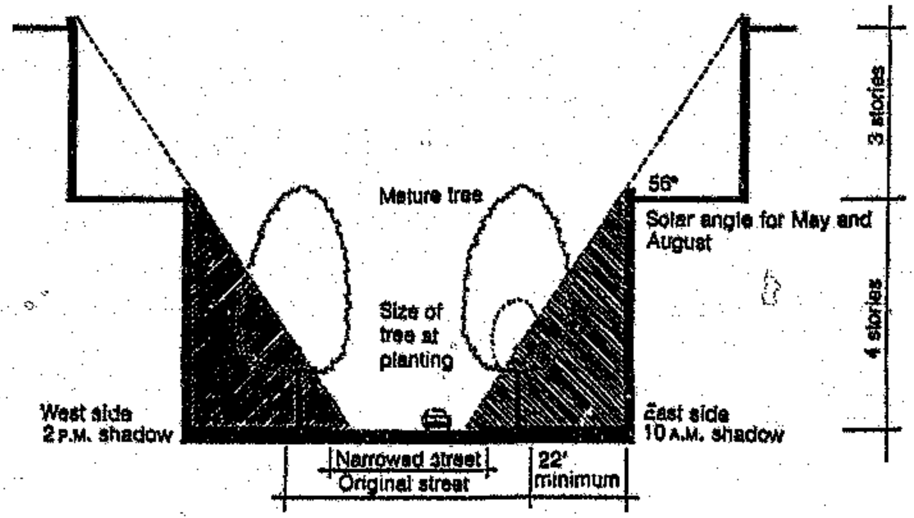
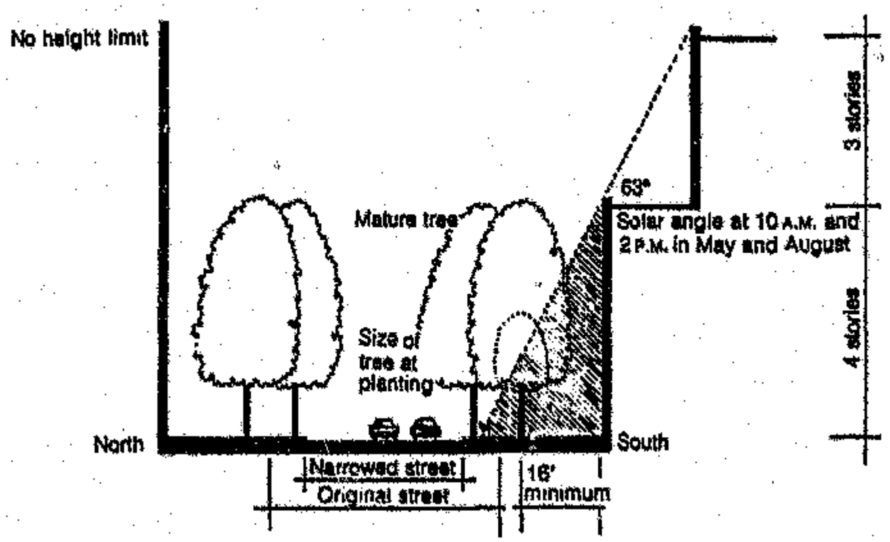


Fig 4.3 and Fig 4.4 - Vegetation reduce the scale of urban environments, creates green oasis in a sea of concrete and create places. (Simmonds, 1978)



reduced air movement and less exposure to direct sunlight. These natural examples should be followed in the choice of species, planting condition and spacing of trees in urban environments.

4.2.3 Vegetation for Scale and Proportion

The well designed planting scheme does not only add to the aesthetic appeal of a space, but should also address scale and environmental issues related to "space making". The scale of a tree or an avenue of trees are well suited to reduce or humanize the proportions of a street or an urban space. It has a wonderful proportioned relationship to the elements, which in combination, defines the ground plain, the vertical scale and the overhead plain - capturing space wherever its positioned (Simmonds, 1978). The detail of the leaves, twigs, branches, stem and roots adds interest and diversity to the space. The seasonal change of the individual elements reiterated the individuality and the wholeness of a tree. The approach to planting should never just be the drawing of equal size green circles on a urban design framework drawing or on a site development plan - it should not be driven only from an aesthetic (symmetry, colour and balance) point of view. See Fig 4.3 and Fig 4.4.

4.2.5 Air Quality and Purification

Most urban areas suffer of air pollution and it in of the utmost importance to improve air quality in order to grow vegetable crops without possible contamination by toxins in the air, or to suffer loss of carved marble and sandstone structures, due to acid rain. Some of these substances in the air prohibit productive growth and yield from crops grown in their presence. Luckily some plants are not as sensitive to these pollutants and all plants contribute to air of a better quality.

The most common air pollutants are carbon monoxide and hydrocarbons (both produced by internal combustion engines), lead (from the petrol we use), ozone (refrigeration plants), nitrogen and sulphide oxides (from vehicles and industry), fluorides hydrogen sulphide. The internal combustion engine is responsible for 60% of all these pollutants. (NASA, 1989)

The basic contribution of vegetation is the maintaining of the carbon dioxide balance in our atmosphere. All plants need to absorb carbon dioxide from the atmosphere, to be used in the photosynthesis process to transform sunlight energy to organic substance. The byproduct is the releasing of oxygen into the air during active photosynthesis - a large tree produces enough oxygen per day to replenish the oxygen used by forty people and urban trees are known to speed up the process by 15 times. (Earth Works Group, 1990 and Spirn, 1984)

Plants transpire moisture and release oxygen into the air. The osmotic process of gas exchange also absorb other gases such as sulphur dioxide, carbon monoxide, nitrogen oxide and even fluorides - all considered to be pollutants in our cities. (Spirn, 1984) It is claimed that plants could contribute significantly to improve air quality by absorbing some of the toxic substances in the air, while continuously releasing oxygen into the air. The specifics of air improvement by plants has been studied in detail as a result in the "sick building" syndrome.

"Sick buildings" are reported to literally recycle foul air which eventually lead to drowsiness, headaches, itchy eyes, skin rashes - all resulting in poor worker performance. Two major reasons for the "contaminated" air has been suggested. The source of outside air for the centralized air conditioning system is already polluted (the air intakes usually are in the parking basement, or from a polluted street). Secondly, and apparently more likely the so called "off gassing" of the materials used for modern interiors are being blamed. It has been established beyond all doubt that naturally ventilated building are less likely to suffer "sick building" syndrome. (NASA Report, 1989)

The most common pollutants are benzine, trichloroethylene and formaldehyde. (see graphs showing results of NASA research) These vapours escape from substances used extensively in a building, finishing and running office environments. Benzine escapes from gasoline, inks, oils, paints, plastics and rubber - all everyday materials. Benzine has for long been known to irritate sensitive skin, eyes and it has been indicated that benzine also could contribute to leucaemia and chromosomal aberrations. Evidence also exists which indicate benzine to be mutagenic to bacterial cell cultures. Humans, after being exposed to relative low levels thereof, complain of headaches, loss of appetite, drowsiness and event anaemia and bone marrow disease.

Trichloroethylene is a commercial product with a wide variety of industrial uses. It is commonly used in dry cleaning processes, printing inks, paints, lacquers, varnishes and adhesives. It is considered a potent liver carcinogen by the National Cancer Institute. Research has proven that these potentially dangerous vapours are being absorbed, at varying success rates, by indoor plants. This is also possible of other toxic substances found in the air. Studies in New York City concluded that sulphur dioxide levels are 40% lower in Central Park than immediately adjacent to it.

The filtering quality of trees, screens and hedges is also important to note. Fiat... ly reduce wind velocity and turbulence which allows larger particles to settle down, but also capture dust and other substances - which would be washed down by water or rain. The effectiveness of the filtering by planting is related to the type of plants used and the pattern in which it is planted.

This improvement of air quality emphasise the importance of approaching the design of the environment holistically. These pollutants can reach toxic levels when it interferes with normal transpiration and respiration processes. Therefore species adaptable to the conditions should be selected depending on the level of pollution

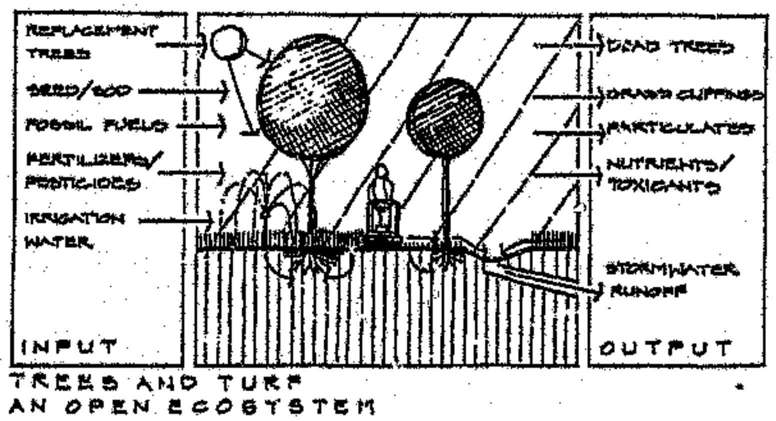
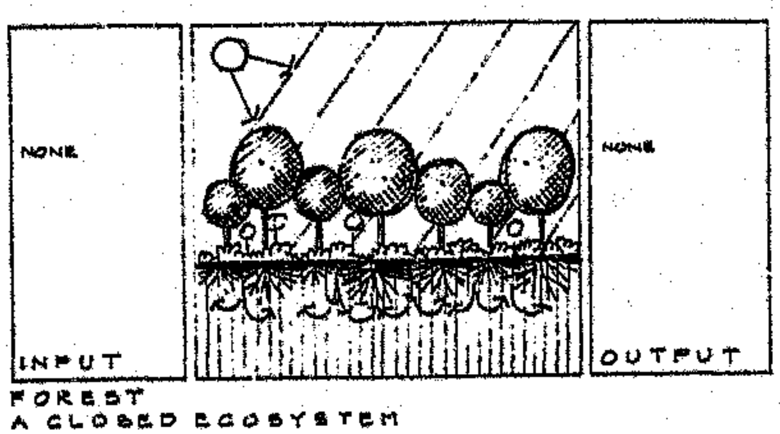


Fig 4.5 and Fig 4.6 - The open ecosystem: trees and lawn, which requires major inputs of energy and materials, while producing very little. The closed ecosystems of the urban forest produces wood, large amounts of oxygen, while filtering the air, requires no maintenance and regenerates itself. (Hough 1991)



and micro-climatic condition prevailing. The bio-chemical processes necessary for plants to live have qualities which not only provide oxygen, but actually absorb pollutants and filter the air. A well considered planting scheme in urban environments would not only assist in improving the aesthetics and micro-climate, but could provide "clean" air.

4.3 THE NATURAL ALTERNATIVE

4.3.1 Introduction

Native plant communities developing in the nooks and crannies, on the vacant lots and on the edges of developments show a definite resilience and vigour in adapting to the urban conditions. The urban designer should look for the links between the natural and the urban processes in developing a strategy for establishing sustainable plant communities. The natural urban plant community is adapted to city conditions without any assistance or maintenance by man. These plants, like the natural forest, regenerates itself, developing through certain growth stages towards a "maturity". The fundamentally altered environment gives birth to original ecosystems which flourish in the absence of maintenance. Again a system of pioneering plants developing an altered environment for the germination of climax species can be traced.

The other important factor is species diversity. In these naturalised areas a diverse arrangement of species, both woody and grassy specimens can be found. In the city of Venice with no soft open spaces, over 147 vascular plants have been recorded growing wild and without any attendance. (Spirn, 1984)

The traditional idea of each tree, shrub and flower being a symbol of man's ingenuity resembling an artifact of the humanised landscape that must be changed. Planting and plant communities should be governed, moulded and shaped by the environment in which they have to survive. We can admire them for their form, flowers, leaves unusual character and unique repetition, but the interdependency of the community and the parts related to a total whole must never be underestimated. Our green, manicured lawns with perfect tree specimens in them, maintained through machines, fertilizers, herbicides, pesticides and manpower are becoming more and more of a burden to the city. (Hough, 1991, Spirn 1984 and others) See Figs 4.5 and 4.6.

The responsible urban designer will try to develop an approach, using natural processes in developing new sets of standards for order, tidiness and common health values for urban plants. Diverse communities of plants which flourish in profusion in our abandoned lots must be carefully checked for clues in developing this new process. Our deep-seated aesthetic values and understanding of orders should be re-examined and the public educated in understanding the broad principles of a sustainable urban environment.

4.3.2 Environmental Design and Cost

The examination of planting specifications and the technical requirements for these plants, can be traced in our construction contracts and completed projects. For any new project, ideal growing conditions must be established for roots, irrespective of the existing soil conditions. Topsoil must be imported, soil fertility improved, compost added and fertilized to allow "ideal" growing conditions for the proposed lawns, groundcovers, flowering shrubbery and specimen trees. Irrigation needs to be installed to ensure regular and systematic watering, 35 mm per week. (average irrigation precipitation recommended by the Turf Irrigation Institute)

The interrelationship between the economic sense and environmental or ecological sense is clear. The high maintenance costs of our urban plant population is pricing itself out of the market. The urban designer must lay down a fundamental designed framework enabling sustainable and low maintenance plant communities which have to be productive in improving the urban environment and could also as shown later, become productive in generating income.

We are thus concerned with the scientific interest in plants as a phenomenon, as well as their place in the economy of nature. The urban design values of the past are adrift, derailed by artistic conventions and a lack of firm foundation and process and function which you will find in the principles of ecology. (After Hough, Spirn and others)

Again the issue of wasted energy is important. The current practices do not comply to Mother Nature's rule of energy in must equal energy out. It is the basis on which the earth as a whole functions, it is the basis on which the movements of planets and stars, the sun and moon are guided through space. These same principles shape our natural environment and should have an impact on our urban environment. This will most probably assure a more productive and economic beneficial investment, giving higher values and a better returns to our urban environment as a whole.

4.3.3 Greens, Lawns and Open Spaces

The pressure on green spaces will only increase in the years to come. Plants will be threatened more and more by extinction and the earth by denuding because of the high pressures on land for settling, land for recreation,

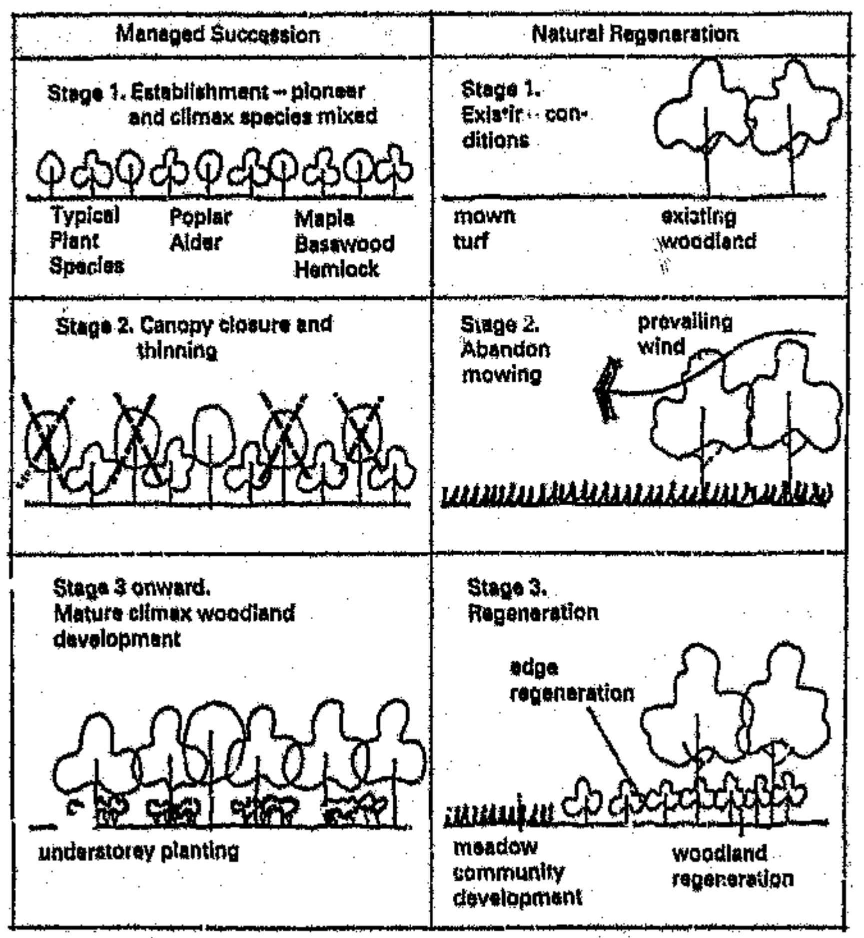


Fig 4.7 - General reforestation practices used in creating urban forests. (Hough 1991)

land for production and the materials needed to enable the above.

The green carpet previously requiring standardised specifications of topsoil, fertilizer, herbicides, watering, cutting heights, pesticides and its yearly scarifying, can now become a productive environment by allowing sheep, for instance, to graze it - not only do the sheep maintain a reasonable maintenance level of the lawned areas, but their droppings provide nutrients and a new educational facility is added. This also enables the landowner, be it public or private, to seriously reduce his maintenance costs, by adding another measure of return, by way of buying and selling of sheep.

As an alternative to the above, the lawn and other plantings, could be managed and maintained in such a way that it provides a range of habitats and environmental spaces. A manicured lawn where it is needed, rougher, more rugged version in less used areas and naturalised areas, should all form part of the diverse ecosystems which would enable a sustainable whole.

4.3.4 Going with Nature

The residential landscape will also be affected through this process of design based on certain fundamental, ecological and social objectives. Movement and recreation are important activities, therefore a tough, highly varied landscape should be proposed, which will not only stimulate play, but withstand the pressures of play and the environmental restrictions of high density living.

The Dutch have developed quite far in their application of these principles. Diversity and long term maintenance programme will not only lighten the burden of maintenance costs, but also allow natural reclamation and more sustainable environments in the long run. To give an indication, the maintenance of lawn is twice as expensive as naturalised meadows and 63 times as costly as a naturalised woodland. It is also 8 times more expensive than groundcovers. Compare the report of the Parks Department of Rotterdam (Hough, 1980). The complexity and robustness of the residential woodland landscape can accommodate the pressures which produce the need for conventional design layouts, with their high maintenance costs. See Fig 4.7

The result of the implementation of these principles can be seen in the William Curtis Ecological Park in London where a whole range of manageable units were established, including planted woodlands of native trees and shrubs, creepers against certain walls, fresh water ponds that support submerged and other aquatic plants, as well as bog planting adapting to the particular soil types and conditions as well as a central meadow with different areas of maintained levels. This not only makes for sustainable ecosystem to develop linked to the diversity of conditions, but it also allows for a much richer educational and recreational experience. Field and Study centres, bird watching, fishing and other games could be promoted. The outdoor laboratory and other

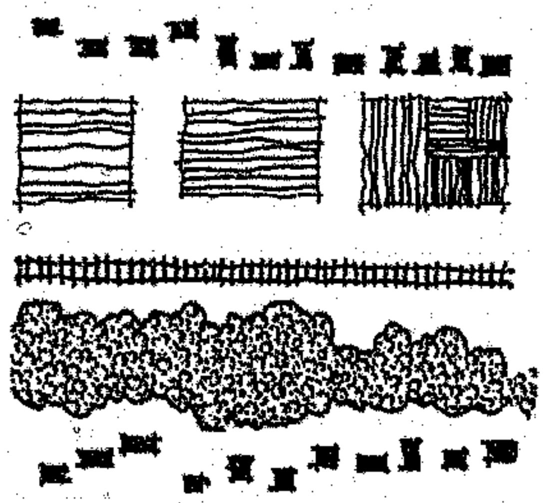


Fig 4.8 - Edge planting criteria. Using different planting strategies, vegetation maintenance and with the introduction of design elements and information the systems becomes more self reliant and more of and educational experience. (Hough 1991)

teachings would now be possible, and there would be no need to visit the countryside to see and understand how and why Mother Nature does what She does.

The last point that needs to be reviewed, is the productive side of integrated environmental management where urban landscapes, urban forests and urban parks not only provide walks, nature trails, cross country cycling, exercise, fitness parks and a range of educational experiences, but also produce commercial timber, food and in South Africa, fire wood, building material and other basic requirements for a developing country. See Fig 4.8.

4.4 URBAN DESIGN GUIDELINES

- Planting screens should establish perpendicular to the prevailing winds. The type of vegetation, function, foreseen maintenance and level of pollution must be taken into account.

- Dense, barrier type planting might be effective in screening winds, but result in unpleasant turbulence behind the barrier. This type of planting should always be accompanied by looser, more permeable plants.

- Pollution generators should be encircled by several layers of plant types to maximize the absorbtion effect, as well as to ensure maximum reintroduction of oxygen and filtering of heavy particles.

- Dense planting is usually more effective than dispersed plantings. Thus tree avenues, heavenly planted courtyards and road verges are preferable.

- The staggering of plants in hedges and screens is preferable to row planting.

- Do not plant food producing plants near or adjacent to busy roads, polluting industries or waste treatment plants, as the health risk overshadows the advantage of producing food.

- Use a mix of evergreen and deciduous planting specifically placed to address the micro-climatical concerns of the space after it had been assessed.

- Use indigenous plant material should be emphasised and promoted. This will not only support the local food chain, but these plants are more resilient under South African conditions.

- Reduce the use of high maintenance planting solutions: large trees in small spaces, tall trees under telephone lines and lawns if not required.

- Limit the excessive use of monocultures as these environments are usually not sustainable in the long run and could be eliminated by a single pest (refer to the Dutch Elm Disease which nearly wiped out all the elm trees world wide)

- Introduce productive landscapes, instead of just open space for the sake of open space.

- That urban design derive its inspiration from functional landscapes of nature and not be bound by aesthetic and horticultural dogma of the traditional approach.

- The integration of natural objectives will assure for a more sustainable underlying framework for design and aesthetic values in urban plant design.

- Plants should be an added multi-functional and ecological discipline to the management of the urban whole.

- An open space structure, founded on sound environmental principles, should be planned and designed in such a way that it acts as service corridors connecting empty lots, waterfronts, river edges, ridges and other open areas to each other, making connections between different habitats and ecosystems to allow for more diverse interlinked and co[illegible]ected ecosystems.

- Landscaped neighbourhoods should be densified to reduce the horticultural landscapes which require constant maintenance. The open spaces which would develop from this approach should become more naturalized to be able to function as a ecosystem, which will reduce maintenance costs, and produce more functional landscapes.

- Urban design frameworks should include the allocation of functional landscapes, in addition to the more conventional

- The more productive use of the arable land in and around our cities should be promoted as part of the urban designer's facilitation process.

- Allotment gardens and urban agriculture, as means for job creation and community focus could be incorporated in urban design framework proposals.

4.5 SOIL PROTECTION AND IMPROVEMENT

4.5.1 Erosion Protection

The protection of our topsoil as a resource is paramount. Existing vegetation cover and the introduction of suitable plant species is one of the most appropriate techniques to protect the soil. The root systems of a wide variety of species are particularly well suited to binding soil and thus protecting it from erosion.

Modern technology could also play an important role in initial stabilisation of disturbed soil. "Sand Glue" was used during Operation Desert Storm to reduce dust on chopper landing sites. This water-like component permeate through the top layer of soil and fixes the particles. Other commonly used methods such as "Geo-Jute" and "Hyson Cells" assist in the protection of soil against erosion. Stability of the soil could be increased by the grading of embankments to a gradient in accordance with the natural settlement angel of the specific soil.

4.5.2 Soil Improvement - The Natural Way

The previously suggested use of organic wastes, produced by our consumer orientated urban societies, as a more balanced alternative to synthetic fertilizer is a viable resource, making our modern environment more sustainable. Through the natural process of recycling the nutrient flow is restored. By processing and dumping sewage and other organic waste products in one place over extended periods of time also result in that the groundwater and soil of the area is becoming polluted.

The presence of heavy metals is a particular concern as it is extremely toxic if concentrated and is easily absorbed by crops and feeding animals. If the processing of sewage and other organic waste are approached from a resource point of view - producing organic fertilizers to be used on highly productive crops in the vicinity, the social, financial cost, and also the cost to our environment - our biosphere as a whole - would be reduced.

Plant humus and mulch from the fallen leaves improves the soil stability, fertility, composition, as well as reduces its susceptibility to erosion. The presence of vegetation cover is a natural method of increasing the general soil condition. Therefore more permanent plant species should be used, with a mix of deciduous and evergreen, to sustain a humus rich mulch on the soil.

4.5.3 Urban Design Guidelines

- Suitable sewage treatment facilities should be developed, taking the resource potential of these organic wastes into account. Sewage treatment works co[illegible] become a producing or recycling plant - not a waste dumping plant.

- The integral part of soil conservation is saving water, conserving water resources and managing water quality. (If we allow the soil to be polluted, water and air will follow)

- Erosion protection measures must form part of detail urban design principles. South Africa loses more than 30 million tons of topsoil per year. (Dr A Botha)

- Soil and topsoil in particular, must be seen as a precious resource which allows our vested capital intensive urban settlements to sustain - although the city does not use the soil productively.

- The use of specialized fertilisers and artificial growth mediums should be reconsidered in the light of the future maintenance programme of a development.

- The deep trenching method of soil improvement (as advocated by Dr Robert Mazibuko in Chittenden, 1993) should be considered in developing communities as a cheap and effective means of improving the qualities of the topsoil.

4.6 CONCLUSION

This not only allows the opportunity of diversification which broadens our social, cultural and education experience, but it also enables a range of sustainable environments to be utilised as productive and functional components of the urban mechanism. The aesthetic notion of lawn and lone tree (after Capability Brown in

FIGURE 1: THE IEM PROCEDURE

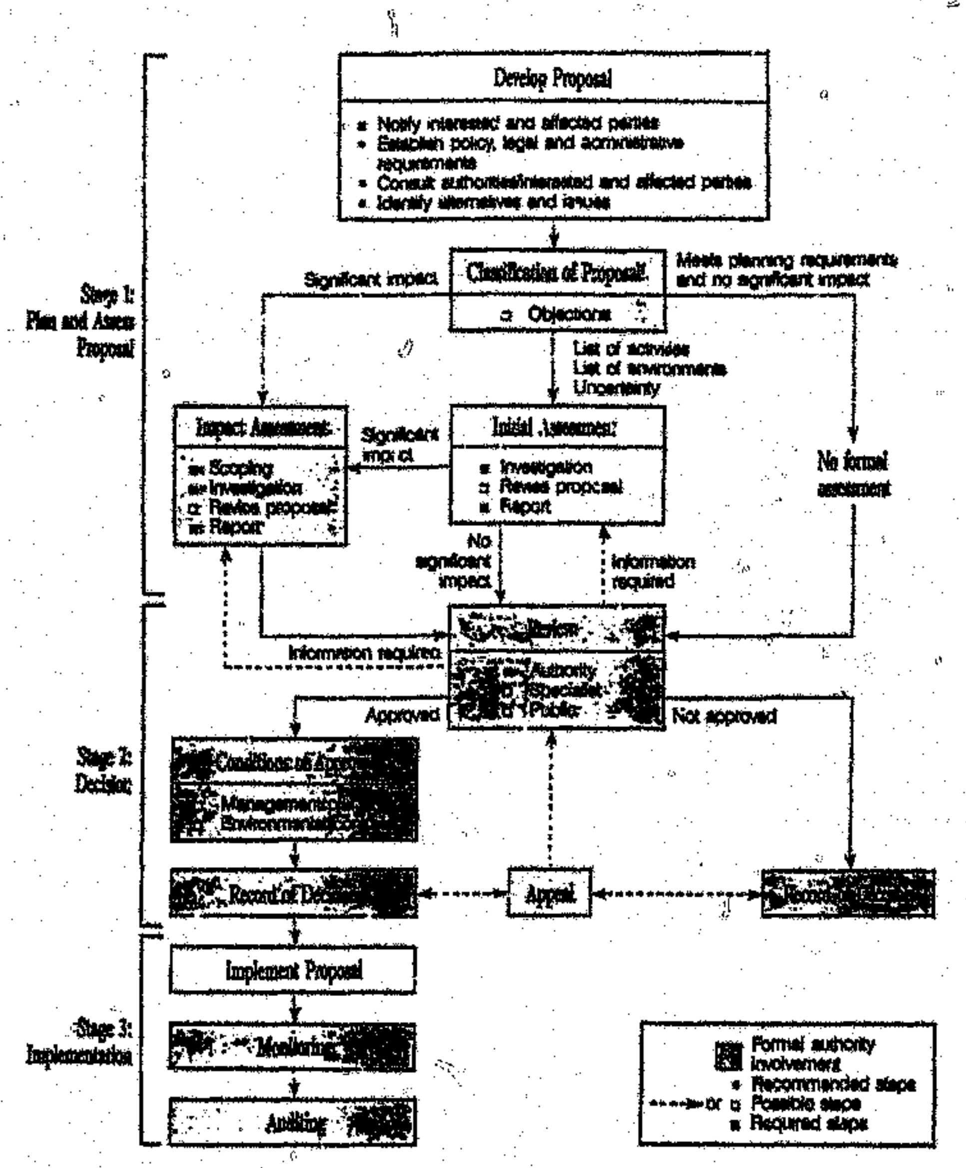


Fig 4.9 - The Integrated Environmental Management Procedure as proposed by the Department of Environmental Affairs, in The IEM Guideline Series, 1992.

Jellicoe, 1975) must be altered to permit a more functional ecological systems with different layers and levels of adaptability to regeneration and development. This will make for lower establishing costs and a reduction in the maintenance costs through a process of integrated environmental management (see diagram of Integrated Environmental Management Guidelines Series, The Council for the Environment, 1992). See Fig 4.9.

Principles such as diversity, succession, productivity and interaction must be incorporated. The initial planting of fast growing, light determining pioneer species which will create a quick vegetative cover aerating the soil, fixing nitrogen, stimulating micro-organisms, producing a forest floor and humus and creating a habitat for birds and other animals to settle and bring in the seed of the climax species.

The creation of cultivated landscapes based on technological horticultural and aesthetic parameters must be confronted by the realities of urban nature. Naturally diverse places and spaces should replace manicured lawn and cultivated plants dependant on man for their very existence. The maximizing of ecological diversity will allow social and educational options and reduce maintenance costs. But an ecological view of plants will require integrated management framework based on plain ecological principles. The concept of urban forests, natural succession, diverse habitats, must all form part of a greater economic and environmental productivity programme which will enhance social and aesthetic values.

The functional aspect must address climate, water, geology and other aspects to not only make the community more sustainable but altering the environmental conditions for human settlement. Thus, natural processes rather than horticultural technology must form the underlying framework. This involves the introduction of natural plant communities and systems into the city, the establishment of woodlands through reforestation, the creation of wetlands where hydrological conditions are appropriate, the development of meadow communities with a variety of appropriate grasses, and the establishment of varied wild life habitats.

Soil as a precious resource should be conserved by mulching, re-instating appropriate vegetation cover, and erosion protection mechanisms. Appropriate technologies for soil improvement should be considered in developing an urban design framework, as to facilitate productive and functional landscapes as an integral part of the sustainability of the settlement and its economy.

5.0 URBAN WILD LIFE

5.1 INTRODUCTION

Just as in plant communities, the population equilibrium or the equilibrium of a specific species in the animal kingdom is maintained through an elaborate system of checks and balances. The loss of a habitat or habitat type for utilisation by a species does not only affect the shelter and the breeding habits, but also the feeding habits. Animals are like humans - more adaptable to change in environment and situation. Some species are obviously more adaptable than others, and may survive and flourish under sometimes extremely difficult conditions.

Nevertheless, the loss of a specific environment type, be that in the city, countryside or in a pristine environment, is still a great loss, seeing it from a wild life point of view. The city as we know it, has radically altered both the natural habitat, as well as the composition, physiological characteristics and community composition of several wild life species.

Just like humans, the interaction in wild life communities as well as different wild life communities must also be understood and studied prior to intervening in these environments. The opportunities for creating new habitats or the preserving of existing ones must therefore be carefully considered and recommended. Again, the approach of developing resource and viewing everything as opportunities rather than constraints, can again be applied to that of urban wild life.

5.2 SELECTED URBAN WILD LIFE ISSUES

5.2.1 Water Habitats

The severe storm water problems which develops after the urbanisation of an area - the increase of surface run-off to such an extent that surface retention and detention are becoming more and more essential. These detention ponds could act in several ways to contribute to the species diversity, as well as the environmental diversity of an urban setting. Forcing of the development of wetlands, marsh areas, dams, open water and streams is obviously a very important aspect of creating new habitats. The same could be said of urban waste water treatment works as wild life habitats.

Again the abundance of water, but then also the abundance of organic material which could act as food, attract a lot of urban wild life to these areas. These areas could then again be developed in such a way as to become not only an educational tool, but also a part of an integrated environmental management plan catering for diverse plant and wild life communities. Hough, for instance, quotes the Ottawa sewerage treatment works which actually attracts more bird life than the nearby natural areas, which shows that there is a real potential in even these kind of areas.

5.2.2 Cities and Wild life

In research done, in mainly America, it was found that the total number of bird species declined in urban environments, but that the total bird population actually increased because of certain species flourishing in the urban environment. The ornamental and horticultural approach to plants in the city, as was referred to in the previous section, also has its impact on the wild life communities. The "sterile landscape" of only trees and large expanses of lawn, maintained by mowing, fertilizers and herbicides, impacts not only on the insects that live in it, but also on the animals that feed on these insects. Severe disturbances could therefore be found in population numbers, as well as social interaction as the result of poisoning. It was found that ornamental trees mostly exotic, often lack the insect life and diversity of indigenous plant material. It was also noted that exotic bird species were the only ones that utilised exotic tree species extensively.

The small elements of native vegetation with its inherent diversity found in ravines, at the edges of open spaces like cemeteries and golf courses, and on undeveloped land, make for interesting contrasts in an urban setting. The ecology of a dead tree, a small patch of grassland, small wetland or an area that has been colonised by primary plants result in diverse and interactive developments of wild life in the city.

These isolated areas become as something of an island in the urban setting, often unfortunately disconnected to other islands which result in poor diversity and therefore also do not have a good chance of sustainability. Linkages are therefore quite important from the ecological point of view. The city, like the earth, can actually not act as a closed environment and should connect to the rural areas surrounding it as well as natural and man-made environments.

Natural corridors could include streams, rivers, and ridges, where man-made corridors could include servitude, canals, highways and railway connections. These corridors can greatly influence the migratory habits of certain wild life. It is known in America for man-made corridors to actually cut off natural migratory routes of, for instance, frogs, tortoises and other small mammals that are easily killed crossing a road or a railway line.

Obviously wild life creates more problems and conflicts than our vegetative component, because it is more adaptable to changing situations than the plant communities, and also because of mobility, more difficult to catch or to kill or to manage. Over-population and uncontrolled breeding are often the consequence of either a poor management system or gross interference with the natural selection process. Because of the abundance of waste in the city, of which a large quantity is usually organic, quite a number of rodents survive and flourish in the urban environment. This obviously could result in a health hazard and must be controlled.

Conflicts in values, priorities and perceptions are often also important aspects of wild life management in an urban environment because animals could become such an emotional issue - the environmentalists on the one side and the health inspectors on the other side could easily distort facts and figures. Because animals, birds and insects are more difficult and expensive to control, they are potentially more damaging to human health and welfare.

Instead of poisoning, the answer would most probably lie nearer to an approach of accommodation, accommodating their needs and their environmental requirements within the urban structure and eliminating or limiting the interference with these communities, and sustainable ecosystems. Linkages to the countryside surrounding the city as well as unspoilt pristine areas are also important in the making of sustainable urban wild life systems.

5.2.3 Wild life Education

The whole educational issue that is inseparable from maintaining and managing wild life systems cannot be stressed enough. The understanding of urban nature is paramount, but the support system needed for that is quite comprehensive, including reasons for sewerage treatment. There are ways of treating sewerage, the different stages of sewerage treatment, the detention of stormwater, the linking of open spaces etc. are all very important aspects to consider in planning and designing an urban wild life environment.

In our education in the city, we are often taught more about the countryside and a pristine environment than about the wild life that sustains in an urban environment. Just like the layering structure of forests provides distinct environments, supports different groups of species, so does the urban environment. The urban plant communities and the urban shelter and availability of food and water provide a living habitat to a wide range of animals.

The rodents, birds, insects and small mammals adapt quickly to the new environment. They have to look at environments that sustain around our cities, easily eutrophic or nutrient rich which attract a large number and variety of wild life species. Therefore wetlands, dams and river systems could easily be transformed into a productive ecosystem providing sustainable habitat for a great variety of usually birds and small mammals. Because of the great variety of habitats ranging from rooftops and parking lots, to lonely clumps of trees to river systems and unspoilt ridges and mountains, the interface or edge conditions between these environments are quite important when studying the urban wild life. These edge areas are usually more diverse than the habitats themselves, and they also provide the continuity between habitats, essential migratory routes and different wild life populations.

5.3 URBAN DESIGN PRINCIPLES

The emphasis on our environments is still that of controlling urban wild life in a very restrictive and health-orientated view. The way in which we could attempt to solve this problem is described in Hough, 1991, where he explains his priorities towards the environment:

- The issues related to environmental literacy and education are the most lacking, especially in the third world countries.

- The question of diversity and choice which remains paramount to health social environments are adhered to, and that rich and varied wild life environments should be promoted and managed in a sustainable way.

- A more utilitarian view of wild life and plants must be seen as indicators of the health of the urban environment and that because humans are part of that, it also has an impact on them.

- The capitalising on the habitat created by the city process provides unparalleled opportunity for enriching the city wild life.

- The design and management should integrate wild life objectives with the recreation and vegetation environmental education together with basic fundamental urban functions provide for great benefits at less cost to both the environment and the socio-economic aspects.

- The success of wild life to survive in any environment depends on the complexity of the wild life community, productivity or the procreation of the species and than also the quality of the habitat which relates to the other environment factors of vegetation, water balance and climate. Public use, of both intensity as well as the type, greatly impacts the pressures of urban eco-systems.

- The tendency world-wide seems to be towards areas with restricted access or areas with no public access are usually the best for development of wild life habitats. This includes reservoir sites, large industrial areas with a low coverage, marshlands which could be developed into bird sanctuaries and other larger sections of open space. The restricted access limits the potential for use for environmental education.

- The provision of a maximum variety of habitat including a range of plant associations and edge conditions improve the resilience of the habitat. Diverse vegetation structure, not only for cover in breeding, but also for food, is essential.

- The area should be large enough to sustain a decent amount of wild life to allow for productivity.

- It should also accommodate help from man, like nesting sites, bird feeders and artificial water sources - all with minimal disturbance of man or the food chain which supports the co-existence of wild life habitats.

5.4 CONCLUSION

Measured by these criteria, it is usually places like golf courses, natural ridges and river systems which could sustain noteworthy wild life habitats. Sewerage treatment plants are another land use that measures up to the criteria set above. Especially bird life and water related wild life could sustain in these large areas with restricted public access. Vegetation can always be used as a trigger activator to attract mostly smaller animals as well as bird life. The diversity of the vegetation structure and complexity allows for a wide range of bird life and small animals to not only find shelter but also feed from the area.

City parts devoted to wild habitats could also be developed as a portion or larger urban parks or as a park in itself. Special provision can then be made for human use and utilisation.

The management of these wild life habitats has as much to do with survival of the species as natural aspects of these sites. The management and maintenance of these areas should be directed to maximising the variety of land form types rather than the conventional mowed lawn with lone tree type of approach. Day to day upkeep is therefore not always necessary although a well thought through maintenance programme should be drawn up and followed.

These areas would not only benefit the diversity of the whole area but also impact on the social aspects of the community. Both educational and recreational activities could be beneficial to the development of wild life habitats. Other environmental issues such as stormwater detention ponds, artificial marshlands, which again add to the aesthetic beauty and the diversity of the area, could incorporate wild life habitats.

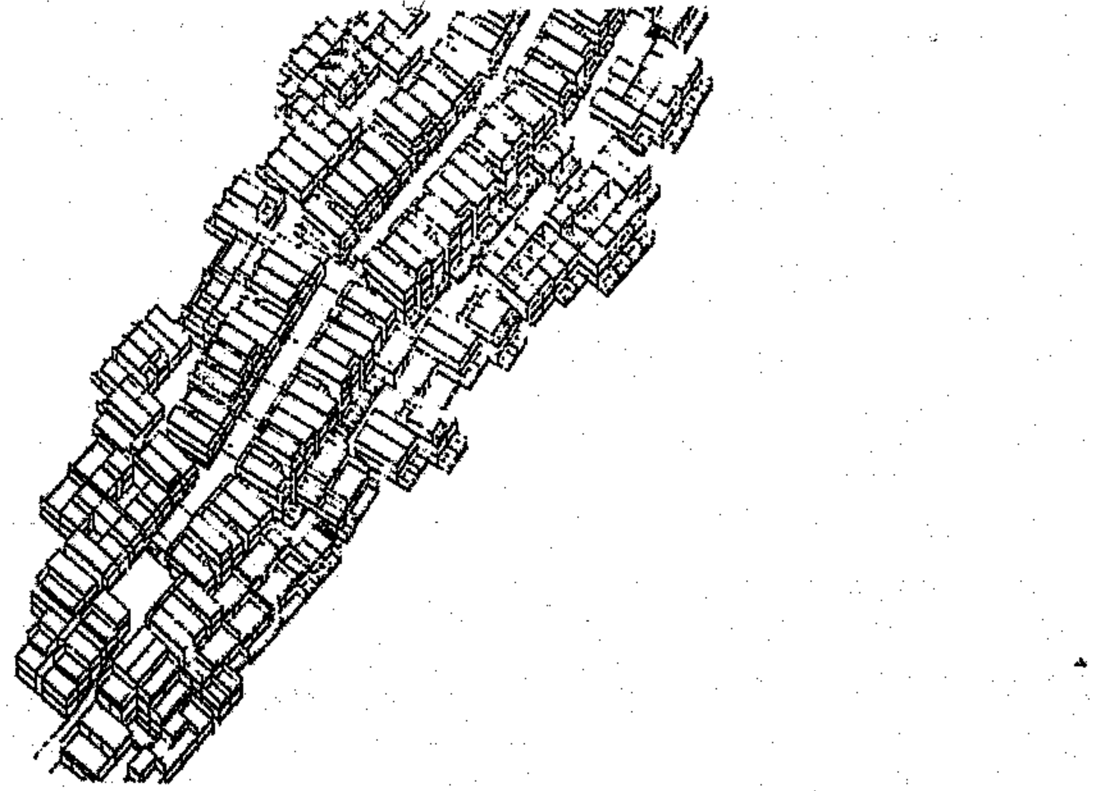


Fig 6.1 - "City of Feet" - promoting pedestrian movement by densification of settlement, reducing walking distance to commerce community facilities and recreation. (Gehl, 1987)

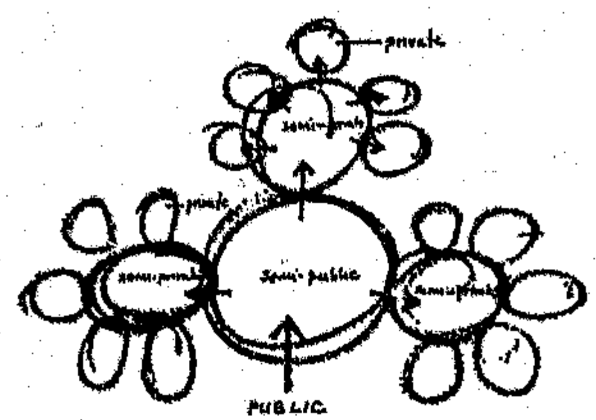


Fig 6.2 - Grading of social space from public to private as advocated by Newman, not only creates a range of interaction possibilities, but also safer environments and also improves the micro-climate of the built space. The notion of single dwellings on private stands resulted in the move to the private yard as opposed to the common square or street. This was amplified by the private car as opposed to the public tram; the entertainment of the television as opposed to the street. The shared courtyards and balconies are not only contributions to the social structure of a precinct, but also to the traditional ways of climate control in buildings.

6.0 SOCIO-ECONOMIC ASPECTS

6.1 THE SOCIAL ENVIRONMENT

More people in cities and suburbs alike are lonely at some stage. The importance of sharing common space - where all men are equal - is very important. Shared space of even modest dimensions, treated in a sensible way, enhances the potential for social contact, community development and safer environments.

Sustainability, as a productive ecosystem, also calls for a strong local social structure - a community with local power, knowledge and responsibility. This requires a hierarchy of space with the emphasis on the shared domains: the public spaces from squares to streets and common yards; from community centres and schools to neighbourhood stores and corner shops.

The modern emphasis on privacy and the tendency of exclusive space, both private and public optimize design principles researched and advocated by Newman (*Defencable Space*); Whyte (*The Social Life of Small Urban Spaces*), Gehl (*Life Between Buildings*) and Jacobs (*The Death and Life of Great American Cities*) - with special reference to their reasons for a social gradient to integrate the private and the public world and response to the environment and micro-climate.

The notion of private stand resulted in the move to the private yard as opposed to the common square or street. This was amplified by the private car as opposed to the public tram, bus or train. The entertainment of the television replaced that of the street and public domain. The shared courtyards and balconies are not only contributions to the social structure of a precinct, but also to the traditional ways of climate control in buildings.

The notion of sustainability contributes to the present environmental awareness by promoting the active interaction of resource utilization with ecosystem replenishment. Urban self-reliance is no individual affair - survival is a collective effort and must be managed as such. These efforts can only be productive if constructive action is applied productive and collective. In the words of Gehl (1987) "... to live content within small means,; to seek elegance rather than luxury and refinement rather than fashion, to be worthy, not respectable, and wealthy, not rich; to listen to stars and birds, to babies and sages with open heart; in a word, to let the spiritual unbidden and unconscious grow up through the common."

6.1.1 Private-Public Space

The grading of social space from the privacy of the household to the common ground of the street and the

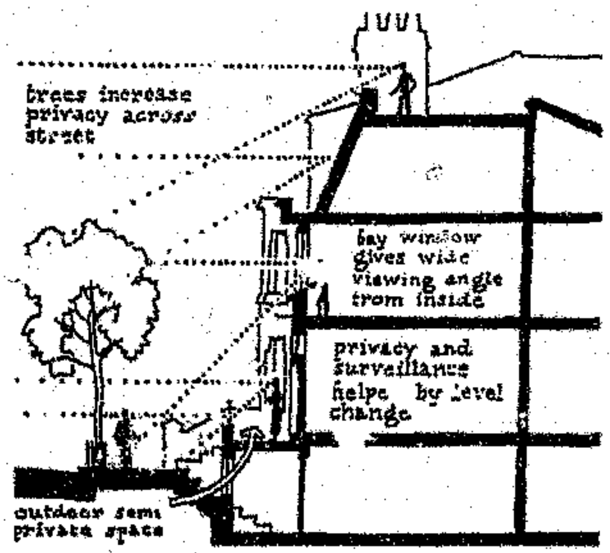


Fig 6.3 - Shared space - grading the public and private interface to alow for a range of activity options. (Bentley, 1986)

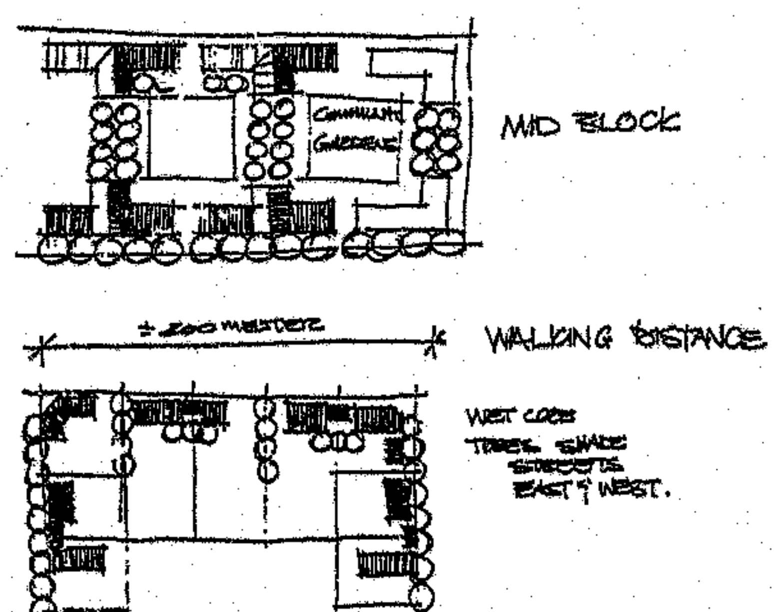


Fig 6.4 - The block is the basic building block of a community as these people are your neighbours, who are sharing the street and the m block. The block size could be determined by the distance one would walk to the corner store, the cafe or a bus stop.

square is paramount. These issues have thoroughly been researched by people like Newman, Jacobs and Gehl. The principles related to the grading of social space is so important and yet it is usually neglected by planners and designers alike. See Fig 6.1.

The zones of transition are the critical areas. So often have we seen common open space been developed right next to a private household. This only makes for conflicting actions and reactions and do not contribute to the sense of place. By placing zones of public-private and private-public between these areas would defuse the potential conflict of social spacial hierarchy. This also makes for a more diverse environment, rich with clues and cues as to the social domain and use of urban space. See Fig 6.2.

This is the reason why porches, small front gardens, steps, pavements and terraces are so important in structuring the social environment. "The planners had failed to realize that people socialized in their neighbourhoods at the front - on the stoops and on the side walks" (Clare Cooper-Marcus in Van der Ryn, 1991) See Fig 6.3.

6.1.2 The Block and Corner

The block, just as the street, also becomes an important catalyst for activating and optimising urban open space. "Mid-block mews" were incorporated, surrounded by family type housing. The children activated the mews zone by using it as their play area, thus making it an enjoyable space to experience, which in turn makes for better community surveillance of the softest component of the community. Parking areas could be consolidated to form small courts immediate adjacent to the mews which could act as activity nodes of playing and socializing. "Gateway" appearances were given to the entrances to these parking lots as clues to the public-private gradient. The hard landscaped areas were balanced with semi-private green space and private gardens. See Fig 6.4.

The sharing of space by small groups of people within the same block will establish a sense of community and belonging - these areas now become safer because it is used more often and surveyed by a number of people at any given time. Not only the centre of the block is shared, but also the front yards also act as a transition between public and private.

The corner should become the local store and information buro (as proposed in Jacobs, 1977) The corner as the potential activity node and intersection of movement should be strategically placed. A proposed method of fixing nodes are the placement of public facilities at these corners, allowing or even providing a retail facility or creating a memorable moment in space. These nodes should be spaced for it to be reached on foot - a corner shop. A few corner shops would support a general dealer etc. Economic threshold, as well as accessibility

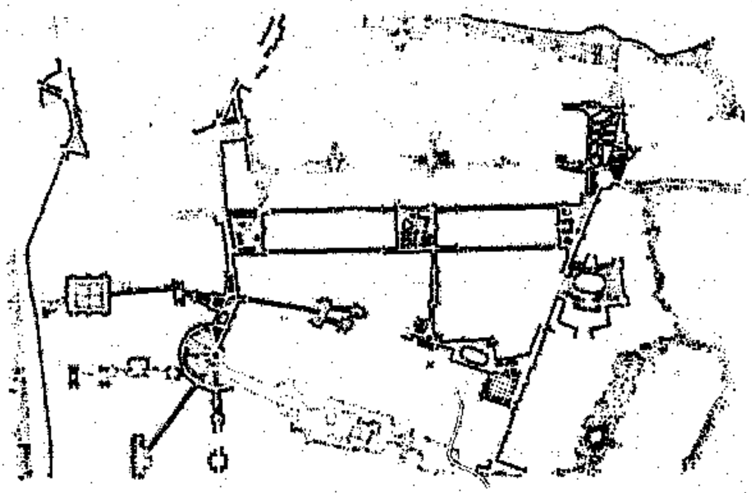


Fig 6.5 - Street corners are important places of energy activity, commerce and scales the blocks. (Dewar, Uytenbogaardt and Rozendal, 1991)

should determine the intersections and thus also the block size. See Fig 6.5.

6.1.3 Social Structure and Defensibility

Up to quite recently the design profession modeled all designs on so called nuclear families - the father, mother son and daughter. This type of family configuration is in a total state of flux - single parents, extended families and even two families sharing accommodation have become more and more common. This will not only influence the composition of our communities, but will also direct the living condition, housing options and level of integration of land uses.

"Little boxes on the hill side..." can not even be consider as a spacial means in developing sustainable communities. Community participation, extendability and self-reliance have become the criteria for establishing appropriate living conditions. Just as the soft space should establish a framework of functional landscapes, the hard spaces should accommodate a social structure of access, opportunity and security.

In the present unstable political climate security has become a serious consideration. The public domain has become unsafe for ourselves, let alone our children. Urban design guidelines would most probably not eliminate the problem, but could address some of the more fundamental issues associated with security and the surveillance of public space.

Parks, river systems and other "natural" open space is under threat of land invasions and already act as temporary living space for the urban poor. This is making these areas unsafe and thus unused by the general public. This would be addressed in allocating functional uses to these open spaces. The hard spaces will only become safe if it becomes part of the social domain of its occupants, if trade could sustain and a mix of land uses could be accommodated. Spacial order is as important as surveillance of and activity within the public space.

6.1.5 Politics and Authority

South Africa's loaded governmental departments, full of biased bureaucrats have for years neglected a large and important part of our society. In the light of political change to notion of getting power to the people has become a intensely debated subject lately. The concept of localising authority has been advocated since Jane Jacobs and it affects the frameworks urban designers must work towards.

Stronger residence associations, community co-op's and other means of local government is being investigated. The outcome of which will be important in dealing with local socio-economic problems, as well as environmental issues. The public remains the party who has to carry the full cost of our degrading environment and therefore local government must be structured in such a way to allow free and easy access to authority - an authority which should be accountable to its local area in the first instance.

The local authority must in turn also have direct access to regional government to be able to voice concerns of a larger scale. "... satisfactory living is having control: having power over changes in the environment as needs change over time." (Clare Cooper-Marcus, in Van der Ryn, 1991)

6.1.6 Nature in the City

Nature or naturalised areas are very important in the establishing of variety in the often bland urban environments. "Nature in towns provides a living source of health, beauty and mental richness" (Halmela, 1988). These areas are also important educational centres and existing play areas for the urban youth. The inherent variety, "wild" (undesigned) and adventure aspects of these places make them interesting and memorable. This notion has been recognised by designers in Holland and America.

In a study done by Clare Cooper-Marcus (in Van der Ryn, 1991) in Berkeley revealed the importance of these areas on the young child. Upon asking her students to write a environmental autobiography, most (80-90%) reflected on the most important environmental experience as being a natural-like place. Those that grew up in the city recalled a vacant lot, ally way or neglected place out of everyday sight.

6.2 THE WORK PLACE

The notion of sustainability not only addresses the job opportunities, but also the relative positioning of employment to housing, shopping and open space. The first goal in achieving an environmentally efficient

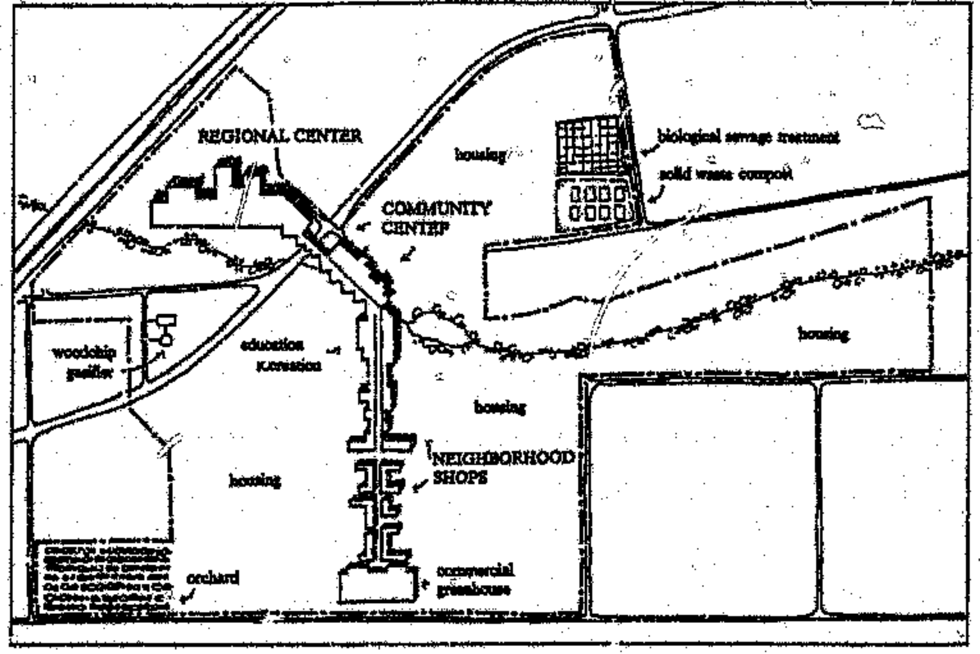


Fig 6.6 - In a move towards a more sustainable future city, we have to make out cities more compact, more integrated and diverse to improve the social structure, robustness, and work opportunity as was done in Golden, Colorado. (Van der Ryn & Calthorpe, 1991)

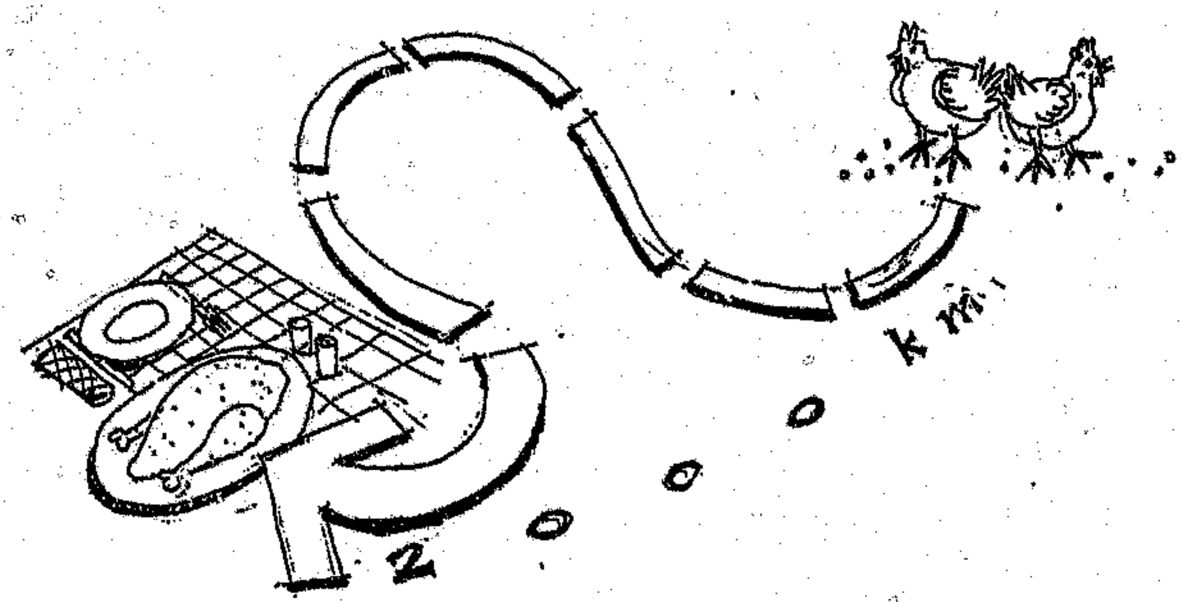


Fig 6.7 - A chicken, selling for R 7,50, was transported 2 000 kilometres from the farm where it was grown, to the table. (Hough, 1992)

settlement is to break from the "modern" idea of segregating urban activities - thus zoning laws must be abolished. Once the feeder, connector and freeway is eliminated between the home and the place of work and provision for employment again exists within the community, two important shifts will occur. See Fig 6.6

Firstly the consumption of petroleum energy (a non-renewable resource) for communicating via the internal combustion engine, would be reduced. This will significantly reduce the air pollution so readily accepted in urban settings, but also limit pollution to the environment because of the large quantities of petroleum which needs to be extracted, transported, refined and distributed. See Fig 6.7

The second shift would be that local businesses, industries and manufacturing plants would be run by local people. They would have to confront the environmental pollution of the industries as they would live close by, their children would walk through it to school. The reasonability of environmental acts and costs would therefore lie within the community in which they socialize. Thus the synergy of environmental, social and individual concerns would be reinforced.

In Schuylkill River Park old unused gravel barges were re-used as floating fish farms. This not only provided job opportunities, but also generated activity along a portion of the Schuylkill River which had fallen into disuse and had become derelict. The gravel barges were moored on the banks in a train configuration. Large translucent plastic cylinders were closely packed to form poly-covered commercial greenhouses or "bio-shelters". River water was pumped into the first barge for biological filtration through a bed of water hyacinths and bulrushes - acting as a concentrated reed bed - purifying and reintroducing oxygen into the polluted water. (In Hough, 1986)

In the next barge the semi-purified, warm water would provide the perfect habitat for catfish, grown for the commercial market. The last barge again would contain a aggressive plant ecosystem filtering the effluent produced in the preceding operations.

This practical, low cost, site specific solution not only provided job opportunities, food and a re-use of disused barges, but also addressed the problem of purifying the Schuylkill River as a additional spin off. The same scheme could be adapted to grow vegetable, cut flowers and nurseries. Being close to its market little additional fuel is required for distribution. The novel idea becomes the marketing slogan and the produce could feed poor, hungry people, as well as earn a lucrative living off a simple recourse.

6.3 RESOURCE ECONOMICS - THE USE OF ENERGY

Our production systems have only developed in one specific aspect: is "bigness" - economical agricultural units

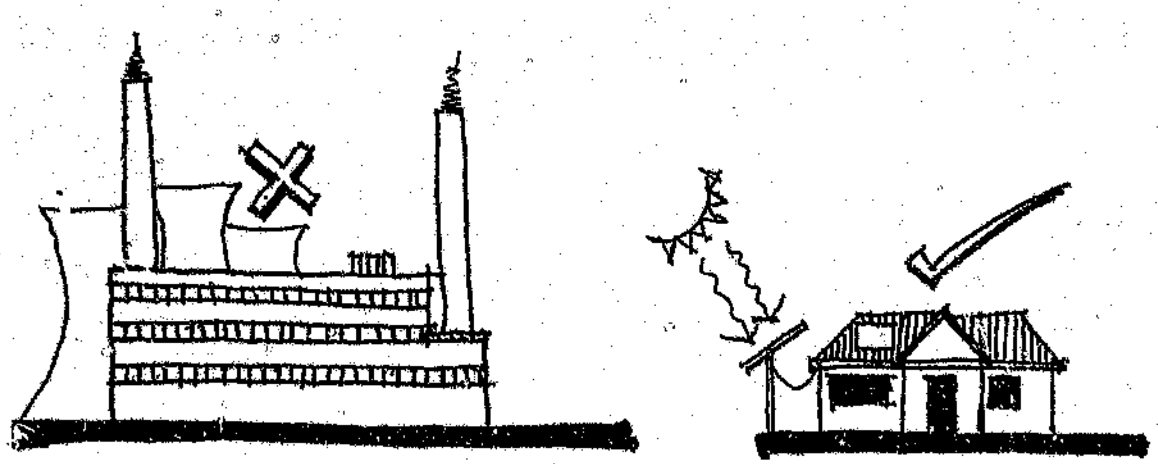


Fig 6.8 - Local solar or photovolt systems are much more cost effective than large coal burning electrical plants.

are bigger, factories are bigger and even the markets have grown bigger. We have fragmented society to the stage where you have to drive every where you go - to school, to the shops, to the hypermarket, to the office, the recreational facilities. Industries have moved out of communities. In 1910 their were a dozen or so breweries in South Africa and today there is only two - a total monopoly. (Kruger, 1993)

The persistence of the escalation of energy costs would significantly impact on this type of approach. The price of crude oil rose by 1500 percent from 1970 to 1980. (Van der Ryn, 1991) This is forcing society to rethink such basic issues as distance travelled to work, city scale, the relationship of the individual to the community and concept of separation as a basis for sound social and environmental planning. This was proved by the reduction in size of power plants in the USA. (After Hough, 1991)

At the beginning of the seventies these power plants were very large and would take about ten years to come on line. In order to make these plants feasible the difficult task was set to accurately plan and locate plants for a future need. The expected demand was predicted to rise by seven percent per year, doubling every ten years. After the oil crisis in 1976 the demand actually dropped and became a negative. By the late 1970's the demand increased again to a level of 1-2 percent per year. At that stage utilities were burdened by excessive energy of plants they do not require. These sudden fluctuations became an expensive financial burden. The immediate response was to move towards much smaller energy plants, which could be made operational sooner to easily adapt to consumer demands. This notion has now been formalized in regulations through the Public Utility Regulatory Policy Act, stripping electric utilities from their monopolies. (Van der Ryn, 1991) See Fig 6.8.

The higher prices created the opportunity of co-generation. Research had proved that for every 100 BTU's produced only 30 reached the user - 70 BTU's were lost as waste. This heat can be recovered, and the higher the price of energy goes the more economical the cost of the recovery would become. Previously this was ruled out as a option because of the very large plants which were sited away from the users - it would be too expensive to adapt and upgrade the equipment. This could even impact on the present ownership pattern. When energy generation becomes a community orientated project of that local scale, privatisation would become a feasible option. But at the moment the vested interest still remains with ESKOM, because of the centralisation of energy plants and the enormous running costs for these installations.

The cost of renewable energy generation had dropped as opposed to crude products. Where a 4,5 litres of alcohol fuel cost three rand and petrol 50 cents in 1978, petrol cost about four rand fifty cents and alcohol fuel about two rand in 1980. (converted from American statistics, Van der Ryn, 1991) The electricity generated from photovoltaic cells today cost 2 percent of what is cost in 1973. By adding co-generation to any one of the above we are, from an urban ecological point of view 'closing the loop' - the waste on the one system becomes the raw materials for an alternate system.

Fig 6.9 - World solar insolation clearly indicating the untapped resource of solar energy in South Africa as opposed to Europe - the world largest users of solar energy. Compare Johannesburg with an average of 6,0 solar hours per day to Stockholm with only 1,0 hours per day. And if taken into account that Sweden are one of the countries in the world which utilises solar power the most, one see to wasted potential in South africa. (After The Energy for Development Research Centre and the Solar Energy Society of South Africa) See Drawing Solar Insulation.

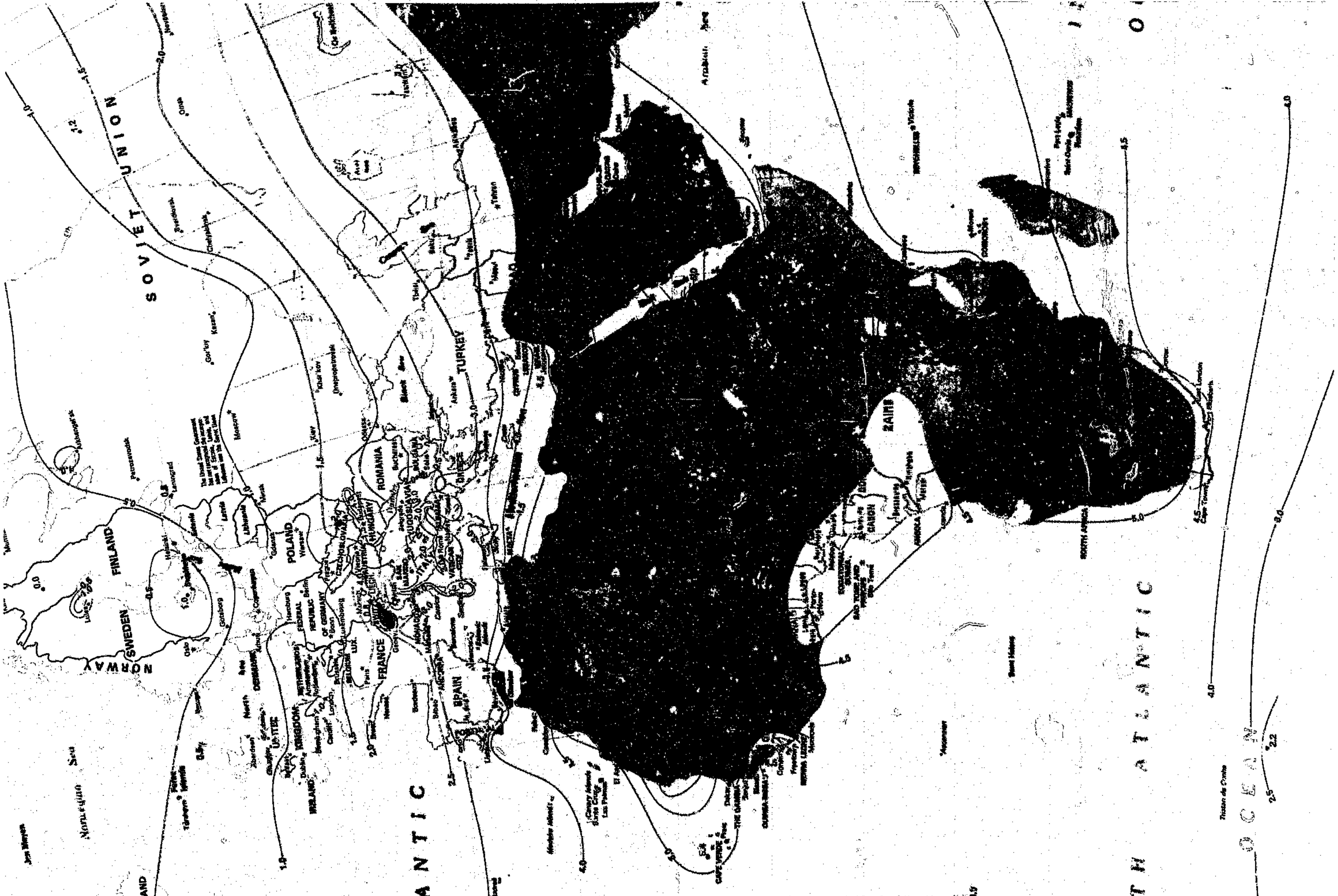
This concept is very important in designing sustainable environments. A city of 100 000 inhabitants generate more paper than a medium sized timber yard, more copper than a average copper mine, and more aluminum than a small commercial bauxite mine. This is a opportunity for a recycling industry adjacent to the city - not only creating job opportunities, but saving on natural resources, as well as energy. Recycling plants use up to 90% less energy, up to 50% less water and they pollute less. The capital outlay is smaller than the conventional mining operation and the area it requires is significantly smaller - making for denser cleaner cities.

The fact that oil, natural gas, coal and uranium are located in concentrated deposits around the world make co-generation even a better option. Even in South Africa the deposits are dispersed over large areas. This makes these resources unviable for small companies to develop - thus larger corporations and quasi-government institutions are the only owners of these generation plants.

On the other side of the spectrum sunlight, wind and water, which are also good sources of energy, could be tapped more easily, almost everywhere. Solar energy in particular is a source of diffused energy and energy generation from sunlight lends itself to decentralisation in location and ownership. Technology has also contributed to being able to generate more energy more effectively. In the fifties hydro-electric facilities could only compete with oil driven power plants when harnessing some of the largest rivers in the USA, producing energy for several hundred thousand houses. During the mid seventies smaller scale hydro-plants became possible producing energy for about 10 000 households. In the 1980's the technology for micro-hydro's became available. These compact and cost effective schemes could the geared to generated electricity for a handful homes, utilising small water sources. (statistics from *Sustainable Communities*, 1991)

Technology can also not harness these renewable energy sources to its fullest capacity. A photovoltaic cell can only operate at a 20% efficiency level (the rest is being reflected as heat), but at least the source is not wasted. Even with these efficiency levels they repay the initial capital outlay within ten years in northern climates. This would even be quicker in southern climates. South Africa is one of the countries with the greatest solar potential in the world. Most of the country can average a more than a five kilowatt-hour per square meter per day, as opposed to Europe who can only average one kilowatt-hour per square meter per day or less. See Drawing *Solar Insulation.*

The above mentioned issues clearly show why an awareness of our energy consumption impact on city, form and the framework which facilitates it. Some of these ideas originate from the book *Small is Beautiful*, by Ernst Schumacher. He was also the founder of the Intermediate Technology Development Group in England. This consulting group, working primarily with developing nations, develops compatible technology for these socio-economic environments. The ITDG thus invents and designs technologies better suited to the local resource patterns, the largely unskilled users and the severe capital restrictions.



SOLAR INSULATION

The approach of resource economics helps us focus on the change in the way in which we have to look at energy consumption and the economic returns which are possible. Keeping the long term maintenance and workability in mind helps to establish a local self reliance into the structure of the proposal. "It can mean the beginning of an era of symbiosis as well as synergy, when we become producers of wealth as well as consumers of goods, when we trade knowledge rather than raw materials, and when the concept of local self-reliance becomes the basis for reconstruction.." (Morris in Van der Ryn, 1991)

We must, within the urban ecological framework, return to the "Small is Beautiful" approach, the basic economy of bartering, sharing, exchanging. This has become the only alternative to the high costs of capital, fierce market competition and escalating price of all energy sources. This "informative economy" is the sustainable alternative to the "formative economy" of big corporations and large institutions. The future lies with local economies: consuming less first and forcing the mass economies to produce less, but of lasting quality. We do not have the resources to keep on throwing away, instead of just replacing the warn components. The informative economy therefore will not replace the formative economy, just include it in an evolutionary process of succession. This notion is supported by Papaneck in his book *Designing for the Real World.*

Our present economy is acting as if resources are unlimited. We must therefore alter our approach from rate of production to quality of production and efficient exploitation of resources. The carrying capacity of the environment must be adhered to secure a future on this planet. Just as ecology is the study of the relationship between organisms and the environment, economy must become a study of the relationship between productions, consumption and the resource exploitation (including its costs to society, the environment and the sustainability of a settlement). Cost benefit calculations are now replacing the old feasibility studies. Where the feasibility studies only focuses on the financial returns to the investor in relation to his capital outlay and risk, cost benefit analysis are also taking the social and environmental cost into consideration.

In 1960 the world population reached 3 billion. It was not co-incidental that, in the same year, a influential book was published called *Building a Sustainable Society.* In this book Lester Brown called for a serious re-look at the way in which we exploit our resources. For the first time the population growth was to exceed the yields from the three basic biological systems, being forests, seas and grasslands. (After Calthorpe in Van der Ryn, 1991)

Local economies, which partly rely on their own energy will be more aware of wastage that is presently the case. If energy efficient transport, buildings and production processes are implemented it would significantly reduce present energy consumption figures. And because energy is produced locally the true cost of the generating process would be for the account of the same local community. It is the inherent social ecology of the informative economy which makes this the "high road". (after Huntley *et al*, 1989)

With our micro-chip technology a trip to a centralized work station or the supermarket is becoming more and more unnecessary. This would add to the saving in fuel consumption. "This is how information is replacing mass - by revolutionizing the design, creation and function of goods and services" (Peter Calthorpe, 1991).

The informative economy, being driven by a social and environmental ethic, draws from our high level of information technology, and replaces the modern notion of the machine and exploitation of our resources - all driven by huge energy bills and the ultimate destruction of our planet.

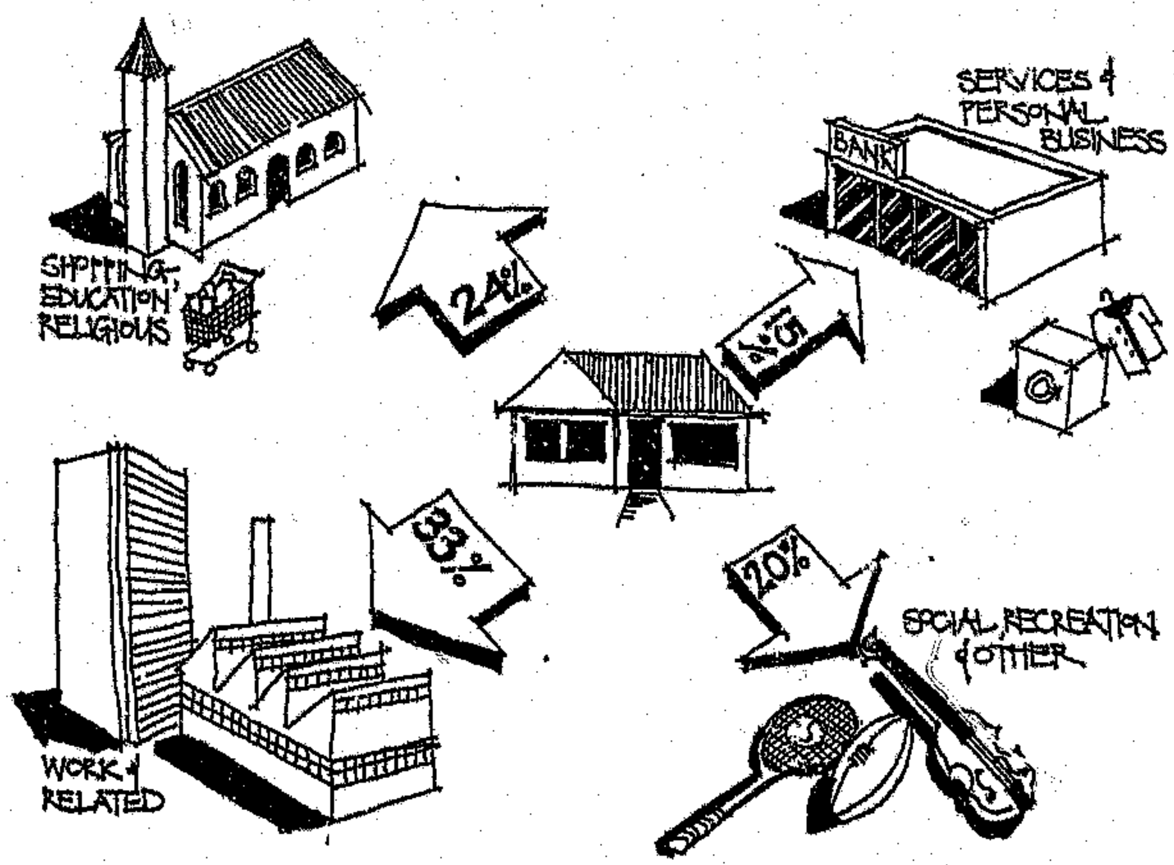


Fig 7.1 - The percentages of mostly travelled destinations should be used to position the most needed activities and land-uses the closest to the consumers. These statistics were confirmed by several other similar surveys on different socio-economic conditions, in different cities, had shown that the time spent on travelling to the above mentioned destinations are remarkably the same. Trip distances, on the contrary are not: the younger the city or neighbourhood is the longer the distances, more rural districts also show longer distances travelled because of obvious reasons. This would reduce travelling time, save on petrol and reduce pollution. (After Reid in Van der Ryn, 1991)

7.0 URBAN FORM

7.1 MOVEMENT SYSTEMS

7.1.1 Introduction

With the invention of the wheel by the Egyptians, transportation became an influencing factor on urban form. The vehicle, supported by those wheels became the measure to our public movement channels - our roads, streets and our squares. The wheel has brought with it a whole technological development, which made life in general easier, made urbanisation a feasible option, but generated a new set of problems and constraints.

As transport was made easier by technological and mechanical achievements, more and more private individuals were able to own or use these vehicles. With the invention of the steam engine and then internal combustion engine the serious pollution problem of all these vehicles became apparent.

7.1.2 Efficient Transportation

Efforts succeeded in developing more fuel efficient vehicles, smaller vehicles and even alternative power sources, but the sear number already placed enormous pressures on the urban environments, as was discussed under *3.4 Air Quality*. The opportunities of the extensive transport planning of the 70's was not capitalised on. The economic well-being of South Africa allowed large sums of money being spent on the upgrading and developing of our transport system. Sadly most of the funds were allocated for highways and the improvement of private transport via the motor car.

If some of those efforts were directed towards the development of more fuel efficient public transport options, all urban areas in South Africa would now have been in better positions. Private transport had become a necessity - it was relatively cheap, extremely flexible and convenient. People could live further and further away from work, shopping, leisure and other activities and therefore more and more people needed transportation. See Fig 7.1

These individual trip distances make for exceptionally high use of fossil fuels - a non-renewable resource, as well as a power resource which has serious pollution risks associated with the extraction, refining, transporting and use of it. Public transport systems usually does not work in our modern cities because of the influence of the private motor vehicle. It allowed us, the general public, to live further and further from our places of work, education, recreation etc. During the 1800's cities had a closely knit urban pattern, because people had to walk to most places or had to use public transport systems. Thus development densified around public transport lines and stations.

The development of "cleaner" powered city vehicles are better and more workable solutions for the private motor vehicles. With the present day technology and the abundance of solar energy in South Africa electrical vehicles could become a practical alternative for city commuting. But if coal burning remains the main source of electrical power - the cost to the larger community will remain as bad as that of the petrol powered options.

All urban problems will definitely not be solved by technology - the social component must not be forgotten. Although predictions were made that advances in the telecommunication field would result in a possible 15-20% decrease in urban travel, it actually increased. (Reid, in Van der Ryn, 1991) Community scale clustering should be the approach to infill, densification and improvement of public movement routes and systems. To ensure the important social component of travel, movement and general city activity are not lost in the restructuring of the transit systems, communities should be approached and incorporated as part of the restructuring.

7.1.3 Urban Design Guidelines

As is the case with all the other components which build our urban environment, the potential impact of transportation on cities are eminent, viewing it holistically. The importance of guidelines directing transportation options in a more sustainable community becomes imperative, if one considers the immense environmental affects of our present transit systems. The other very important lesson for urban designers in understanding the transportation short falls is the fact that transport will not be improved by technology alone.

- In a more resource orientated city the access of private motor vehicles must be re-looked and limited to where it serves well.

- Densify neighbourhoods as well as activity zones, with in walking distance from each other or a public transportation system.

- Limit the capital investment in road systems which are basically only developed for the private motor vehicle. Rather redirect these funds for the implementation of more effective public transit systems.

- Use existing public transport systems as the structure for redevelopment and densification, both the living and the activity components should be looked at.

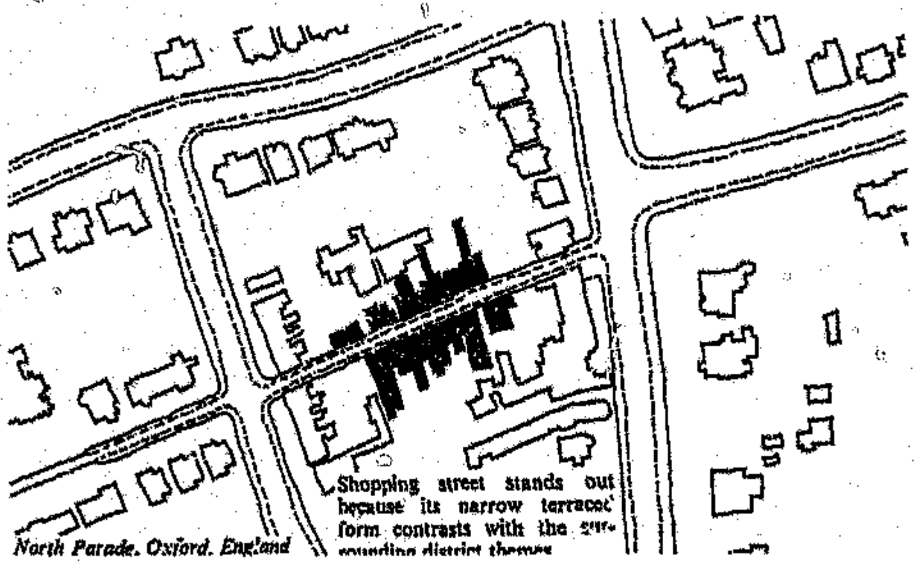


Fig 7.2 - Wide streets with unnecessary building setbacks deforce the public life from the private domain. Narrow streets with a grade of social spaces add to the energy and activity of such streets. (Bentley, 1986)

- Re-align roads to accommodate dedicated bus lanes as a workable intermediate measure to improve and prioritise public transit.
- Restrict the free access of the private car - be it through taxation, restricted access zones or public transport incentives.
- Sustainable transport patterns are closely related to sustainable land use patterns. High density, mixed use and vertical zoning principles should be promoted as part of a comprehensive strategy.
- The public environment must be structured to promote pedestrian movement, rather than vehicular. This refers to the social and environmental strategies which will be discussed later.
- Approach restructuring of cities from a community scale, by using small social identifiable groups as "building blocks".

7.2 THE STREET AS CONNECTION

The planning criteria for suburbia was born in a decade of world wide prosperity. These settlement forms were usually over engineered and over planned. The three-dimensional form was not the concern, neither was the social dimension of communities and neighbourhoods. These intangible aspects were not considered to be affected by the frame work captured in the planning solution. Berkeley, California, introduced traffic calming measures to eliminate high speed through traffic in neighbourhoods. Traffic barriers were placed at certain intersections. By doing this a street hierarchy was established, not by street size, but traffic volume. This created a street structure more suited to neighbourhood needs. The restricted movement of motor cars promoted pedestrian traffic as well as cycling.

Streets were too wide, left over space became "open space" - only the developable space was considered part of the community. Wide streets would usually bisect neighbourhoods, to meet up with an arterial. Narrow streets however provide scale, intimacy and thus promote public life. Public and private spaces are more integrated and provide a richness and defensibility. See Fig 7.2.

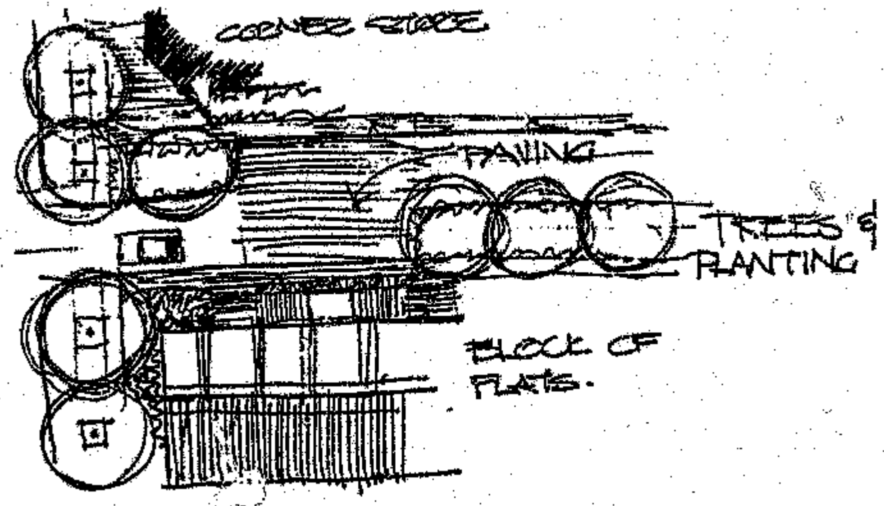


Fig 7.3 - The 'Woonerf' idea refers to a new type of street - one where the pedestrian dictates, usually paved, with no definition of where pedestrians or motor vehicles should move. Landscape elements are usually also incorporated to promote the use of these streets.

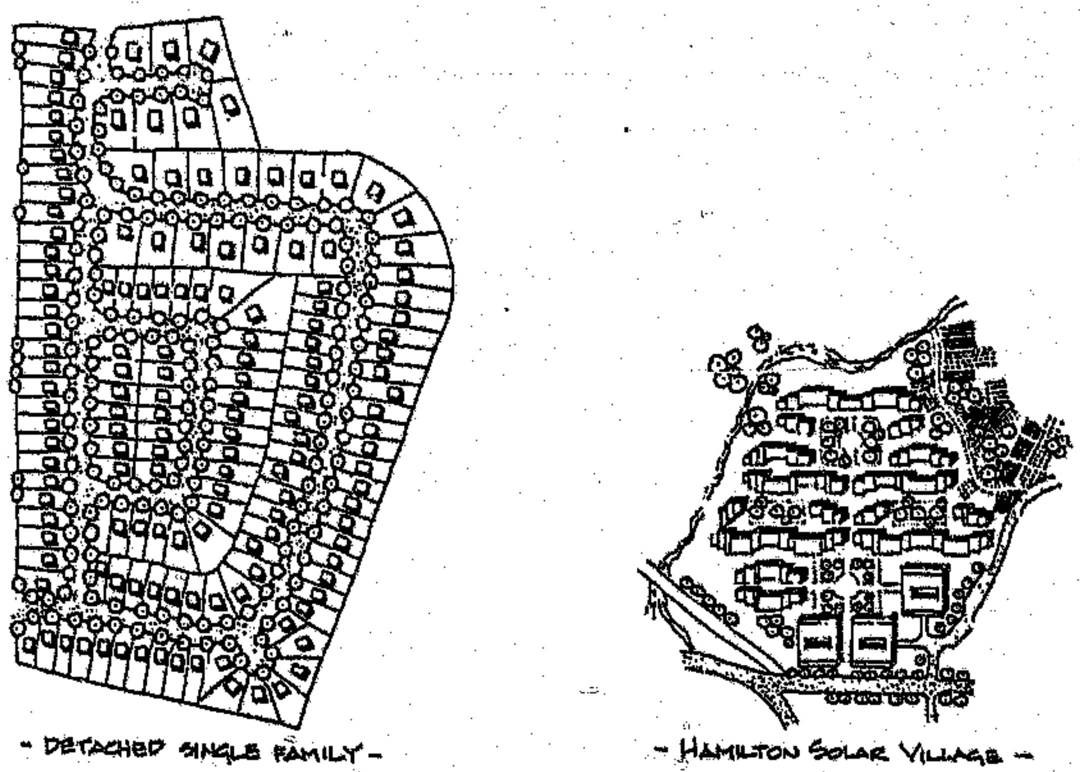


Fig 7.4 - The re-invention of the community as opposed to the sprawl of the residential neighbourhood.

The street has been referred to as the "glue" of the city (Jacobs, 1977). The aim of creating a sustainable community is, among other things to create a more coherent neighbourhood, which produces food, stimulates communal social life and responds to the specific site. The responsibility of assuring the implementation of a sociable street space is spread over several design and planning professions - but the principle structure ought to be guided by the urban designer within a spacial framework, prior to the detail design of the neighbourhood.

The "woonerf" concept was made famous be the Dutch planners who developed the street as a social space. The rigid demarkation of road, pavement and parking bay had been eliminated. This created the opportunity for more informal interaction between vehicles and pedestrians. Roads are usually winding, narrow and paved, not tarred. All curbs are eliminated and landscape elements, such as trees, planters, bollards and human scale lighting posts are introduced. See Fig 7.3.

A holistic planning and design approach is required. The street space is born from the layout principles of narrow street servitude, no small building lines servitutes on the portion fronting onto the street and the block layout pattern. This space is then defined by the building setback, the tree planting scheme and the treatment of the pavement and eventually filled with the community culture of public life.

7.3 THE RESIDENTIAL SUBURB

In the prosperous years of the sixties and seventies, the highway building programme and suburbia seemed to be the feasible option. The improvement of the national road network made it more feasible to farm further and further away from the market places on bigger and bigger farms with extensive irrigation systems and a large degree of mechanization. Thus the loss of vast tracks of agricultural land was not seen to be a loss to residential suburbs.

Decentralization, partly driven by our apartheid system, was also experienced in America. Office parks, large shopping malls and industrial growth centres were developed as an alternative to dense urban living conditions. Urban sprawl had adopted a "mega" approach. The planning ideals for modern urban settlement have reached: "healthy, secure, convenient and pleasing places for young families to fulfil their aspirations for the good life." (Van der Ryn, 1991) See Fig 7.4.

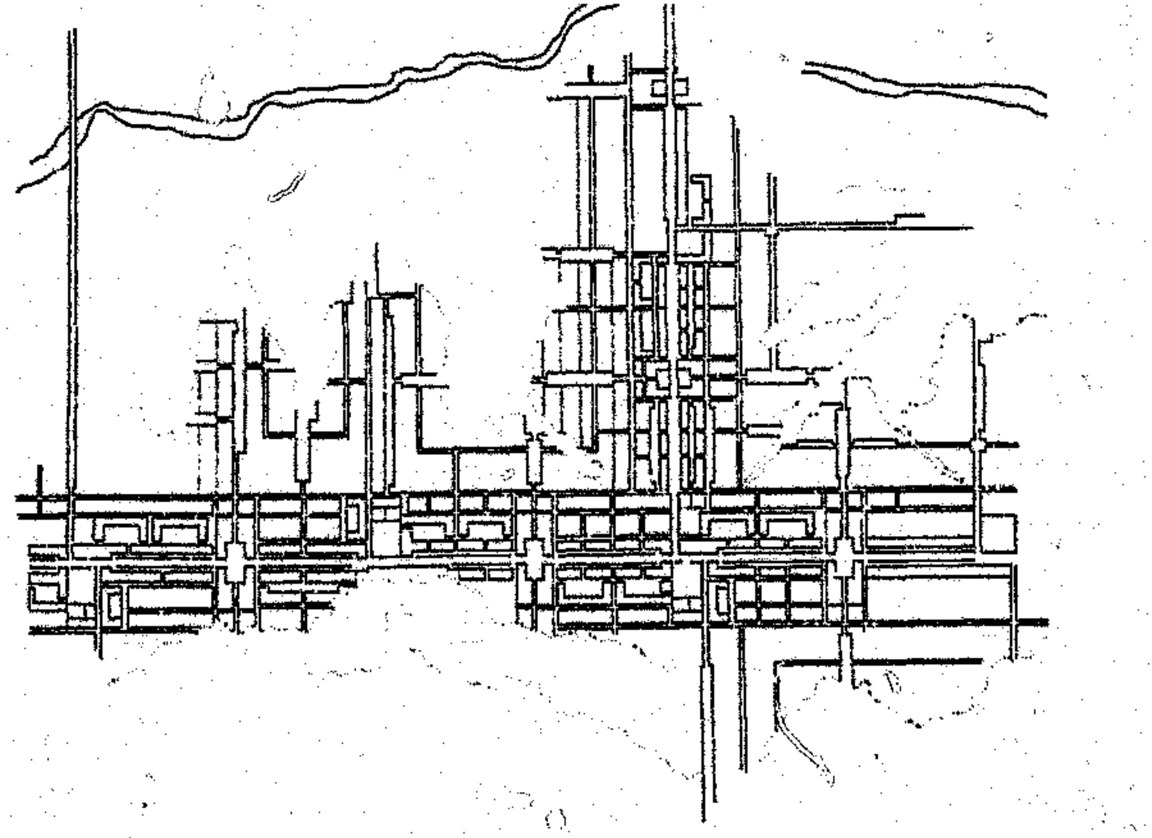


Fig 7.5 - The grid pattern's greatest advantage is the fact that it creates order, views, images, corners and if a hierarchy is given to the different streets energy would attach itself to nodes, spaces and places. The Mariahill Structure plan is a case in point. (Dewar, Uytenbogaardt & Rozendal, 1991)

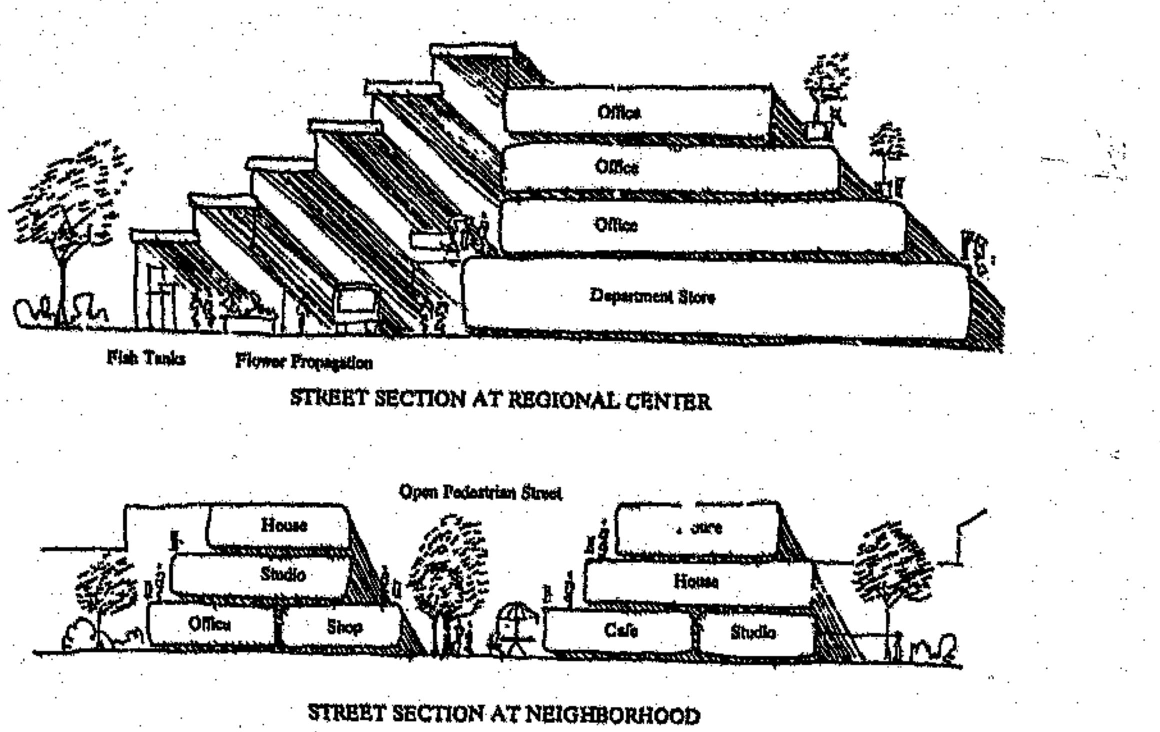


Fig 7.6 - The Strip must become multi-functional, incorporating living, work and commerce into an integrated environment. The idea of a "Bio-shelter" is proposed in Sustainable Communities, 1991.

World wide this lifestyle was restricted to the white middle and upper income groups. In South Africa the rest of society had no choice - 51/9 housing was the solution for poorer communities and the domentory towns - "little boxes, on the hill side, little boxes ...." The issue of urban sprawl and the creation of the suburb as a settlement form, optimized the misfit of urban living and the squandering of costly resources. (The word "costly" is deliberate as we so often refer to the "price" of a resource or a service. The price usually only refers to the immediate financial implication, where as "cost" refers to the total actual benefit of (usually) detriment of such an item)

The archetypal suburbs is quite easy to summarize - The freeway, the off-ramp leading into a major arterial and commercial strip with the decentralized shopping mall at the first or second robot. And the pattern like residential blocks radiating to the horizon. Every building is set back from the street by the tarmac of a parking lot and the feeder roads are always packed with other vehicles. Every house has a driveway leading up to a double garage of some sort. The grid pattern could also generate a different urban mechanism. See Fig 7.5.

The gridiron pattern in urban design remains a paradox: on the one hand it symbolizes the insensitive history of city planning by surveyors and the mechanizing of urban sprawl. On the other hand though it has enabled a rich imageability and legibility for the user, reinforcing the street and square as the common, as well as enabling vertical zoning and mixed use, relying on these mixes and that of the building types and ages to create memorable urban forms. Variation therefore is a product of the land use patterns, the street life and the neighbourhood. See Fig 7.6.

The grid pattern does easily incorporate a grading of space form a private atrium, to the front door, the porch, the front gate, the pavement, the street and ultimately the square. The streets and crossings, the fundamental elements of the grid layout becomes the glue of the urban fabric of the individual elements in a single block. But the grid has also proved its weak points.

In re-developing a grid or to pro-actively plug into the gridiron pattern the importance of conservation of diversity has been proved over and over again, as in the case of the redevelopment of the Sacramento River by Governor Jerry Brown. In urban ecology conservation means more than protecting old buildings, but also preserving the older qualities of the city - the mixed use, corner stores, general dealers and light industrial, all vertically zoned to accommodate the owner's home above his shop or trade. (After Calthorpe, in Van der Ryn, 1991)

This resulted in the 24-hour community, of public surveillance and of community spirit. The very human scale of building elements are retained and activity of old city streets are kept in tact. Infil of buildings contribute to the above by being sensitive to the existing city scale and architecture, by proposing vertical and mixed zoning practices and by designing more energy efficient building types.

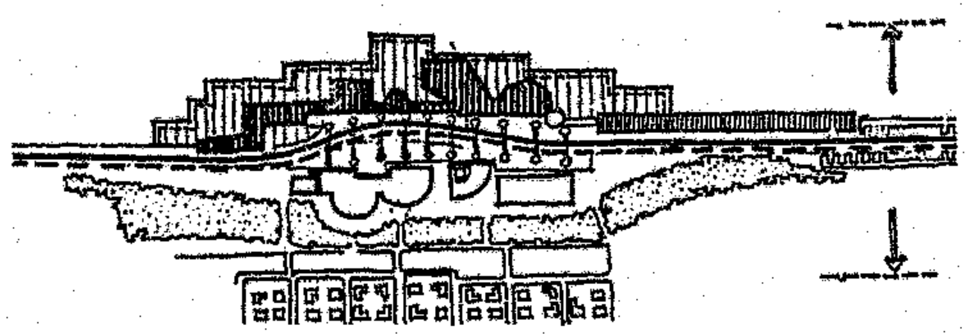


Fig 7.7 - The "Life Belt" concept as proposed by Sustainable Communities - the shopping centre becomes the "CBD" of a community. (Van der Ryn & Calthorpe, 1991)

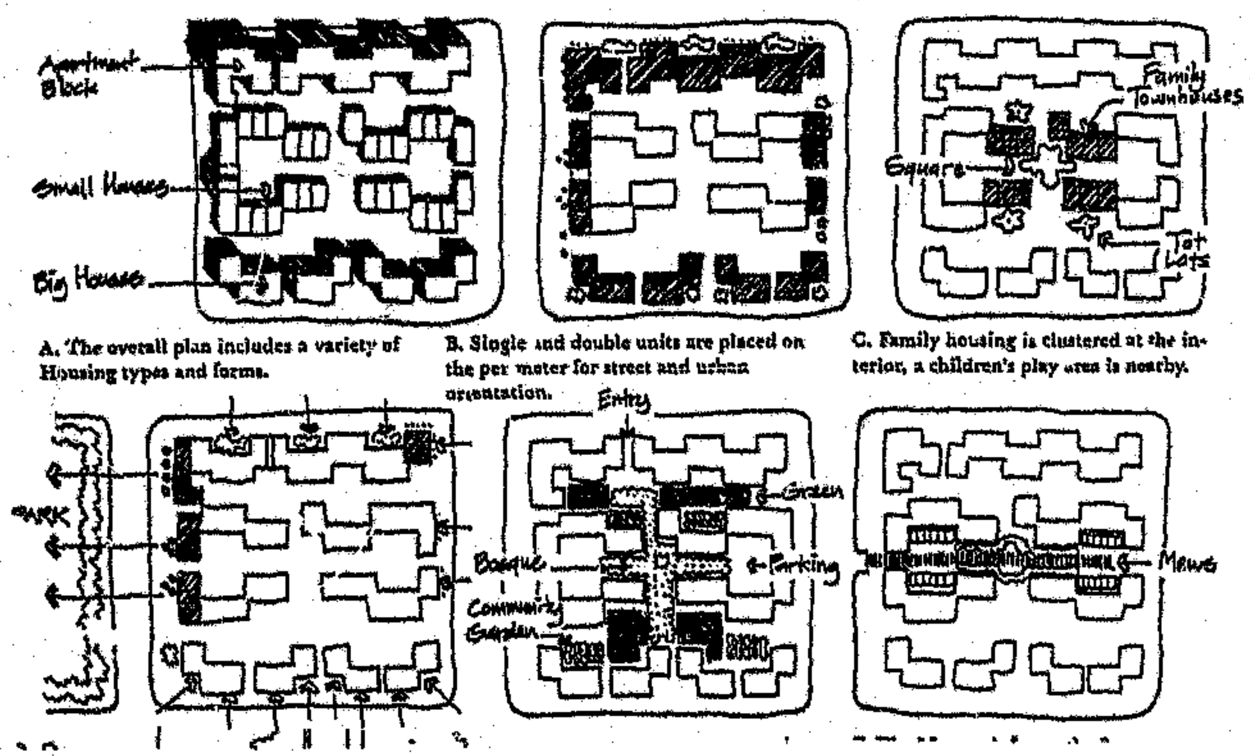


Fig 7.8 - The residential block as a component of an environmental framework. The "Mid-block Mews" associated with a mix of housing types makes for a more sustainable community. This example of a Sacremento scheme in Sustainable Communities, 1991.

This could be achieved by a medium rise height restriction, regulations specifying buildings which incorporate passive solar and climate responsive design principles and allowing so called vertical zoning practices. This type of settlement could accommodate a range of housing options, for the whole socio-economic spectrum allowing for a more balanced community (as is still found in older neighbourhoods). The high densities, availability of existing infrastructure and the possibility of cross subsidization resulted in quite affordable housing being developed.

Therefore the trend towards a more environmentally sensitive type of housing is becoming more important. The escalating cost of new housing (and the high bond repayments which go with it) forces people to start looking at housing with lower maintenance and running costs. The move should be towards cheaper houses - smaller and more flexible with a greater emphasis on shared space and facilities, grouped in denser development types which still allow open space and natural systems to function, is the only way in which we will be able to significantly address the housing backlog in South Africa. The most important move is towards a urban form of a human scale providing spaces for people to live.

7.4 THE SHOPPING STRIP

The existence of the strip is devoted to the private motor car. Vehicular access is of paramount importance, with adequate parking space and large bill board-like signage. Bright lights and colourful window displays draw the attention of the driver. But within a sustainable society this becomes to expensive and spread out.

An alternative would be to increase the density of the residential component surrounding the commercial strip development, also allowing residential units on top of shops, businesses and offices. This would allow a greater pedestrian access to the strip. The strip would gradually be restructured through market forces into a dense linear, mixed-use zone which could incorporate light industry, commercial, office, business, retail, as well as community facilities, upper level housing. See Fig 7.8.

Vehicular access would be reduced, improving the pollution associated with the internal combustion engine. The scale of streets and parking space would improve to accommodate social activity, landscape elements and informal trade. The possible introduction of a light rail system could be considered, depending on its feasibility. The emphasis must be on more efficient transportation to enable a saving in total energy consumption.

As the emphasis shifts from a primary private motor vehicle access to a more mixed transport option, sprawl should become confined to the movement parameters of a local scale. Distinct nodes will become denser and a stronger hierarchy of function patterns would emerge from the local fabric - in scale and within the means of the local community. Ideally it would become a horizontal, linear city.

This would free space for functional and productive landscapes in the form of urban agriculture, allotments and stormwater detention ponds, as discussed previously. The high concentration of people would visit, use and ultimately benefit from the spin-off's and pay-offs of this intensified and integrated settlement.

7.5 HOUSING WITHIN AN ENVIRONMENTAL FRAMEWORK

The design standard for modern planning was the nuclear family. Today with the increase of single parent families, extended families etc. this can no longer be accepted as the norm. The higher costs of livin building costs soaring and the ever increasing cost of energy have altered the course of housing provision. Home businesses and industries are becoming an employment alternative. More and more married women are joining the formal employment sector, which result in smaller families (who started their families later than before. These factors are changing the spacial and social needs of the community in which they live.

The building of so called Granny cottages, converting of garages and outer buildings into rentable space is also slowly emerging as a reaction to higher costs of living. This creates the opportunity for low density neighbourhood to increase their population density, incorporating a larger spectrum of socio-economic group into the area and retains a balanced age distribution within the community.

Increasing density within the block not only permits a more balanced community, but also contribute to the saving of energy and resources. Energy is used more productively, less fuel is wasted to travel far out to new neighbourhoods and space is utilized more efficiently. The principle of improved energy use because of reduced energy loss applies. The most important spin off from higher residential densities will be the reinstating of the corner store, the local general dealer and a range of small businesses operating on a local scale. These smaller retail pockets could easily be developed and sustained by the local residents which do not require large capital investment or consolidation of land. Further more it would "fit" the social scale, local conditions and needs.

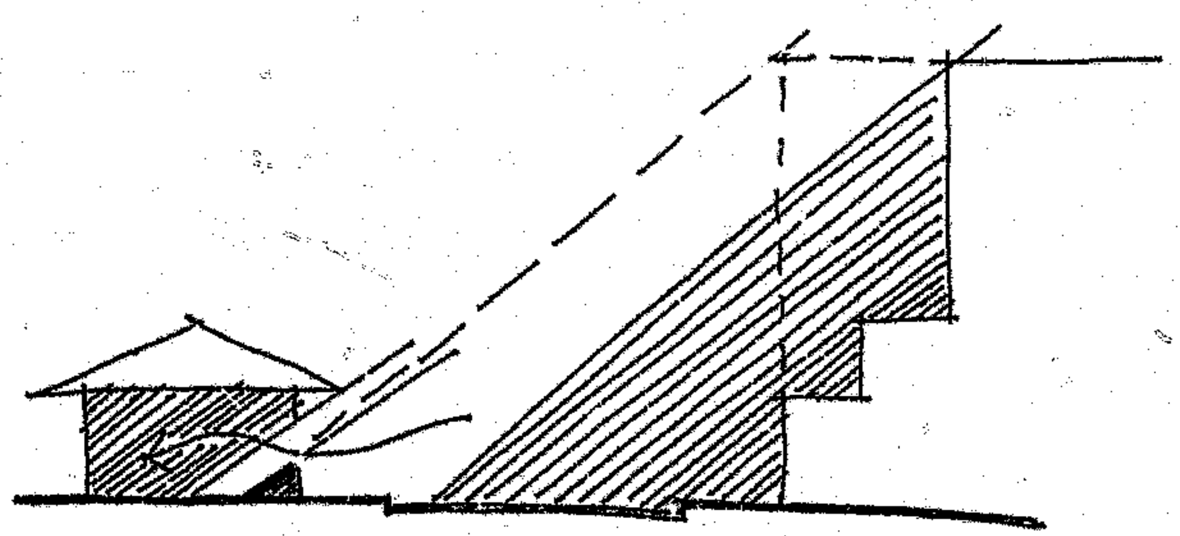


Fig 7.9 - The fundamental criteria for an environmentally sound house, school, building is ventilation on both sides, solar access and air of an acceptable quality. Scale is also important and therefore step backs from the street canyon is preferable.

Gentrification is another more common phenomenon - although a less positive one. Older areas closer to the city centre, which are usually populated by a older and poorer section of society, are being "invaded" by younger, more affluent groups, who are willing to move into older buildings, having realized the opportunity of living closer to the CBD. The relatively old houses with its special charm are usually restored or completely rebuilt. The relatively low land values require smaller capital outlays with reasonable returns than new developments on the outskirts. The sad part of this process is the older, poorer people who are now forced to move to the outskirts, far from public transport and the public amenities they so desperately need.

These people could now be accommodated in a largely self sustaining community, where most of their needs would be met within walking distance from their residences. The range of residential options, some partly subsidized by the presence of businesses would make this an affordable option for old and young alike. As the social community establishes itself the younger would care for the older,as well as share in their wealth of knowledge.

Densities of up to 97 units per hectare were achieved in this redevelopment project. (as in Solar Village in *Sustainable Communities*, 1991) Building heights were graded to human scaled structures on street fronts, reducing the scale of larger building behind. This stepping down of building heights allow for better solar penetration into streets and buildings. See Fig 7.9.

The mixing of housing with business, retail and manufacturing (incorporating urban agriculture in allotment gardens) make not only for a more integrated community, but for a more efficient one. Residents working within the limits of the neighbourhood was within walking distance of both shops and work. In addition to this they have access to allotment gardens which could provide in their daily fresh produce needs.

Vegetation and specific construction techniques turned passive solar energy into and active source method of climate control and heating. A well thought through tree planting scheme did not only make for an aesthetic pleasing environment, but also had thermal spin-offs - regulating sun access during summer and winter - and creating scaled outdoor space for interaction and human activity.

A mix of transport options were also proposed for user convenience. This not only promoted more human activity on the streets, but enabled retail and restaurants to be sited at nodes of transport transition. For example restaurants and shops were specifically placed at the light rail station the promote street activity by activating the existing pedestrian movement to and from the station.

The main challenge of low income housing is not to provide cheap shelters or services, but the establishment of maintainable environments, expandable shelters and cheap infrastructure. The cost of running and maintaining these investments by the local community has proved to be a specific problem in South Africa. The

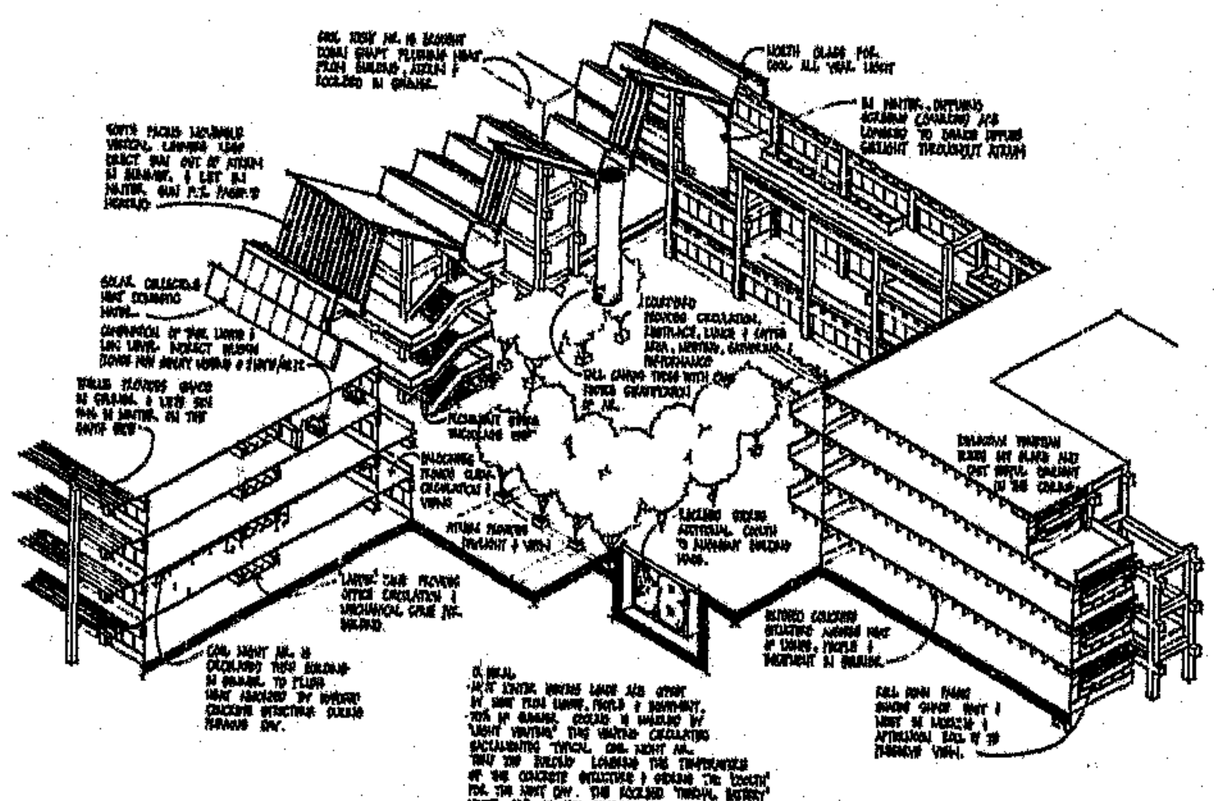


Fig 7.10 - Green Architecture does not only include state of the art technology or equipment - the building need only comply to basic environmental criteria to already improve the effectiveness of the building to relate to its environment. (Calthorpe, 1991)

guiding principles for the planning and design of these affordable settlements should be environmentally driven. Passive solar climate control, photocell energy generators and social responsibility should be the issues which need to be addressed. The need for community participation, job generation and urban agriculture is of paramount importance for these settlements' long term survival.

7.6 GREEN ARCHITECTURE

7.6.1 Introduction

The framework goes further than just addressing the planning and design of the public space - the design principles of the buildings are also addressed. The urban ecological approach calls for energy efficient building types. In view of the fact that a family spends up to 40% of their living expenditure on heating and cooling is proof that energy consumption must be addressed in sustainable urban settlements. All buildings should be seen as productive bio-shelters as opposed to only a shelter - not only consuming material and energy, but also productive technology must be incorporated.

In so called Green Architecture issues such as local micro climate, solar access, natural ventilation and insulation are incorporated in the objectives of design. Natural sunlight would take president over artificial lighting. South Africa with its long and reliable sun filled days has an ideal climate for this approach. South Africa is one of the countries most suited for solar power utilisation. Fig 6.10. Not only do we have long sunny summers, but our winters are relatively mild. Well designed solar access, insulation and passive solar technology could radically reduce the consumption of expensive energy. Expensive in terms of cost not in terms of the price the South African consumers pay. Our household energy is largely derived from burning fossil fuels, close to the mining sources. This process not only produces atmospheric pollution, but also requires large quantities of water (a resource which is not abundant in our country) and very inefficient in terms of resource utilization.

It is therefore an ecological response to climate which steers the urban designer towards solar energy optimization in the designing of South African settlements. This approach will address present problems of "sick building syndrome" experienced in modern building where the local climate was not considered, nor the requirements of the user or the cost of long term maintenance of the settlement.

Urban ecology stresses the importance of synergy between social, technological and environmental concerns. The courtyard, acting as a thermal buffer, as well as allowing light and natural ventilation, also becomes a very social space. The light and warmth of the space contributes to the identity and generosity of an atrium as opposed to a dark elevator lobby or entrance foyer.

7.6.2 Pro-environmental Approach

This approach is environmentally friendly in several aspects. It not only reduces the consumption of energy, usually derived from fossil fuels in South Africa, but utilizes existing unexploited sources of energy. The cost of the technology might not always be less expensive, but the running costs is radically reduced.

Building technology has reached the stage of being able to sufficiently deal with a broad range of solar options. Solar technology can now be installed for specific purposes - pumping water for domestic supply, pre-heating water, swimming pools etc. As our technology of batteries and storage of energy improves more solar energy can be stored and greater voltage would be possible.

Old design concerns are now being reinstated such as northern orientation, local wind patterns, solar envelopes (building massing that do not shade adjacent buildings) and the thermal qualities of material (fired clay brick structures for instance proved to be cooler in summer and warmer in winter than cement brick structures). World wide experience has proven that good solar access is possible with building densities of 95 dwellings per hectare (after Van der Ryn, 1991). The traditional orientation of the grid layout to be north south again is proved to be environmentally friendly.

Urban ecology, as was stated earlier, also includes the principles guiding the architecture of the city. Response to place is most certainly the most important criteria suggested by the notions of urban ecology and sustainable settlements. A respect for the spacial milieu in which buildings are being placed is what is lacking from most of the modern developments in cities world wide.

7.6.3 Climate Control

The criteria for climate control which should be considered is the response to the local environment and energy efficiency. Northern orientation is essential for maximum solar exposure and daylight penetration. Therefore the different orientations calls for different facade treatments. Skylights and atriums are methods to overcome constraints in northern orientation, allowing sun light penetration and reducing energy cost for artificial lighting. Courtyards and atriums also act as a thermal buffer, providing zones in which heat exchange can take place.

Insulation and ventilation completes the fundamental considerations guiding building design from a ecological point of view. Insulation retains the solar energy allowed in day time during winter. Ventilation is the natural method to distribute the heat or reduce the build up of heat in summer. North facing windows and patios can also be replaced with skylights and courtyards to allow sunlight penetration into all living spaces of the building.

Greenhouse type structures added to the northern and the southern elevations of a building would improve the interior climate significantly. The traditional northern sun room functions as a passive solar heater, warming the interior of the building by trapping the relatively long infra-red light waves. More advanced southern greenhouse type structure act as "entry vestibules" which replaces detailed climate control. It also allows a steady amount of light into the 'darker' side of the building, which reduces the need for artifici l lighting.

7.6.4 Contextualism

The notion of contextualism is drawn into urban ecology as a fundamental prerequisite for sustainability communities. If not only addresses form, but also functional fit of proposed building types. Where as the "progressive modernist (sees) the function of a building to define its form rather than its relationship with its neighbours or its responsibility to the large urban framework." (Van der Ryn, 1991).

Contextualism is defined by Peter Calthorpe as "...responding to the needs of the neighbourhood by reinforcing the street while providing for the private needs of the inhabitants with internal spaces, responding the local climate while respecting the urban traditions; fitting in visually by using sympathetic form while modifying the plans to satisfy current household types."

In urban ecology the social aspect of buildings is also important. As is the case in the natural ecology social structure and interaction is a fundamental part of the ecosystem. Buildings and the spaces they form is proven to allow or disallow social interaction. The transition between public and private space, as described by Newman in *Defensible Space*, gives a good idea of the subtle influe ilt form on social interaction. The design of all built form therefore should incorporate these ideas as t ate and regulate social behaviour in and through these spaces.

The basic principles could be summed up as follows. Firstly the structure should be on an inviting scale - relating the size and scale of man. Setbacks, attention to detail and the emphasis of entrances would begin to achieve just this. Secondly the building should give a clear indication or clue to the user or passer-by about the hierarchy of space. The public domain, transition zones and the private inner sanctuary should be defined by a spacial progression, articulated by elements such as steps, gates, entrances and levels. This makes for a well understood environment, both for the locals and the visitor.

Entrances of buildings should allow for a grading of space from public towards private, providing space for socializing, meeting and generating street activity. The actual entrances should still be public enough to invite the visitor and give clear clues to the stranger as to the social status of the space. The internal spaces should again provide for more intimate socialization in atriums and courtyards, not only hall ways and foyers. "As in housing, semi-private places such as these support the conviviality necessary for healthy city life. Without places such as these, people retreat into their private world, losing common identity or responsibility." (Peter Calthorpe, in Van der Ryn, 1991)

It is this common responsibility which become important in generating a sustainable community. In the ecological system all actions are directed towards maintaining a dynamic equilibrium. "In some intractable way, climate responsive design forces buildings to become more locally and socially responsive and responsible." (Peter Calthorpe, in Van der Ryn, 1991) Environmental concerns reinforce the common places - usually those places which the 'building as a machine' approach eliminated. It has always been these spaces which made places more habitable. Thus ecological character of a place goes hand in hand with solving serious social and economic problems.

7.7 ENVIRONMENTAL TECHNOLOGY

7.7.1 Solar Attic

It is specifically useful in residential units with pitched roofs. The rafters and ceilings are super insulated and lined with black plastic. Double glazing panels are installed in the northern facing side, together with "heat rods" (plastic tubes filled with eutectic salts that have 20 times the heat retention capacity of dense materials often used for heat storage such as concretes. The heat captured in the attic is then distributed through a conventional duct and fan system to other parts of the dwelling. The big advantage, besides its relative low cost, is the fact that the space it utilizes is usually unused in the house. See Fig 7.11.

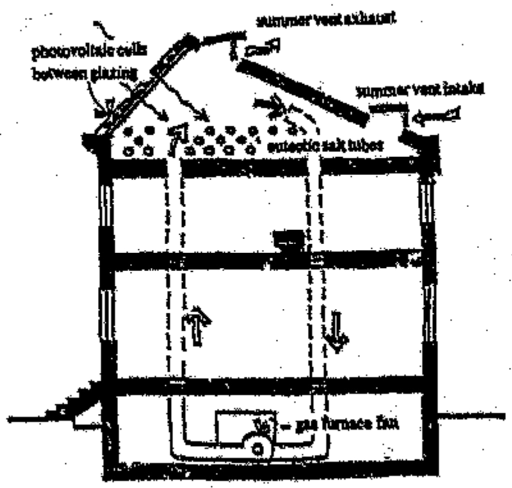


Fig 7.11 - The Solar Attic as an example of basic technological components which could be incorporated into the design of houses. (Calthorpe, 1991)

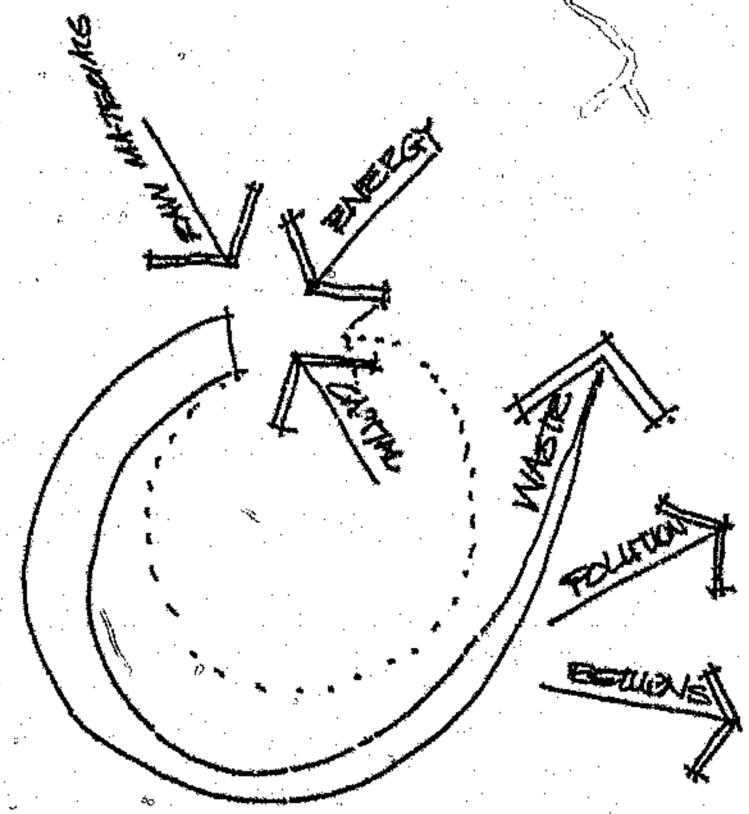


Fig 7.12 - The present urban environment is too open-ended to allow a recycling of energy, resources and material. This makes for the present waste problem.

7.7.2 Solar Greenhouse

This wooden or aluminum structure added to the north facing portion of the dwelling, not only acts as an extra wall to restrict heat loss, it acts as a passive solar heat collector. This simple addition to the house could be used as the conventional "sun room" or as a proper greenhouse to grow vegetables all year round. In colder climates so called solariums are built which incorporate double glazing and other insulation features.

7.7.3 Sewage Treatment

Waste treatment must also be incorporated in the study of urban ecology and is actually an important part of an ecosystem. Steve Serfling (in Van der Ryn, 1991) developed a waste treatment system called the "solar aquacell". The system creates a poly-cultural habitat in which a plastic substrate provides a surface for bacterial growth. The bacteria in turn is being fed on by arthropods and other marine micro-organisms. Floating water hyacinths take up the majority of nutrients in the effluent. The system is covered with commercial double - layered plastic greenhouses to maintain a stable high temperature for optimum biological activity. See Fig 7.12.

The energy use of the system is far below that of conventional secondary treatment plants. The proposed system also poses no environmental hazard (such as airborne viruses, odour or unsightliness) as it is completely contained. The purified water is of a recreational quality and could be stored in retention ponds for irrigation purposes.

7.8 MANAGING OF WASTE

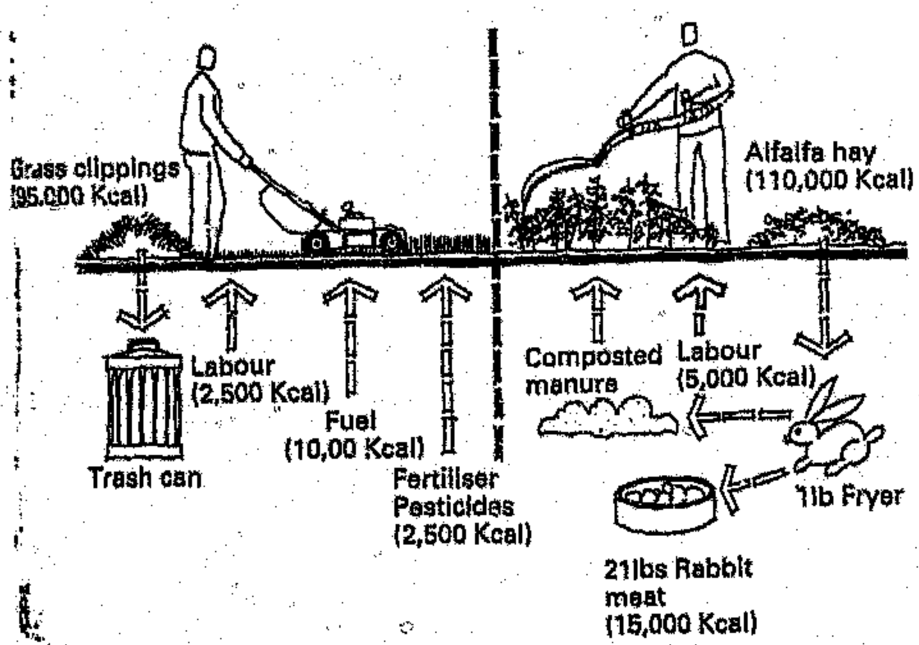
The emphasis must shift from crop management to resource management. A healthy total environment make for a successful and good crop - not only pesticides of fertilizer or mechanized technology, but also the soil condition, the water quality and the functioning of a ecological feeding pyramid. The necessary corollary of that role - the generation of sewerage, garbage, and other waste resources - is commonly ignored, or at best seen as a nuisance." (David Katz in Van der Ryn, 1991) If waste production can be approached from a resources potential point of view, we could start closing the ecological gap between exploitation, production, consuming and waste. Urban agriculture provides the link in completing the flow of nutrients and energy.

Once this approach is incorporated in our urban environment to economic value and environmental pay-offs of mitigating dumping sites reaching toxic levels, of using organic waste as fertilizer and of defray the costs of actually "disposing" of the waste produced by modern living. The potential locked in our organic waste has not yet been researched in South Africa. The Metropolitan Washington Council of Government, produced similar statistics showing the following: The city of Washington, with a population of 756 000 people, produces 309 million gallons of raw sewerage per day. It is claimed that it contains enough nutrients to fertilize 13 790 hectares at levels to support most crops. If the usable organic component of the domestic waste is added the area increases by nearly 20%. (Hough, 1991)

Even if 50% is lost through the collection and processing of the organic fertilizer eight thousand hectares would become productive land. If this land in turn were to be subdivided into small, intensively farmed plots the advantage would increase. With intensive crop production systems, utilising inter cropping and successional cropping practices, the agricultural yields must increase. Add to this the lower capital outlay of re-using the organic waste produced in close proximity - there must be economic pay-offs.

The added spin-off of the intense, productive and ecology based agricultural practice would be that, in addition to the food which is being produced, the waste and energy which are being recycled the farmed plot would produce oxygen, purify the air, moderate temperatures and be aesthetically pleasing to the eye. It could also act as a educational centre and recreational resource.

The sustainable approach thus shows clearly - a small portion of the whole would not be able to produce consistently if it was abused. The prevailing ecosystem must be understood and acting forces should follow the natural system. It also proves the enormous potential locked in the waste streams of our urban settlements. If the above system is opted for, cities must become more responsible for the toxic products and the heavy metals in their waste lines. The solution lies in the developing of strategies to prevent any dumping of these toxins into the waste stream in the first place. A long educational process and effective economic incentives may allow this to be done.



	Energy input Kcal	Energy yield plant	Kcal: Human food
Lawn	15,000	95,000	-
Alfalfa	5,000	110,000	15,000

Fig 8.1 - Farming should be an alternative to gardening - a garden which produces and not only consumes. An example of an alternative to the backyard. (Hough, 1991)

8.0 URBAN AGRICULTURE

8.1 INTRODUCTION

"To-day and even more so in the future, the agricultural ecosystems besides the unique natural ecosystems will play an important part and role in the equilibrium between urban and the open landscape, between human and natural needs." (Ryszkowski, 1986). It has been said previously that the driving force behind urban ecology is the fact that urban settlements and the systems which operate then must be geared, not only to consume, but to produce. The home and every other building thus become a power station, rather than a consumer. The same concept must be projected into the urban landscape. Whole cities can become more self sustaining in food and energy production, and spin-offs such as job creation, cleaning of urban blight and environmental improvement, could all form part of this integrated approach. See Fig 8.1.

8.2 MODERN FARMING AND IT'S FALSE ECONOMY

Farming world-wide is kept on its feet so to say, through capital intensive subsidies. South Africa is no exception. We are in the process of reducing the dependence on subsidised consumer prices and controlling boards, but the results are slow to show general improvements in the markets. In addition to this all our major cities are sprawling daily over arable land, in the portion of the country with relatively higher rainfall averages. In America the metropolitan areas account for 51,7% of the prime agricultural land. The reason being that city usually developed around river mouths, on flood plains (after Katz, in Van der Ryn, 1991) and around productive agricultural markets (after Jacobs, 1977).

City climates contributes to the potential of intensive agriculture because of relative higher temperatures, rainfall and the abundance of organic waste. The limited space and proximity of energy make for sophisticated production methods to be utilized for maximum yields. Irrigation with grey water collected from the immediate community and the germination of seedings in greenhouses next to the houses, allows the potential of a very productive farming economy. See Fig 8.2.

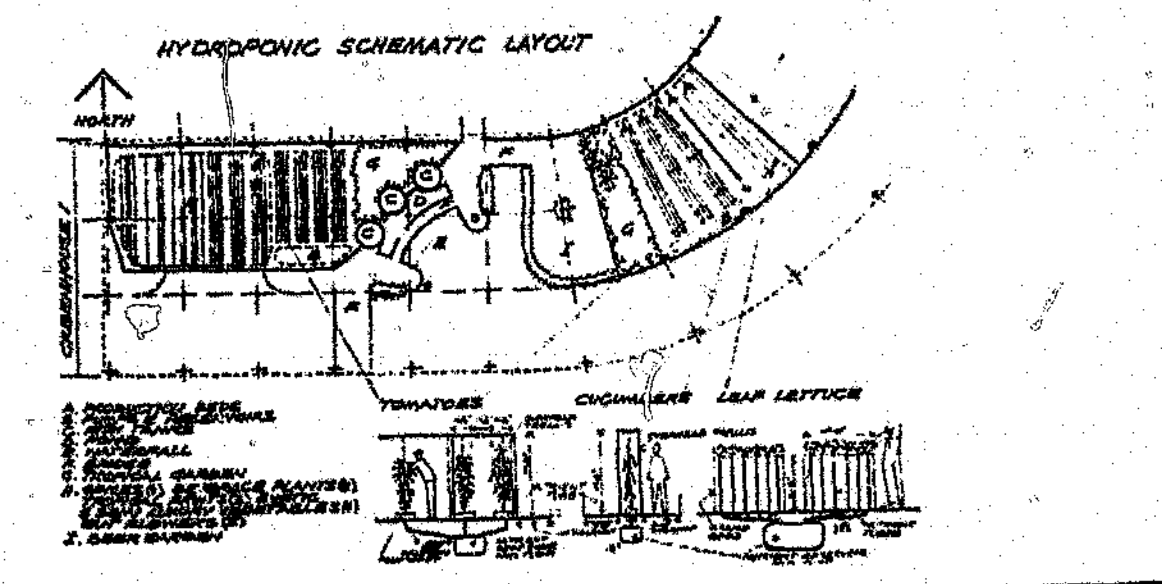


Fig 8.2 - A schematic layout for a hydroponic greenhouse or miniature farm.

8.3 FERTILIZER, PESTICIDES AND HERBICIDES

Modern agriculture and its need for, excessive use of, fertilizer, pesticides and herbicides to produce "good" crops implies an enormous environmental cost. Despite the development of hardy, pest resistant cultivars for every type of crop, it has become common practice to "secure" crops with the use of these potentially toxic and expensive additives. These additives do not only add to the exorbitant capital outlay of the modern farmer, it pollutes and disrupts the food chain and eventually builds up in us, as the end consumers, to toxic levels. The biologically sustaining control of pests becoms incredibly susceptible to catastrophic collapse of the feeding pyramid, followed by the possibility of a major pest outbreak.

The reason for the extreme dependence is the exclusive farming of monocultures. If a certain pest would invade the monoculture the whole crop would be devastated. The ecological approach would be to promote diverse and mixed agriculture. The inter planting of legumes between conventional crops, not only improves the soil fertility by binding nitrogen, but also limits the risk of losing the whole crop by 50%.

With the mechanization of farming in general and the surge of large co-operative farms, the problem of soil erosion through wind and precipitation have taken on disasters as measures - 3,5 billion tons of topsoil is being lost in South Africa per annum. For a country of which 65% has become untillable due to climatic and topographic constrains this is serious. (Kruger, 1993)

The proximity of a consumer group also saves on the cost of transport and marketing, which pay-offs by reducing the cost of food to the broader community. Generally farmers only receive 25 - 30% of the retail price for his produce. Transportation, packaging, marketing and the wholesale and retail sector all take their slice to the detriment of the productive part of the agricultural sector. By involving the community in germinating, planting, maintaining and harvesting of the different crops, a large portion of both the environmental and marketing costs would be eliminated thus reducing the cost of basic and nutritious food.

Fertilization costs could be reduced by using the organic waste of the community to fertilize the soil and replace the essential organic component lost during tilling and intensive farming. Intensive farming could also assist in the improving of the treated effluent percolating through the soil, by withdrawing large percentages of the nutrients. Through this practice water is re-used, benefitting the groundwater quality and the environment at large. Note the educational value of urban agriculture.

8.4 SOIL FERTILITY

Soil fertility remains an ambiguous subject, with different opinions and many misconceptions. Soil fertility and crop production was the basis for human settlement after a nomadic hunter gatherer life style. It is still one of the important reasons why cities sustain, without having to produce or find its own food. The biggest environmental problem today is the eutrophication of all our water bodies. The main culprits are the chemical industries and the farmers - the custodians of the soil, water and the landscape. Through aggressive marketing and vested interests farmers are depending more and more on petroleum based fertilizers to boost crop performances and yields.

To maximize the nutrient absorbtion by the crops irrigation has become imperative. The excessive use of low "priced" (but "costly") irrigation water on over fertilized fields result in two serious environmental impacts:

(i) The substantial surface run-off to the existing drainage ways, which feed out of rivers and dams - not only eutrifying the water reservoirs, but also resulting in silting of these expensive dams and toxifying the water body floor because of the build-up of insoluble phosphates in the silt. (The Hartebeespoort dam is a case in point - most of the bottom feeding fish have died as a result of the toxic quantities of phosphates, as well as the clogging of the floor by dead blue-green algae.)

(ii) The pollution of ground water resources due to the enormous quantities of nitrogen - which is very soluble -which is being leached because of the over saturation of the needs of the planted crops. The problem is already resulting in water quality problems in the Western Transvaal.

(iii) It is the squandering of precious resources in more than one way. Not only are crops being over fertilized, but the produce is usually far from its market and excessive transport costs are incurred.

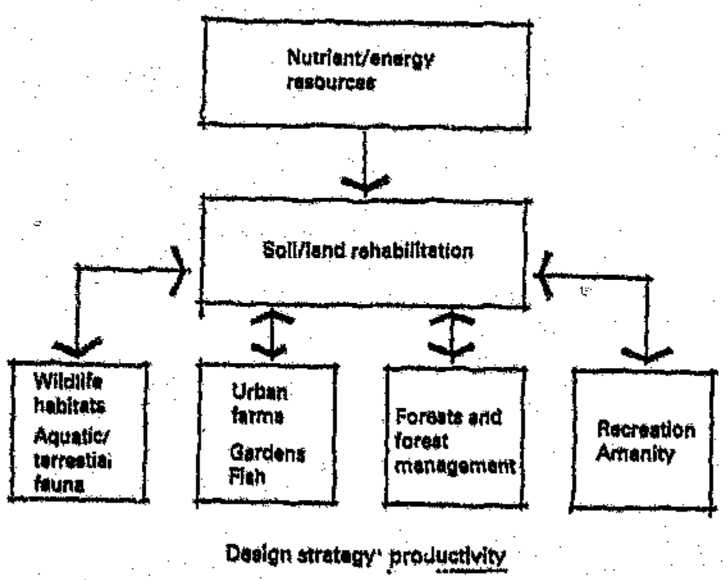


Fig 8.3 - The educational value of urban farming is easily overlooked. It sets a framework for a more diverse biological environment, with the emphasis on the integration of man and nature. Urban Agriculture also promote integration of human and natural processes which could reduce the cost of urban environments to nature. (Hough, 1991)

8.5 CONCLUSION

Urban agriculture refers to farming or open space used for an agricultural use within our cities. Agricultural systems are man-made but the links between plants, animals interacting with soils, micro-climate, and lately technology (referring to the technology of seed, fertilizer, irrigation and mechanisation). Unlike self-perpetuating natural systems, modern agricultural systems are unstable. Cultivation, fertilizing, maintenance and irrigation are all therefore important requirements. Yield and appearance of the produce are the main goals.

Although a large portion of nutrients are recycled as part of the natural process, detrimental chemicals are also added in the form of nitrogen rich fertilizers, pesticides and herbicides. This may improve soil fertility and growth of the plant, but affects the natural systems present in the vicinity of the disturbance. As only a very small portion of the produce is being recycled, depletion of the natural composition of these systems is inevitable.

The more traditional mixed farming practices allow for a wide variety of cultivated species which also help to maintain a certain degree of ecological balance. The nutrient input from agricultural animals and the principle of crop rotation, crop variety and the inclusion of natural communities for hedges or windbreaks are quite significant in maintaining a more sustainable system. The fossil fuels and industrial machine has unfortunately changed this for ever. Mass farming, chemical controls and soil preparation practices have made for more commercially orientated farming, farming monocultures over large expanses of land.

The complementary benefit of crop and live stock farming is also disappearing as they are separated for management reasons. These two arms of agriculture work well together to cycle energy between them by closing the gap between exploitation and production. On the one hand animal farming has enormous quantities of manure to get rid of, and on the other hand the crop farmers have to import enormous amounts of fertilizer and other chemical growth simulators.

The above seem to improve production figures, but is contributing little to sustain the non-renewable sources of energy, topsoil and fragile ecosystems. It therefore has high environment costs, viewing the system holistically. The concentration of chemicals, fertilizers, pesticides to maximise homogenous crops threatens the life in the soil, depletes the soil nutrient levels, i.e. the humus, the trace elements, as well as the biological health. The pollution of the groundwater, streams and rivers which are being eutrified, as well as the disturbance of the hydrological cycle all limit the long term sustainability of the system. If urban farming is approached in the correct way, it will not only serve to reduce the impact of cities on ecology, but will also benefit the social, environmental, and the urban setting as a whole. Urban agriculture could help feed and improve the economic problems as a result of the enormous influx of poor rural people to our cities.

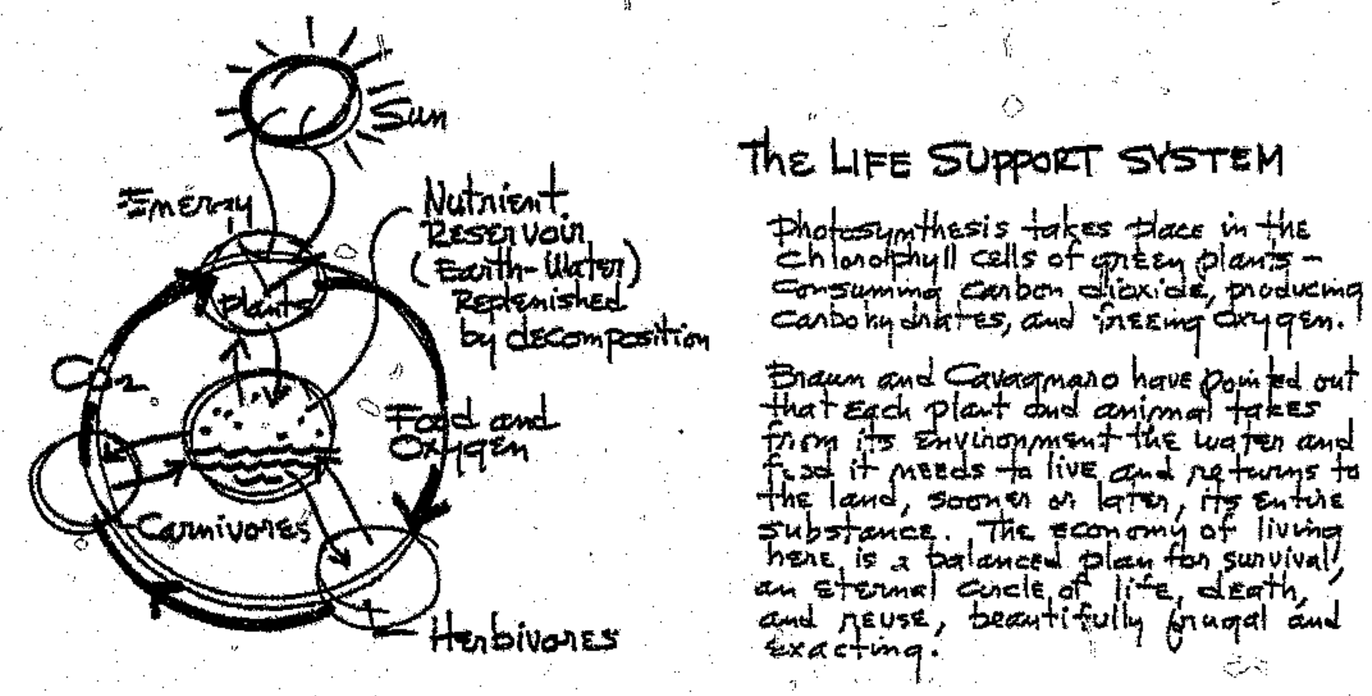


Fig 9.1 - The "Life Support System" as a model for a holistic approach to urban design. (Simmonds, 1986)

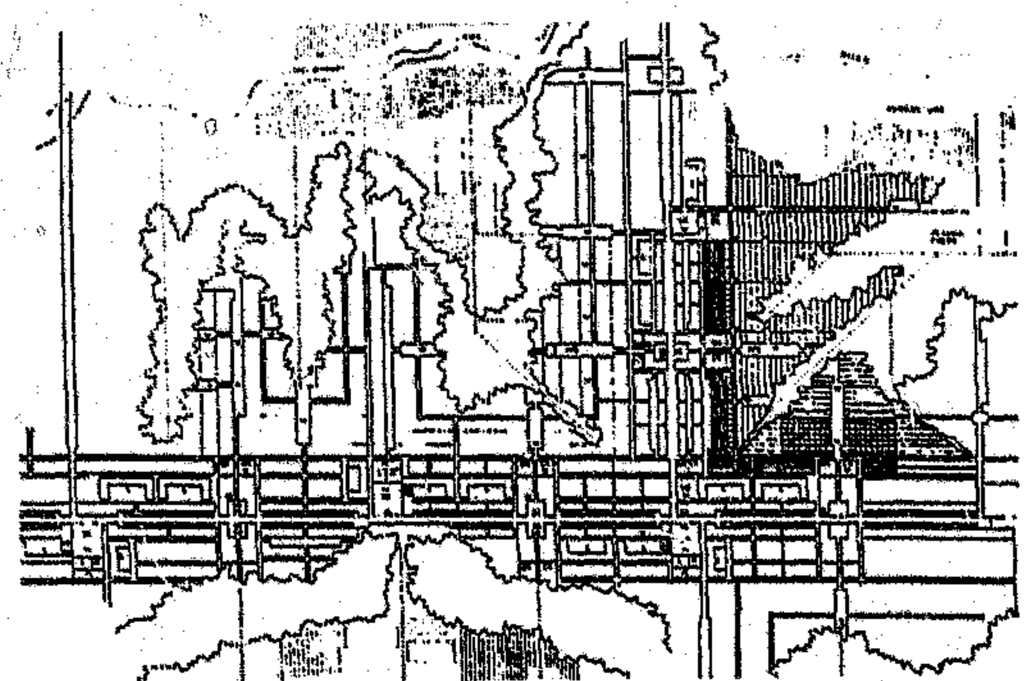


Fig 9.2 - Making cities work harder by optimizing space; mixed land use and direct link between production and consumption. Marianhill as case study, Uytenbogaardt and Rozendal, 1989)

9.0 PROPOSED URBAN DESIGN MODEL

9.1 URBAN ECOLOGY GOALS

The first goal must be to view any project holistically - set in a ecological and social setting with pertinent opportunities, but certain critical limitations and needs. By understanding the local and regional environment as well as the critical ecological factors sustaining it, the urban designer would be able to assess and evaluate every aspect of his proposal's performance within the limitations of the setting. A basic understanding of ecological principles related to sustainability would contribute to his ability to optimize the potential of nature as a partner in improving and maintaining settlements. See Fig 9.1

The second goal is that of a healthy and integrated social environment, relying on the local economy to maintain economic growth and development of any community. This should be addressed by providing economic opportunity, accessible for the specific community who ultimately is being settled. Diversity in the socio-economic opportunity, as in nature, would reinforce the enabling framework of an informative economy. People will not care for nature if they are hungry, cold and have no shelter against the elements.

Make cities work harder - activity corridors should be densified, mixed use must be promoted and nodes be amplified and reinforced. Direct connection should be made between production and consumption. Public facilities should reinforce this notion of integration. Optimum use of space and land should be the thrust in creating more efficient and sustainable cities. See Fig 9.2.

The creation of functional landscapes and a means to fix an open space structure and ensuring its future existence. The open space system should be seen as a functional land use, doubling up as agricultural allotment, woodlots, wind breaks, drainage ways, stormwater detention zones or conservation areas. Public amenities such as sewerage treatment facilities, as well as schools, parks, sport and recreational facilities could be used to reinforce the extent of these open spaces.

Environmental education, local knowledge, field and study centres should all be directed towards the understanding of the urban ecological concerns and reasons for a sustainable community. Urban ecology would provide the theoretical framework for the above. Social and economic value should be allocated towards dense settlements, as well as open spaces flood lines (Alexandra), underlying dolomite (Ennerdale) and geo-technical aspects (Vosloorus) could not be held as the only reason for not developing or squatting within these productive landscapes. Finding a way in which people add value to land without destroying its potential.

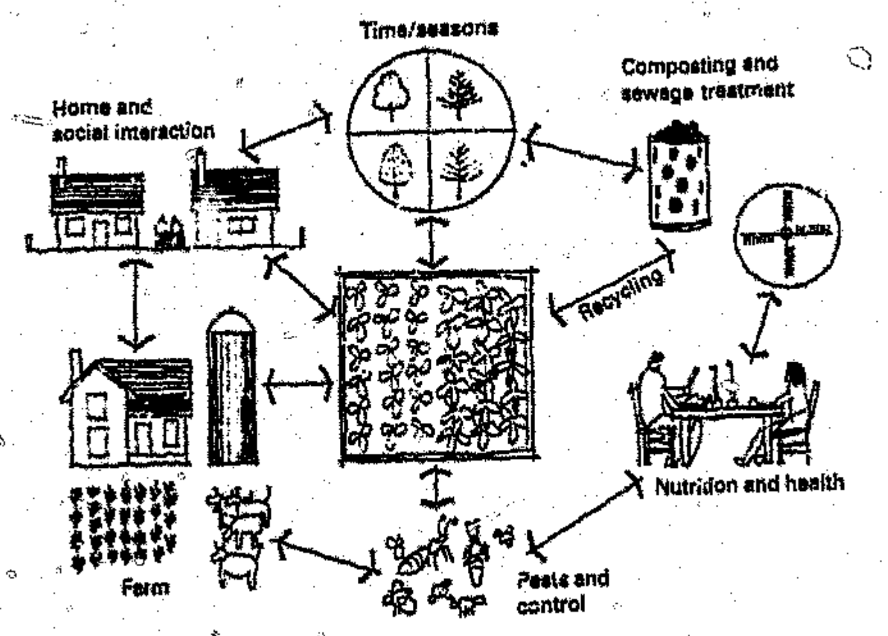


Fig 9.3 - Environmental Education: the combination of different open space uses around schools would assist in relaying the message.

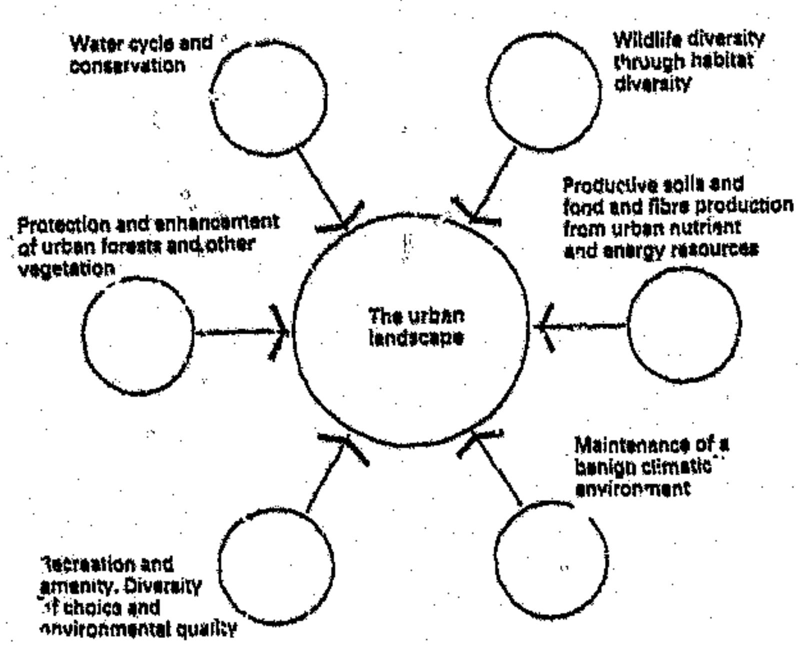


Fig 9.4 - Urban Ecology as a strategy for design to implement a self-sustaining rehabilitated urban landscape. (Hough, 1991)

9.2 URBAN ECOLOGY STRATEGIES

Approaching the implementation of urban ecology and sustainable development from a pragmatic and realistic point of view produces the only workable solution. The change towards such a society will be slow, incremental, but accumulative. Creating such societies would require a fundamental paradigm shift from consumer orientated to resource orientated.

The change will have to be driven, both by the private and the public sector. Planners and designers will have to set the frame work facilitating an alternative approach to city growth and development. This should be followed (or even preceded) by governmental policy or incentives for the initial implementation of some of the mentioned proposals. The private sector must follow by encouraging urban ecological principles if and when they are convinced that this would result in financial and economic spin-offs and pay-offs.

The policy support and capital investment of the government - be it local, regional or central - must be the most critical step. But it should be the urban designers who must lobby for this alternative approach from a holistic and realistic point of view. Understanding the critical environmental issues, both regionally and locally. If the local soils, climate and land allow, local food production should be stimulated. In our present First world - Third world split this could become a means for those with little experience, no means and understanding of the urban economic system, to employ their rural skills to generate an income. This would also feed themselves, without having to buy expensive food and it would stimulate the local economy.

A typical strategy would be to reconnect home, work, shopping and recreation with the environment through sound spacial organisation and layout. This should be done in such a way as to reclaim valuable land from the vehicle to release it as functional landscapes. Cities would become denser, which would allow strong pedestrianised connections to develop, more space people and activity. Denser communities would treasure and use their open space more productively. Land-uses such as allotment gardening, recreation, wildlife conservation and stormwater detention would become important and provide functional, aesthetic and ecological value to these open spaces.

The relative high density, low rise residential and built fabric could allow for good solar access, as a grading of social space (from private courtyards to streets, squares, parks and common open space). Reduce the percentage of area being set aside for streets and infrastructure. By restricting vehicular access and developing pedestrian and bicycle trails the following is achieved: consumption of fuel would be reduced; the threat of motor vehicle dominance of the public realm is eliminated and a tighter knit community would develop - freer public interaction. The present notion of categorizing of streets should be promoted to establish a clear hierarchy of streets. The capacity of major arterial will never be sufficient - the attitude of better roads, more vehicles will persist. The approach to sustainable transportation should be, in the words of Sim van der Ryn

"... without impending movement or assuming diminished travel, (the design should) give cohesiveness to blocks and neighbourhoods ... and encourage pedestrian movement ... and uses rationalized into a 'Lifebelt' or linear pedestrian-orientated multi-use (nodes)". (Van der Ryn, 1991)

The main emphasis should be to reduce the length of local trips to services, retail and job opportunities. This would be achieved by densifying the residential component near business and retail nodes, promoting mixed land use rezoning and by lobbying for incentives to develop housing as part of business and retail developments. The compactness of the residential areas would reduce infrastructure costs and promote a high level pedestrianisation - reducing the need of the private motor car, as well as promote the idea of "city of feet".

The residential component should focus on a mixed use commercial "life belt" incorporating all services needed by the local community, from public amenities to retail, business and leisure facilities. The importance of energy saving and fit to the environmental conditions of the specific site should be emphasises on all levels. Lastly the social functioning and management of such a "sustainable community" must be suggested by the settlement form as well as its maintenance, as proposed in the development framework.

Energy remains one of the most important issues in design for sustainable living. Linking people directly to land, food and energy systems as a means of introducing them to the urban ecology is important. This is only possible through the provision of the opportunity, as well as the education programme which is required to alter present values and attitudes. The minimizing for the import of energy which could be generated locally and limiting the loss of energy through bad design would be the approach. In the calculation of energy cost on doing feasibility studies on different option must take into account the total cost of generating the energy, rather than the price paid by the consumer. For example South Africa as a whole has a nearly perfect location for the utilization of solar power as part of the domestic energy supply. See drawing *Solar Insulation.*

Waste disposal is seen as an important resource within the urban ecological paradigm. The proposed framework must allow for sewerage, waste water and solid waste to be recycled locally as far as possible. The most important effect would be the separation of waste at the source - the household - for more cost effective recycling. This would be cost effective if the open spaces would be designed as functional land uses, accommodating agriculture and other functions as discussed previously.

PART 2:

BOKSBURG CASE STUDY

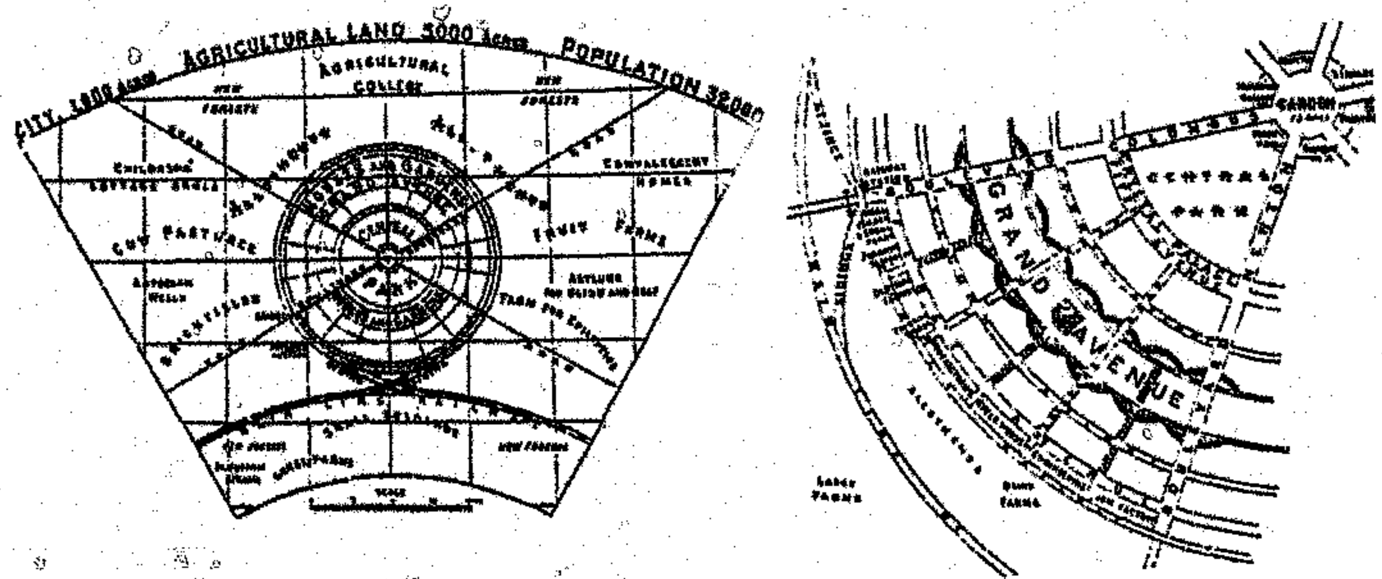


Fig 10.1 - The Garden City Movement - Ebenezer Howard's plan indicates a concern to reconnect the rural with the urban, to improve the quality of the environmental health. (In Sustainable Communities, 1991)

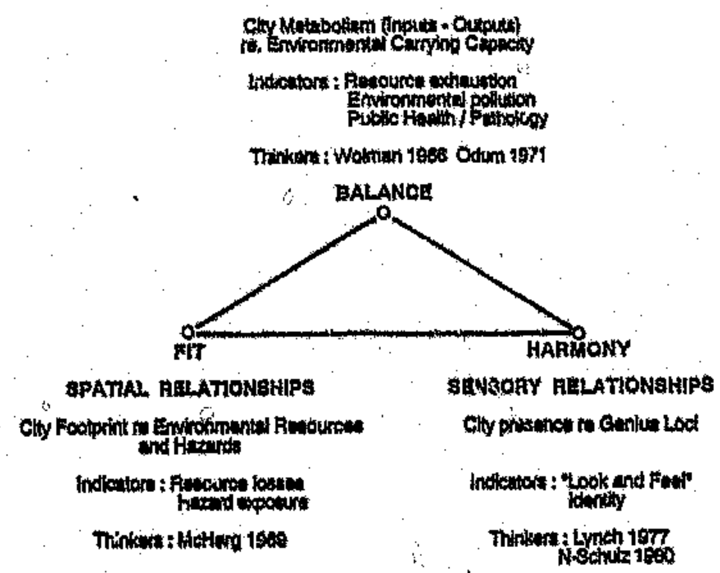


Fig 10.2 - Balance, Fit and Harmony - a model used to evaluate the bio-physical status of the Cape Town region. (Gasson, 1993)

10.0 THE QUESTION OF AN ECOLOGICAL BIAS

10.1 INTRODUCTION

As stated previously the environmental movement is relatively young in the history of city planning. The earliest attempts to plan for a "greener" city (Howard and others in the Garden City Movement) was primarily advocating a stronger cohesion between the machine driven, industrial city and the agriculture orientated countryside. See Fig 10.1.

The question of an ecological bias is directed towards a more integrated approach, specifically taken into account the environmental factors which have so often been neglected in the planning and design of settlements. As in the case of the Garden City Movement, the fundamental reason for this being improved environmental health, creating a more diverse economy and attempting to make the city an more livable environment. "...the purpose of new town shifted from a means occupation or escape to a response to industrialisation and its ill effects." (Calthorpe, 1991)

The goal is not anti-city, but rather an attempt towards a more sustainable city: ecologically, socially and economically. The understanding and studying of both the human inspired (socio-economical and technological) notions, as well as the nature (socio-ecological and environmental) driven factors are therefore important. The forces creating and shaping our urban environments have, to date, been dominated by the capitalistic bias towards economically sound and feasible city environments. Feasibility studies are always very important, but the social and environmental implications of these proposals must address a larger environmental framework. It should go further and include strategies and design guidelines which are related to cost benefit analysis and ecological implication. The hidden costs of social and environmental factors will determine the long term cost to society and Mother Earth.

The key note of the plan must be sustainability in the ecological sense: balance, fit and harmony - a balance between people living in a community and the available jobs; a fit of the resources local needs and consumption; and a harmony of maintenance and the natural environment - of health, food, shelter and social living within the laws of the earth. It is about ensuring the energy flow into the system is comparable to the waste flowing out. (After Gasson, 1993) Urban design frameworks must address the total environment, both hard and soft spaces. See Fig 10.2

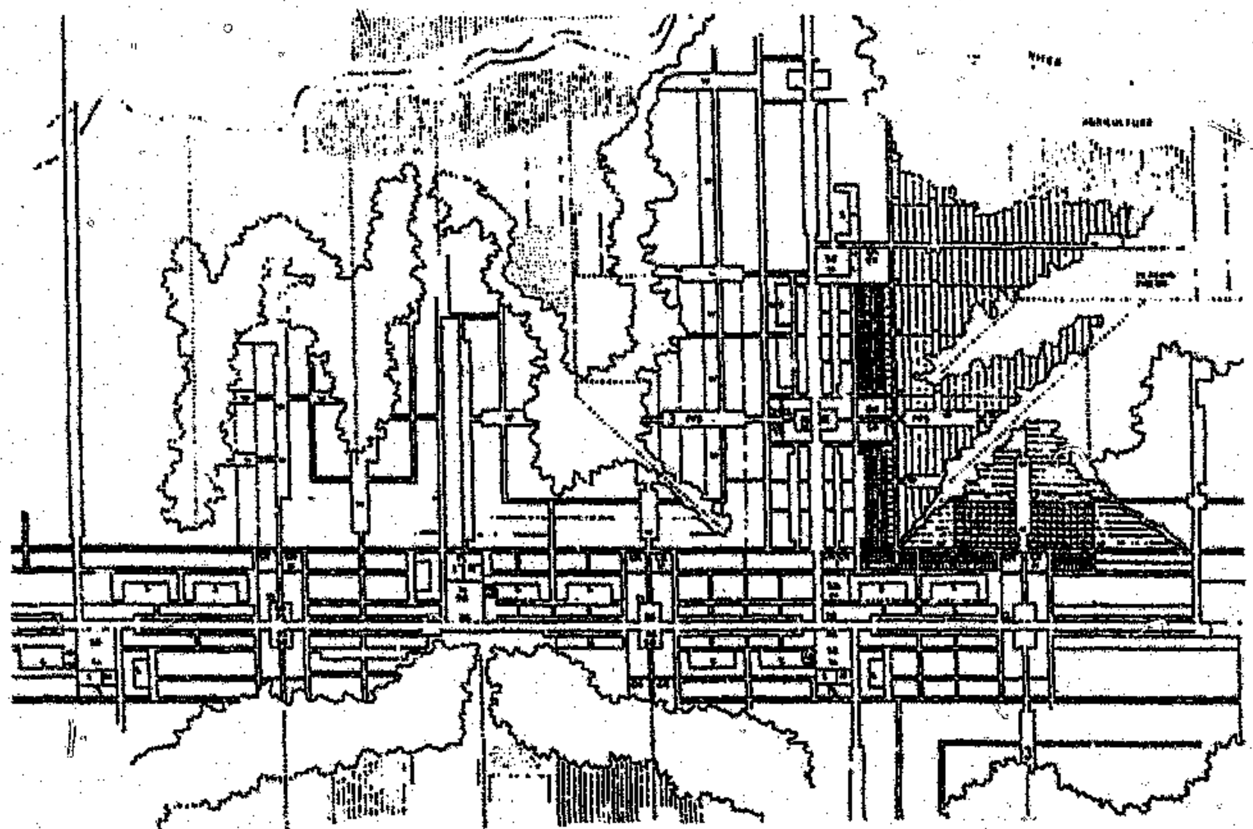
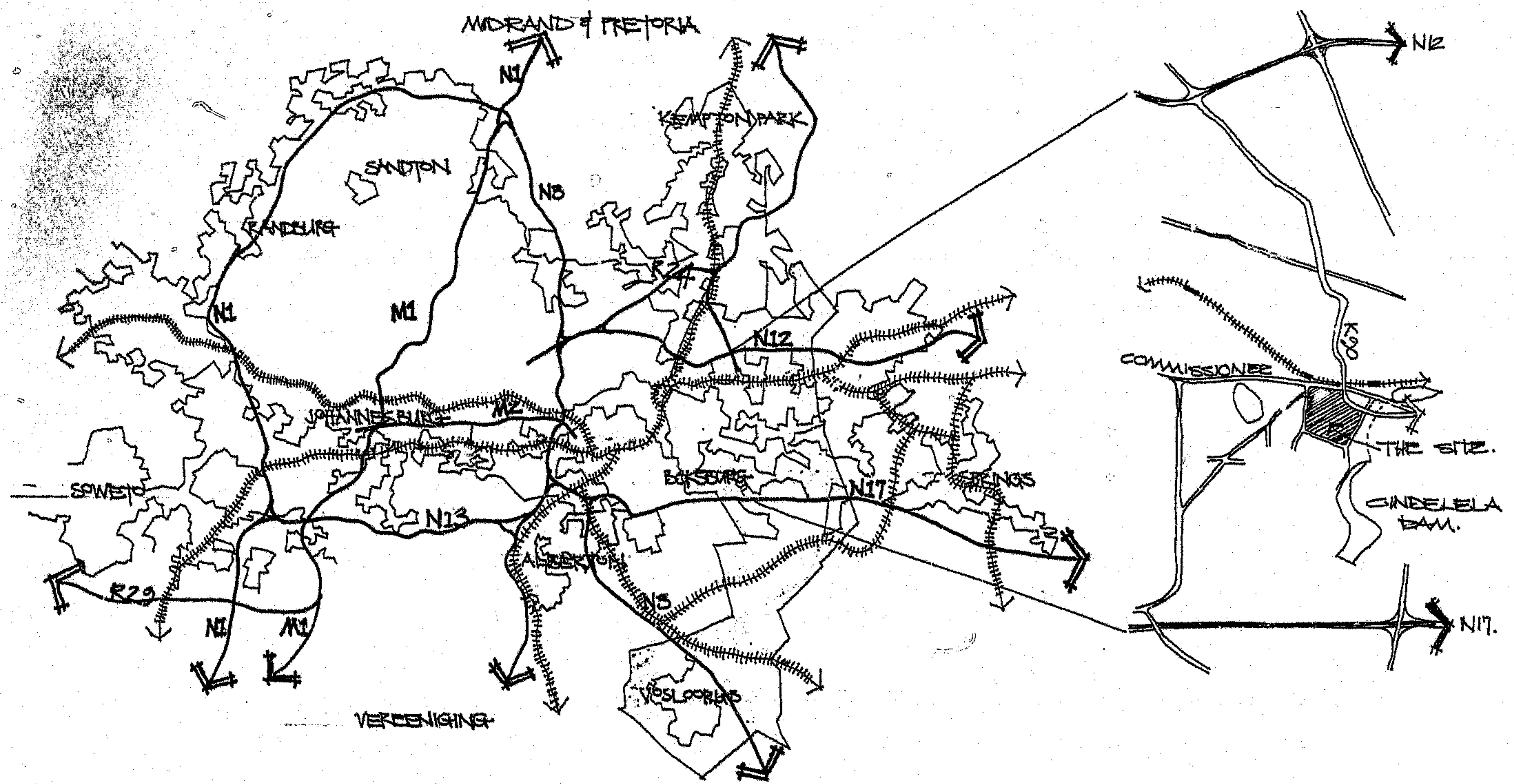


Fig 10.3 - Marianhill as a example of a framework which integrate the community and the ecology, (Uytenbogaardt and Rozendal, 1989).

In addition the ecological bias the framework should have inherently address the pressing needs of communities, especially in developing societies. The structure should empower people to sustain themselves locally through an informative economy. Basic needs must be met - food, tenure, public amenities, a market and easy access to opportunity and commerce. The Marianhill Structure Plan set guidelines for a more integrated community, with a balance between urban and rural, commerce, consumption and production - where both the soft and the hard space work harder. See Fig 10.3.

10.2 THE QUESTION OF SCALE

To ensure that proposals, frameworks and strategies are truly interactive with its environment, the important aspect scale must be understood and incorporated in the understanding and assessment of any urban design framework. Scale is particularly important in developing the ecological principles and sustainable requirements which will eventually guide the urban design proposals. See Drawing *Metropolitan Context.*


MIDRAND & PRETORIA
N1
KEMPTON PARK
SANDTON
N3
RANDBURG
N1
M1
N12
JOHANNESBURG
M2
SOWETO
N13
BOKSBURG
N17
SPRINGS
ALBERTON
R29
N1
M1
N3
VOSLOORUS
VEREENIGING
N12
COMMISSIONER
THE SITE.
GINDELELA
DAM.
N17.

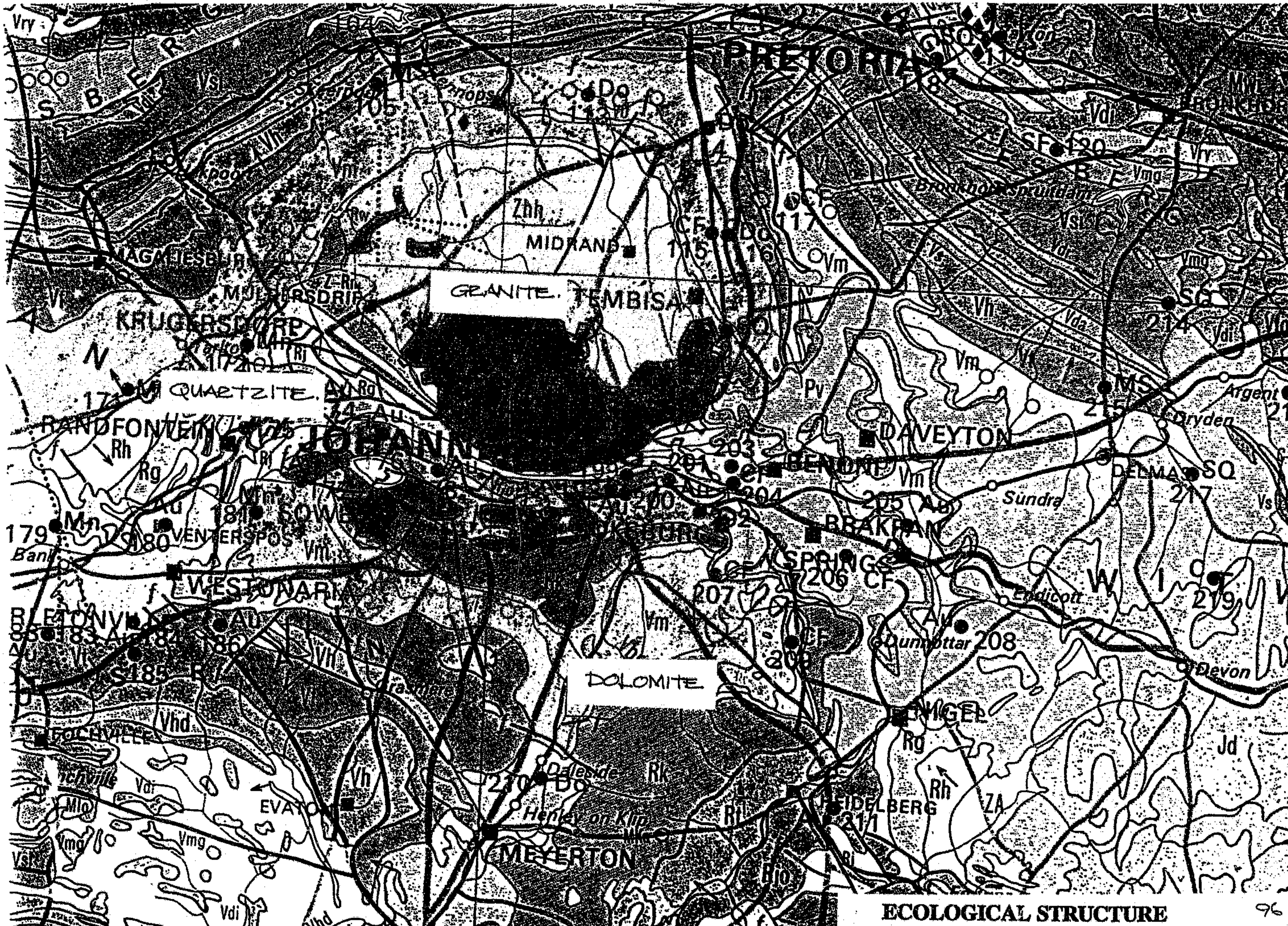
10.2.1 Regional Scale

The regional scale is the broadest environmental scale which need to be understood in setting up the urban design framework which will enable a sustainable and viable settlement. The understanding of the basic underlying geological structure of a study area is important. Geology gives an indication of the geo-technical characteristics, as well as the hydrological potential of an area. The suitability for foundations, sewerage disposal by means of septic tanks, the type of soil and its permeability, as well as the potential for ground water reservoirs could all be derived from a geological map. This could lay the fundamental structure for the morphological growth of an area as was the case with the Witwatersrand. See drawing *Ecological Structure.*

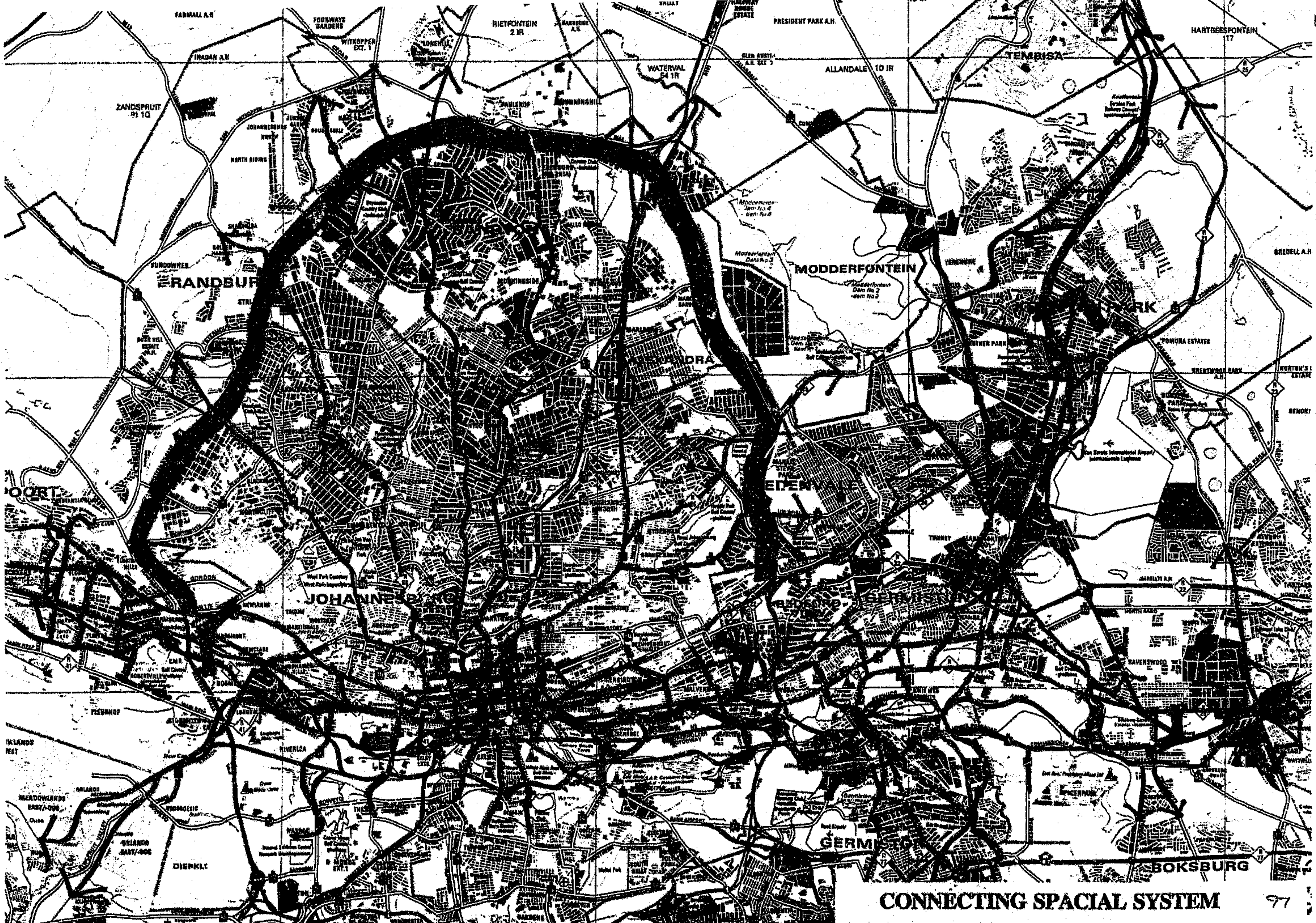
The thin gold baring quartzite reef had given structure to the present morphology of Johannesburg. As most of the surface rights were held by the mining houses, and certain portions had been shallow undermined (which made it undevelopable) the effect of the reef is still evident on the landscape. The railway lines immediately north of the reef, and several large holding dams still indicate the positions of closed or abandoned shafts. Just south of the main reef a large dolomitic dome is found. which had always restricted development to the south. The landscape is characterised by large marshes, pans and short rivers, disappearing into the soil.

With the disappearance of the sludge dams and mine dumps vast tracts of land is suddenly available for developments. Add to this the railway lines the major arterial routes fanning out to the north onto the stable granite dome, which stretch to the Schurweberg mountain range. The highway system reinforced this notion of development towards the north. In addition to the fan-like morphological growth to the north of the Johannesburg CBD, another development access had developed along the railway line stretching north east. This activity axis connects Vereniging, Germiston, Kempton Park with Midrand and Pretoria. The notion of an activity corridor on a macro scale could predict the enormous potential locked in the railways and the associated industrial developments. Boksburg, situated three kilometres east of the crossing between the Reef system and the north-south industrial spine, would benefit from the development of these employment spines. (See Drawing *Transportation Structure*) The railway lines, highways, arterial routes and undeveloped space is presently reinforcing an ecological structure with human activity and access. The edge of the granite dome to the north of the reef will limit the geophysical growth of Johannesburg (as proposed by Erky Wood).

As can clearly be seen the energy potential of the Reef is still evident in the maze of roads, connections and access to undeveloped mining land. The Transport structure, with the rivers and associated green belts integrates the Main Reef with the urban fabric surrounding it. It is accepted that not all of this land is suited for urban developments, therefore the potential of creating a system of functional and productive landscapes should be investigated. (See Drawing *Connecting Spacial Systems*)



ECOLOGICAL STRUCTURE



CONNECTING SPACIAL SYSTEM

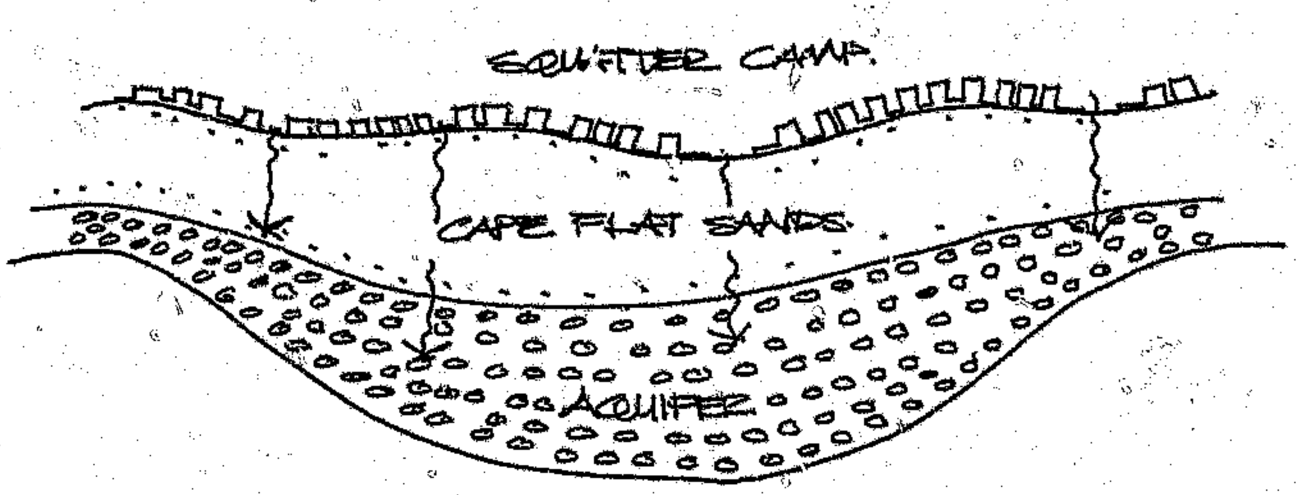


Fig 10.4 - Khayalesha - an example of a poorly sited settlment with inappropriate infrastructure for the specific geology. (after Gasson, 1989)

10.2.2 Metropolitan Scale

On the metropolitan scale the importance of ridges and streams should be stressed. The utilisation of the existing largely undeveloped ridges and rivers (because of steep slopes and 50 year flood lines respectively) could make for both functional and ecological viable open space links. As the ridges mainly run east-west (due to the alternating geological layers of quartzite and shale) and the rivers for the most run north-south (following the lines of geological shift) it would give structure to the urban sprawl through natural features. The beginnings of such an ideal had been the Braamfontein Spruit Trail which can clearly be seen on the drawing *Open Space Structure.*

COCCOS has compiled several documents to stress the importance of connecting the ridge and river systems. They have through meetings between the relevant councils compiled a policy document addressing the need for coordinated and linked open space (COCCOS, 1988) Witwatersrand ridge form a very important watershed in that the water to the south flows to the Orange river drainage basin, which mouths in the Atlantic ocean. The north flowing rivers drain into the Crocodile-Limpopo drainage system which flows to the Indian ocean. The potential to establish north-south green links along the Braamfontein spruit and its tributaries have already received a lot of attention. The Braamfontein Trail Master Plan (Johannesburg City Council, 1990) is in the process of implementation.

Ecological features and functions thus could play an important role in the guiding principles for structuring any settlement. If the ridges, streams and wetlands could be linked to form a nature related open space network, the systems could function as an integral part of the city morphology. On the East Rand several large water bodies are found, but very few of them are connected or form part of an ecological system. The Cinderella spruit, as well as the Elsburg and Natal spruits are important open space links to the Riet spruit in the south.

It is therefore important that open space systems are structured on a metropolitan scale to enable sustainable management of these ecological features. The open spaces should also be developed as functional landscapes, creating a balance between conservation and land use - production and consumption. (see drawing *Existing Catalysts*) The functions of these open spaces should fit the capacity of the system. In doing so a harmony between social, economical and environmental concerns would be possible.

OPEN SPACE STRUCTURE

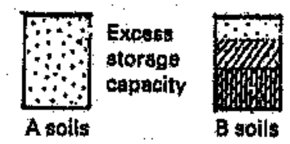
TRANSPORTATION STRUCTURE

EXISTING CATALYSTS

AB soils (LA,EU,BL,BOH,AL,WI) which receive no run-off from other soils

These soils have a high storage capacity for excess run-off, but when located upslope from less permeable soils, they cannot be used to drain them. In this condition, the excess storage capacity should be used to recharge run-off from higher density development on the AB soils themselves.

A soils have more excess storage capacity than B soils. Therefore, less area of A soils is required to recharge a given amount of run-off.

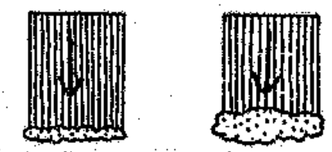


Management Guidelines

A soils may be cleared up to 90% and still achieve local recharge of the 1" storm.

B soils may be cleared up to 75% and still achieve local recharge of the 1" storm.

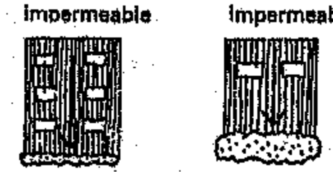
Areas used for recharge should remain wooded.



Housing Suitability

On A soils all types and densities are suitable.

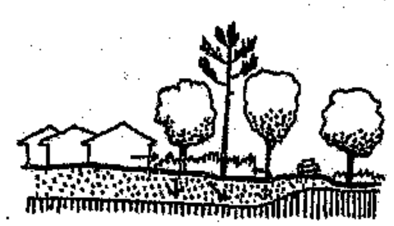
On B soils most types and densities are suitable. Housing types and densities which require more than 75% clearance cannot be accommodated without additional uncleared A or B soils. This would result in decreased gross density.



Siting Considerations

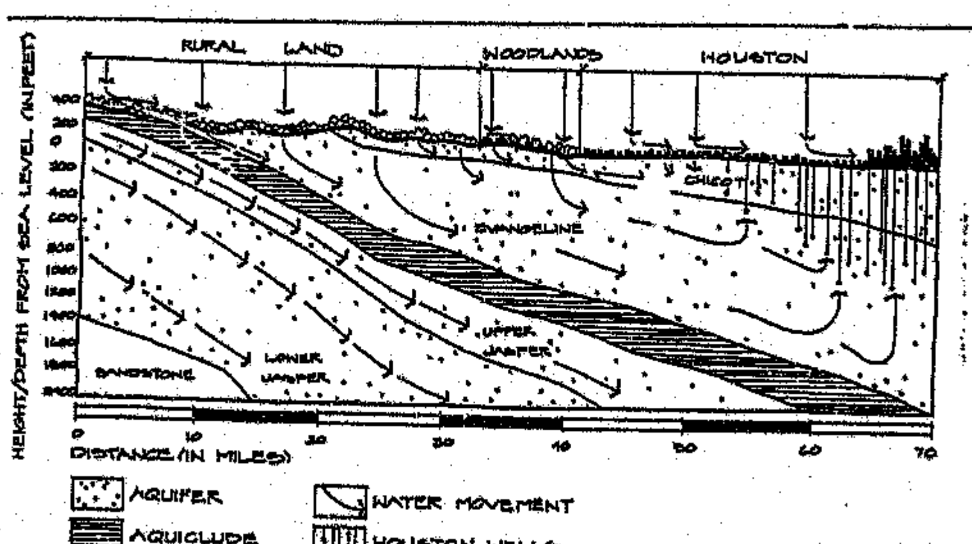
Situate buildings and impervious surfaces on higher elevations so that run-off will drain to lower elevations where it can be recharged.

Situate buildings and impervious surfaces so that they drain to the uncleared area.



(From Wallace *et al.*, 1973)

Fig 10.5 - Woodlands - drainage patterns as design directive for urban settlement. (Hough, 1991)



10.2.3 Municipal Scale

The importance of ecological factors in urban planning and design of municipal areas has varied significantly. In the study of urban ecology we have seen just how important certain ecological features are within the urban environment. Natural systems, if incorporated into the urban structure, could function as water purification works, storm water detention areas, "green lungs" to improve air quality, etc. In the case of most municipalities open space structure plans are only compiled once urbanisation is in an advanced stage of disruption of natural systems - rivers are canalized, marshes have been filled in and dumping sites have been positioned on top of water aquifers.

Professor Mallows has proposed the fixing of open space structure as the first priority in his four point strategy for urban planning. This notion has been confirmed by Barry Gasson, David Dewar, Roelf Uytenbogaardt and others as sound urban planning practice. This also complies with the principles set out by the theorists of urban ecology - Ian McHarg, Micheal Hough and Lawrence Halprin.

Rivers marshes and ridges could be utilised as the framework or backbone in providing catalysts for ecological systems to sustain. The 50 year floodline calculations, steep slopes, hazardous soils and the underlying geology should be incorporated into understanding the environment which has to be designed. All of the above would contribute to design criteria which would save on costs, be less expensive to manage and maintain and be more durable and sustainable.

Again a clear knowledge and understanding to the ecological composition and function of such an area in important. The specific geological composition and hydrological regime of the Cape Flats were never taken into account on identifying and developing Khayalesha (Gasson, 1989). Overseeing the fact that Khayalesha was built on one of the largest single aquifers in the Cape Peninsula optimises the lack of understanding of the natural system and its impact on the planning and designing of the urban environment. See Fig 10.4

The most known ecological factor influencing urban planning and design on a municipal scale is that of the 50 year floodline. It most certainly impacts on any proposal on the banks of streams, rivers and dams. The potential of this single planning ordinance has a significant affect on the three dimensional space which would have to be left undeveloped. But the environmentally sensitive approach to surface run-off goes further than just preserving a strip along drainage ways. It must be a more integrated approach addressing water pollution, stormwater run-off, soil erosion and aquifer recharging. Therefore the geophysical environment must be designed in such a way as to make more out of the opportunity. Natural drainage systems, rivers and stream should include weirs and detention ponds, a range of surface treatments to reduce runoff, lessen the runoff velocity, "vlei" and marsh areas, etc as per the site planning guidelines implemented in Woodlands, Huston (Hough, 1989). See Fig 10.5

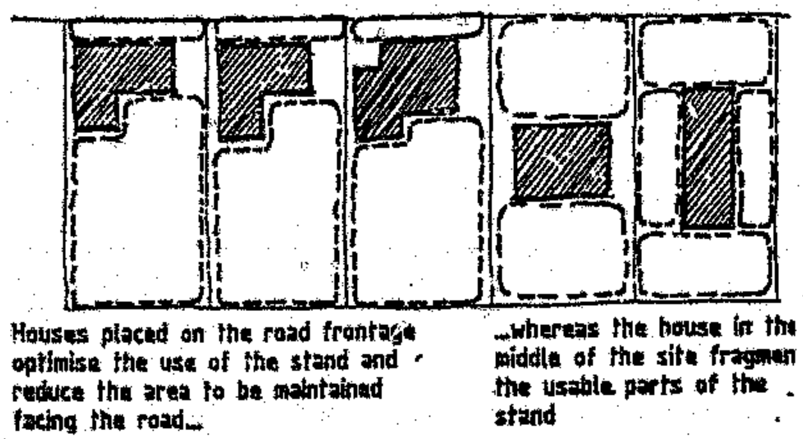


Fig 10.6 - Stand Optimisation - the placement of building onto a given site determines the potential uses of the stand. (Senior, 1988)

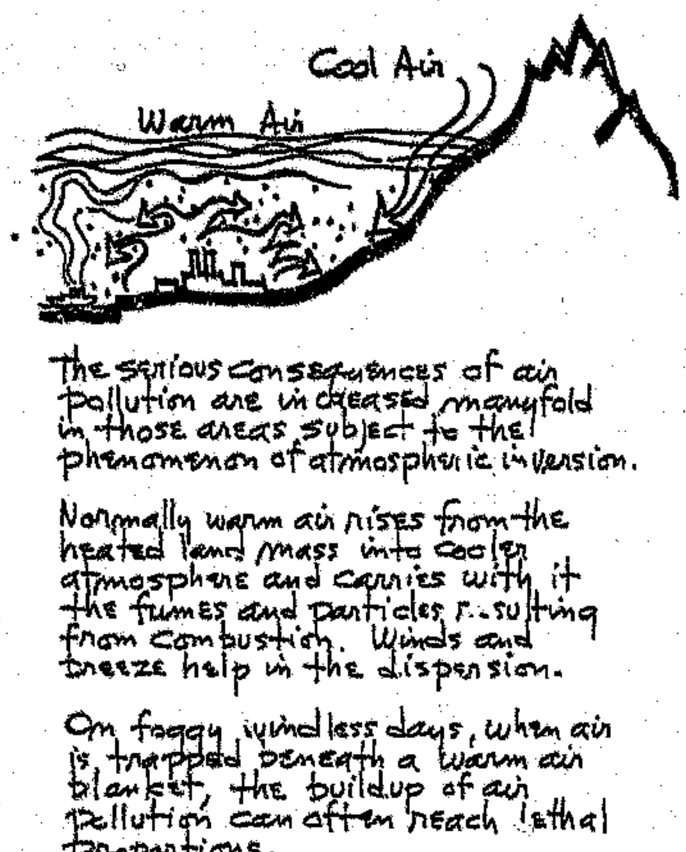


Fig 10.7 - Micro-climate - Inversion layers develop over cities due to specific environmental characteristics. (Simmonds, 1986)

10.2.4 Neighbourhood Scale

(a) <u>Solar Access</u>

On the neighbourhood scale the individual buildings become important as it, in conjunction with the stand layout determines the solar access of each and every stand. In sunny South Africa the potential of passive solar design has been ignored in so many of the neighbourhoods. Solar design had been incorporated by the ancient Greeks and Chinese as far back as 500 B.C. (Solar Energy Society of Southern Africa, 1993).

As is clearly illustrated in drawing - *Solar Insulation - Africa and Europe*, South Africa has a huge untapped source of energy. In fact South Africa is one of the countries with the largest area with an insolation value of more than 6.0 kilowatt-hours per square meter per day, second only to the Saharan countries. The most solar kilowatt-hours in Europe is 5.0, in Switzerland and 5,5 in Western USA.

(b) <u>Optimising Stand Utilisation</u>

By placing buildings as close to the entrance boundary as possible the private portion of the stand is available for productive activities - be it growing of vegetables, farming with shacks or fixing vehicles. By doing so the defensibility of the public space is optimised (after Newman, Alexander and others). This clearly demonstrates how environmental factors influence the social functioning of communities. See Fig 10.6.

Courtyard configurations also optimizes the area available for building (see the principle of the Fresnel square, Senior, 1988). This principle could be used in developing block layouts to maximise the communal space within the block. These areas are then freed for agricultural production.

(c) <u>Micro-Climate</u>

The micro-climate of the area also comes into play on this scale. Slope orientation, drainage of cold air, anabatic and catabatic (day and night breezes) air circulation and even soil colour and composition could become influencing factors. By understanding the topography of the site and effects of the above mentioned factors appropriate design guideline could be developed in assisting the community and other professionals in addressing micro-climate, rather than ignoring it. See Fig 10.7.

(d) <u>Geo-technical Aspects</u>

On a neighbourhood scale the specifics of soils are very important. Collapsible sands or expansive clays could

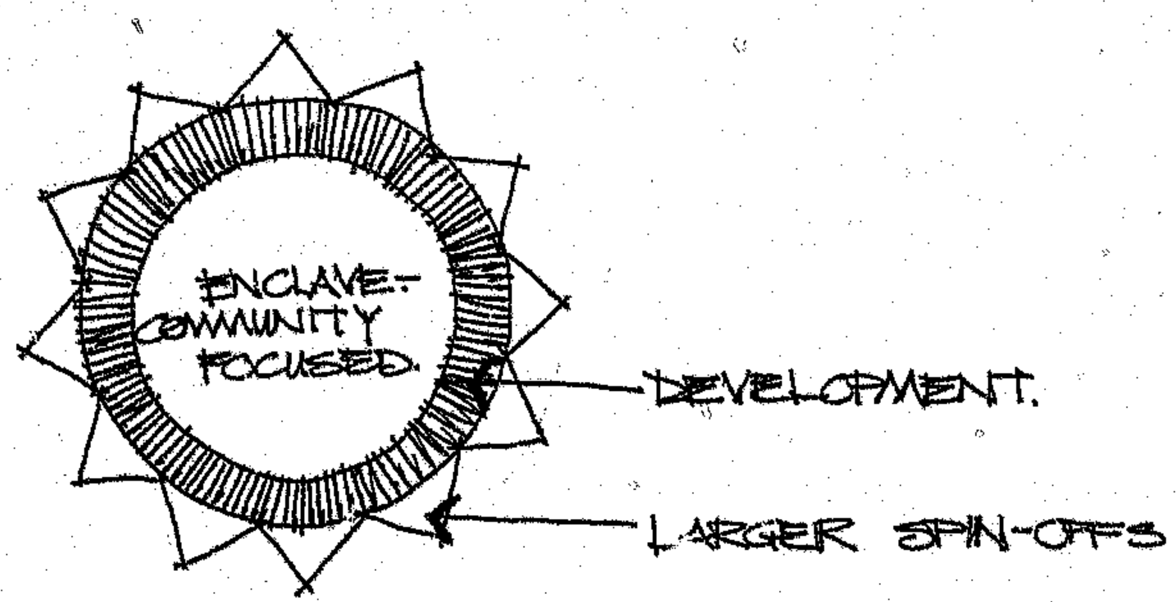


Fig 10.8 - The Enclave Settlement as a model for informative economies.

not only add to the costs, but make any development totally unpractical. Soils, in association with the geology give the site its geo-technical properties, which might make a scheme totally unfeasible or unsafe for occupation. A good understanding and study of the existing soil will therefore determine what area should be developed - it becomes a critical factor in the more local scale planning and design.

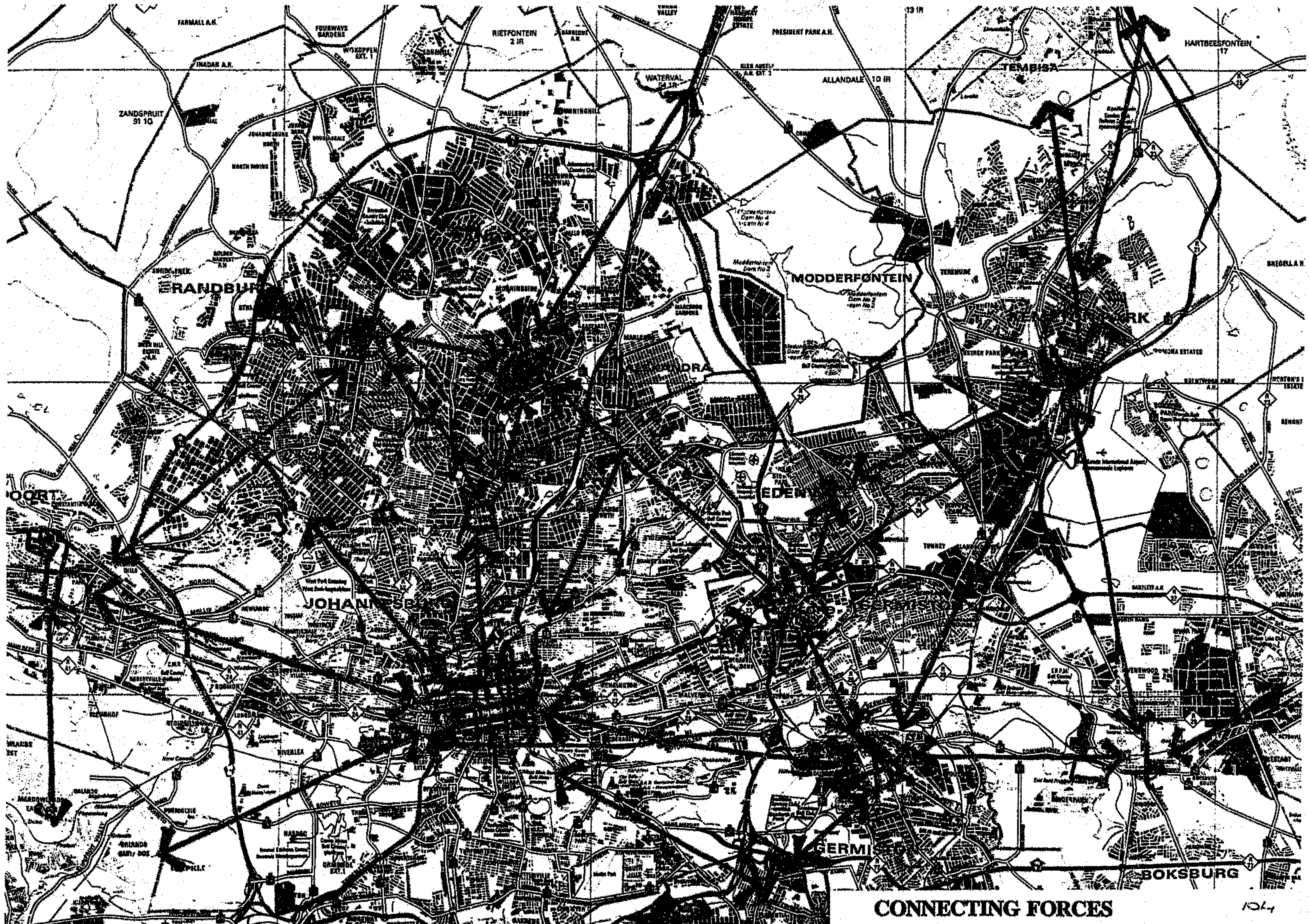
Soils also have positive properties. The agricultural potential of soils should also be considered. Deep rich loamy soils would be wasted if high density housing would be developed. A more sustainable approach would be to allocate this land to urban agriculture, allotment gardening or a use which would add to the existing potential.

10.3 AFFORDABLE HOUSING - AN ENVIRONMENTAL FRAMEWORK

The Apartheid system of segregation and separated development did not only result in duplication of amenities, but also the removal of the poorer communities of society to dormitory towns. These Townships were usually separated from any White community by "buffer zones". The mining land, associated with the Main Reef was one of these buffer zones. This meant that poor people, often unemployed, had the added burden of transport costs to carry. As the law prohibited commercial development within these townships till the late seventies, no employment opportunities existed close to their only lawful home.

Housing is reliant on employment and work opportunity to sustain. Within the Witwatersrand certain connecting forces, between the major employment centres do exist. This makes for a healthy economy through diversity, choice and opportunity. These connecting forces create energy which give rise to economic activity. (see drawing *Connecting Forces*).

Along the mining belt, just south of the expanse of industrial development had become sought after land for commercial development as it is well connected, with good access and infrastructure. It has also been investigated for the provision of housing to the millions living in squatter camps and informal settlements. The identification of development enclaves (see drawing *Enclave Developments*) could identify parcels of land available for settlement of people close to economic opportunity. These settlements would be glued together by the connecting transport routes and the function landscapes resulting from floodline restrictions, shallow undermining and poor soil types. See Fig 10.8.



CONNECTING FORCES

ENCLAVE DEVELOPMENT

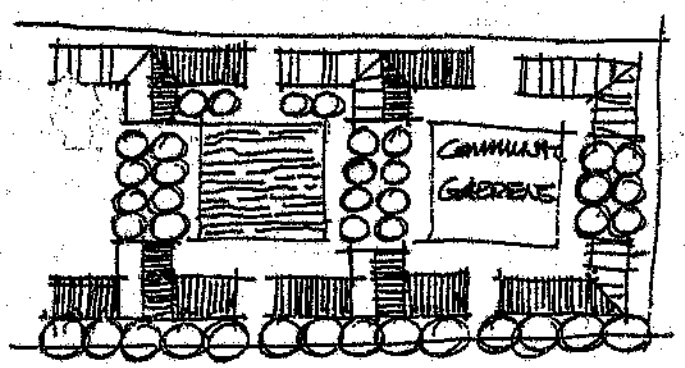


Fig 10.9 - Mid-block Agriculture - a local scale landscape option to incorporate in housing projects also addressing environmental concerns.

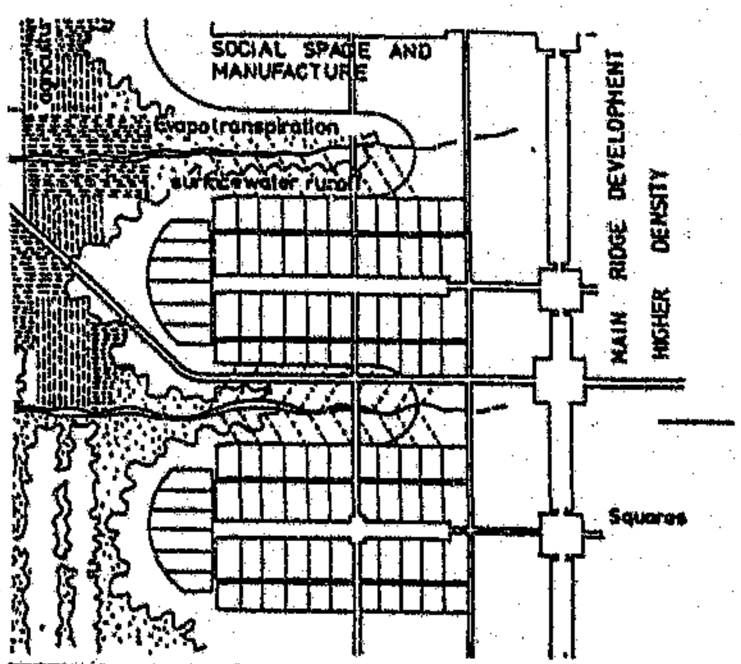


Fig 10.10 - The "Ways of the Water" - a catalyst for mid-block agriculture. Based on the Marionhill case study in Dewar and Uytenbogaardt, 1991.

It has been said that the only way in which poorer communities will be able to be incorporated into our market economy is to position affordable housing close to economic opportunity. These people require security of tenure, basic services, but more than that - they need food, skills and a means to plug into the urban economy. The notion propagated within the case study to follow is that most of these informal settlements consist out of rural people, with rural skills. Most of them had some knowledge of agriculture. Land should thus be allocated in such a way that agriculture could be incorporated within the settlement - within the block. Fig 10.9.

Initially the tenants would produce food for themselves, while looking for work, or building a house or learning a skill. Soon the income would be supplemented by selling a portion of the crop. Once the occupants are able to compete in the urban employment market the production of food would be neglected and only have a supplementary function. This would free some space to build additional rooms to rent out. The rural economy of producing vegetables would now make way for an urban economy of "farming with shacks". The next generation of rural emigrants would at least have a foothold, shelter and access to the urban economy.

Agriculture requires water. It is proposed that water should be collected from surface run-off, treated effluent and domestic grey water. These collecting drainage ways and detention ponds, would, as the area becomes more densely populated, become the open space structure. The idea of functional landscapes as the future of parks, lawns and trees is thus promoted. These "ways of the water" would in future become the recreational space and would still be assisting in managing stormwater run-off. See Fig 10.10.

11.0 THE SITE

11.1 INTRODUCTION

The site, situated in Boksburg - between Reiger Park and Commissioner Street - has already been identified as a terrain for affordable housing provision. The City Council is in the process of negotiating with ERPM regarding the reliance of this land for this purpose as the shaft is in the process of decommissioning.

The study will show the implications of the previously explained urban design principles to set the framework for suitability incorporating urban ecology, as well as critical urban, social and economical opportunities and constraints which will ultimately make this proposal practical and sustainable.

11.2 LOCAL CONTEXT

The site is situated between Commissioner street (north) and Reiger Park (south) a coloured township south-west of the CBD of Boksburg. Towards the east it slopes down to the Cinderella Spruit and Dam. E.R.P.M. owns the ground to the west of the site, which include the Angelo Dam, reduction plant, hostels and associated engineering works. See Drawing *Site Analysis*.

The site was chosen as the mining activity on the site will be discontinued shortly. Like so many other situations the underground mining restricted surface development. This "undevelopable" strip of land running east-west has been used as a buffer zone between "white" cities and "non-white" townships. This has also been the case in Boksburg.

Reiger Park was developed with lots of small stands, schools and even a floodlit sports stadium - the W J Clement Stadium. Recently a clinic and community centre was added to the expanse of "little boxes". Small retail developments were allowed within the neighbourhood, but no provision was made for job creation, for business and commercial activity.

METROPOLITAN CONTEXT

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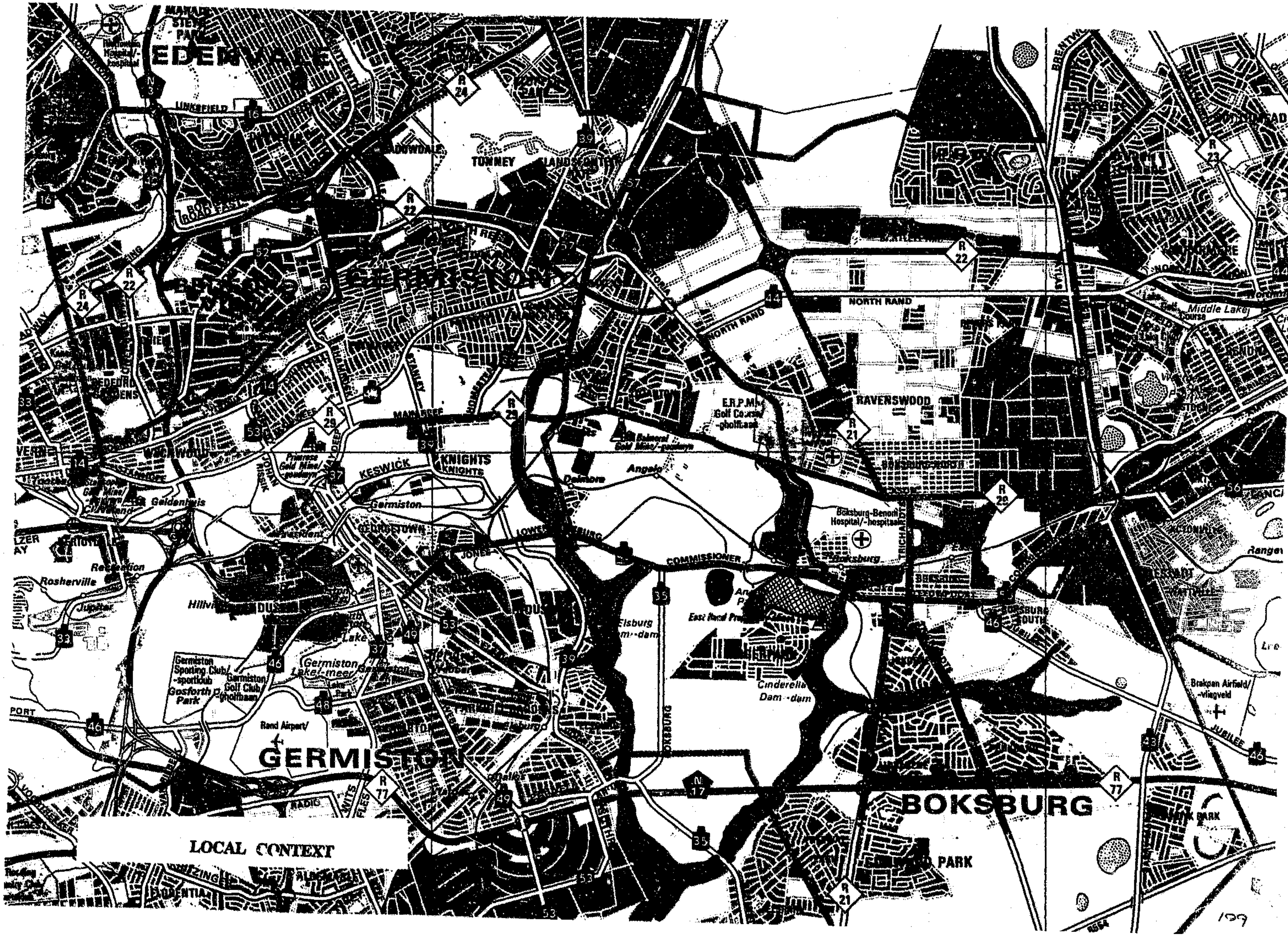


LOCAL CONTEXT

Reiger Park is at present totally over populated with a population net density of 5000 people per hectare or even more. (Boksburg 2000, 1985) Job creation is a pressing problem as unemployment has left the community poor, underfed and crime is uncontrollable. Reiger Park is a dormitory town which is lacking economical, and ecological *sustainability*. As a result of two of this the whole community becomes unsustainable.

Through the choice of this site an attempt is made to improve the present situation. The site would physically, and mentally connect Reiger Park to the energy spine of Commercial Road (running from the Germiston CBD, through Germiston Industrial, Boksburg CBD to Benoni). Some of the existing energy and activity generated by the road could be utilised and "plugged into".

By developing this site an important step would be taken forward, by erasing the so called buffer strip separating white and non-white. The land is largely held by the Municipality and E.R.P.M. (who only holds surface rights on most of its land). This would make the development of the land easier as the Council could instigate the process by developing the capital web by making the reconnections and placing public facilities (after Bentley, 1985) and key installations (after Senior, 1988). By doing so they would activate the true potential of the land and market forces would provide the incentive.

The pressing environmental aspects must also be addressed. At the moment it is almost impossible for a child being raised in the township to develop any value for the environment. Play parks and school grounds are dusty with small patches of lawn. The whole neighbourhood is bland, lacking trees, shrubs, flowers and vegetables. Environmental education is impossible as there are no places of environmental interest - the whole visible landscape is the product of man exploiting Mother Earth.

The proposed urban design framework must address these pressing environmental and economic concerns in order to improve the social environment as well. The notion of sustainability as described earlier provide the frame of reference to achieve this. By making the environment work for the people, hereby saving on costs, more capital would be available in future to continue with the proposed programme.

11.3 METROPOLITAN CONTEXT

The municipal area of Boksburg is situated on the East Rand, bordering on Germiston (west), Kempton Park (north) and Benoni (east). Drawing *Metropolitan Context* shows its position relative to the major centres of the

Pretoria-Witwatersrand-Vereniging region. It is quite clear that if present development trends suffice, Boksburg is well situated, just to the east of the strongly developing Pretoria-Verwoerdburg-Kempton Park-Vereniging axis. Because of the well developed communication infrastructure and the availability of undeveloped land this north-south axis is being recognized as an important development core.

Boksburg is also home to the East Rand Propriety Mines (ERPM), who occupies large stretches of land. As in most other municipalities the potential problem of land invasions are investigated. The Johannesburg Consolidated Investments (JCI), another large landowner, has already produced a master plan which indicate specific future development plans of all their land. They are at present negotiating with the c' council on zoning rights, land transfers and joint developments. (Personal communication JCI and City Council)

11.4 HISTORIC CONTEXT

Boksburg is situated on the original farm of Carl Ziervogel, called Leewpoort. It was strategically situated on the Voortrekker wagon route between Heidelberg and Pretoria. The first settlement rose overnight after one P J Kilian and Adolf Vogel, both prospectors, struck gold in the vicinity of Leeupoort.

Prospectors rushed to the area and the Government proclaimed a few farms public diggings. To cope with the increased activity and growing population, as well as the need for local administration and control of the diggings, Paul Kruger insisted in a local survey to establish a town. It was found that all the area in the vicinity had already been taken up by private farms and claims. After a certain amount of adjustments a 1000 erven were put out to auction.

The town was named after Dr W E Bok, the then Secretary of State of the Republic. The first private house to be built was that of the Mining Commissioner in Commissioner street. Most of the public buildings were built on the portion west of the perennial stream, now known as Cinderella spruit. This areas became known as Vogelfontein. Only the Post Office and the Mining Commissioner's offices were built east of the stream.

The lack of any local sources of good quality coal nearly terminated Boksburg and its gold mines. As the reef quickly tilts under the overlaying quartzite, large machinery was required. In 1888 coal was discovered on the farm Vogelfontein, which stimulated the whole mining industry of the Reef.

Soon a railway line was lobbied for between Johannesburg and Boksburg to transport the coal. Kruger at first disallowed it, but the first track was laid in 1890. President Kruger named it the "Rand Tram" - needless to say it was an immediate success. Underground fires during the late 1890's resulted in the closure of the coal mines to the north-east of the lake.

Boksburg was a depressing site during the late 1800's. According to a diary inscription of Mr Moteque White in 1888 "... it struck me as being one of the most uninviting spots I have ever seen ... from the hotel where I was staying not a tree or shrub could be seen." Apparently the closest tree was 15 mile away, popularly known as "The Boksburg Forest". Moteque White played no small part in transforming the landscape surrounding the mining town. He proposed a lake in a vlei to the east of the existing town and a plantation of 40 000 trees to the north-west of the lake. Despite widespread hostility he eventually obtained consent, but only after Paul Kruger himself visited the site and remarked that this is no lake but an inland sea!

Using the local prisoners White embarked on the ambitious project. The lake was completed in 1889 amidst a severe drought. Relief only came in 1891, when an early Spring cloudburst filled the lake overnight. The lake soon established itself as a prominent attraction for picnics, sail regattas and weddings - the first regatta in 1898 attracted 10 000 people.

In 1903 the Heath Council, which governed Boksburg, was replaced with a local authority. Apparently the first mayor was announced a few hours before Johannesburg got their first mayor - the second mayor in the Transvaal. Stands were now sold for more than 150 pounds. Boksburg was now the administrative head of the East Rand. The Courts of the Civil Commissioner, Landdrosts, the offices of the Mining Commissioner, the headquarters of the Police and the Native Departments were all situated within the town boundaries.

In the same year Sir George Farrar negotiated the amalgamation of most of the smaller gold mines into the East Rand Proprietary Mines (E.R.P.M.). ERPM invested alot into Boksburg over the years. 1905 saw the Boksburg-Benoni hospital being opened by the High Commissioner of South Africa. They built the Cinderella Dam in 1915 as a means to assist with frequent water shortage.

Reiger Park was first planned as an Asiatic area named Zindabad, but when it was proclaimed in 1952 as a coloured township, it was renamed after one of Jan van Riebeeck's ships - De Reyger. It officially consists as 268 erven and the first extension, in 1973 added another 567 erven. The council is presently negotiating with ERPM on the purchase of some 23 hectares to add 800 stands to the north of Reiger Park Extension 1.

11.5 SOCIO-ECONOMIC CONCERNS

The mining history of Boksburg resulted in distinct socio-economic class differentiation. The municipal area could, without detail research, be understood in socio-economic terms. Unfortunately the 1991 census statistics could not be obtained to verify the below mentioned conclusions.

Boksburg has developed a very haphazard settlement pattern. Communities dispersed across large areas with considerable open space between neighbourhoods. The term "lost space" (after Trancik, 1986) immediately comes to mind after studying the morphology of the area.

Boksburg does not include a so-called black township, although Vosloorus lies immediately south of its municipal boundary. Dawn Park and Windmill Park are both "grey" settlements to the south of the N17. A new neighbourhood has been laid out south-east of Dawn Park, but no houses were built as a result of the present recession and the security problems of living close to Vosloorus.

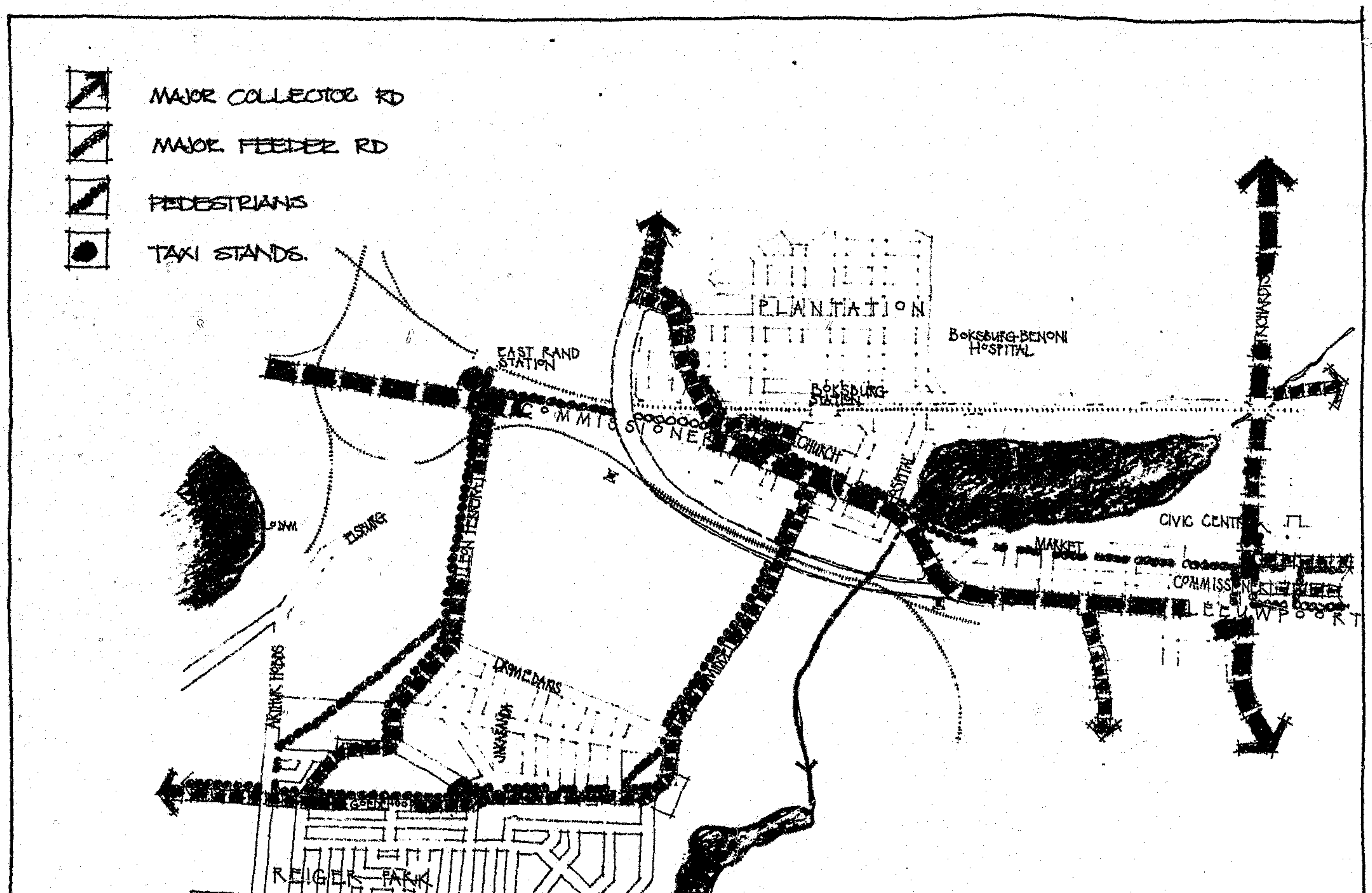
The white communities, for the most part, surround the CBD, highways and major access routes. The more wealthy neighbourhood is situated south of the CBD (between the CBD and Vosloorus). North of the CBD a mix of middle class and poor white communities are found. Atlasville and Witfield, to the north-east and north-west respectively, are again well established middle-class settlements.

Reiger Park, immediately south of the site, is a large, densely populated, coloured settlement south-west of CBD. The community, by large is poor, presently unemployed and of a low socio-economic class. The present situation will deteriorate upon the decommissioning of the shaft just north of the site.

11.6 INFRASTRUCTURE

11.6.1 Transportation Systems

Boksburg as a municipal area is well connected by road, rail and air, with the Jan Smuts International Airport immediately north of its municipal boundaries. Two highways run east-west through Boksburg - the N12 three kilometres north of the study area, and the N17 one and a half kilometres south of the study area. The site is situated just south of Commissioner Street running east-west, from Germiston through the Boksburg CBD to Benoni. See Drawing *Transportation Structure*.



TRANSPORTATION STRUCTURE

The new (presently under construction) K90 is the northern boundary of the site. Leon Ferreira street forms the western edge of the site. The eastern link from Reiger Park to Commissioner street is Middle road running through the site. It can therefore be said that although Boksburg as a municipal area runs north-south the east-west connection via major roads and highways have become the life-lines of Boksburg - Commissioner street acting as a activity corridor between Germiston and Benoni, also linking several important public facilities within the CBD.

The rail road, also running east-west along the main reef, north of the study area has become an important means of transport for mainly the poorer sections of the population. Reiger Park is a case in point, being situated only one kilometre south of Boksburg East Station. The potential of these stations as activators should form the backbone of the development of activity corridors.

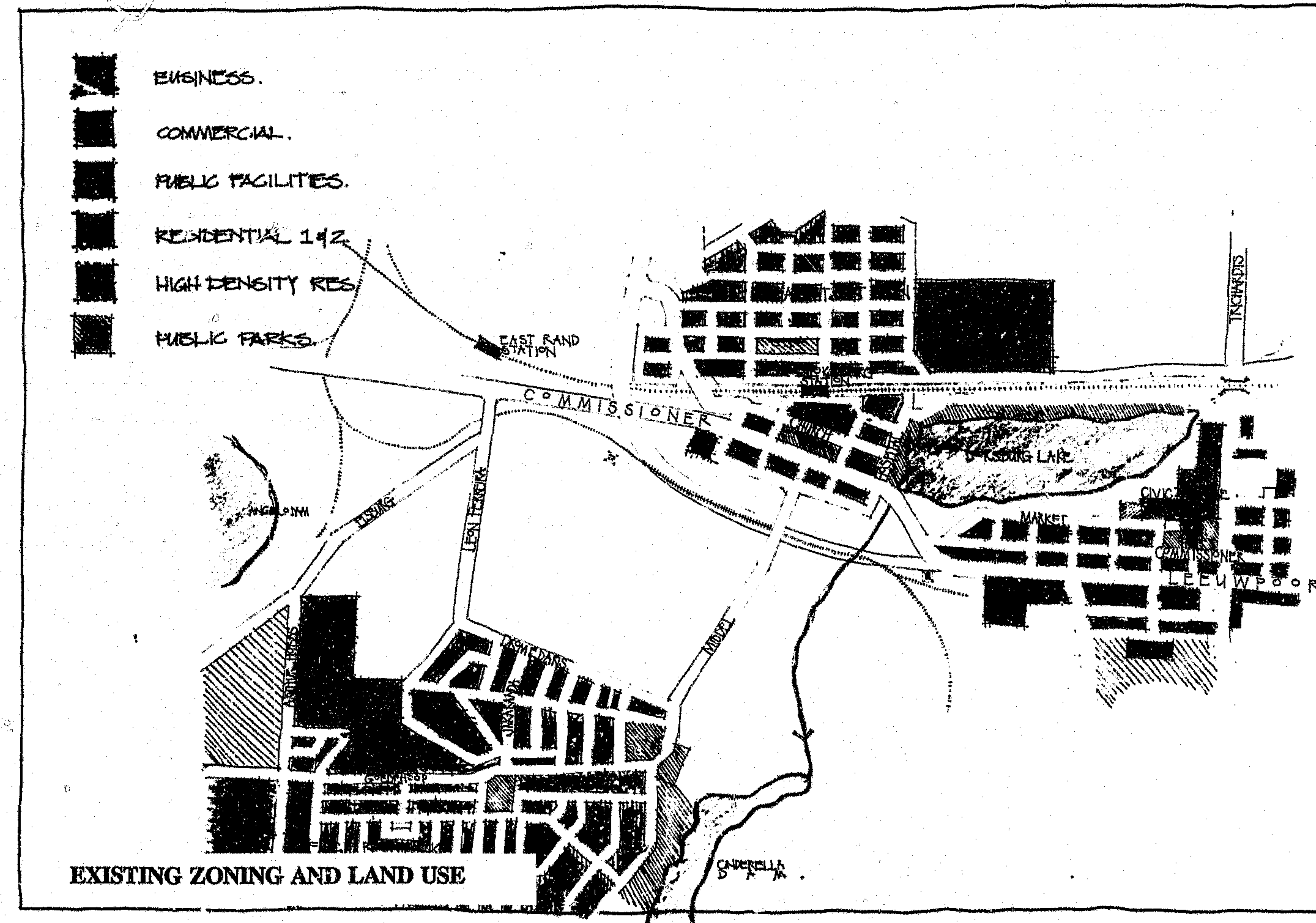
The rail connection along the mining belt has become an important structuring device. The fact that it connects Soweto with Germiston, and Tembisa with Roodepoort is significant. This implies that, as long as one can attach yourself reasonably close to the railway line, the variety of choice gives one the flexibility of an enormous job market. The cost in time and monetary terms of travelling does add to the complication, but the choice is the opportunity.

As far as energy is concerned trains are much more economical than any other existing system. The implementation cost burden of a technological advanced system such as light rail will kill the poorer communities and Witwatersrand capital development budget. Within our Third World milieu, capital intensive projects place enormous burdens on money needed for more pressing social problems - food, health and shelter.

11.6.2 Zoning, Land use and Ownership

The general zoning reflects a mono-functional approach to the development of residential, business, retail and industrial area. Typical of most municipalities the practice of "blob" zoning is evident. Large industrial and commercial areas dominate the land use north-east and north-west of the CBD. Neighbourhoods are also designed with "blobs" of retail and business centres. See drawing *Existing Zoning and Land Use*.

Vertical zoning can only be found in the older parts of Boksburg, where small shops usually have flats on top of them. The traditional corner cafe or shop has been replaced with shopping centres and larger shopping malls. No attempt was made to integrate the residential component with the other land uses.



EXISTING ZONING AND LAND USE

Boksburg's dispersed layout is largely the result of vast tracks of land being owned or the surface right being leased by the mining companies. This is also the case with the site, largely belonging to E.R.P.M. The municipality also owns the south-western corner of the site. As the site has seriously been erode by mining activity the privately owned land could be bought at a reasonable price (personal communication - Boksburg City Council) See Drawing *Land Ownership.*

Owners of undeveloped land are presently in the process of analysing their situation as squatting is becoming a major problem. This is also the case with the site in question. If left undeveloped for much longer, an informal settlement could grow overnight. The need for affordable housing close to employment, of transport to employment sectors is a pressing need.

11.6.3 Energy and Activity

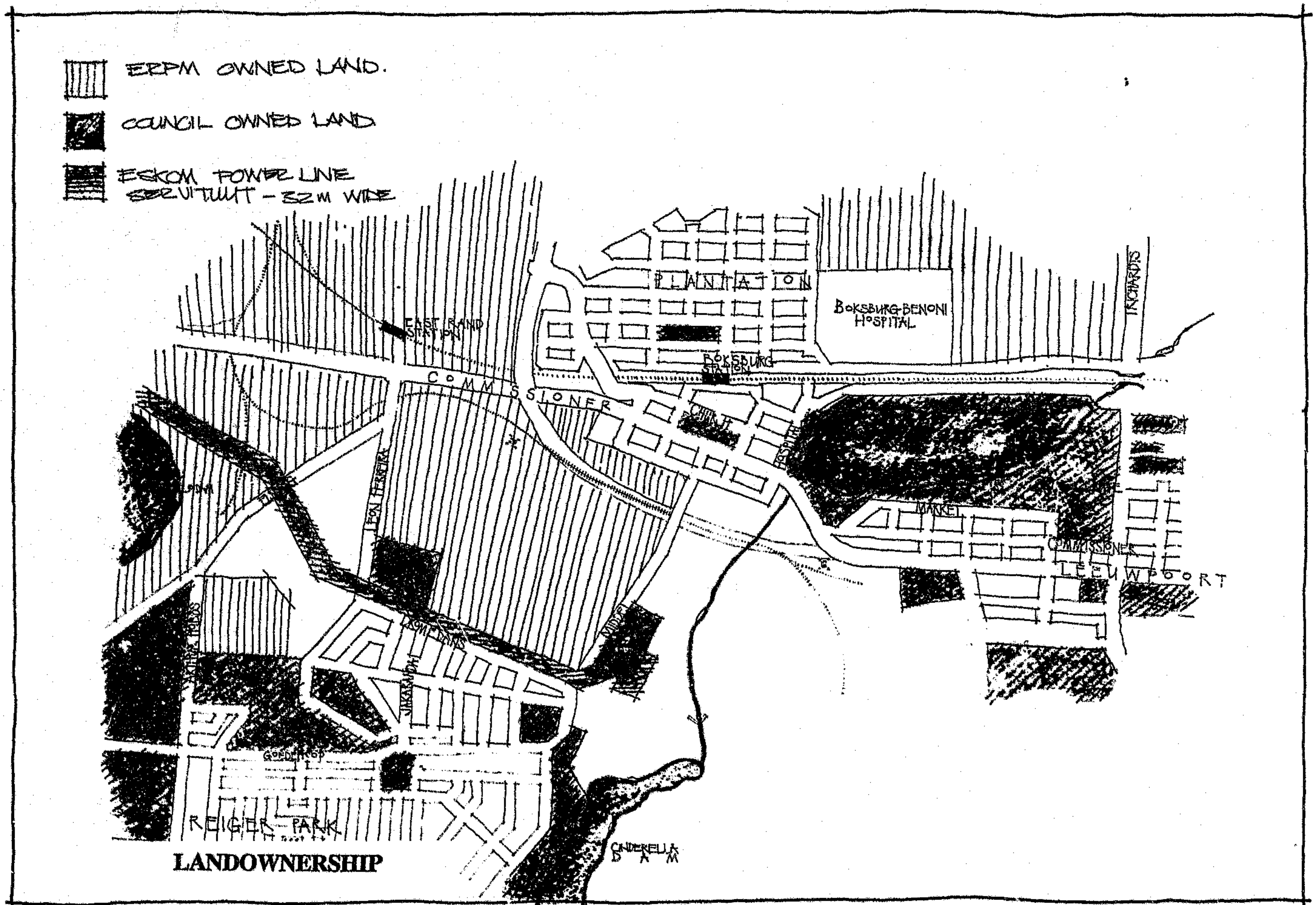
The narrow municipal area, stretching from Kempton Park in the north to Vosloorus in the south, will have a significant influence on strengthening the above mentioned development axis. The strong east-west connections are important activators. This include the railway line, Commissioner street and the highways.

The first hypermarket was developed in Boksburg. This has grown to become the Boksburg Mall, one of the largest shopping centres in South Africa. The fact that it is situated just south of the N12 and right next to the termination of the Pretoria-Jan Smuts highway, the R21 confirms the energy which exists along the axis.

On a local scale the most obvious places of activity are the nodes which developed as a result of the Reiger Park access routes intersecting with Commissioner street. Small informal taxi ranks have developed at the points, with a informal market latching on to the activity of these intersections as an indication of the potential of these intersections.

The two stations (Boksburg and East Rand stations) are also places full of energy and activity. Positioned only one kilometre apart, they are physical reminders of the duplication of the apartheid system. The fact that both are situated in line with the only two access routes into Reiger Park suggest the potential of these amenities in the "new", non-racial South Africa.

The existing shopping strips within Reiger Park are very important social focuses. As most people rely on their feet to get to the shops. The pavement, parking area and adjacent land has become important gathering places with informal trade dimensioning the social spaces. The importance of a more mixed land use pattern is clearly demonstrated by these same retail nodes.


ERPM OWNED LAND.
COUNCIL OWNED LAND
ESKOM POWER LINE
SERVITUUT - 32M WIRE
EAST RAND STATION
PLANTATION
BOKSBURG-BENONI HOSPITAL
TRICHARDTS
BOKSBURG STATION
COMMISSIONER
MARKET
COMMISSIONER
LEEUWPOORT
JAKARANDA
REIGER PARK
CINDERELLA DAM
LANDOWNERSHIP

The schools, clinic and parks also seem be have become activity nodes. As most families are young, with more than four children per family (personal communication - Boksburg City Council), places where the children recreate has also become important social areas. The focus of any new developments should be associated with the important public facilities as was also suggested by David Crane, Dewar and others.

11.7 ENVIRONMENTAL DATA

11.7.1 Introduction

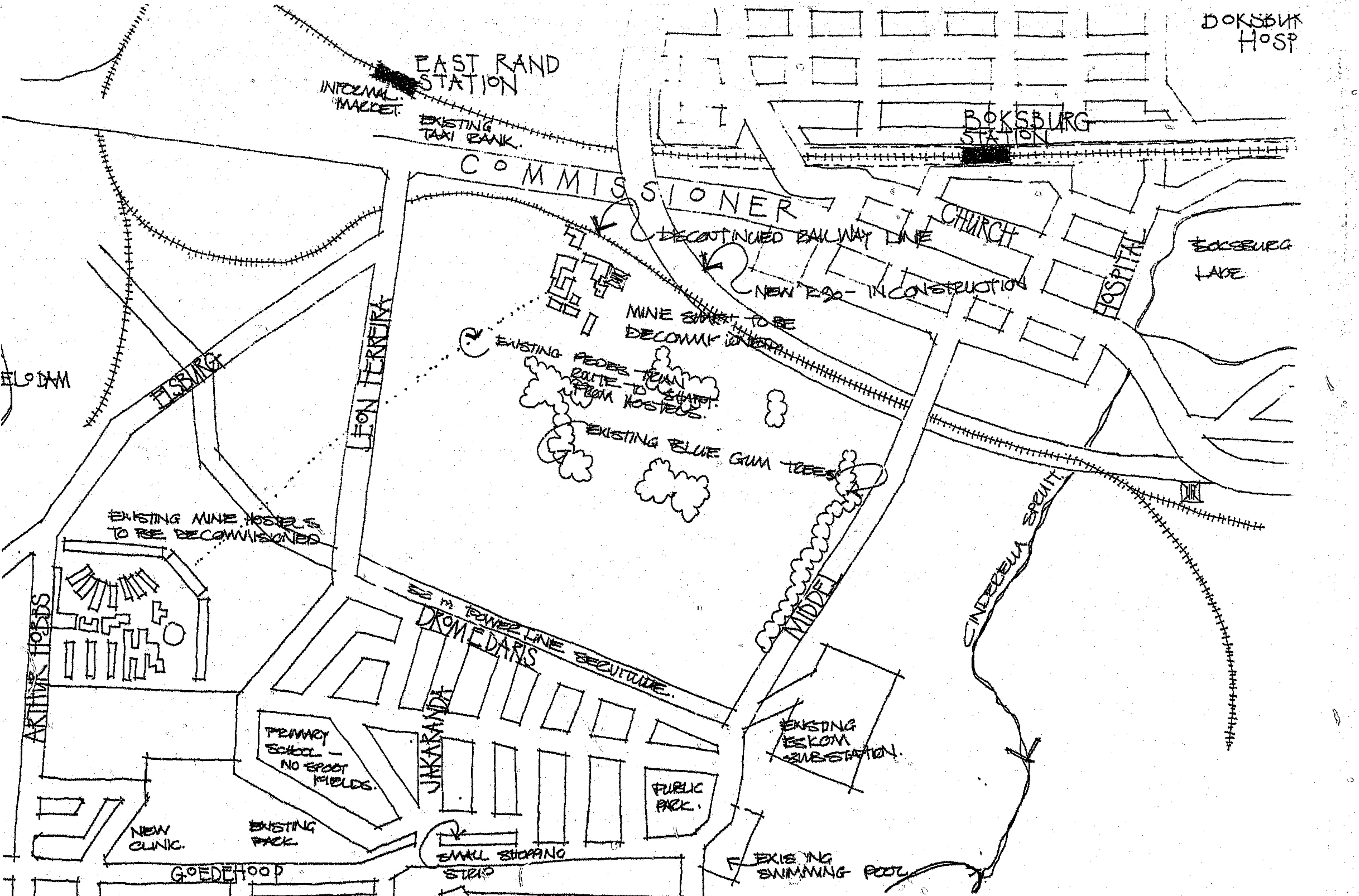
The mining history has severely altered the ecological and aesthetic environment of Boksburg. The only natural features still remaining are Ralf's Pan (in Jet Park) and the existing water course. Mining activities are extremely destructive with large mine dumps (presently all in the process of being recycled), the many slimes dams, spoil dumps, blue gum plantations and scattered buildings over a vast area of land.

11.7.2 Topography

Boksburg is situated on a fairly flat landscape as is the case with most East Rand towns. The dominant geology, being dolomite, give rise to a soft rolling landscape as it weathers easily once exposed to the elements. Small intrusion of quartzite exists in the area. An exam is found just south-east of the site. The gold-baring reef produces no notable topographical change as it is angled at more than 26 degrees to the vertical.

The small rivers and streams flowing through the landscape creates only shallow ravines, because of the small difference in levels. Marshes and vleis are common in the landscape as a result of the geology. The landscape therefore tends to be flat and uninteresting, especially to the east.

A few large water bodies exist in the main drainage ways, being the Homestead valley (in Benoni), the Cinderella Spruit and the Elsburg Spruit (west) - all draining in a southerly direction. Interest should therefore be directed towards the small valleys, marshes and dams as a means to accentuate the topography. See drawing - *Site Analysis*



SITE ANALYSIS

11.7.3 Climatology

(a) <u>Wind</u>

As Boksburg is situated on a fairly exposed landscape wind is recorded from almost every direction, especially in winter. These winds are often gusty and strong as no topographical barrier exists to reduce the velocity. The most persistent wind directions are the following:

SEASON	DIRECTION	FREQUENCY
Summer	North-North-West	27 - 42 %
Winter	North-West	27 - 28 %

As there seems to be no clear dominant wind direction in winter (which is the most uncomfortable and cold wind) no specific guidelines can be extracted. But if one considers the notion of the wind being more persistent from the general direction of the north-west, no land uses which create an order or discard of large amounts of polluted air or smoke should be placed in this sector of the town. It should be noted that on a city scale the new Jet Park Industrial area is being developed exactly north north-west of Boksburg. This could result in order and pollution problems in the future.

(b) <u>Rainfall</u>

Boksburg receives a fair amount of rain, as is the case with most of the Witwatersrand. The average precipitation is said to be between 688 mm - 742 mm per annum. The highest ever recorded rainfall was in 1909 when 1087,6 mm was measured. During 1935 the lowest rainfall was recorded - a mere 409,7 mm.

This confirms the fact that Boksburg has been seen as a productive agricultural area. Especially more to the south of the N17 highway, where good soil is found vegetables and other crop farming still persists adjacent to urban development. The production of food close to the urban area therefore is both possible and viable and must be promoted.

(c) <u>Temperature</u>

Boksburg, as the whole Witwatersrand has a "moderate" climate referring to the fact that the temperature fluctuations are moderate and therefore comfortably above freezing temperatures. It is always difficult to extract representable figures from tables of recorded temperatures, but the following should give an indication of the weather:

SEASON	MAXIMUM	MINIMUM	NIGHT-MIN
Summer	26.4 °C	16.7°C	5.1°C
Winter	14.3 °C	3.2°C	-5.1°C

Frost is common in the region. Only data taken in Germiston was obtainable. The most common period for frost is said to be between 1 June - 24 August, with an average of 8 - 10 days of frost per season. It could therefore be said that the weather in summer is moderate to warm, with hot days. Winter is also moderate, and because of the flat, open topography frost pockets and severe frost is limited to extreme weather conditions.

(d) <u>Solar Data</u>

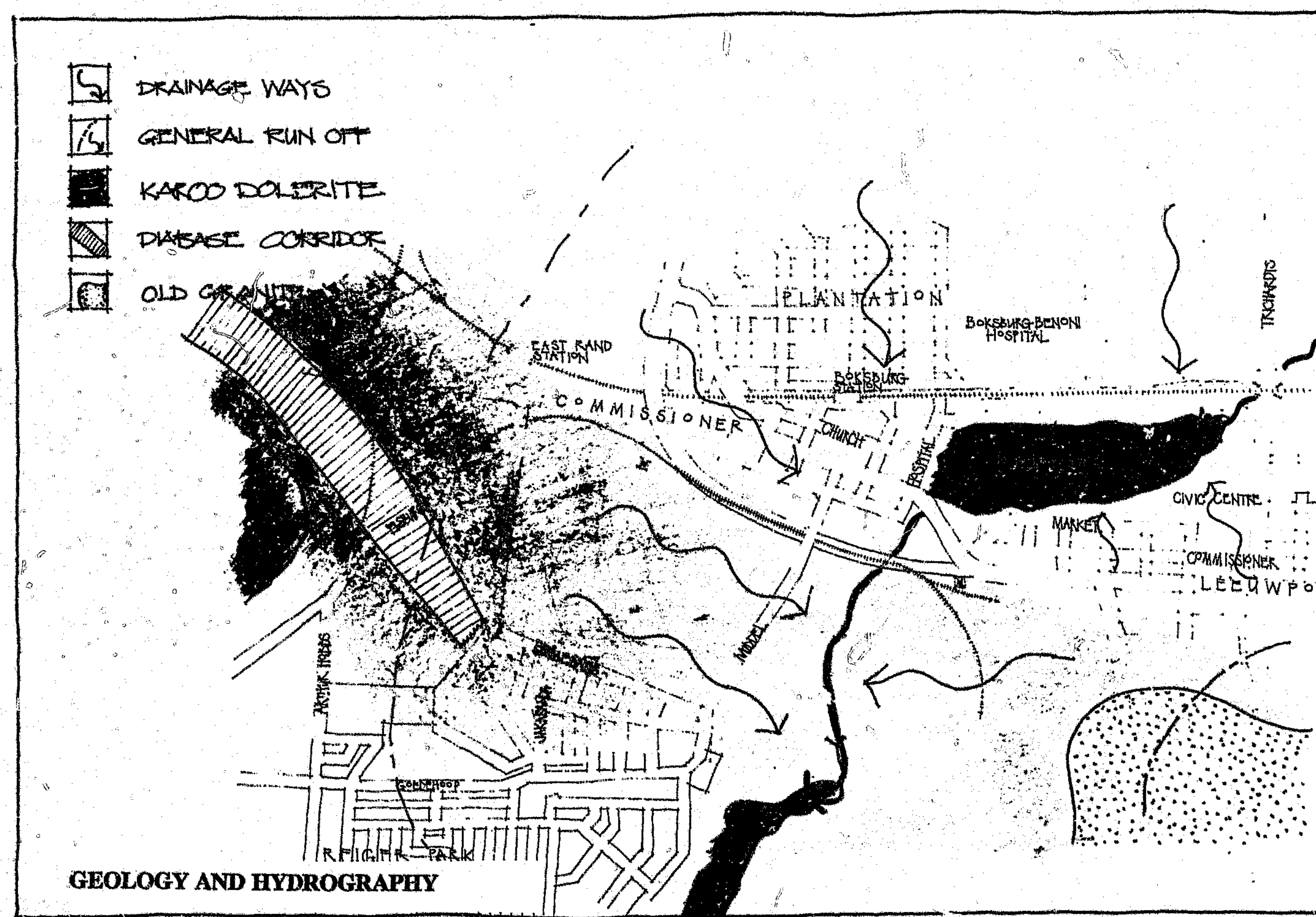
Boksburg, like Johannesburg is situated on the 26th latitude, which results in the following solar angles:

SEASON	DATE	ANGLE OF SUN
Summer	22 December	88 °
Winter	22 June	41 °

These angles should play an important role in the detail design of all buildings in the area. It not only influences the interior climate of the building, but also the winter shadows on adjacent properties. Solar angles should therefore always be investigated and the results incorporated in design guidelines for urban developments. In the case of the 26th latitude the problem is in winter. A northerly orientation is important to ensure winter comfort within buildings (especially those with no air conditioning systems - which is the goal in this case). In winter the shadow reaches a stage of more than double the height of the building (49 down from the vertical) - in summer the shadow is reduced to 2 degrees from the vertical.

11.7.4 Geological Substructure

The geological formations evident on the site are found between the Johannesburg and Turffontein subgroups - both gold baring quartzite reefs. The site itself is situated on Karoo dolerites, with a small diabase corridor



GEOLOGY AND HYDROGRAPHY

penetrating the formation from the north west. Both geological formations are stable and suitable for development. The area in general forms part of the Transvaal super group, one of the oldest geological formations in South Africa. See Drawing *Geology and Hydrography.*

Further to the south, towards Vosloorus, dolomite is found, which is classified as unstable geological formations (forms part of the Malmani sub group). These specific areas are not known to have any sink holes and therefore housing development has taken place.

11.7.5 Hydrography and Drainage

Most of the East Rand is considered to be a flat rolling landscape largely as a result of the geological substructure. The general fall of the area surrounding the site is to the south and the Riet Spruit basin.

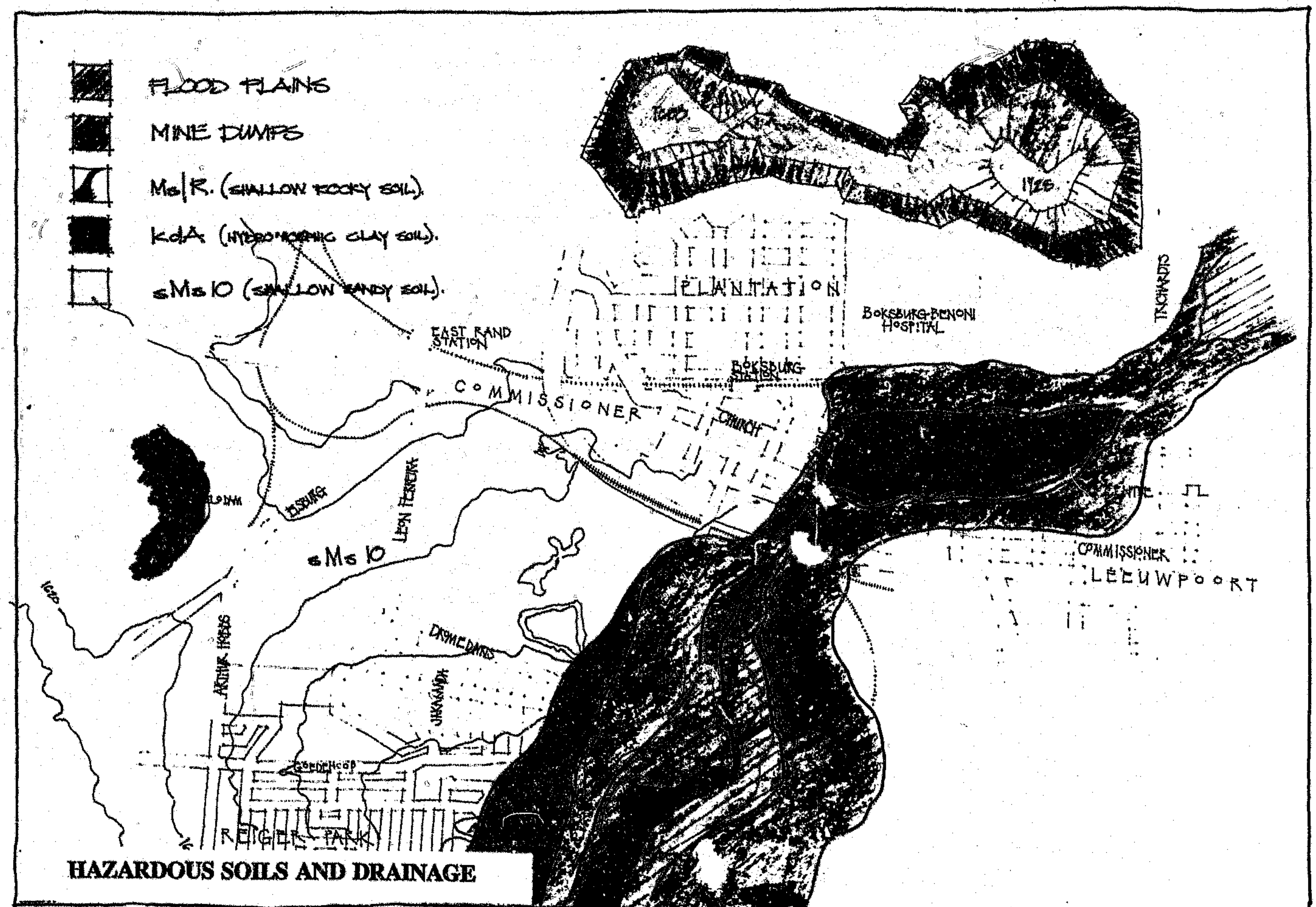
The Cinderella Spruit basically drains the most of the Boksburg municipal area. It stretches from the Boksburg East Industrial area, through the CBD towards Reiger Park and joins the Elsburg spruit further to the south-west. Two notable dams exist in this drainage basis. The first being the Boksburg Lake, which was the main attraction of Boksburg during the early part of this century. Presently the Civic Centre, as well as other recreation facilities are situated on its banks, but sadly under utilised.

The second dam is the Cinderella dam, built by E.R.P.M. as a retention dam for their water requirements. This beautiful large dam is actually sterile because of all the seepage from the adjacent mine dumps. The water quality is visually pleasing, but actually no life is possible due to the toxins, low pH and sulphur in the dam.

The Angelo dam, to the west of the site, was also built by E.R.P.M. as a retention dam for their refinery, treatment works and mining activity. It is actually situated on the crest of a gentle mound and is totally surrounded with mineral rail tracks and mine buildings.

The site itself drains south east towards the Cinderella Spruit and the Cinderella dam - which form the eastern geographical boundary of the site. As can be expected of a urban river flowing through old industrial areas and the CBD, the stream is very polluted. The City Council is monitoring the situation at the moment and water samples are taken regularly to determine the cause of the pollution.

It is therefore proposed that a portion of the stream should be designated to introduce natural mechanisms to improve the water quality. Weirs, reed beds and detention ponds should be introduced as means to improve the water quality.



HAZARDOUS SOILS AND DRAINAGE

11.7.6 Hazardous soils

Soils are a very important environmental component of a site. The characteristics of the top soil, as well as the subsoil must be noted and understood. Soil affects the corrosion of underground services, the structural design of foundations, fitting, paved areas and other structures. Boksburg is known to have large expanses of clay soils in the depressions and shallow, rocky soils on the crests of the undulating landscape. See Drawing *Hazardous Soils and Drainage*.

In the Reiger Park area the pH of the natural soil poses no problems, but the constant pollution of run-off from the adjacent mine dumps, have resulted in the Cinderella dam becoming sterile as a result of the low pH of the run-off. This also affected the pH of the soil surrounding the lake. The site is not particularly affected by this though.

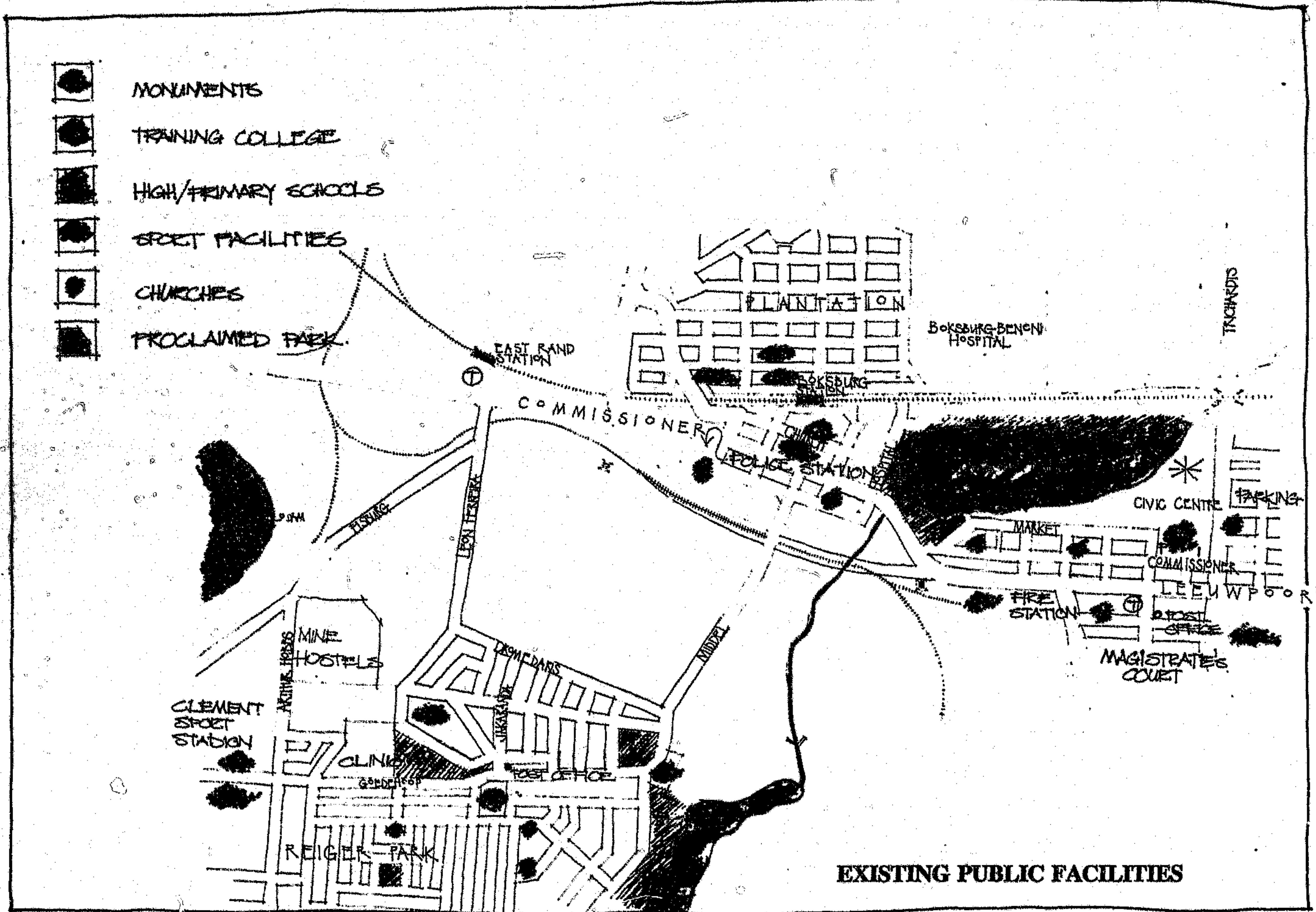
The flood plain of the Cinderella valley, east of the site, consists out of two dominant layers. The top portion could generally be described as a deep (1500 mm +), grey sandy loam or sand with no inherent structure. This is characteristic of an imported or alluvial soil and is common to flatter drainage basins. This top layer is therefore considered to be fertile and useful agricultural land. Beneath it a grey hydromorphic clay is found with a moderate blocky structure and calcareous characteristic. In association with the high water table of the area this subsoil have heaving properties which make these areas unsuited for development. The distinct difference of the two layers, as well as the heaving properties of the subsoil and shallow water table make this area more suited for ecological, recreational or agricultural type uses.

The rest of the site itself is situated on a shallow, brown-grey structureless sandy-loam on sandstone, with quartzite outcrops and swithstones. These areas pose no real problems for building, although trenching and excavations could be difficult in places.

The site has also been used as a terrain for dumping of excavated soil in localised area which should be analysed. Large areas have also been disturbed by mining activities. It could therefore be said that the whole area to the west of Middle Road could be developed without serious additional costs. The area west of Middle Road should rather be utilised for agriculture as it would result in serious additional cost to be developed. The flood plane itself, being waterlogged, should be used as a stormwater detention area, as well as a water purification zone.

11.7.8 Fauna and Flora

As the site has been exposed to mining activity until recently, it has been denuded of its natural indigenous



EXISTING PUBLIC FACILITIES

vegetation through the years. Only some of the indigenous veld grasses still sustain. Because of the shallow, unfertile soils one would not have expected many trees and the area most probably has been a grass plato.

Several invader species have established in the disturbed areas as well as the clumps of large blue gums scattered across the terrain. As most of the site has got no valuable plant communities, it could be developed accordingly. The long history of human presence, noisy mining activity and the lack of any rich habitat no animal populations are worth conserving.

11.8 CONCLUSION

From studying and understanding the social, economical, functional and environmental data of the study area more appropriate decisions can be taken. The urban ecological approach calls for the development of urban environments based on sound environmental principles. The fact that this site has been disturbed and almost been denuded from all its natural features is a problem. But the opportunity locked in this fact is what we should focus on. In the synthesis of the above it must be noted that critical social, functional and environmental features could complement each other. The Cinderella spruit has not only scenic beauty, but is of ecological value. The potential of aquaculture, stormwater detention ponds, vleis and weirs, all would add to the environmental potential of the site. But the social and functional spin-offs of the above will only add to the site, as well as reduce the cost to society and the environment.

12.0 SYNTHESIS AND CONCLUSIONS

12.1 CONSTRAINTS

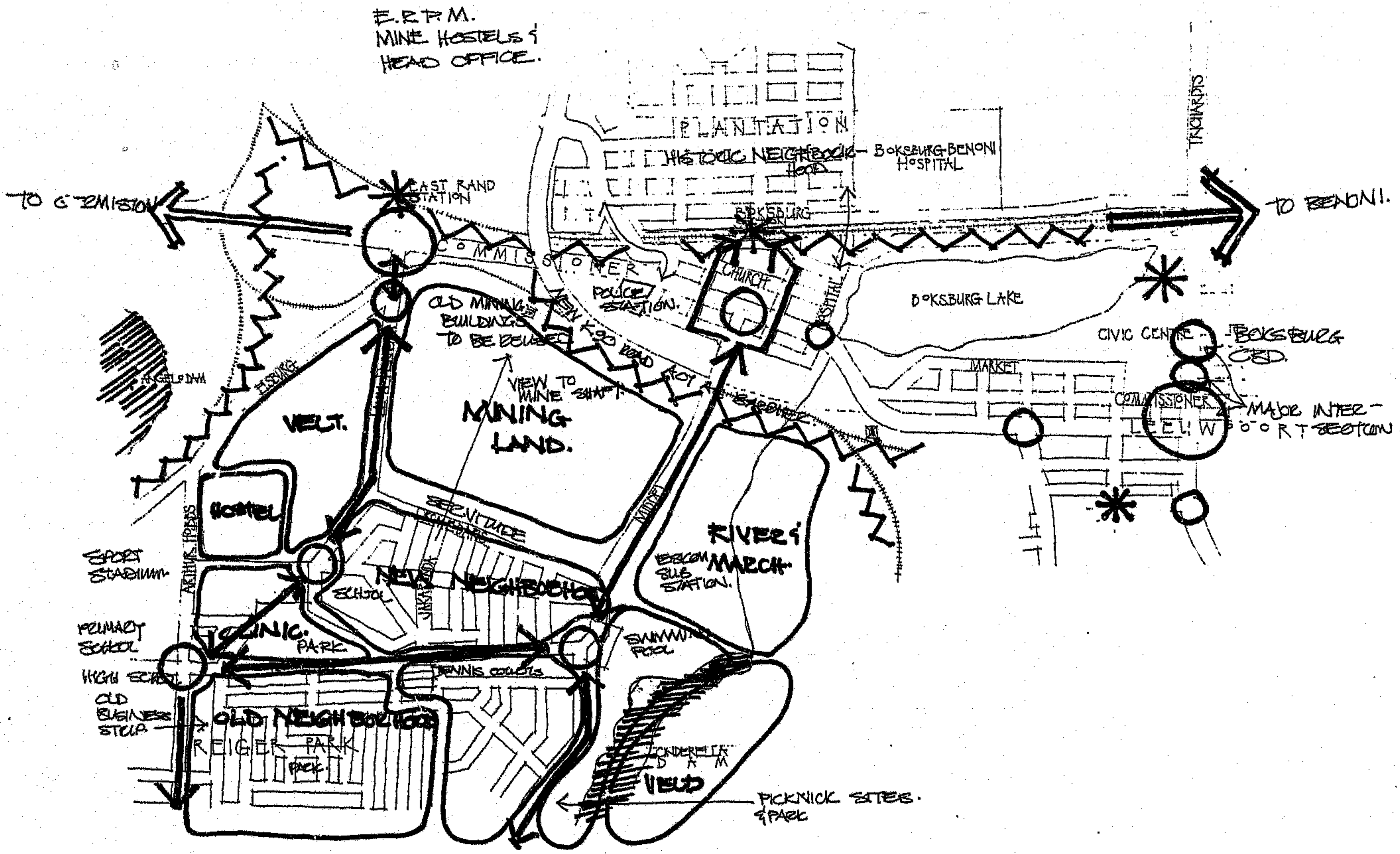
The present limited economic activity is certainly the most pressing problem. The fact that as part of the apartheid system no or limited business, commercial and industrial development were allowed in, or near the non-white townships. These people had to travel great distances to work and back every day. The limited education, knowledge resources and ability to network for information is another serious social problem relating to the Reiger Park community (personal communicatio). Most of the people do not know how to read and write, make their own clothes and a range of other basic skills.

The wide road servitude which is associated with the new K 90 route physically keep the site away from the Commissioner street. Only Leon Ferreira and Middel streets run through to Commissioner street allowing energy to permeate, uninterrupted, along the spacial connection.

The ESKOM power servitude, 32 m wide, running directly north of the existing Reiger Park again becomes a spacial diversion between the old neighbourhood and the new development. The space should again be developed as a functional landscape, creating activity and bring people from both sides into the spa.

The neglect and pollution of the Cinderella spruit and dam is eroding the ecological potential of the drainage system to function - the biological component of this living system is being killed as a result of the fact that no value, be it ecological, social, educational or economic had been placed on the area, and the water flowing through it.

The road structure, layout and street width of the existing Reiger Park resulted in a disinterested community and a lack of public life as a result of the three-dimensional environment which grew from the planning layout. The potential energy lock into the road hierachy (at present all roads are the same width, but some are used more frequently) has not been exploited through the capital web of public facilities.


E.R.P.M.
MINE HOSTELS &
HEAD OFFICE.
TO GERMISTON
EAST RAND STATION
COMMISSIONER
PLANTATION
HISTORIC NEIGHBOURHOOD
BOKSBURG-BENONI HOSPITAL
TO BENONI.
BOKSBURG
CHURCH
POLICE STATION.
BOKSBURG LAKE
CIVIC CENTRE
BOKSBURG CBD.
MARKET
COMMISSIONER
MAJOR INTERSECTION.
OLD MINING BUILDINGS TO BE REUSED
VIEW TO MINE SHAFT.
MINING LAND.
VELT.
HOSTEL
SERVITUDE
RIVER & MARCH
ESCOM SUB STATION.
SPORT STADIUM.
NEW NEIGHBOURHOOD
SCHOOL
CLINIC. PARK
PRIMARY SCHOOL
HIGH SCHOOL
SWIMMING POOL
TENNIS COURTS
OLD BUSINESS STRIP
OLD NEIGHBOURHOOD
REIGER PARK
PARK
CINDERELLA DAM
VELD
PICKNICK SITES & PARK

12.2 OPPORTUNITIES

As was stressed by Micheal Hough the potential of every situation should be investigated first. The example used was sewerage. If we could see sewerage as a potential resource and not only as a waste, the constraint of cities producing sewerage suddenly diminishes. See Drawing *Opportunities and Constraints*

The most important opportunity is the location of the site. Well served by road, rail and services the infrastructure cost is significantly been reduced. The fact that it is directly accessible from the Commissioner street activity corridor, as well as its close proximity to the Boksburg CBD is an important opportunity.

The good road and rail links to the rest of the East Rand, as well as west to Germiston and Johannesburg allows for access to a larger market. Mass transport is being used on these routes, therefore it would also save in energy. The large, 50 m, K90 road servitude could actually become a spacial connector. If the servitude is used as a functional landscape it would bring people together, tilling, planting and harvesting the land. The same can be said of the 31 meter power servitude immediately south of the proposed site.

In view of the fact that vegetables is known to be absorbing pollutants, especially heavy metals, from the forecasted traffic flow on the K90, the choice of agriculture becomes important. A crop such as maize should be planted. Maize is more drought resistant, the maize are protected by leaves from the possible pollution from the road and maize produce a good yield (2,5 tons - a family of seven require 14 times 70 kg bags per annum - personal communication Institute of Soil, Climate and Water) per hectare.

Alternatively a part of the servitude could be mounded and planted with fast growing trees. The mounding would not only reduce the noise pollution, but the trees would contribute in screening the road as well as improve the air quality. These trees should preferably be a mix of indigenous (for wild life habitats and food) and exotic's (for wood and construction material).

The ecological opportunities will have a definite influence on the urban design. The fact that the site is situated on a stable geology, eliminates the need for additional costs for geo-technical surveys, foundations and road construction. The present soils also clearly direct development to the rocky Mispah soils. The hydroscopic clays in the flood plane suggests the possibility of agriculture.

As the site has been disturbed over a long period of time by the mining activity, no real natural features exist to contend with in the proposed design. The proposed design could be seen as part of the process of rehabilitation. The clumps of blue gum trees are invasive exotic's and need not be incorporated into the layout.

In view of the site being largely undeveloped, and partly owned by the city council, public amenities can easily be developed without the need to demolish anything. The decommissioned mining building could be upgraded to light industrial or commercial uses with minimal cost.

In view of the present problem of unemployment and few work opportunities, the proposed mixed use development will have significant *spin-offs* to the Reiger Park community. The creation of jobs and the improvement of local skills should form part of the implementation of the development. As Reiger Park has little retail activity at the moment, the creation of a self-sustaining community is of paramount importance.

12.3 GOALS AND OBJECTIVES

In urban ecology the goal must be to add to the existing potential locked into the study area. Land-uses conflicting with the potential assimilated from the environmental analysis and ecological principles, should not even be considered. As in nature the social structures supporting the ecological functions, as well as the economic concerns relating to a sustainable environment, must form part of a holistic approach.

The goal would be to develop the site in such a way that we not only meet the present pressing social and economic needs, but that the site again can be integrated with its ecological setting. In other words the site must be able to contribute to ecological functions required to improve the environmental quality.

The objectives could be summarized as follows:

(a) Improve the present functioning of the Cinderella Spruit as a water course and ecological system.

(b) Not to develop the areas with underlying hetromorphic clays. These areas should be set aside for recreation, leisure and agricultural purposes.

(c) Incorporate linking corridors between open spaces to enable the connection of habitats, the migration of wildlife and thus the increasing of the diversity of the ecosystem.

(d) Introduce a variety of functional landscapes - agriculture, woodlots, detention ponds etc. incorporated into a mixed use urban setting.

(e) Propose housing typologies which incorporate passive solar design guidelines. The calls for looking at street layout, block development, stand size and orientation. Solar power should be integrated into the power supply network.

(f) Use buildings, trees and vegetation to regulate and improve the micro-climate. This would call for the planting of wind breaks, deciduous or evergreen trees, screening shrubs and placing of buildings in relation with the above.

(g) The incorporation of planting schemes in creating a hierarchy to spaces. This could be an inexpensive way of giving prominence to certain precincts, as well as improving air quality and human scale.

(h) Localize services such as sewerage treatment, which would make it less expensive in capital costs; more efficient as nature could be used in the secondary treatment phase; the solid waste can be composted and used for agriculture; the local community could take responsibility for it and run it themselves.

12.4 URBAN ECOLOGICAL STRATEGY

The overriding approach in implementing these urban ecological goals and objectives would be to "design with nature". The potential of the environment should be matched with the needs of the community, or socio-economic class which would occupy and use the development. Three important aspects an urban ecological strategy must be pointed out.

A broad understanding of certain *general ecological principles* should be incorporated in the urban design frame-work. These general principles should form part of the basis of the urban design strategy. This would include the closing of energy cycles (recycling and discarding less), the promotion of diversity in activity and opportunity, the understanding of carry capacity and threshold requirements of the site and the different land-uses.

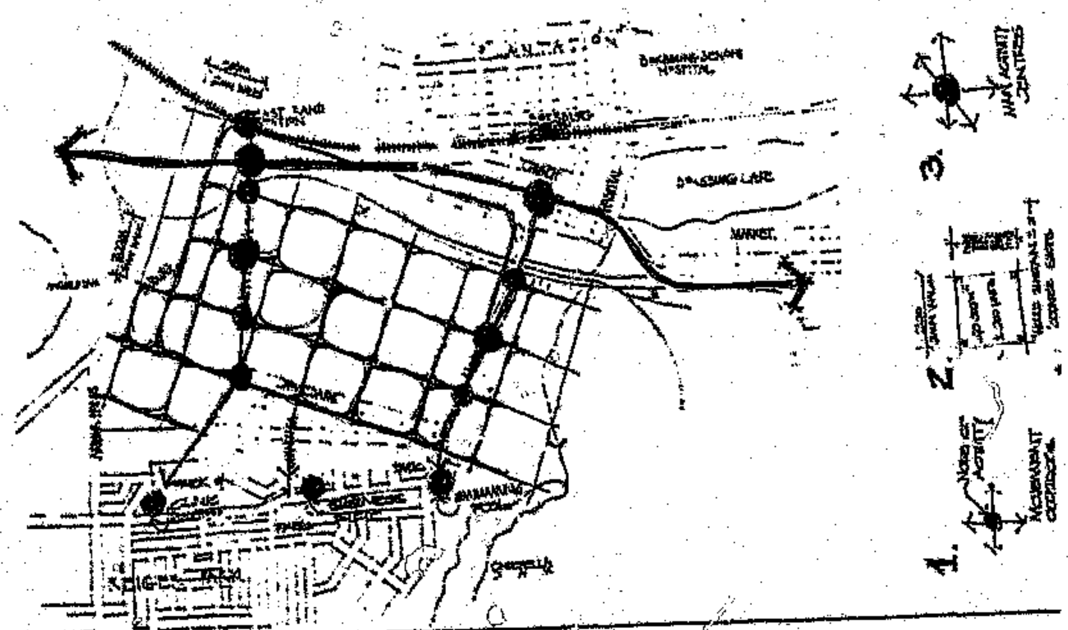


Fig 12.1 - The supergrid as a means to attach a settlement to the land. It was developed from 200 x 200 meter blocks which would allow and promote pedestrian movement to activity nodes at coners.

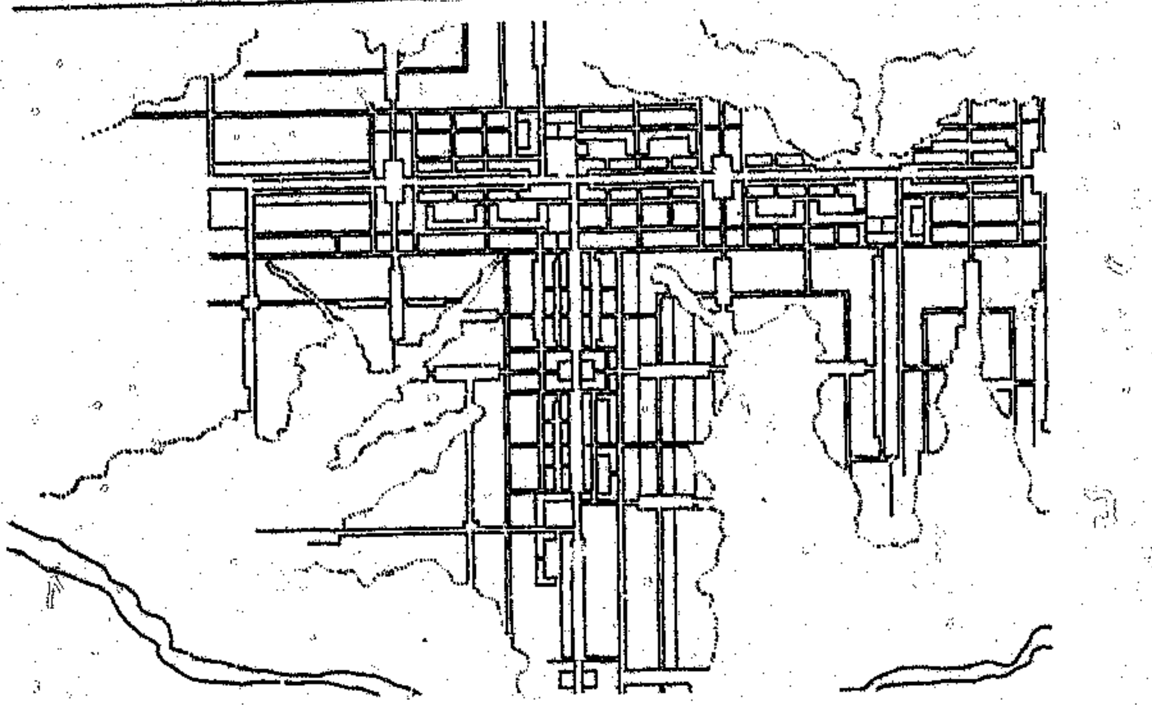


Fig 12.2 - Making cities work harder by optimizing space; mixed land use and direct link between production and consumption. (Marianhill as case study, Dewar, Uytenbogaardt and Rozendal, 1989)

In association with the general ecological principles the study of the local environment will reveal certain *critical environmental factors* related to settlement on the land. These critical factors should be high-lighted and incorporated into the design strategy as determining or deciding factors. The presence of dolomite, heaving clays, collapsible sands or unique habitats are such features which would prohibit development.

The third aspect would be the incorporation of *specific environmental design guidelines* for the layout and design of a sustainable environment. These guidelines would include the orientation of individual stands for maximum solar exposure, the development of on-site treatment of waste, and the inclusion of specific functional landscapes to start a process of self-maintaining communities.

The strategy for the reconnection of Reiger Park to the activity corridor of Commissioner street, the stations and the Boksburg CBD can be described as follows:

- The open space, as dictated mainly by the ecological constraints and servitudes should become more functional and productive to be of value to the community surrounding it. The open space structure is reinforced by the placement of public facilities, schools, sport fields and recreational areas on the edge of it. These key installations would be accessed by means of major connecting roads. See Fig 12.1.

- By picking up from the existing energy along Leon Ferreira and Middle streets, as well as the activity nodes centred around the station, taxi ranks and existing public and retail facilities a few roads are proposed as an initial hierarchy of streets - the rail being of the first order, Commissioner of the second order and Ferreira and Middel streets of the third order. The block sizes, as dictated by the fourth order streets, are determined by the distance a person walks to the local shop (two minutes or 200 meters). connecting elements. See Fig 12.2.

- The road structure should become the channels directing the energy and activity through the community. The interim blocks only define the major internal activity streets. Ferreira, carrying most of the traffic is proposed to become the "high street" of the development, in terms of density, building height integrated land uses - making it more urban than Middel street, facing onto the agricultural allotments.

- The emphasis in the social and housing component of the strategy is directed towards creating a range of housing options, closely knitted in a more urban (as opposed to a sub-urban) environment.

12.5 URBAN DESIGN FRAMEWORK

The urban design framework is a combination of many factors, all with a three dimensional concern into a spacial structure, organising activities, energy, movement, land-use, etc in a diagram or plan. The following procedure was followed in producing the proposed urban design framework for the site:

12.5.1 Open Space Structure

The open space framework was dictated by two factors to a large extent, namely the road and power servitudes and the presence of heaving soils and 50 year floodlines. These areas are designated to open space, but not only lawn and trees. These areas should be given to the community for agricultural purposes, environmental education, as well as recreation and leisure. See Drawing *Green Structure*.

The Cinderella spruit channels all the stormwater from the Boksburg CBD as well as surrounding areas and is therefore under tremendous pressure during storms. A series of detention ponds are proposed to act as a scenic backdrop to the environment, provide irrigation water to the nearby allotment gardens and to feed aquaculture ponds where a local enterprise could farm with fish.

The local sewerage treatment facility, consisting out of a primary treatment plant, screening and aerating the sewerage, as well as a secondary facility which was based on more ecological principles. This would include hyacinth dams (covered with a hothouse structure to enable all year round functioning), reed beds, aerating weirs etc. The effluent is then gravitated into the stormwater detention ponds for further maturation. As the Cinderella dam has a very low pH, as a result of the leaching of chemicals from the nearby sludge dams, the added nutrients in the stream would not enable any prolific growth of algae or water plants.

The primary treatment facility also provides compost for agricultural purposes. The series of dams in the secondary treatment facility produces fodder for animals, produced from the hyacinth ponds. Stormwater detention, aquaculture ponds, an agricultural information centre and sport facilities (in association with the schools). The open space must therefore be promoted as a productive landscape, rather than a horticultural space - full of planting beds, roses, and tree avenues. In doing so these areas would be used and land invasion could be controlled by the community themselves. This would also ensure the maintenance of these areas.

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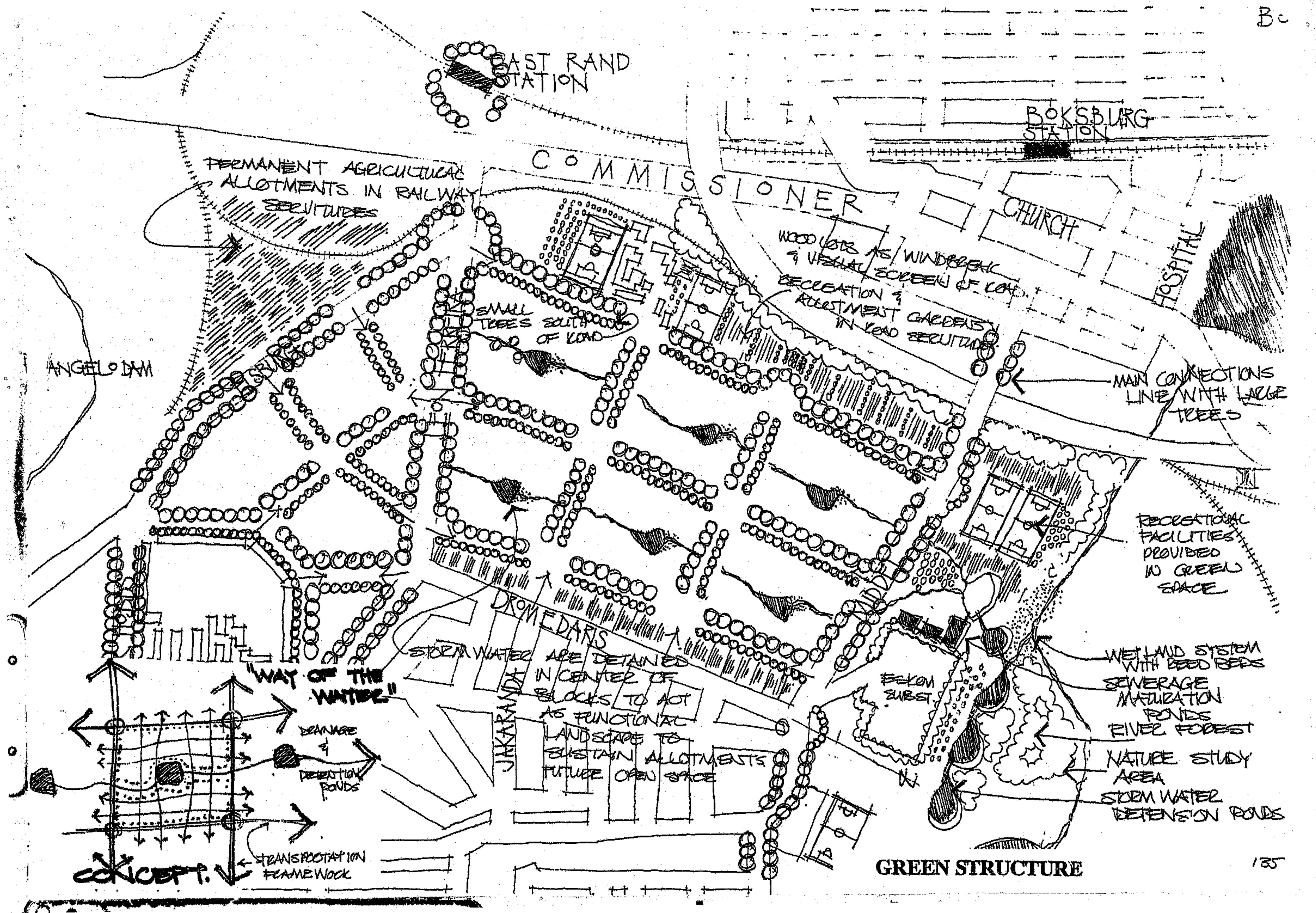


GREEN STRUCTURE

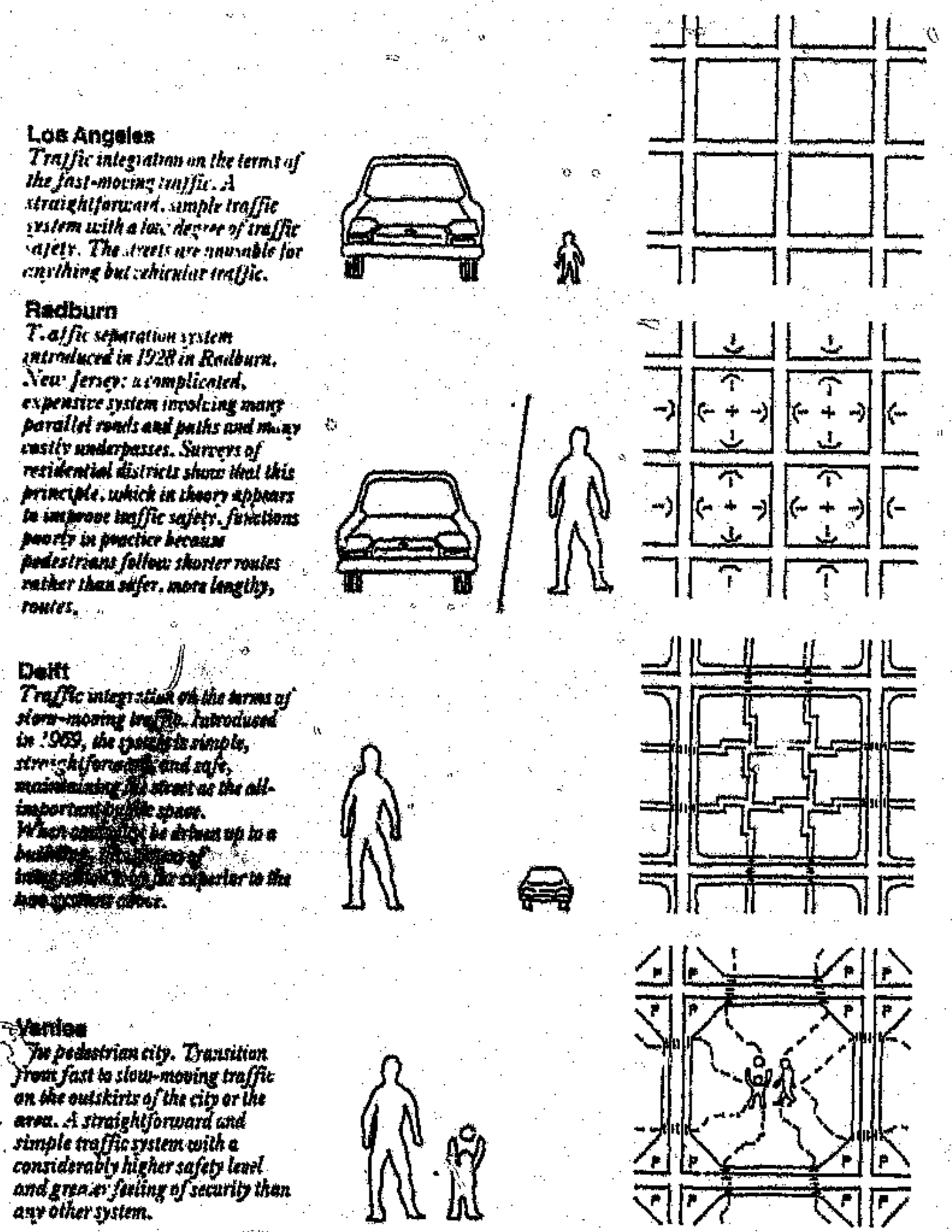


Fig 12.3 - Four traffic planning principles to improve pedestrian movement, as well as allow vehicular access, in Gehl, 1986.

Except for the existing picnic area, most of the open space on the periphery of the new development should be designated to allotment or communal agriculture. As a large percentage of the existing population is unemployed these gardens would enable them to produce their own food. The surplus produce could be sold to the nearby markets.

All the community sport facilities would be provided for at the new and old schools, as well as the Clement Sport Stadium. Community facilities should be shared with Reiger Park as to socially integrate the area.

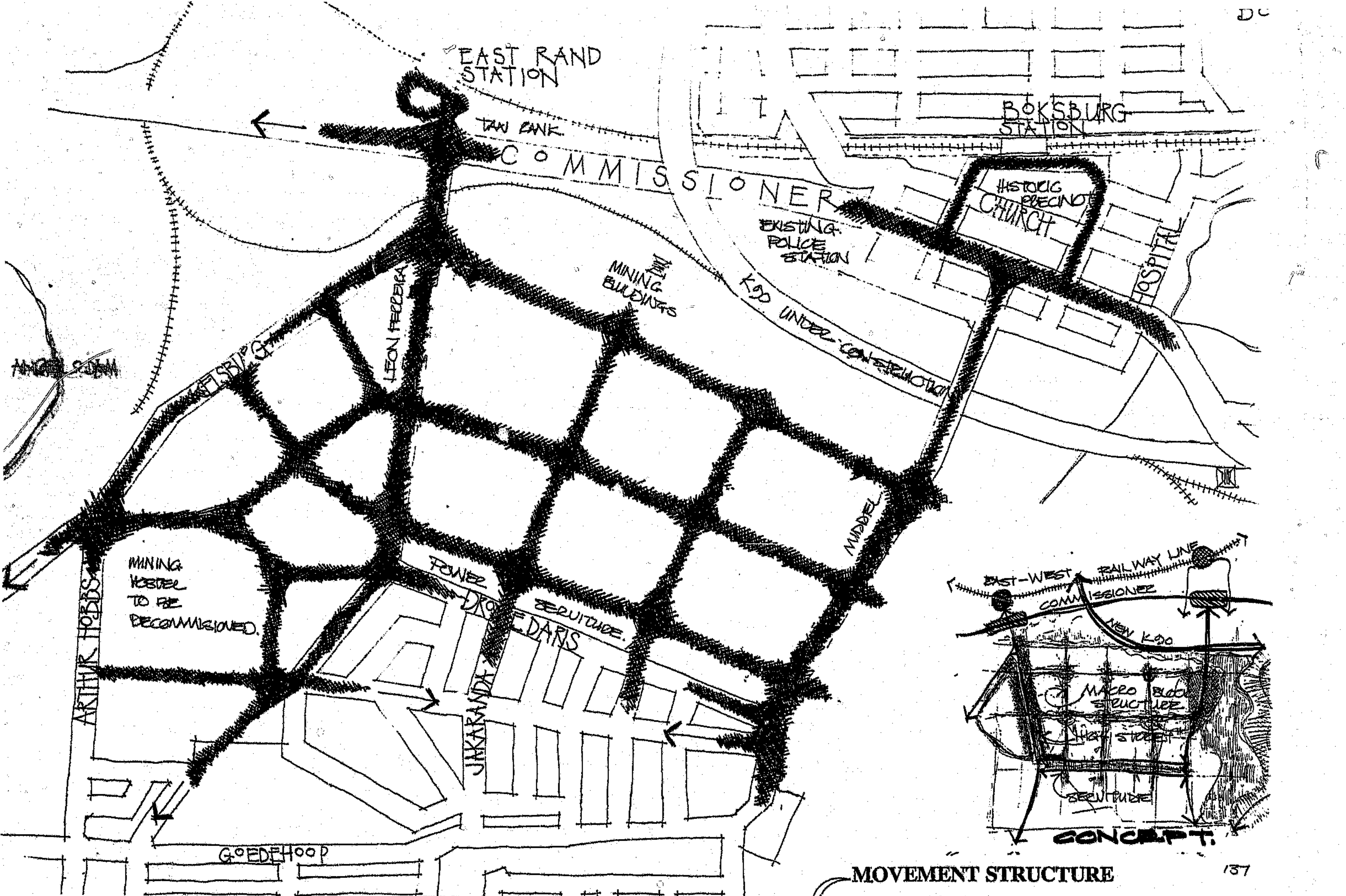
12.5.2 Transportation Structure

The existing two roads connecting Reiger Park to Commissioner street is proposed as the activity spines as these roads already have alot of movement and activity. The permeability into these roads poses a difficult problem. See Fig 12.4 - Four Traffic Planning Principals.

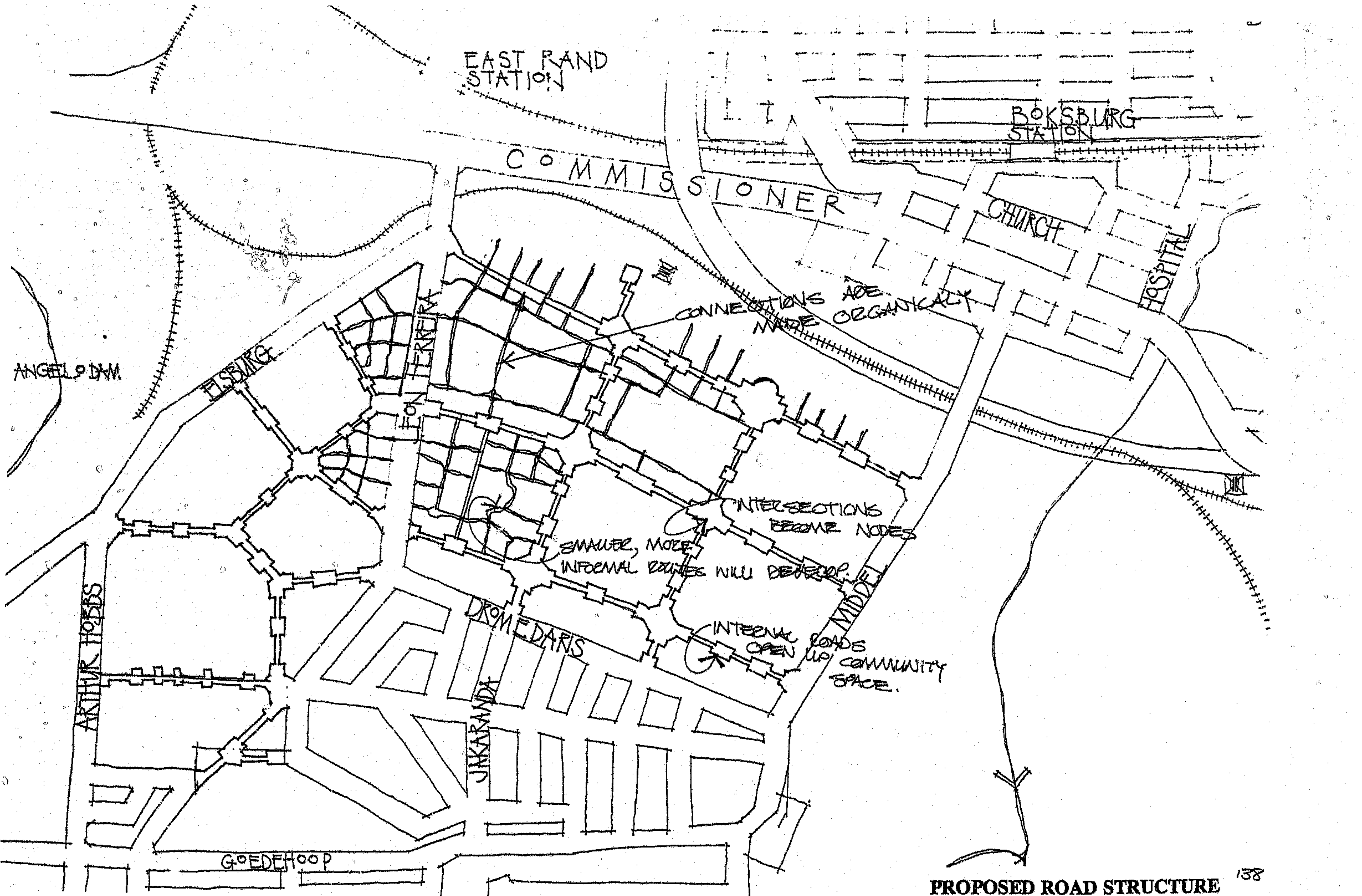
To improve permeability into these roads, as well as to increase human activity short blocks of 80 meters long is suggested. In the light of the present through traffic volume many intersections are not desirable. It is therefore proposed that a supergrid be implemented as a means to organize the community within the 1000 meter by 700 meter site. The size of the supergrid blocks were determined by the walk to the local store or corner shop being ± 200 meters. The blocks were orientated directly north north-east which will also allow maximum solar exposure. See Drawing *Movement Structure*.

Leon Ferreira is seen as the more important "activity corridor" and is therefore proposed as the "high street" with small stands and several public facilities allocated to it. The provisional road servitute is to be seventeen meters wide to accommodate future parking pockets as a means to break the monotony of wide, straight streets. The building line would be the same as the edge of the road servitute. The intention is that people would settle close to the edge of the future street, improving the devensability of the private space and freeing up the stand for a vegetable patch, rentable rooms or a small business.

In mid-blocks the road is widened to accommodate a possible children play area, as well as parking for additional motor vehicles. As the stands facing these parking areas are smaller than the rest, the children will be encouraged to use and play in these spaces. During the nighttime the close proximity of houses increase the surveillance of these parking lots, thus making it a safer place to be in. See Drawing *Proposed Road Structure*.



MOVEMENT STRUCTURE



PROPOSED ROAD STRUCTURE

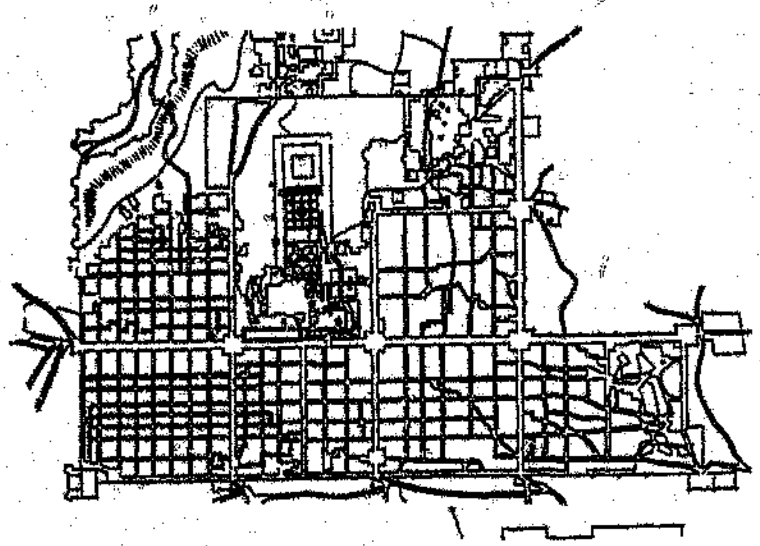


Fig 12.4 - The Supergrid Pattern - the grid in Jaipur acted as a spacial structuring mechanism which enabled formal and organic/informal growth and settlement. (In Dewar and Uytenbogaardt, 1991)

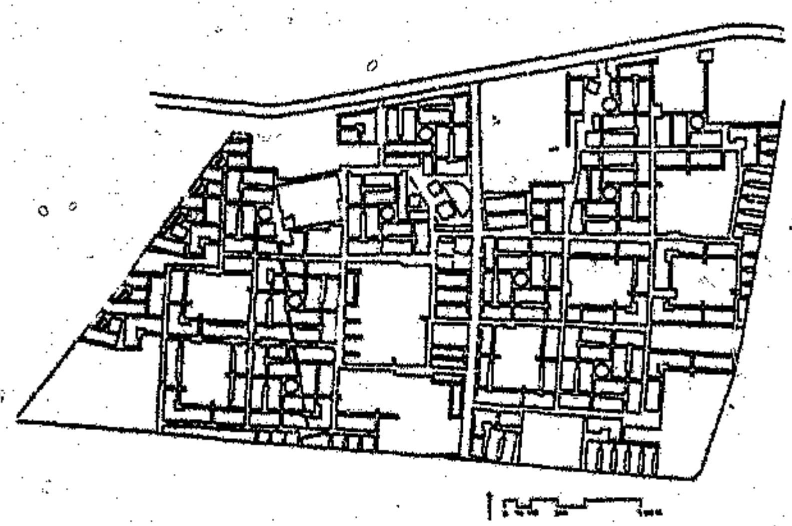


Fig 12.5 - Belhar Housing Development, Dewar & Uytenbogaardt, 1978, was taken as a model describing hierarchy of space - the treatment of intersections and so called "high streets" as catalysts for future commerce. In Dewar and Uytenbogaardt, 1991.

As the settlement grows new minor routes would inevitably develop incrementally, supporting the super grid-structure. The initial large stands would be subdivided to support the minor routes through the mid-block areas. In allowing this the huge initial infrastructural costs would be reduced. These savings would be used establishing the community facilities.

A major connecting road, between Leon Ferreira and Middle streets - immediately north of the power servitude, was specifically proposed to eliminate the idea of the new development "turning its back" to the old neighbourhood. This also allows more houses to face the open space corridor. As this road would connect the community centre with the high school it would also be an important pedestrian link. See Fig 12.5.

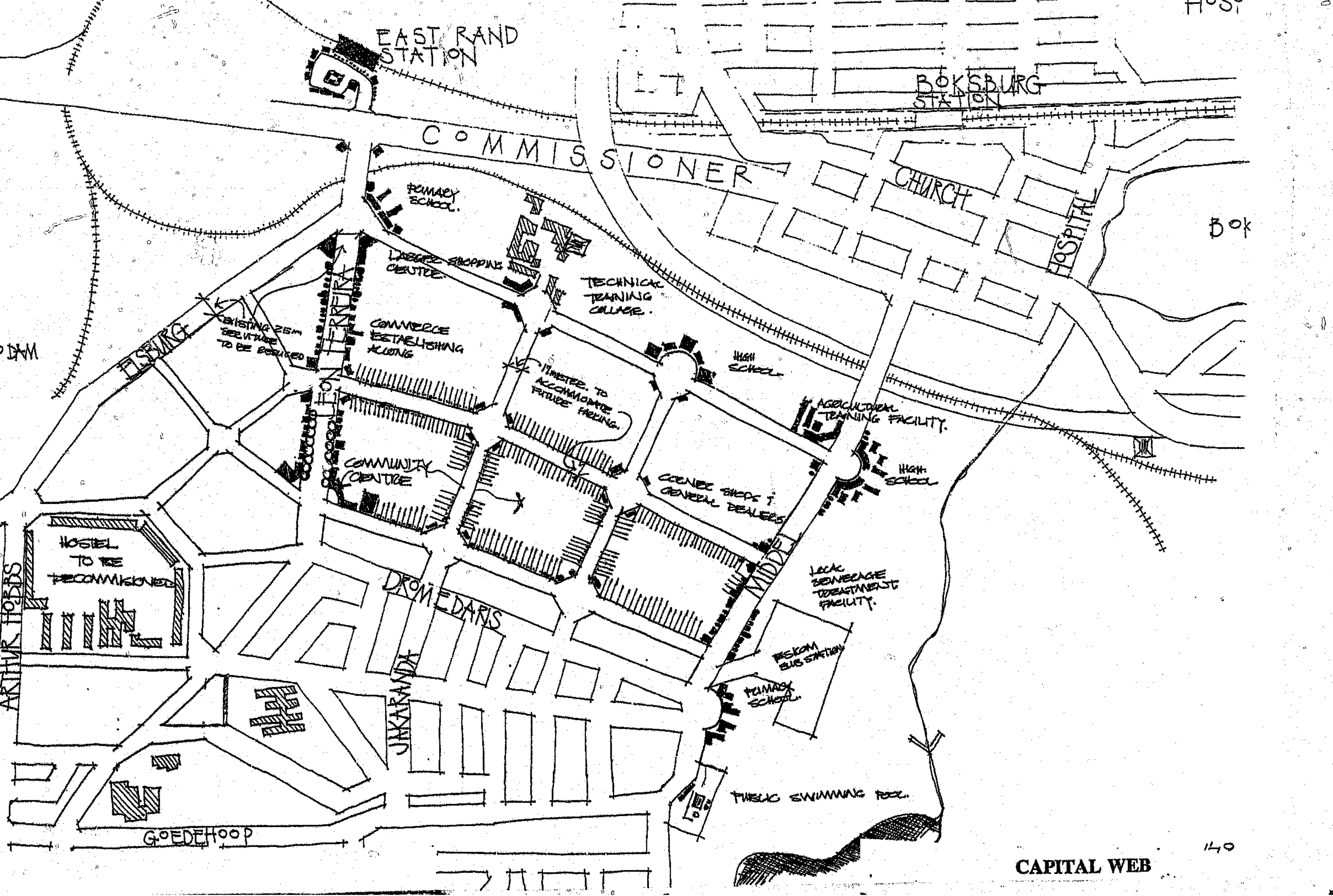
12.5.3 Capital Web and Key Installations

The concept of a "bioshelter" as described previously in Sustainable Communities was taken as the model to develop Leon Ferreira street as a socalled high street, flanked with commercial and business activity. The proposed public facilities have also been incorporated in the land-use structure of Leon Ferreira street. As the council owns land along this street, land swaps is proposed to obtain the desired positions.

The community centre was placed at the node connecting Reiger Park with the new development. The activity associated with this public facility would act as a catalyst in indicating the process of growth. These key installations could act as cues to set off small, local retail and business developments.

It was felt that the existing mining building surrounding the decommissioned shaft should be retained and renovated into a technical college, with associating light industrial, manufacturing and commercial trades. Although the site of these buildings are not good from an access point of view, the potential, existing services and cost implication should be deciding factors.

Schools are positioned at major intersections and nodes as to define the importance of these places in the future. In addition to this the proposed schools also plug into the open space, defining it and adding functional value to these areas from the start. Sports fields, environmental education centres and school gardens (as part of a community feeding and education programme). The buildings are pushed towards the street to define the space and give importance to the place double up for more local community functions, i.e. the school hall could be used for evening classes, community meetings and fetes.



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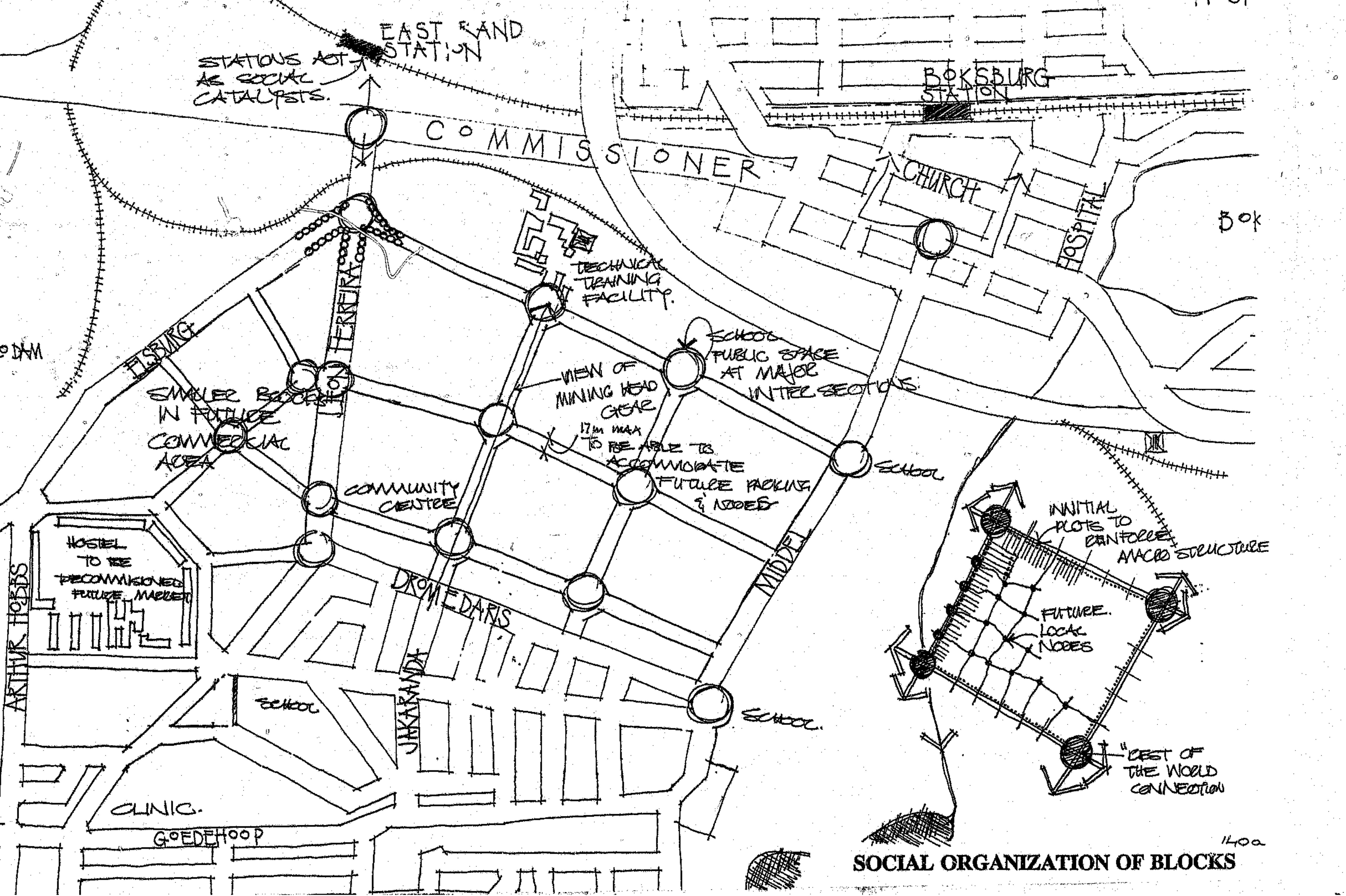
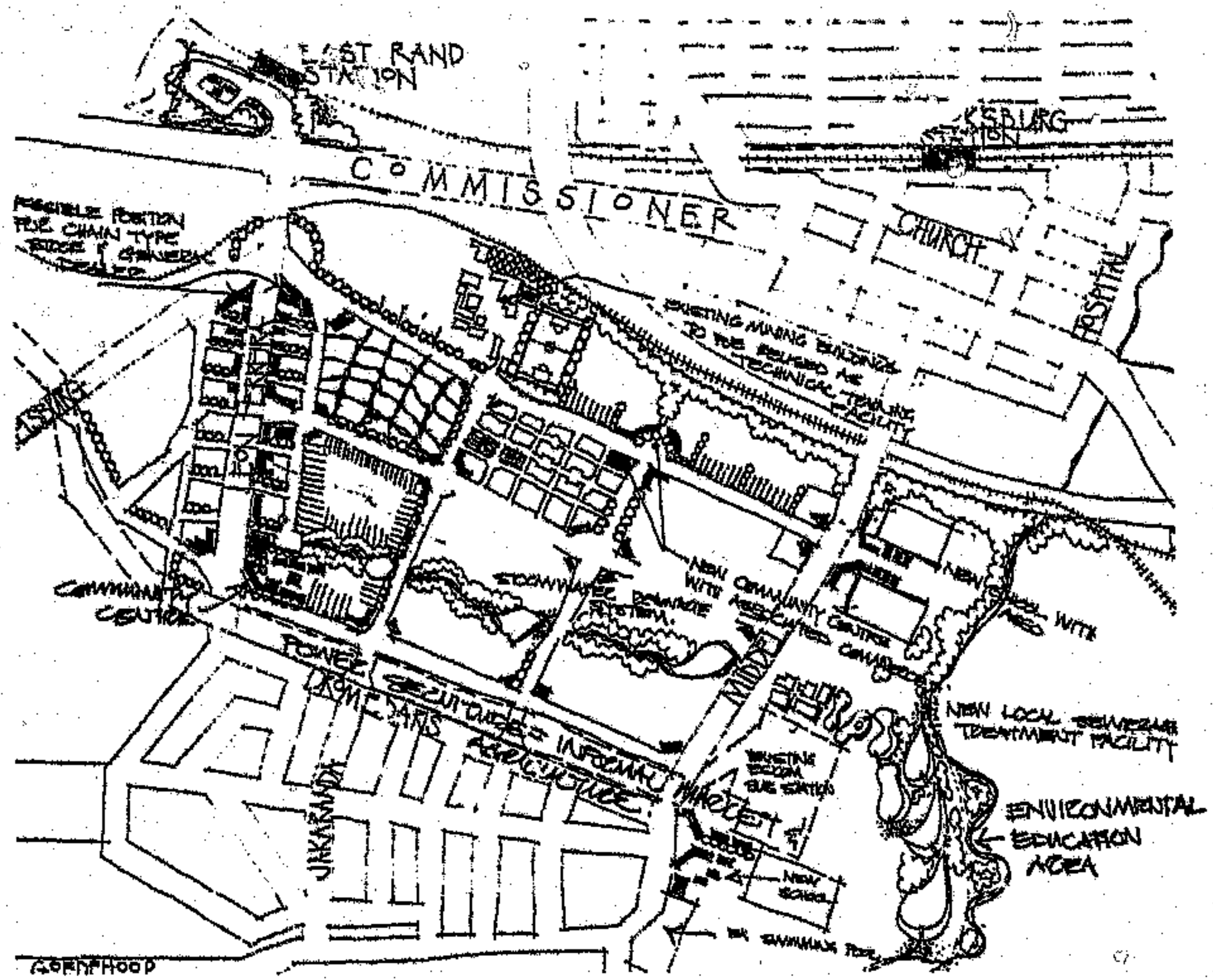
CAPITAL WEB



SOCIAL ORGANIZATION OF BLOCKS



It was felt that the precinct surrounding *Middle* street should be developed as a lower key commercial strip, relating to the agricultural produce of the Cinderella valley, as well as handcraft, small shops and businesses. Home industries should be encouraged as a means to a more balanced local economy. See Drawing *Capital Web*.

12.5.4 Social Spacial Structure

The approach, similar to Belhar (Dewar & Uytenbogaardt, 1978) in Cape Town was followed in producing a settlement which was one of diversity, range and choice. Flats on top of the high street businesses, walk-ups and houses being built close to the street would increase security and 24 hour life of the precinct. The high street should be flanked with high density units - three-storey walk-up's and row-houses to enable a large section of the population to live close to transport, work and the shops.

The strong street hierarchy would predict the type of housing and the possibility of future expansion of business and commercial land-uses. Smaller stands are proposed for street corners, units are placed close to the street. Mid-block stands have narrow frontages with deep backyards would allow vegetable gardens - all form part of a concerted effort to increase the choice and variety within the community. In urban ecological terms it relates to a more balanced social structure. These stands could be sub-devided in future to increase the building density, thus making the open spaces more valuable and functional.

12.6 URBAN ECOLOGY: TOWARDS A MOD..

Urban ecology is therefore not something completely new within the theoretical framework of urban design. It rather draws from fundamental urban design principles related to place, spacial organization, movement, social and economic concerns, with a definate biase towards the environment factors which could be associated with the future sustainability of the settlement. The theory draws allot from the basic arguments of the Garden City Movement and their concerns in developing new towns.

The model is obviously more directed towards "green fields" settlements with a strong thrust for the integration of urban and rural, commerce and subsistance, people and the environment. The emphasis is on the local, self-contained village type approach, but set development precidents for future expansion and integration with its urban setting. Communities caring for themselves by caring for their environment and its ecological health drives the social health, which was the original concern, of the proposed model.

The idea that everything must be seen for its potential opportunities - even waste could be a resource - add the approach of a generalist and thus also the urban designer. The level to which the ecological system is integrated with its setting as a means to the earth's simbiotic sustainability and ultimate survival. Ecosystems adapt to the changing environment by recycling its energy efficiently, through diverse mechanisms of birth and death, of growth and decomposition. Urban environments squander these resources in a bid to out-perform its economic competition. Is there a future in a framework which perpetuate exploitation, consumption and waste?

The concept of functional landscapes as a means to conserving open space for the future densification of settlements is a contribution to the urban theory in relation to the developing world. The value which functional landscapes add to the settlement as an important land use enables the education of a more sustainable urbanity in future. Once sound ecological principles had been integrated within the urban design framework, the foundation would be layed for a less costly, more sustainable community and ultimately, a more sustainable city. A serious problem in the model and the existing theory which was incorporated is the technology, which is often First World driven. Therefore an appropriate technology relating to poor communities and the developing world would significantly contribute towards the model and argument for an urban ecological framework.

In closing a quote from Huntley, Siegfried and Sunter *The present generation of mankind is the first one that can irreversibly transform the face of our planet for the worse. It is also the last generation with the capacity to introduce the changes required to avert environmental disaster. The environment is finite. The model of an environment of limitless resilience is no longer realistic or plausible. The world is simply not large enough to accommodate all assaults of a rapidly expanding human (urban) population and its industries. South Africa is a microcosm of the challenges facing the world. Will we choose a path which provides a rich and sustainable heritage for our children or will we decent into a wasteland of lost opportunities?*

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PERSONAL COMMUNICATION.

Dr Abel Botha, Institute of Soil, Climate and Water.

Mr Kamile Burger, Head of City Planning - Boksburg City Council.

Mr Stoffel Hattingh, E.R.P.M. Representative.

Ms Grobler, Directorate of Nature Conservation, TPA.

Mr Basil Moore, Resident, Naturalist and Historian.

Mrs Conny Nelson-Esh, Resident, Architect and Historian.

Prof Wiliem van Riet, Head of the Department of Landscape Architecture, University of Pretoria.

Mr Andre Wiehan, Town and Regional Planner, - Boksburg City Council.

Mr Graham Young, Department of Landscape Architecture, University of Pretoria.