JERICHO HILL VILLAGE - EXPLORING THE SPATIAL DESIGN IMPLICATIONS OF APPLYING ECOLOGICALLY BASED DESIGN PARAMETERS TO A SUBURBAN COMMUNITY IN THE GREATER VANCOUVER REGION

by

KEVIN JAMES CONNERY

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LANDSCAPE ARCHITECTURE PROGRAM
Department of PLANT SCIENCES
The University of British Columbia
Vancouver, Canada

Date JUNE 30.
ABSTRACT

JERICHO HILL VILLAGE -
EXPLORING THE SPATIAL DESIGN IMPLICATIONS OF APPLYING
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Kevin J Connery
JUNE 1994

This thesis begins with an examination of the social and ecological problems related to
contemporary suburban development in North America and recently emerging factors that indicate
an alternative approach is not only necessary but already in process. It explores the field of ecology
to better understand how basic ecosystem function might be used to help organize this alternative.
With the understanding gained from ecology and the information gleaned from the precedent of
pilot projects and other innovative ecologically based design explorations, a series of ecological
design parameters are developed to assist in the planning and design of a more sustainable
suburban community. The ecological design parameters are then applied to an existing suburban
community in the Township of Langley, subject to urban growth pressures to understand the
spatial implications and opportunities of an ecologically based design approach.

In the process of exploring different design options it becomes clear that ecological features can be
embodied in the spatial form of the community, and that their contribution makes the community
more legible to its residents and develops a stronger “sense of place” than the conventional suburb.
A comparative analysis between the proposed Jericho Hill Village and Walnut Grove, a nearby
conventional suburban community also in Langley is provided to illustrate the fundamental
differences between the two design approaches. A discussion of the importance of energy and
water to the community’s design is provided. The thesis concludes by noting some of the
impediments posed by the current development process and some of the opportunities that might
change the status quo.
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“Sustainability is inherent in what earlier people - and many people today - hold sacred, and yet, it has been dismissed, ignored, and desecrated by the idea of progress. Our vision is that what is sacred is our relation to life and living processes, and that this can be made manifest in the design of our everyday environments. We see design not only as the application of science and technology but as an act of faith in humankind’s wish to survive, adapt, and find a place of balance in a world that does not permit domination by one species for very long.”

Sim Van der Ryn & Peter Calthorpe, Sustainable Communities

• Introduction

The Greater Vancouver Metropolitan Region is among the fastest growing urban areas in North America. By 2021 the region’s current population of 1.8 million people is projected to grow to 3 million. This immigration is coming to Vancouver from other parts of Canada and from around the Pacific Rim at a pace that is exceeding the supply of housing and services, particularly in nontraditional urban areas. To the east of the city of Vancouver municipalities such as Langley, Matsqui, Abbotsford, Coquitlam and Port Coquitlam and the city of Surrey are all expecting their respective populations to double if not triple in the next 30 years.

Such rapid increases in population are occurring without consideration for the region’s ecological constraints such as its water and energy supply, waste disposal, food production, biological diversity and wildlife habitat. These rarely enter into the evaluation criteria used to judge the merits of a given project. Similarly, little consideration is given to region’s transportation systems thereby reinforcing patterns of suburban sprawl and automobile dependency. Consequently, the increase in automobile use and atmospheric emissions has lead to a deterioration in the region’s air quality. The distended suburban sprawl has also resulted in the fragmentation of the region’s forest cover, the alteration of natural drainage patterns, rivers, creeks and ground water tables and the loss of productive agricultural land to urbanites seeking an arcadian image of home while retaining contact with the city.
Unfortunately these problems are not unique to Vancouver. Rather they are common to virtually all cities and towns which for centuries have been organised around a few fundamental, yet flawed, assumptions: the limitless supply of developable land; inexhaustible and inexpensive water, and energy; and, the ability of nature to absorb the waste and byproducts of a rapidly expanding, consumer society. Urbanization in the form of cities, suburbs and towns has been at the expense of prime agricultural land, local and regional ecosystem integrity, and, perhaps most insidiously, community identity.

To begin restructuring our communities towards a more sustainable future our approach must operate on many fronts. We must not only encompass the appropriate technical solutions, but we must also engage the psychological and spiritual components of human settlements. We cannot simply argue for more energy efficient homes, increased domestic agricultural production, or the reduction of waste and pollution. Our solutions must seek to reconnect our daily experiences with those natural cycles operating around us. We must recognise that we are part of the ecosystem, not separate from it. Ekhart Hahn, in a presentation at the 1992 Conference for Central European Metropolises argued,

“It is not enough to seek technical solutions to the problems of pollution, waste and resource depletion. Cycles and environmental relationships must become perceptible for the individual...The aim is to make environmental and social relationships apparent to the user, to overcome the anonymity and reduced awareness of environmental resources, making sensually perceptible the relationships between the development of technology, its use and the natural environment. The role of humans as responsible partners shaping their relationships with nature must again become clear.”(Hahn, 1992, p.4)

The intent of Jericho Hill Village is to explore the spatial implications of applying an alternative, ecologically based design approach to a typical suburban Vancouver community. A community which, if current development patterns continue, will exacerbate the region’s emerging ecological problems.

Specifically;

It is my contention that sufficient information regarding ecologically based design has emerged in Northern Europe and North America to allow a series of ecological design parameters to be synthesised and applied to a growing suburban community in the Vancouver region, resulting in a more sustainable existence.
• **Goals and Objectives**

The intent of this thesis and the specific design of Jericho Hill Village is guided by two goals and a series of objectives.

**Goal 1**
- To develop a better understanding of ecological design as it is currently being practised and/or discussed in North America and Europe.

**Objectives**
- To define what is meant by ecologically sustainable community design as it applies primarily, but not exclusively, to suburban conditions.
- To identify current practices and emerging concepts in sustainable urban and suburban development and ecological design.
- To develop a series of ecologically based design parameters which can enhance already accepted community design principles.

**Goal 2**
To apply these ecologically based design ideas to a suburban community under urban growth pressures in an effort to structure the community’s physical form so as to minimise its impact on local and regional ecosystems.

**Objectives**
- To identify the spatial, social, and ecological problems plaguing typical suburban community design.
- To select a site and understand its opportunities and constraints with respect to ecological design.
- To use ecological design parameters to organise a community which respects the ecological carrying capacity of the region.
- To compare the relative ecologically merit of the ecologically based community with an existing conventional suburban community.
• Scope of Study

Jericho Hill Village is a conceptual design enquiry into the implications on the form of a community when ecological design principles are prioritized. It is a physical exploration that reflects my interests as a practising landscape architect in translating conceptual ideas into physical form. I have chosen to limit my focus to those features of ecological design which I believe have direct spatial consequences. I have not looked extensively at planning policy which might or might not foster more sustainable communities. This is not intended to dismiss the important role policy making plays. Official Community Plans and Zoning Ordinances are among the most powerful forces currently shaping cities and towns today. I have chosen to defer to other researchers who have discussed the limitations of current planning policy, pointed out many inadequacies and offered alternatives they believe will foster more sustainable communities. (Calthorpe, 1993; Perks and Van Vliet, 1993; Krieger, 1991)

Similarly I have not provided a thorough evaluation of the social and experiential issues related to creating more sustainable communities as the literature on this subject tends to be quite disparate and vague. This exclusion is not intended to suggest these more illusive concerns are somehow less important than spatial considerations. According to many place theorists (Steele, 1981; Norberg-Schulz, 1980; Relph, 1976) understanding and reconciling the social and psychological features of a space is equally important in creating a sense of place. However, for the sake of brevity and clarity I have chosen to rely on the knowledge I bring to these social and psychological issue as a practising landscape architect with several years of urban design experience rather than formalize them.

Another limitation of this thesis concerns the science of ecology. My background is in landscape architecture and horticulture, not ecology. Therefore, when it has been necessary to translate ecological concerns into a new approach to design, I have approached the complexities of ecology from three perspectives. The first is the use of design precedent which has incorporated an ecological perspective in its development. The second has involved using reports and research done by ecologists which begin to touch on ecology’s spatial design implications. Finally, as a landscape architect with a general understanding of biophysical relationships, I have attempted to evaluate design decisions based on their basic ecological qualities.
My research for precedent has been limited to European and North American examples due to the similar economic, cultural and political similarities to Canada which allow for an easier transference of ideas. Furthermore literature is available in English from these areas as opposed to potential initiatives from other parts of the world. This does not imply that examples of ecologically sustainable design are exclusively eurocentric. Valid examples from other parts of the world undoubtedly exist. However, they are either poorly documented or poorly translated into English which excluded them from this design enquiry.

Jericho Hill Village is ultimately a conceptual design investigation and is not intended to offer the quintessential definition of what sustainable communities are, nor what they should look like. Sustainable communities are the responsibility of all those who live in them, not a few professional planners or designers. These communities will emerge only when an implicit understanding of the local and regional ecosystems pervades conscious and subconscious thought of all residents. It is a design exercise that offers a few possible, conscious steps towards a more ecologically sustainable suburban community. It is merely one of the many steps which must be taken.

• Methodology/ Chapter Summary

The methodology used in this thesis is guided by two questions: Why? and How? For years it has been apparent to me that our current approach to designing communities is flawed and a new approach essential. What I did not know was why it was wrong and how it might be changed. Therefore this thesis reflects a quest to answer these two questions.

The thesis began with an information gathering phase that was followed up by a planning and design phase. The specific process can be best described through a review of the individual chapters in the thesis. It is important to note that while the chapters imply a linear process, the process proved to be quite iterative as new information surfaced and as the design began to evolve; a process whereby the design informs the research and the research informs the design. These are interconnected partners with overlapping ideas and issues.
Information Gathering

The first year of this thesis primarily involved searching through books and periodicals, for a clearer definition of ecological design, examples of ecological design and for a better understanding of the problems inherent in our current approach to designing suburban communities. These phases are summarized in the first three chapters and account for the bulk of the information gathered.

Chapter One - The Problems With Suburbia summarizes the features of today's suburb that explain why it looks and operates the way it does and why it has the problems it does. The research focused on the social and physical characteristics of suburbia to better understand the changes that will be necessary if a more sustainable approach to community design is to be realized. These are changes which affect our general perceptions of our cities, the social and economic systems that have created them, and the design process which has facilitated their physical form. The research behind this chapter was important in answering the "why" of the thesis.

The ideas represented in Chapter Two - The Urban System emerged early in the life of this thesis in response to arguments that said a sustainable approach to development is one that works within the limitations of the planet's natural ecosystems. Consequently chapter two looks to ecology and its understanding of natural ecosystem function for clues as to how the urban system might be restructured to better reflect how natural systems operate. It advocates viewing the city, suburb or town as systems within, and dependent upon, larger natural systems. It describes four ecologically-based organizing principles that help structure a system based approach to community design. Chapter two expands on "why" and gives some indications of "how" a new design approach might work.

Chapter Three - Ecological Design Parameters synthesizes the research on ecological design into a series of design parameters. A portion of the background information used to formulate the parameters was the result of ten weeks of field research in Europe during the summer of 1992. The research focussed on visiting projects that had incorporated one or more different ecological design features and documenting these features. These were issues related to energy and water conservation, waste management, transportation systems, community based agriculture, and
vegetation. The site visits and interviews with people involved in the various projects were combined with information gleaned from the literature searches to create the design parameters. The parameters begin to explain how to design more ecologically sustainable communities. A list of the projects and sites visited can be found in appendix one.

**Planning and Design Phase**

The planning and design phases formally commenced during the winter of 1992 with the selection of a specific site. The process of elimination began with identifying possible areas and identifying regional planning concerns such as the availability of current biophysical information, the proximity to adjacent urban areas, current development pressures and land use, and the potential for making a positive contribution to adjacent ecosystems. This process is briefly described in *Chapter Four - Context* and the reasons for selecting the Willowbrook Community in the Township of Langley. Included is a review of the Township's current development plans for Willowbrook and an analysis of those plans from an ecological perspective.

*Chapter Five - Concept Plan* describes the goals, program and design features of Jericho Hill Village that are graphically represented in the chapter's accompanying drawings. The final concept plan is the culmination of a process that involved numerous design scenarios, each attempting to test out the ecological design parameters. The first proposal was prepared for a design competition on ideas for more sustainable communities sponsored by the American Institute of Architects in the spring of 1993. Subsequent designs attempted to reconcile the ecological design parameters with Jericho Hill's specific site issues and its program. This design process was intended to answer some basic questions related to these design parameters: are some more important to spatial form than others? do the parameters lend themselves to creating a sense of place? are the parameters currently too rigid to create a strong sense of community? are there other ecological design parameters that have been missed? Each design was reviewed with the thesis committee to determine how well the different designs responded to ecological AND place making concerns.

Observations on the ecological design parameters and the community that emerged are described in the final two chapters. *Chapter Six - Comparisons* explores the differences between Jericho Hill Village and Walnut Grove, a conventional suburban community recently developed within the
Township of Langley. Using Walnut Grove as a benchmark of standard suburban community
design allowed quantitative and qualitative comparisons to be made regarding the public realm,
accessibility, permeability; energy, water, waste, vegetation and agriculture.

Chapter Seven - Conclusions. provides a summation of the thesis and the implications on suburbia
of an ecologically based approach to designing communities. It also includes observations on the
ability of the ecological design parameters to be implemented and to create a sense of community.
The chapter concludes with a discussion on the likely future of ecologically based design and some
of the changes that will be required to support it.
1.0 - THE PROBLEMS WITH SUBURBIA
We have developed systems that are fragmented. We fragmented the three fundamental functions of any economy: production, use and disposal. We have separated the farmer from the kitchen, the power plant from the appliance, the worker from the work place, and eventually, the bank from the depositor and the borrower, and the government from the citizen. Today the average commuter travels about twenty to twenty five miles to work; the average kilowatt hour travels about two hundred miles to do its piece of useful work; and the average food molecule travels about two thousand miles to do its piece of useful work.

David Morris, “Green Cities: Ecologically Sound Approaches To Urban Space”

1.1 Suburbia - Historical Background

At the end of the nineteenth century, 51 percent of Americans lived in the city (Hayden, 1984, p.24). Of the remaining 49 percent most were agriculturally based, living in small rural communities. A small percentage could be found in newly emerging streetcar suburbs, the antecedent of today’s suburb. By 1980, this small percentage had grown dramatically to account for approximately 65 percent of all Americans. (Rowe, 1991, p.4) The city and the countryside had become net exporters of people to this suburb. This emigration is remarkable in that the suburb as we know it today is a post-World War II phenomenon. Two generations ago its meandering streets, low densities, architectural homogeneity, automobile dominance, and segregated land-uses did not exist.

Cities and The Rise Of Suburbia

The suburb, however, is not a twentieth century phenomenon. Mumford observes “that the suburb becomes visible almost as early as the city itself.”(Mumford, 1961, p.483) Ur, the great Mesopotamian city of 4000 years ago, supported a burgeoning residential and commercial community outside its city walls. The cities of the Maya 1000 years ago had housing extending well beyond the densely populated centre. And the evolution of Paris is notable for the succession of city walls, each enveloping the adjacent suburb, only to see a new suburb develop once again outside the new walls. (Lozano, 1990)
The earliest suburbs were characterized by agrarian life with peasants living in small houses, tending the farms adjacent to the city. “In biblical times, we find mention of little huts that were built in the midst of the open fields or vineyards.” (Mumford, 1961, p.483) The vitality of the city was entirely dependent on the success of these local agricultural practices. Simultaneously the suburban countryside provided a necessary relief for many urbanites seeking to maintain some rural connections. During medieval times the suburb became home to nonagricultural uses such as monasteries, and the city’s elite seeking temporary refuge from the city’s heat, noise, and over crowding.

“As early as the thirteenth century...Villani reported that the land for a circle of three miles around Florence was occupied by rich estates with costly mansions...The privileges and delights of suburbanism were reserved largely for the upper class; so that the suburb might almost be described as the collective urban form of the country house - the house in a park - as the suburban way of life is so largely a derivative of the relaxed, playful, goods-consuming aristocratic life that developed out of the rough, bellicose, strenuous existence of the feudal stronghold.” (Mumford, 1961, p.484)

With the demise of feudalism in the fifteenth and sixteenth centuries urban populations grew as people discovered other work opportunities than farming existed, particularly in the city. At the start of the 16th century, Europe had approximately seven cities with a population in excess of 100,000 people. By the end of the century this number had doubled. (Funk, 1973, p.148) Cities of lesser size were also growing, and in all cities this burgeoning population lead to increasing levels of overcrowding and disease. As the edges of the city expanded, access to the suburban countryside became less and less immediate for all but the wealthy. “One of the chief penalties for continued urban growth was that it put this pleasurable setting at such a distance and confined it more and more to the ruling class.” (Mumford, 1961, p.482)

In the eighteenth century the urban suburban relationship began to change once again. And the agrarian lifestyle, which some seven millennia earlier had displaced a nomadic social structure, was now itself a victim, as the Industrial Revolution established a new set of criteria for commerce and economy. The smaller medieval city, whose growth was limited to the carrying capacity of the immediate landscape, gave way to a larger city based on a new economic system involving regional and international trade. Industry, mechanization and money exchange superseded life on the farm, small scale village economies and bartering. As industry required concentrations of labour, urbanization inevitably increased at the expense of farmland. Coupled with increased trade, the city
was losing its subsistent relationship with the land. The countryside, which for thousands of years dominated the town, would now become dominated by the town. (Bookchin, 1980) Societies that once treasured and protected the land, and once owed their very survival to fertile agricultural soil now voraciously consumed it.

“All the elements of society begin to change their dimensions. Civic and political gigantism parallel industrial and commercial gigantism. The city acquires dimensions so far removed from the human scale and human control that it ceases to appear as the shelter of individuality.... Cornered in a sense of isolation that is accentuated by the massive, unknowing, impersonal crowds that surround the urban dweller, the individual ceases to be gay or even blase, but fearful.” (Bookchin, 1980, p. 146-147).

The rapidly growing, industrial city created new problems of livability. Factory workers, crowded into tenements with minimal sanitary provisions, were plagued with diseases. Industry, based on coal fired steam energy, blackened the sky with its emissions. Fresh water supplies became scarce as the growing city polluted local supplies. In the process, the role of suburbia as refuge was strengthened and offered a permanent escape from the squalor of the city. Thus, with the advent of rail travel, the middle and late nineteenth century marked the beginning of a permanent exodus to the suburbs.

This new mode of transportation liberated people from preindustrial technology, which for centuries had restricted urban expansion. Housing opportunities in a pseudo rural setting became accessible to urbanites. Travel times of days and weeks were reduced to minutes and hours. The urban-suburban relationship was transformed and what began slowly with trains and trolleys, would later explode with the arrival of the affordable automobile.

**An Anti-Urban Reaction**

The malaise of the industrial city spawned new ideas of how and where people should live, and strengthened the image of suburbia as a catharsis. A few, more radical approaches, sought to replace the city with a new form of development such as Ebenezer Howard’s, “Garden Cities of Tomorrow”. Published in 1898, Howard’s proposal was for small, decentralized communities designed in such a way as to be self-sufficient. He felt a polynucleic structure of smaller communities surrounding a larger town, separate from the city, could resolve the city’s inherent social and economic problems. Mumford considered Howard’s work to have, “done more than any
single book to guide the modern town planning movement and to alter its objectives.” (Howard, 1965, p.29)

However the late nineteenth century embrace of suburbia as an alternative to city life has much deeper roots than the industrial age. There is evidence an anti-urban, suburban like ideal had been lying dormant for centuries, repressed by limited personal mobility and no dominant middle class. Jeffrey Hadden, a noted urban sociologist, points to the Old Testament in which the city is condemned as “an environment of disobedience to God, presumably because the city is an ‘unnatural’ setting created by man in defiance of God’s will.”(Masotti, 1973, p.88) Hadden also cites Matthew of the New Testament,

“Jesus Christ’s strongest reproachment of cities...At no point does Jesus speak favourably about cities. He often retreats to the countryside to teach and pray. Frequently he admonishes typically urban behaviour and life styles. And, in the end, a big-city boss releases him to an unruly urban mob to be crucified.”(Masotti, 1973, p.88)

Both Plato and Aristotle favoured an agrarian setting for people and the sensibilities it nurtured, over those engendered by the city. (Masotti, 1973) During medieval times Saint Augustine’s influential writings on personal salvation and God included a vilification of cities; “The cities of man, thus, are founded in sin. They manifest demonic forces and serve the epithet ‘city of the Devil’.”(Masotti, 1973,p.89) Newman and Kenworthy (1989) identify a body of literature from the eighteenth and nineteenth century which further points to an anti-urban bias, suggesting there had been a latent desire for a pastoral home which suburbia helped satisfy.

“Despite being a basically urban race we have never really been committed to the city. We do not have a belief in the city as a positive force for good, a place where culture can grow and all that is best in the human spirit can thrive...In general the English, American and Australian traditions have been to idealise places that are rural...Cities only serve to corrupt the purifying aspects of country life.”(Newman and Kenworthy, 1989, p.93)

The promise of suburbia rested with its ability to reconnect the urbanite with the countryside, to awaken the senses dulled by the problems of city living.

“The pastoral representation of the American landscape also reflected the dissonance created by urban growth and constituted an effort to resolve the conflict between urban and rural values. The mythic figure of the farmer and the poetic map of the middle ground between wilderness and the city merged into American ideology because they resolved a profound conflict between the values of the ‘real genuine America’ and the attraction of the city and its clusters of new technology.”(Masotti, 1973, p.95)
Thus as cities failed to provide the basic livability people sought an urban exodus to suburbia appears to have been inevitable. For Americans, where the contemporary suburb is most prominent, it marked a natural emigration in pursuit of their ideal image of cities as a bridge between the wilderness and urban civilization. The city had become too large, too overcrowded, and too filthy. With the emergence of a dominant middle class and public transportation systems, the late nineteenth century suburb offered a setting closer to that ideal, a utopian existence set in a middle landscape. (Krieger, 1991; Rowe, 1991; Kelbaugh, 1989)

“What gave shape and meaning to this protean growth of the American city was the juncture of the powerful ideal of rural virtue and the growing vexation with the assertiveness of urban society. The rural ideal promised relief from the ‘rasp and graze of splintered normality,’ from the ‘clamours of collision.’ Though it was a dream more than a little false, the rural ideal recovered the link between pastoral and family life whose loss Americans had begun to mourn in the 1830s. Thus the movement outward of the middle class was not simply an escape from the city; it was more importantly an attempt to find a pleasing context in which to enjoy the newly discovered pleasures of family life.” (Masotti, 1973, p.106)

The Corporate Suburb

Early in the Twentieth century suburban growth was limited to the corridors serviced by the railways and street cars. These new communities developed as clusters adjacent to rail stops, with homes and services located close to the stations. The streetcar suburbs where generally closer to the city core where the more maneuverable street car had an advantage over rail. Both systems fostered compact, pedestrian scale neighbourhood units. However, while the popularity of these communities grew they still represented a level of exclusivity. (Hayden, 1984; Mumford, 1961)

After World War II a new settlement pattern emerged in response to war veterans reintroduced to the work force, industries retooling production for domestic consumption, major government expenditures on road construction and subsidies for family and housing. The old city core was obsolete in appealing to the new freedom of mobility made available by automobile ownership and this emerging suburban aesthetic. The new vision was of single family homes set amidst green fields, separate from the city yet close enough to commute to, and enjoy its cultural amenities;

“The dream house replaced the ideal city as the spatial representation of...hopes for the good life. It not only triumphed over the model town, the dream house also prevailed over two other models of housing, one based on an ideal of efficient collective consumption of scarce resources, the other based on the ideal of the model neighbourhood.”(Hayden, 1984, p.38)
Don Mills, Ontario marks something of a watershed in the history of Canadian cities. It was here, in 1952, that E. P. Taylor developed Canada’s first significant post World War II suburb, turning a vast track of farmland into a sea of single family detached homes. It heralded a new form of suburban development, one which would be quickly disseminated throughout the country. Don Mills was referred to as Canada’s “first corporate suburb” in recognition of the influence the corporate world now had over the development of the suburb. (Gerecke, 1991, p.31) It parallels the development of another corporate suburb, Levittown, in New York State.

Collectively the forms of Don Mills and Levittown embodied principles which would come to define suburbs throughout North America. First, the streets were to be curvilinear, not rectilinear, with no clear sense of hierarchy. This made traffic circulation circuitous, discouraging outside vehicles from cutting through the neighbourhood. Furthermore, the curvilinear street and cul-de-sac were perceived to offer more privacy and security.

The second principle involved the separation of land uses into discreet areas. Commercial areas were segregated from institutional uses which in turn were segregated from residential areas. Few pedestrian connections were provided. Residents depended on their automobile to go from home to the store to school to the recreation centre to work.

The promise of space and access to nature defined the third principle. Single family detached homes were evenly spaced on large lots with generous sideyard clearances. Macklin Hancock, planner of Don Mills, believed these spatial qualities offered residents “more contact with the land.” (Gerecke, 1991, p.32) The consequence of these spatial patterns and the ensuing low density was the corporate suburb’s insatiable appetite for land.

The final principle defining suburban form involved its implied social structure. The nuclear family was the main client and in many neighbourhoods, ethnic minorities were prohibited. (Hayden 1984) At the centre of the neighbourhood was a school, not to jointly serve as the community hall as was the case in many smaller, rural communities but to serve as the institutionalized educational epicentre, to the exclusion of community facilities.

“The school was to be at the centre of social life - both figuratively and metaphorically, showing that the important aspect of life was not the present or the past, but the future as embodied in the children...Either culture would come
through some other means (television was then becoming popular) or from some other place (like the city). Thus a very static social structure was programmed in from the beginning.” (Gerecke, 1991, p.33)

1.2 The Obsolescence of Suburbia

Today the suburb is being challenged as a viable settlement pattern on the grounds that it is haunted by social dislocation, economic disadvantage and ecological fragmentation. (Hough, 1991; Rowe, 1991; Relph, 1987) What was once seen as a utopian balance between affordability and pastoralism, between the civility of the city and the allure of the wild, has in fact become a landscape of homogeneity, anonymity, and isolation.

"The middle and upper classes are abandoning cities to the poor, and large parts of urban areas are slowly becoming live-in ruins. A majority of the affluent population has been resettling in a segregated and dispersed suburbia that is neither urban nor rural and commuting daily to work. Suburban life in a dispersed, homogeneous environment is expressed in routines devoid of symbolism or spontaneity; here is a functional simplification that has reduced personal contact and the exchange aspects of the community and, with them, a sense of belonging." (Lozano, 1990, p.6)

The problems are the consequence of interrelated spatial and social problems. Implied segregation of people and activities, low density sprawl, and automobile dependancy strike at the very heart of the suburb's problems.

The Erosion of Community

Of the problems suburbia suffers from perhaps none is more insidious than the disappearance of a community sensibility. Its spatial characteristics have transformed the dynamism of human settlements into a linear phenomenon (Rowe, 1991; Vale, 1991). Patterns of human nature have been simplified into functional, economic characteristics. Sennet (1970) argues the consequence of suburban form is the emergence of an ambivalent constituency.

"The simplification of the social environment in suburbs is the logical end in the decline of diverse communities...[for] in the suburb, physical space becomes rigidly divided into functional areas...The desire of people beyond the line of economic scarcity is to live in a functionally separated, internally homogeneous environment." (Lozano, 1990, p. 135)

The dispersion and segregation of activities erodes a clear sense of community, leading to what Rowe (1991) claims is an apathetic social structure based on privatised rituals.
“In the end, with so much decentralisation, it is not inefficiency and irrationality that undermine the suburban metropolitan experience. It is the darker underside of the idea of democracy, where people forget that it involves the common good as well as individualism.” (Rowe, 1991, p.44)

With the construction of wide streets encouraging the movement of automobile traffic and discouraging their use by pedestrians, community interaction vanished. With no hierarchy of open spaces, no clearly defined public places, and virtually no public transit, the public realm, vital for its opportunities to meet, converse, watch, sit, laugh and foster a general civicness has disappeared. (Moudon, 1987; Hester, 1984)

“As soon as the motor car became common, the pedestrian scale of the suburb disappeared, and with it, most of its individuality and charm. The suburb ceased to be a neighbourhood unit.” (Mumford, 1961, p.505)

Krieger argues that contemporary environments such as the suburb fail to achieve “propinquity, probably the most important criterion for true civility.” (Kreiger, 1991, p.11) In fact suburbia perpetuates a stereotypical image of the nuclear family. With its rapid growth, large scale, and uniformity of housing the suburb has failed to accommodate the diversity in contemporary society. In the process it has forsaken the essence of community. Seniors and children, who may not have easy access to automobiles become dependent on inadequate public transportation and ill-conceived pedestrian circulation systems to reach distant commercial and social centres. In restricting their mobility, they become isolated from the larger community. This in turn entrenches both their own, as well as the larger communities’ sense of social dislocation.

“The image in the United States of the traditional family - a married couple with young children, with an employed husband and a homemaker wife - that characterised the 1950s and 1960s does not match today’s demographic realities. Other types account for nearly 79 percent of the households created since 1980, whereas the traditional married-couple family accounts for only 21 percent.” (Franck and Ahrentzen, 1991, p.xi)

**Anonymity and Placelessness**

Helping to erode a true sense of community is the physical homogeneity of suburbia. In Relph’s (1976) description of “placeless geography” he outlines five components which manifest placelessness: 1. Other-directedness in places; 2. Uniformity and standardisation in places; 3. Formlessness and lack of human scale and order in places; 4. Place destruction; and 5. Impermanence and instability of places. (Relph, 1976, p.118-119) Each can easily be applied to
suburbia. Its stylized architecture attempts to emulate patterns or forms from "other" idealised places, rarely responding to regional conditions or building traditions. Its streets, houses, commercial strips and malls follow predictable patterns and formulas to such an extent that one suburb looks like another. Its dependence on the automobile has lead to a scale sympathetic to the car, not the pedestrian.

The suburb transforms large tracks of land into suburban communities so quickly that rarely are the defining characteristics of the undeveloped place preserved and incorporated. Forests are clearcut, wetlands filled, streams culverted, and topographical features irrevocably altered. Suburban communities also rarely engender any sense of permanence. Their architecture appears as static as their placement on the site. The buildings rarely carry with them an intergenerational presence.

“Ours new suburbs and new towns...seem all begun yesterday and completely finished then. There is no crevice through which one can venture back or forth." (Lynch, 1972, p.60)

Characterised by spatial segregation, a lack of hierarchy, and an appropriated architectural uniformity, the formlessness of suburbia lacks identifiable features, makes orientation difficult and leads to a sense of anonymity and isolation (Newman and Kenworthy, 1992; Krieger, 1991). It is what Relph refers to “subtopia:”

“a set of randomly located points and areas, each of which serves a single purpose and each of which is isolated from its settings, linked only by roads which are themselves isolated from the surrounding townscape except for the adjacent strips of other-directed buildings.” (Relph, 1976, p.109)

**Job - Housing Imbalance**

The preindustrial city had places of work, commerce, worship, agriculture and housing within its boundaries. Virtually all activities were within immediate reach. Settlements were compact as transportation was limited to foot or horse travel. Today, the suburb with its exclusionary zoning, segregated land uses, and uninhibited mobility excludes people from living and working within the same community. It is an imbalance which has simultaneously lead to and reinforced the following problem.
Automobile Dependence

Suburbia demands its citizens be automobile literate as the car is the datum by which the community is organized and experienced. Yet as a datum the automobile suffers from well documented spatial, social, economic and ecological costs. (Cervaro, 1991; Gordon, 1991; Lowe, 1990; Newman and Kenworthy, 1989) Land use patterns become appropriated by the automobile to the exclusion of the pedestrian. (Bookout, 1992: Andersen, 1991; Krieger, 1989; Van der Ryn and Calthorpe, 1986) Strip commercial developments and shopping malls define the commercial persona of suburbia. Primarily accessible by generous roads these commercial nodes focus on accommodating the car and develop a palette of bright neon signage directed at the car experience.

“Speed blurs details, signs have to be big and bright, land uses can be mixed up and spread out because distance is of no great importance to the driver.”(Relph, 1987, p.84)

Socially, a suburbanite dedicates much of the day to sitting in an automobile in a segregated world, driving from home to work, to the day care, to the store, to the recreation centre, and back to home. In addition to the traditional travel corridor to and from the city centres over “40 percent of all commute trips are now from suburb to suburb.”(Walter[ed.], 1992 p.28) This is time spent away from family, or social or recreational opportunities. And as mentioned earlier those who do not have access to automobiles become isolated from the community.

The economic disadvantages of depending on automobiles are both explicit and implicit. The explicit costs include the obvious expenditures for insurance, gasoline, and maintenance, each of which increases with the length of the commute and the relative isolation of the specific neighbourhood from services. Collectively these and other costs such as car loans, and parking spaces at the office represent thousands of dollars each automobile owner must annually pay.

The implicit costs include the taxes on gasoline for road maintenance and transit systems, new road construction and servicing expanding, low density sprawl. (Gordon, 1992; Hanson, 1992; Newman and Kenworthy, 1989) It is estimated that in typical urban and suburban developments over “40% of the initial cost of development is automobile related.”(Walter [ed], 1992, p.214) The community also bears the hidden costs related to automobile injuries and deaths, and environmental degradation from atmospheric and ground water pollution, and loss of land and forest cover.
**Fragmented Ecosystems**

Urban expansion through the proliferation of suburbs is responsible for the loss of regional biodiversity, ecological integrity, and arable land. Suburbia embraces concepts of universal mobility, cheap energy, cheap land and low density developments serviced by cars. The ecological consequences for the regional ecosystems are severe.

“The private automobile...exacts an enormous and hidden price from society. Not only the individual car owner, but every member of society pays the price in terms of air, water, and soil pollution.” (Spirn, 1984, p.238)

Sprawling land-use patterns demand vast amounts of land, energy and water, and return these in the forms of atmospheric pollutants, and tainted water supplies. (Register, 1987; Hough, 1984)

“The modern suburban city....is extremely wasteful in its use of land, resources, energy and human beings. It is a zoned monoculture of huge housing subdivisions, industrial parks, office plazas and shopping malls....imported water, polluting waste disposal systems, energy wasting buildings and power grids, and specialised service elites...Suburban cities are industrial solutions that sacrifice long-term health and sustainability for short term profit and productivity.” (Van der Ryn and Calthorpe, 1986, p.xi)

The irony rests with the lure of suburbia since the nineteenth century. It represented a verdant, healthy alternative to the squalor of the city. It now suffers from many of the urban problems the exodus was initially responding to -- air pollution, traffic congestion, and a lack of open green space supporting a bounty of wildlife.

“The advancing city has often replaced complex natural environments of woods, streams and fields, with biologically sterile man-made landscapes that are neither socially useful nor visually enriching...There are enormous water, energy and nutrient resources that are the by-product of urban drainage, sewage disposal and other urban processes. Having no perceived value, these contribute instead to the pollution loads of an already overstressed environment” (Hough 1984, p.2).

**1.3 Seeds of Change**

“The physical limits of growth in human uses of a finite planet indicate that we cannot sustain our present trajectory. In order to change our trajectory it is imperative that we change our society. If we do not plan ahead and change thoughtfully, nature will force change upon us through pain.” (Milbrath, 1989, p.17)

With the social, economic and environmental costs of sprawl development becoming more apparent, and with yesterday’s suburban bliss being replaced with today’s apprehension, changes
in suburban form are challenging our basic understanding of human settlement patterns. The assumptions and decisions of the past have proven to exclude ecological consideration, the basis for all life. Change, for no reason other than self-preservation is inevitable.

Today, perhaps as never before, issues are emerging which suggest that support for an alternative, perhaps more sustainable design approach is genuine and more universal than ever before. We now see people actively engaged in recycling activities. The media regularly includes, however simplified, stories on proactive environmental action, and environmental problems. More specifically there are two 'seeds of change' which are already influencing the way we think of and build our communities.

**Changing Households**

During the last three decades household demographics have undergone fundamental change. Hans Blumenfeld calculated that in Canada, between 1971 and 1981, the population increased by 13.2 percent while households increased by 37.3 percent. By 1981, one-person and two-person households accounted for approximately 50 percent of Canadian households, with four-person and larger households representing less than 33 percent.

The Canadian nuclear family is disappearing yet housing typologies are not changing in response. While the household unit has shrunk and the number of households multiplyied, the average dwelling unit size has increased from 5.4 rooms to 5.7. The market is still failing to respond to mainstream demographic needs, preferring to dwell on the construction of larger homes for smaller, more affluent families. Blumenfeld calls this the “maldistribution” of housing. (Gerecke, 1991, p. 197-205)

Clare Cooper-Marcus argues that designers, planners and developers should be clear on who their projects are for.

"This may seem patently obvious; yet, when we look around at new housing, most is still being built for the traditional nuclear family. Mom, Dad, two kids, a dog, and a station wagon. This, despite the fact that we’re seeing an increasing number of small and single-person households because of divorce, people marrying later, having fewer children, etc. We’re also getting more and more unconventional households: two men sharing with occasional visiting children; a divorced woman plus children renting rooms to students to keep up the mortgage payments; etc. And yet, we see very little housing currently produced for anything other than the
nuclear family.” (Van der Ryn and Calthorpe, 1986, p.121)

The suburb’s preference for single family housing fails to acknowledge these changing households. Non nuclear families, particularly middle class singles, single parents and seniors are disenfranchised by the inflexibility of the housing types. It is quite possible that unless more diverse and affordable housing units are provided, the cost of suburban living will price the suburb out of the market for most singles and couples. However, as is the case with free markets systems ruled by supply and demand, the demand for new forms of housing will eventually force change in the profile of suburban housing.

**Changing Workplaces**

A technological and managerial revolution is rapidly transforming the nature of work and workplaces in the post industrial age. (Garreau, 1991; Castels, 1985) Business, particularly service based industries, are now trying to control the flow of information as much as the flow of goods. Mass production and blue-collar jobs are being surpassed by white collar, service niches, with flexibility to adapt to changing markets. In the United States between, 1973 and 1985 “five million blue-collar jobs were lost nationwide while the service and information fields gained from 82 to 110 million jobs. This translates into new office complexes, with 1.1 billion square feet of office space constructed. Nationwide, these complexes have moved outside the central cities, with the percentage of total office in the suburbs shifting from 25 percent in 1970 to 57 percent in 1984.” (Kelbaugh, 1989 p. 9)

Computers, fax machines, and cellular phones allow universal access to local, national and international markets and businesses, without ever leaving the office. The command control and hierarchical management structures of the industrial age is being replaced with more horizontally integrated management approaches. The central office, housing all employees, is being replaced by decentralized satellite operations and “back office” functions located outside the traditional urban core (Castels, 1989).

“Decentralisation of services is taking place on at least three different levels: between regions; from metropolitan to non-metropolitan areas and small cities; from inner cities to the suburbs of metropolitan areas” (Castels, 1989, p.154).
This transformation and the burgeoning interest in telecommuting and home based offices offers opportunities to redirect the job-housing imbalance and the automobile dependency of suburbia.

1.4 A New Way of Looking

Moreover these “seeds of change” are among many which are enabling us to reflect upon the problems of current urban development and seek an alternative approach to community design. The transformation of households and workplaces change the demands on how and where we can live and work. The frustration of traffic congestion and gridlock provides further impetus for seeking locally based, if not home based, employment opportunities. And our general understanding of environmental problems is beginning to influence how we interact with the world.

It is a perspective which has gained momentum since the release in 1987 by the World Commission on Environment and Development, of a report titled “Our Common Future”. It was the culmination of four years of United Nations sponsored research into issues of development, economy, and the environment. Chaired by Gro Harlem Bruntland of Norway, the Commission generated numerous recommendations for addressing environmental degradation and economic inequity. The commissioned popularised the phrase, “sustainable development”, defined as a means to address “the needs of the present without compromising the ability of future generations to meet their own needs.” (WCED, 1987)

While the concept of sustainable development has been criticised as being oxymoronic and ambiguous, the notion of living on this planet in a manner which neither endangers our future nor that of the planet has lead to some provocative thinking and writing. Many are referring to this thinking as a “paradigm shift” or change in our world view, and certain elements of the shift implicate the design of our communities.

The paradigm shift argues, as its central thesis, that a move away from our present ‘I - It’, anthropocentric relationship with nature towards an ‘I - thou’, biocentric approach is essential for profound change to occur. (Rees and Roseland, 1991; Sale, 1991; Milbraith, 1989; Rees, 1988; Bookchin, 1980) It argues that western society perceives humanity as a separate, distinct
phenomenon from nature. Nature is a third party referred to as the “environment”, hence the I-It relationship. The “paradigm shift” involves an alternative perspective based on accepting humans as active participants in the biospheres, wholly dependent upon nature for sustenance. Without a shift away from the status quo towards this new paradigm, it is argued society will collapse as will natural ecosystems. (Milbrath, 1989; Rees 1988)

Comparing Paradigms

“Constants of human behaviour, such as the maintenance of individual spacing, and of group territories, the search for identity and the need for orientation and social structure must be re-evaluated, and the implications reflected in future architecture and urban development.” (Hahn, 1992, p. 7)

Paradigms, or world views, define a society’s collective consciousness, what it knows and values, how it organises itself, and how it lives. To clarify a society’s world view is to understand its attitudes and expectations. These attitudes and expectations are manifested in the forms cities and towns, houses and roads, and forests and rivers. To fully understand how a new paradigm might effect the spatial qualities of community form it is worth comparing our current world view with this sustainable paradigm.

Western society’s current paradigm can be traced back to the theories and hypotheses of Francis Bacon, Rene Decartes, Isaac Newton and Galileo Galilei during the sixteen hundred’s (Rees, 1991; Berman 1981). These men revolutionized the relationship Renaissance society had with nature. Their enquiries lead to the belief that nature could be compartmentalised; that humans could separate themselves from a given phenomenon, observe it, predict it, and ultimately control it. The consequence was the emergence of a mechanised view of the world, a separation of humans from nature. It is a vision which believes the impacts of human activity are benign. The current paradigm, and its economically driven assumptions, “posed no survival threat to society as long as the economy was small relative to the scale of the ecosphere.” (Rees, 1991, p.16)

The conventional world view has not been without its critics. In 1948 Aldo Leopold published the Sand County Almanac in which he argued for a stronger “land ethic”. He claimed modern society
was disenfranchised from the cycles of nature as urban and suburban communities consumed enormous amounts of land and resources. This apparent contempt for the idiosyncrasies and integrity of natural systems, Leopold argued, would undermine the very existence of these communities. Leopold perceived modernist society as a divisive force between people and land, impairing humanity’s ability to judge the anonymity wrought by the current paradigm’s segregation.

“Perhaps the most serious obstacle impeding the evolution of a land ethic is the fact that our educational and economic system is headed away from, rather than toward, an intense consciousness of land, Your true modern is separated from the land by many middleman, and by innumerable physical gadgets. He has no vital relationship to it; to him it is the space between cities on which crops grow.”(Baron and Junkin, 1977, p.337)

However, Leopold’s arguments were marginalized as the United States was emerging from a depression and a war looking optimistically towards a more prosperous future. People were seeking a more affluent way of life with secure jobs and friendly neighbourhoods. Arguing that society was on a path to self-destruction contradicted the conventional view of the world as a benign place, an “equilibrium-centered view: nature constant.”(Holling, 1978, p. 294)

The paradigm shift is a move away from this “nature benign” perspective to one of nature as a dynamic interconnected entity. The shift further argues that he truisms and assumptions of the past are foundering as ecological degradation is becoming increasingly clear. Ecosystems worldwide are under pressures from rapidly increasing population and an inflexible social and economic organisation. (Brown, 1981) Rivers, lakes, and estuaries are increasingly polluted while tropical and temperate rainforests are deforested daily. (World Resources Institute, 1992; Odum, 1989) Simultaneously, disintegration plagues social systems. Inequity in the distribution of wealth has never been so extreme while the growing homeless population appears to be systemic. (World Watch Institute, 1992; WCED, 1987) Society’s economic system, the very heart of the conventional paradigm, is collapsing under an ever increasing number of bankruptcies, unemployed workers and defaulted loans, and enormous national and provincial debts. (Costanza, 1991; Daly & Cobb, 1989)

The following table offers a comparison of the fundamental differences between the conventional world view and the tenets of the paradigm shift.
TABLE 1 - Comparing the Conventional Paradigm with the Sustainable Paradigm

<table>
<thead>
<tr>
<th>Issue</th>
<th>Conventional/ Socioeconomic Paradigm</th>
<th>Sustainable/ Environmental Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relationship</td>
<td>a. low value/contempt</td>
<td>a. high value/respect</td>
</tr>
<tr>
<td>With Nature</td>
<td>b. I - It, human as dominator</td>
<td>b. I - Thou, nature as sustainer</td>
</tr>
<tr>
<td></td>
<td>c. disassociation with others</td>
<td>c. life interconnected</td>
</tr>
<tr>
<td></td>
<td>d. anthropocentric</td>
<td>d. biocentric</td>
</tr>
<tr>
<td></td>
<td>e. mechanistic</td>
<td>e. dynamic system</td>
</tr>
<tr>
<td>Social Order</td>
<td>a. myopic</td>
<td>a. intra &amp; intergenerational</td>
</tr>
<tr>
<td></td>
<td>b. hierarchical</td>
<td>b. equality</td>
</tr>
<tr>
<td></td>
<td>c. individual rights</td>
<td>c. individual responsibilities</td>
</tr>
<tr>
<td></td>
<td>d. emphasis of jobs for</td>
<td>d. emphasis on worker satisfaction</td>
</tr>
<tr>
<td></td>
<td>economic needs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e. de-emphasise emotions</td>
<td>e. emotions part of life</td>
</tr>
<tr>
<td></td>
<td>f. linear time, no longer</td>
<td>f. time cyclical and seasonal</td>
</tr>
<tr>
<td>defined by natural cycles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic Growth</td>
<td>a. unlimited potential</td>
<td>a. limited to ecological carrying capacity</td>
</tr>
<tr>
<td></td>
<td>b. inequity inevitable</td>
<td>b. equitable distribution for all</td>
</tr>
<tr>
<td></td>
<td>c. competition</td>
<td>c. cooperative</td>
</tr>
<tr>
<td></td>
<td>d. production and consumption</td>
<td>d. quality over quantity</td>
</tr>
<tr>
<td></td>
<td>e. large scale, rapid turnover</td>
<td>e. small scale, incremental</td>
</tr>
<tr>
<td>Organisation</td>
<td>a. command control</td>
<td>a. devolution of control; community</td>
</tr>
<tr>
<td></td>
<td>b. left-right polarity</td>
<td>empowerment and local control</td>
</tr>
<tr>
<td></td>
<td>c. market controlled</td>
<td>b. consultative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. emphasis on planning and process</td>
</tr>
<tr>
<td>Technology</td>
<td>a. science &amp; technology</td>
<td>a. science &amp; technology not always</td>
</tr>
<tr>
<td></td>
<td>boon to society</td>
<td>beneficial</td>
</tr>
<tr>
<td></td>
<td>b. emphasis on hard technology</td>
<td>b. emphasis on soft technology</td>
</tr>
<tr>
<td></td>
<td>c. information poor</td>
<td>c. information rich</td>
</tr>
<tr>
<td>Land Ethic</td>
<td>a. land viewed as commodity</td>
<td>a. carrying capacity critical</td>
</tr>
<tr>
<td></td>
<td>b. resource to be exploited</td>
<td>b. conservation</td>
</tr>
</tbody>
</table>

Changing Perspectives in Design

The sustainable paradigm is already at work changing society’s behaviour; in the form of blue box and newspaper recycling programmes, in energy conservation programs such as B.C. Hydro’s “Power Smart”, and in allotment gardens found in many communities. Change is also occurring in the planning and design professions. Issues of recyclable building materials, healthy indoor air environments which reduce the release of noxious fumes from synthetic materials, passive and active solar architecture, xeriscape and native habitat design are becoming more accepted. (Walter, 1992; Vale, 1991; Van der Ryn and Calthorpe, 1986; Hough, 1984; Spirn, 1984)
What follows is a comparison of the conventional planning and design paradigm with the ecologically sustainable design paradigm. Many of these new values have not yet manifested themselves into a design model, nor substantially altered the form of cities and towns. Change can happen, however, as evidenced by such standard practices as ensuring clean air and water, and producing environmental impact assessments, each of which was at one time a controversial initiative. It should also be noted that the following information is my synthesis of ideas from many, sometimes disparate sources, and that I provide it for the purposes of discussion.

**TABLE 2- Comparative Analysis of Conventional and Ecological Planning and Design Values**

<table>
<thead>
<tr>
<th>Conventional Planning and Design Values</th>
<th>Ecological Planning and Design Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>• city perceived as closed system, isolated from changes in the outside environment.</td>
<td>• city perceived as part of larger interdependent system.</td>
</tr>
<tr>
<td>• assumes empirical understanding and control of natural systems.</td>
<td>• accepts and respects limits of knowledge pertaining to ecosystems.</td>
</tr>
<tr>
<td>• perceives few physical limits to design.</td>
<td>• respects ecological limits on design.</td>
</tr>
<tr>
<td>• water, air, land, energy, abundant - no conservation strategies required.</td>
<td>• water, air, land, energy, resources scarce - require conservation.</td>
</tr>
<tr>
<td>• willing to manipulate natural systems for perceived economic benefit.</td>
<td>• manipulation of environment only as can be sustained by ecosystem.</td>
</tr>
<tr>
<td>• strives for predictability and stability and the elimination of variation.</td>
<td>• regards integrity and persistence as desirable recognizing fluctuation inevitable.</td>
</tr>
<tr>
<td>• design objectives constrained by technology and cost.</td>
<td>• design objectives limited by carrying capacity of environment.</td>
</tr>
<tr>
<td>• considers only short term implications max. 5-10 years.</td>
<td>• long-term time horizon, intergenerational.</td>
</tr>
<tr>
<td>• concerned with the flow of money.</td>
<td>• concerned with the flow of energy.</td>
</tr>
<tr>
<td>• land values determined by market forces and economic indices.</td>
<td>• land value and use determined by ecological indices.</td>
</tr>
<tr>
<td>• environmental health and social costs of marginal concern relative to economic and political concerns.</td>
<td>• equally concerned with social and environmental health, and equitable distribution of wealth.</td>
</tr>
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</table>
• project success based on revenues and expenditures.
• evaluates project health/success based on impacts on biomass, wildlife populations, energy flows.

• favours larger scale projects.
• projects small scale, incremental.

• individual projects occur in isolation.
• projects are interrelated, cumulative.

• growth patterns tend toward low density, sprawl and scaled for efficient movement of machines.
• compact growth patterns with village centre and human scale.

• automobile dominates transportation systems.
• multimodal transportation, prioritise pedestrian and bikes.

• single use zoning, segregation of perceived land use conflicts
• mixed use development and diversity essential.

• development controlled with prescriptive codes, standards, guidelines.
• development controlled with performance based codes, standards, guidelines.

• design priorities are primarily economic.
• design priorities respect ecosystem integrity.

• investigation into energy conservation and reclamation practices are primarily public initiatives
• ongoing investigation into energy conservation and reclamation joint private and public initiatives.


1.5 Conclusion

These two paradigms could hardly be more antithetical even though both are value laden and both espouse to know the truth. The conventional paradigm is, without question, more aggressive towards nature. (Fowler, 1991; Rees 1991) Where it pushes the other withdraws. Furthermore, the conventional paradigm has fostered a society so disassociated from the land it inhabits that little is known of nature’s qualities and characteristics. Most understanding of ecosystems is through vicarious means, not direct experience. Western society has become ignorant, if not oblivious, to the dynamic of natural systems continuously cycling amongst us.

This is particularly true of suburbia whose physical form epitomizes the wasteful, exploitive nature inherent in the current paradigm. As discussed earlier in this chapter suburbia consumes land with
a ravenous appetite while simultaneously segregating traditionally interrelated concepts of home, work, shopping and play. It dislocates not only the physical community but the social community as well. (Rowe, 1991; Hough, 1990; Kelbaugh, 1989; Newman and Kenworthy, 1989; Hayden, 1984; Relph, 1976) Suburbia has become a vicious cycle of increasing sprawl, increasing consumption of resources, and increasing commitments of travel time to reach places of economy and socialisation. An alternative approach, based on the ecologically sustainable paradigm, is needed. The chapters which follow explore an alternative approach which accepts as its foundation, and its point of departure from the status quo, this new sustainable paradigm.

"Without self-understanding we cannot hope for enduring solutions to environmental problems, which are fundamentally human problems"

*Yi-Fu Tuan*, Topophilia
2.0 THE URBAN SYSTEM
“While we are used to thinking of cities as geographically discreet places, most of the land ‘occupied’ by their residents lies far beyond their boundaries. The total area of land required to sustain an urban region (its ecological footprint) is typically at least an order of magnitude greater than that contained within municipal boundaries or the associated built-up area. In effect, through trade and natural flows of ecological goods and services, all urban regions appropriate the carrying capacity of distant ‘elsewheres’, creating dependencies that may not be ecologically or geographically stable or secure.”

William E. Rees, 1992

2.1 Introduction

It has been argued that the earth is a highly dynamic organism, with a complex web of interdependent relationships. (Hahn, 1992; Rees and Roseland, 1991; Odum, 1989; Deelstra, 1988; Lovelock, 1988; Holling, 1987) These relationships form the web of life and help to maintain the integrity and viability of life as we know it. Incoming solar energy, the flow of water, the transfer and exchange of resources and materials, biochemical reactions, microbial activity, various plants and organisms, all interdependent, conspire to create a diverse and relatively stable planet.

Within these interrelated systems exist cities and towns, most with rapidly expanding populations and physical footprints. In 1950, 25 percent of the world’s population lived in urban areas. By 1980 this had increased to 41 percent, with prospects for the year 2000 to be greater than 50 percent. (Brown, 1981, p.268) The corresponding growth in the footprint of cities has been at the expense of forest and farmland, water bodies, marshes, aquifers, and floodplains. These are the various landscapes features responsible for basic ecological functions and their loss has had serious environmental consequences as is evidenced by the litany of polluted watertables, eroded arable land, species extinction, noxious atmospheric emissions, and loss of forest cover -- potentially lethal impacts perpetuated by human settlement patterns. (Hahn, 1991; Spirn, 1984)

Finding alternative solutions to these human settlement problems depends on our ability to transform our understanding of cities. We need to reject the notion of the urban system as an
autonomous entity, disconnected from regional ecosystem function, and accept that it is a dynamic organism that must develop the symbiotic patterns and exchanges characteristic of natural ecosystems. This chapter examines the ecology of the urban system to identify opportunities which may exist for redesigning the way it operates.

2.2 The Heterotrophic City

The first change involves looking at cities as systems dependent on incoming flows of energy, water, raw materials, products, and people from other places while out of these cities comes a separate flow of goods, products and wastes (Rees, 1992; Deelstra, 1988; Van der Ryn and Calthorpe, 1986; Hough, 1984; Spirn, 1984). Odum (1989) understands urban systems as analogous to certain natural ecosystems which are equally dependent upon the input of external nourishment. Both these natural "heterotrophic" ecosystems and the urban system require the continuous input of various forms of energy, air, water, sunlight, and food for the survival of the system.

Figure 1 - Heterotrophic ecosystems
"In natural and semi-natural landscapes that contain a variety of ecosystems (e.g., forests, grasslands, farmland, lakes, ponds, streams), autotrophic and heterotrophic activity taken as a whole tends to balance; the organic matter produced is utilised in growth and maintenance over the annual cycle. Sometimes production exceeds use, in which case organic matter may be stored (as peat in a marsh for example) or exported to another ecosystem or landscape (as in agriculture). In contrast, cities (and industrialised landscapes in general) consume much more food and organic matter than they produce, and are accordingly heterotrophic ecosystems... Figure 5 [figure 1] compares an oyster reef, one of nature’s heterotrophic ecosystems, with a city; both must get their food and other energy from outside. ..There is nothing wrong or bad about our cities being heterotrophic - so long as they are linked with adequate autotrophic systems that supply the food and other energy (not to mention the raw materials) required and can also assimilate the large output of wastes produced by the city.” (Odum, 1989, p.44-45)

Should the heterotrophic system consume more resources than the autotrophic system can produce and sustain, both systems will ultimately fail. What differentiates the reef from the urban system is that reef has no mechanisms for appropriating energy from beyond its immediate environment. Its growth is regulated by the energy and nutrients which wash over its surface. The urban system, on the other hand, has developed extensive infrastructure to ensure the continued appropriation of resources and materials from distant lands. (Rees and Roseland, 1991; Odum, 1989) Odum describes the relationship as that of a host - parasite;

"The city is a parasite on the natural and domesticated environments, since it makes no food, cleans no air, and cleans very little water to a point where it could be reused. The larger the city, the greater the need for undeveloped or lightly developed countryside to provide the necessary host for the urban parasite. When we discuss host-parasite relationships later, we will note that a parasite does not live for very long if it kills or damages its host. The well-adapted parasite not only does not destroy its host - it actually develops exchanges or ‘feedbacks’ that benefit both itself and its host so that both may survive. And so it must be for the well-adapted, sustainable city.” (Odum, 1989, p.17)

### 2.3 Ecologically Based Urban Systems

If the “well-adapted, sustainable city” is to be realised, it must develop the exchanges with local and regional ecosystems which characterize natural ecosystems. Specifically the urban system must recognize and build upon the following concepts of ecological function and sustainable landscapes. (Forman, 1990; Odum, 1989; Holling, 1987)
- **Input-Output Flows**
- **Diversity**;
- **Intergenerational Planning; and**
- **Fabricated, Domesticated and Natural Environments.**

Each concept is presented in with two components. The first component discusses the idea as it applies to ecosystem function. The second discusses how the idea relates to the urban ecosystem.

### • Input-Output Flows

All ecosystems, be they heterotrophic or autotrophic require some basic inputs such as solar energy to sustain themselves. These inputs provide the necessary energy, food, water, or air to support the system’s activities. More often than not these inputs find themselves being transformed by exchange mechanisms developed within the system for better utilization. One of the most important features of this transformation is that by-products are created that the system may not be able to use. Consequently these by-products or ‘outputs’ leave the system and become necessary inputs for another system. (Odum, 1989; Holling, 1987) Odum offers the following organisational model,

![Figure 2 - Model of an ecosystem](image)

"We can label the system...and two large funnels that we can label input environment and output environment. Energy is a necessary input. The sun is the ultimate source for the biosphere, and directly supports most natural ecosystems within the biosphere. But there are other energy sources that may be important for many ecosystems, for example, wind, rain, water flow, or fuel (the major source for the modern city). Energy also flows out in the form of heat and other..."
transformed or processed forms such as organic matter (e.g., food and waste products) and pollutants. Water, air, and nutrient necessary for life, along with all kinds of other materials, constantly enter and leave the ecosystem. And, of course, organisms and their propagules (seeds and other reproductive stages) enter (immigrate) or leave (emigrate)." (Odum, 1989, p.39).

Input and output environments represent the symbiotic exchanges which develop between different ecosystems and which each system ultimately becomes dependent on. It is the absence of these symbiotic inputs and outputs which undermines the sustainability of the urban system. Its inputs are indiscriminately taken from other systems, transformed and discharged out of the system in an unusable and often noxious form. Clearly understanding the urban system's principal inputs and outputs, and their associated problems, will help define a more ecologically based design approach.

Energy Inputs

"Urban-industrial developments (fabricated environments) actually cover a small area of our landscape, but they are so energy intensive, i.e. they require so much energy and create so much waste heat and pollution, that they have an enormous impact on the (natural and domesticated) environments. For example, the energy density of an urban-industrial area is 1,000 or more times greater than that of a forest." (Odum, 1989, p.9)

The urban system is an energy intensive system based on the input of a cheap and limitless supply of energy from outside the system. Electrical energy enters along high voltage power lines from distant hydroelectric, coal fired or nuclear power plants to illuminate and heat buildings, power machinery and appliances, and fuel specific transportation systems. Fossil fuels are imported for use in transportation systems, to heat buildings and for use in the manufacturing sector. Food energy enters as imported produce on railcars or trucks. The urban system presumes these energy supplies to be cheap and limitless. It is a critical assumption because the system has little capacity to generate any of its own energy, despite its considerable demands. Yet all of these energy sources are either finite in supply and or ecologically destructive in use.

Water Inputs

"As water is used, it evaporates from vegetation, lakes, and other surfaces, percolates through soil into groundwater, and runs off in streams and rivers to the sea. No matter how water leaves the ecosystem it must eventually be replaced by rain if commerce, agriculture, recreation, or any part of human life is to continue as before." (Odum, 1989, p. 108)

Just as the input of energy is critical to the success of the urban system so is the presence of water. It is used for drinking, washing, flushing toilets, irrigating lawns and gardens, cleaning cars, and in some cases, to heat houses. Industrially and commercially it serves as a coolant and lubricant for machinery, as an ingredient in the processing and manufacture of goods, and as a heat exchanger in air conditioning systems. Water also supports a variety of recreational activities including gardening, swimming, boating, snow skiing, skating, and golfing. However, despite its importance, the flow of water through the urban system is hidden from view. It mysteriously enters either via subsurface pipelines connected to hidden plumbing inside houses, or as surface runoff which is quickly diverted to a labyrinth of curbs and gutters, storm and sanitary sewers, and culverted streams. (Hough, 1984; Spirn, 1984) Little connection is made between the water flushed down the toilet and the water that fills the drinking glass.

Urbanization marginalises local water supplies by altering natural drainage patterns, paving soils, draining swamps, marshes and ponds, culverting streams, increasing runoff and decreasing infiltration. (Walter[ed.] 1992, Odum 1989, Spirn, 1984) Aquifers are contaminated by wastewater and toxic pollutants percolating down from the surface. In general the input of water into the urban system undermines the value of water to the local system. It is removed physically from the landscape, and mentally from the psyche of the resident, despite the importance of water to our physical well being.

"Water is a source of life, power, comfort, and delight, a universal symbol of purification and renewal. Like a primordial magnet, water pulls at a primitive and deeply rooted part of the human nature. More than any other single element besides trees and gardens, water has the greatest potential to forge an emotional link between man and nature in the city." (Spirn, 1984, p.142)

Food Inputs

In many respects cities owe their existence to agriculture. Without the ability to produce large quantities of food plants and animals, cities could not have developed. Until the industrial age arrived the size of any given city was effectively limited by its local agricultural productivity. (Mumford, 1961) However, as cities began to grow and imported food supplies became available, prime farmland was no longer an essential component of the urban system.
"One of the distinctive characteristics of cities is that they depend on food surpluses produced elsewhere. In fact urbanization first began with the development of agricultural surpluses made possible by technical advances such as irrigation and the use of animals....But whereas in the past cities drew on nearby land for food supplies, in the modern world they import from distant countries. Their hinterland in now worldwide. This reliance on food supplies from distant sources illustrates the fragility and vulnerability of the urban ecosystem." (Boyden and Celecia, 1981, p.25)

Fowler (1991) argues that the current urban ecosystem is based on an agribusiness which prioritizes large production and distribution economies of scales at the expense of local productivity. The importation of food allows local arable land to be forsaken for urban sprawl.

**Land and Material Inputs**

The urban system requires the input of land to grow and accommodate development, road construction, and commercial and industrial activities. The system also requires the input of construction materials to support these activities. Land is cleared of natural vegetation and drainage patterns are altered to allow imported gravel, wood, masonry, metal, and or plastics to transform the site. Simultaneously the replacement of existing buildings requires further inputs of materials and energy. Yet land and materials are finite in supply and appropriating them for use in the urban system will inevitably lead to some environmental consequences, albeit removed from the urban system.

**Waste Outputs**

"The squandering of resources and the contamination of air, earth, water, and life are two faces of urban waste. Cities are forever short of energy and raw materials and struggle unceasingly to rid themselves of their waste. Waste disposal has been a perennial problem of cities; but the problem is more severe today than ever before." (Spirn, 1984, p. 231)

After the urban ecosystem processes these inputs of energy, water, food, land and materials, most emerge from the system transformed. Water, no longer clean and potable, exits the system as sewage effluent or surface runoff tainted with oil and gas. Food wastes are discharged either as sewage effluent or solid waste to be dumped in landfills. These are joined in the landfill by material waste such as paper and plastic products, and building materials. The use of fossil fuel energy results in the release of CO₂, SO₂, NOₓ, and other hydrocarbons to the atmosphere as pollutants. Vast amounts of heat are also generated by various activities and released to the atmosphere.
resulting not only in the loss of a valuable resource but in the fuelling of the "heat island effect." (Spirn, 1984, p. 52). These are typically one way flows where the output is generally too noxious for natural ecosystems to assimilate. In extreme cases these outputs are lethal to natural ecosystems.

"Every inhabitant of a modern western country...generates around 2 tons of rubbish per year: 1 ton of domestic refuse and 1 ton of factory waste from industrial products we all purchase" (Girardet, 1991, p.172).

The indiscriminate handling of waste in the urban system is severely affecting the health of natural ecosystems yet the urban system is well insulated from these problems. The problems associated with inputs are generally left in the place where the input was manufactured or harvested and the problems associated with outputs are moderated by the fact that disposal happens away from the urban system (Rees 1992).

Managing Input/Output Levels

The keys to restructuring the urban ecosystem is to manage these various inputs and outputs as valuable resources for reuse within the urban system. The urban system must limit its inputs to those which can be easily converted into a desired product or output, on a sustainable basis.

"Input management of production systems (e.g. agriculture, power plants and manufacturing) is a practical and economically feasible approach to improving and sustaining the quality of our life-support systems....(the urban system must begin) assessing inputs to the whole system first, then internal dynamics and outputs second. Applying the concept of wastes means that waste reduction takes precedent over waste disposal." (Odum, 1989, p.267)

The urban system must be organized in such a manner that the dynamics of inputs and outputs mirror the symbiosis found in natural ecosystems. It must balance the productivity of what it uses with what it returns. The current linearity of the urban system must become circular with every output becoming an input and every input an output. (Girardet, 1991) The ecologically sustainable urban system must be designed in ways which make visible the flow of water from the time it enters the urban ecosystem to the time it leaves. It must find ways to enhance local food supplies and reconnect residents with the importance of local agriculture. It must find ways to become more self-sufficient in its own energy supply. In general the urban system must be designed to minimize inputs and the appropriation of distant resources. Furthermore, the outputs that do result must be in
a form that is usable to the recipient system.

- **Resiliency and Diversity**

A second feature of natural ecosystems which is relevant to defining a more sustainable ecosystem is the concept of “creative destruction” and its relationship to diversity. Holling (1987) argues ecosystems are constantly cycling between four general states of organisation: 1. Exploitation; 2. Conservation; 3. Creative Destruction; and 4. Renewal.

“The full dynamic behaviour of ecosystems at an aggregate level can therefore be represented by the sequential interaction of four ecosystem functions....The progression of events is such that these functions dominate at different times: from exploitation, 1, slowly to conservation, 2, rapidly to creative destruction, 3, rapidly to renewal, 4, and rapidly back to exploitation. Moreover, this is a process of slowly increasing organisation or connectedness (1 to 2) accompanied by gradual accumulation of capital. Stability initially increases, but the system becomes so overconnected that rapid change is triggered (3 to 4). The stored capital is then released and the degree of resilience is determined by the balance between the processes of mobilization and of retention. Two properties are being controlled: the degree of organization and the amount of capital accumulation and retention. The speed and amplitude of this cycle, as indicated earlier, are determined by whether the fast, intermediate, or slow variable dominates the timing.” (Holling, 1987, p.307)

The main lesson of the creative destruction model is that ecosystems are never static but are constantly battling the forces of increasing order and forces of entropy. It is a struggle which actually leads to an ongoing renewal and strengthening of the system. It ensures the system does not become homogenous and dominated by a few main features.

An old growth forest can serve as a good analogy. At first glance it appears to be a static somewhat uniform entity. However, a closer look at its canopy reveals patches of older, dying forest and younger, vibrant forest. Here the forest is subject to perturbation from insects, disease, lightening, fire and old age. It is an indication that the system is renewing itself to remain strong and vital. The plant species that invade the site will eventually give way to the climax species once again but not before they have enriched the soil and diversify the landscape. The reason the entire forest ecosystem does not collapse all at once is that the majority of the system is actually quite diverse and resists the forces of change which affected the patch. If, however, the forest was as homogeneous as it at first appears diseases would have a better chance of infecting the whole...
Holling argues this process can serve as an analogy for the growth and destruction of cities. “there are strong hints, at least from analysis of institutional organisations, from the perspective of cultural anthropology and technological developments, that functions similar to these four ecosystem functions (exploitation, conservation, creative destruction and renewal) operate.” (Holling, 1987, p.312)

A close examination of the life of cities illustrates this dynamic of growth and atrophy is commonplace, if not predictable. In Mesopotamia, the Sumerian city of Ur grew to prominence in 3,000 B.C. only to collapse 1,000 years later after its local ecosystems collapsed and it lost control over the more distant ecosystems which were supporting it. Alexandria, Rome, and Athens each share similar stories of preeminence and deterioration. Cities in Meso and South America, such as the Mayan’s Tikal and the Inca’s Cuzco grew and collapsed under the success and failure of their societies. (Ponting, 1990) In eighteenth and nineteenth century England and Eastern North America numerous cities enjoyed the prosperity of the industrial revolution only to see their fortunes evaporate in the post World War II era as their undiversified economies collapsed. Most recently the fortunes of cities such as Montreal, Toronto and Boston have withered as the same economic prosperity which fuelled their growth vanished.

The process of slowly increasing organization or connectedness, leading to a situation where the ecosystem is “overconnected” is applicable to the urban system. For example, as communities grow their demand for basic supplies of food, energy and water increases. Eventually this growth exceeds local supply, forcing the community to look elsewhere for these resources. This was the scenario in the early 1970’s when the oil crisis created chaos for the United States, which found itself overdependent on an imported supply of oil that became scarce. Another example is the ongoing battles between Los Angeles and San Francisco for drinking water as both systems are overextended in their water supply and therefore subject to variations in supply. This process of overconnectedness is a process whereby the urban system grows beyond the capacity of the region to support it economically and ecologically. The system becomes vulnerable to perturbation economically, ecologically and socially.

“As a particular technology matures, it tends to become more homogeneous and less innovative and adaptive...the technical options worth considering become narrower and narrower...What happens is that through its very success a new
technology and its supporting systems constitute a more and more self-contained social system, unable to adapt to the changes necessitated by its success." (Holling, 1987, p.313)

What the creative destruction model implies for the urban system is that for it to become more sustainable it must reduce, if not eliminate those features which lead to increased levels of social, economic and environmental homogeneity. It must also reduce those features which lead to an increased dependency on supplies of resources and materials which are appropriated from outside the region. These tendencies result in a less resilient and adaptable system.

In essence the urban system must diversify itself by prioritizing locally based economic, social and ecological features. It should no longer rely on other systems to handle its waste, clean its water, supply it with energy and food. It must construct buildings to be flexible in their use to allow them to adapt to changing demand. It must maximise opportunities for local business and employment. It must develop local patterns which provide energy and food. And it should focus on those features which are small, diverse and adaptable.

**Intergenerational Planning**

Forman (1990) argues that all land use decisions in the sustainable landscape must be made with concern for the ecological impacts one to two hundred years in the future. This is the time horizon which most closely matches the cycles and changes inherent in natural ecosystems. It allows decisions to be made based not only on the insight of past successes and transgressions but on the likely consequences for future ecological and human health. Lynch (1972) considers a clear, long-term understanding of time is essential as it brings with it a clearer concept of natural rhythms, cycles and change.

"The quality of the personal image of time is crucial for individual well-being and also for our success in managing environmental change, and that the external environment plays a role in building and supporting that image of time." (Lynch, 1972, p.1)

Long term planning spanning many generations contrasts the urban system's current approach to growth and development which is at best two to three decades long, and more commonly guided by short term political and economic agendas.
“Perhaps historical analyses of cycles of climatic change, biological evolution pulses, major technological innovations, and so on, could make the time period of sustainable development more precise than ‘over human generations’.” (Forman, 1990, p.263)

• **Fabricated, Domesticated and Natural Environments**

The final ecological concept relevant to the discussion of urban ecosystems is the distinction between fabricated, domesticated and natural environments. Odum (1989) argues ecosystems can be broadly divided into three types of environments as most of the planet has been subject to some level of alteration due to human activity. These three categories reflect levels of productivity and characteristics unique to each environment.

**Fabricated Environments**

These include cities and their related infrastructure such as transportation and utility corridors. These are “fuel-powered systems” requiring the input of vast amounts of non-solar based energy from outside its immediate boundaries. (Odum, 1989, p.9)

**Domesticated Environments**

Domesticated environments sit on the cusp between the natural and fabricated environments and are characterised by extractive resource and agricultural practices. They are considered “subsidised solar-powered systems” because they supplement incoming solar energy, with inputs of fuel based human activity, such as labour, and machinery. (Odum, 1989, p.9-10)

**Natural Environments**

Natural Environments are the critical, autotrophic systems from which the fabricated systems draw support. They are relatively undisturbed systems considered as “basic solar-powered systems” because their principle energy source is the sun. Consequently they are the only “self-supporting” system of the three. (Odum, 1989, p.10)

Odum (1989) argues that it is the combination of natural and domesticated systems which comprise the earth’s life-support systems. The key to sustainability, therefore, is that the fabricated system must not undermine the balance between natural and domesticated systems, either by expanding
activity in local domesticated environments beyond capacity, nor by appropriating the productivity of more distant domesticated environments. The fabricated system must not lead to a net reduction in the productivity of the natural environment.

This characterisation is useful because it recognizes that the urban system will never be an entirely autonomous entity, that as a system it will always require an association with a domesticated environment to supply it with the resources and food it cannot produce on its own. However, the demands of the association are that the fabricated or urban system can never exceed the carrying capacity of the natural and domesticated system, therefore the size of the urban system must be determined by this balance.

2.4 Conclusions

These ecologically based principles begin to describe the features or qualities the urban system must embody if it wishes to survive. By introducing input-output flows into the requirements of all design activities the current linearity of the urban system will develop the circular exchanges exhibited by natural ecosystems. By diversifying the urban system’s structure, its landscape patterns and its building types the system’s homogeneity will disappear, its dependence on external inputs will be reduced and its ability to adapt to local changes will increase. By incorporating a planning time line which reflects ecological change rather than political or economic agendas short term speculative development will disappear and more ecologically based development will emerge. Finally, if the urban system is to become sustainable its size and shape must be defined and limited by the region’s carrying capacity.

These four principles are already affecting change in the way the urban system, and its constituent parts, is organized. Chapter three identifies several projects found in Europe and North America which are directly or indirectly responding to these principles.
3.0 ECOLOGICAL DESIGN PARAMETERS
3.1 Introduction

Virtually all systems and organisms change through mutual interactions. Few plants reproduce without pollination by bees and few bees exist without the nutrients they gain from pollination. Similarly the hydrologic cycle is influenced by vegetative cover which in turn is affected by the hydrologic cycle. These are symbiotic, mutually supportive interactions and what distinguishes them from the urban system is the lack of symbiosis in the latter. As described in chapters one and two the urban system is organised by dubious and ultimately predacious planning and design strategies. However, as the rules of ecology demonstrate quite clearly, without symbiotic exchanges such a system will ultimately fail.

The intent of this chapter is to identify alternative solutions to the design of the urban system and develop a set of ecologically based design parameters. These are parameters that seek to develop a more symbiotic relationship with local and regional ecosystem; that return water from the urban system to the natural ecosystem free of pollutants; that reduce dependencies on non-renewable, distant resources; and that transform waste into a resource for other organisms and systems. This is the essence of ecologically sustainable design.

The parameters address such issues such as water conservation, waste recycling, energy self-sufficiency, food production, mixed uses, and multi-modal transportation systems. They were derived from site visits, interviews with project designers and literature searches of a variety of projects in Europe and North America which explore the notion of ecologically sustainable design. Once defined, these parameters will be used to guide the design of an alternative, and hopefully more ecologically sustainable vision for a suburban neighbourhood in Langley.

For ease of discussion the information has been organized into the six categories. This categorization is not intended to imply that one operates exclusive of another. Rather, as with most symbiotic relationships, these categories represent the building blocks which collectively can shape the future form of the community.
Interestingly many projects reflect local, grass roots initiatives rather than governmental impetus. Most tend to be small in scale with modest technical complexity though there are a few which demonstrate larger scale applications.

The methodology used in selecting the examples was somewhat subjective due to the lack of consensus as to what constitutes sustainable design and how one measures it. More important, however, is that the very nature of ecological design eludes the methodological techniques of other disciplines. Statistical evaluations are inevitably incomplete since statistics depend upon the ability to isolate dependent and independent variables, an impossible task within the context of ecology. While the energy savings of a particular building can be quantified it becomes much more difficult to measure the ecological benefits of that conserved energy. Similarly while the number and variety of tree species can be counted, measuring something as amorphous as the forest’s biodiversity is difficult.

Therefore I relied upon a few basic questions:

- Does the project engage a broad spectrum of ecological issues?
- Are there measurable savings of energy, water, waste or land?
- Does the project produce its own energy or food?
- Is waste recycled?
- Does the project improve local hydrologic patterns?
- Is the project designed with flexibility and adaptability in mind?
• Does the project rely upon local materials and local economy?
• Are the technical demands of the project simpler than conventional approaches?
• Does the project add to, rather than subtract from, ecological diversity?
• How does the project address issues of community?
• What are the place making qualities of the project?

In the end this assimilation of ecological design features into a list of parameters does not presume to be a definitive list. It is simply a list which provides a new direction for design to explore. Christopher Alexander said of his seminal book, A Pattern Language, that “we hope, of course, that many of the people who read, and use the language, will try to improve these patterns - will put their energy to work, in this task of finding more true, more profound invariants.” (Alexander, 1977,p.xv) I believe this listing is an elaboration of Alexander's patterns towards an ecological design aesthetic.

3.2 The Antecedents of Ecological Design

While the scope of this thesis is limited to contemporary examples of ecological design, there are many features embodied in early industrial and preindustrial cities which are relevant to an ecologically based design model and worth a brief review. (Kostof, 1992; Alexander, 1977; Cullen, 1961; Mumford, 1961)

Compact, Dense, Pedestrian-Oriented Form

Cities and towns with these forms are ubiquitous in Europe and annually attract tourists captivated by the character of these compact communities. It is this same compact form, characterised by high densities and short distances which can provide valuable lessons in the search for sustainable communities. With a reliance on walking, all services and functions are connected by a network of pedestrian paths. The compact form of community reduces the amount of energy expended on transportation. At the same time agricultural land is conserved to maintain local food supply. Similarly ecologically sensitive lands such as creeks and marshes are spared due to the difficulty of developing them. This compact, densely populated form of community results in discreet boundaries and a strong community identity.
Human Scale Design
The overall scale of the preindustrial city is much less imposing than today’s cities and towns. Road widths accommodate the movement of people and horses, not automobiles. Buildings are not setback as the conservation of land would not allow such indulgences as exist in today’s single family house. Limited building technology restricted buildings to a maximum of five or six stories. And locally based economies and small building modules contrast today’s large building floor plates which serve larger companies with national and international interests.

Live/Work Relationships
The preindustrial city or town is characterised by a mixture of uses. Without modern mobility people lived, worked and shopped in the same neighbourhood. Consequently little time and energy is spent commuting.

Public/Private Realm
Row houses and apartment buildings with internal courtyards and strong street related facades help to clearly define public and private space. Plazas, promenades, public markets and urban parks play an important role in the public image and accessability of the community as a great deal of community life occurs in them. Contrasting this is today’s city where the public realm is more ambiguous, where it is subject to corporate influences. (Hough, 1992; Rowe, 1991; Hayden, 1984) According to many ecocity planners and designers (Calthorpe, 1993; Hahn, 1992; Deelstra, 1991) the presence of this publicness is an important enabling factor in the search for more ecologically sustainable communities.

Common Walls
Another benefit of the row house found in cities throughout history is its common wall. In sharing at least two walls and in many cases the ceiling and floor, row housing reduces the exposed walls per household by a minimum of two and a maximum of four. This means space heat is lost in, on average, two or three directions. (Walter, 1992; Brown, 1985). Alternatively the single family house exposes four walls, a floor and a roof to the elements resulting in energy loss in six directions, or double to triple the number of surfaces in a typical row house.
**Incremental Growth**

Change generally happened, and still happens, much more slowly in the preindustrial city than in today's city of mercurial transformation. Demolition, reconstruction and renovation were largely modest in scale, responding to changing family or business needs. (Lozano 1991) This incremental change or "piecemeal growth" (Alexander, 1987) unknowingly resulted in an intergenerational architectural legacy which continues through today and which is fundamental in defining the identity of the community. This legacy and subsequent identity contrasts that of the anonymity of the modern city and suburb where rapid change makes it difficult to retain local identity and where styles are appropriated from another context. (Hough, 1992; Relph, 1976; Lynch, 1972)

From an ecological perspective this incremental change offers the community the opportunity to monitor the impacts of change more easily and adjust as necessary to better respond to ecosystem function. Poor design decisions which are modest in scale are more easily rectified.

**Self-sufficiency**

Cities and towns were largely dependent on regional supplies of energy, food, water supplies and building materials as inter-regional trade was limited. In many cases the supplies of these resources was a limiting factor in the ultimate size of many communities.

These are all centuries old responses to limited technology and regional autonomy. All predate the rapid technological advances of the last two hundred years and therefore exhibit considerable resource efficiency. In many respects these features are among many older patterns which can offer valuable insight in the search for more sustainable cities and towns. Admittedly certain features of these communities were imposed by circumstance, not choice, with many residents living under repressive government, limited personal wealth and trying sanitary conditions. Nonetheless the characteristics exhibited in these earlier communities include features with direct and ancillary ecological benefits. Not surprisingly many of these features are reemerging with the search for more viable forms of community. (Torsted Vest, 1993; Calthorpe, 1993; Hahn, 1992; Krieger, 1991; Deelstra, 1991)
3.3 ENERGY

• Introduction

Every system and organism on this planet depends on the input of energy to exist. It may be in the form of direct solar energy such as that used in photosynthesis and the hydrologic cycle, or it may be transformed and embodied energy such as that found in wood or fossil fuels. Ultimately all are the product of solar energy. Fortunately the supply of solar energy is more bountiful.

"The earth receives as much energy from sunlight in 20 days as is believed to be stored in the earth's entire reserves of coal, oil, and natural gas...Over 40,000 exajoules (EJ) of sunlight fall on the US landmass each year, an amount equivalent to 500 times current US energy consumption." (Brower, 1992, p. 40)

Despite this abundance our society has elected not to utilize solar energy as its principle source of energy. In the United States approximately 85 percent of all energy consumption is met directly or indirectly by fossil fuels. (Brower, 1992, p. 5) In Canada, despite large scale hydroelectric power plants, oil and natural gas account for more than 60 percent of the energy used to heat our homes. (Statistics Canada) This dependence on nonrenewable resources is problematic. The release of greenhouse gases associated with burning oil and gas is traumatizing the planet's forests and acidifying its waters. The use of fossil fuels accounts for 70 percent of all human emissions of carbon dioxide, and 55 percent of the atmospheric emissions effecting global change. (Brower, 1992, p.10) Oil spills, large and small, contribute to polluted water tables and destroy wildlife and their habitat. The extraction of coal, oil and natural gas has left a legacy of denuded landscapes complete with toxic byproducts.

A dependence on fossil fuels raises other problems. What once was thought to be infinite in supply during the 1950s and 1960s is proving to be quite limited. Based on 1989 production levels the World Resources Institute (WRI) predicts the supply of oil will be virtually extinguished by the year 2030 (WRI, 1990, p.149) In 1990 the Environmental Protection Agency speculated that current global consumption of fossil fuels could double by the year 2025 based on current trends, exacerbating supply problems. (Brower, 1992) While these figures may change with the discovery of new reservoirs and the development of more efficient extraction techniques, it is clear that the supply of fossil fuels is finite. Yet most cities and towns in the western world assume these fuels to
be in limitless supply and consume them accordingly, in patterns of consumption that can be
categorized into three general sectors: (Gordon, 1991; Browning and Lovins, 1989)

- Transportation - 28% of total consumption: energy used for transporting people and
goods, of which more than 99% is derived from fossil fuels.

- Residential & Commercial - 36% of total consumption; includes heating and electrical
requirements, of which greater than 50% is derived from fossil fuels.

- Industrial - 36% of total consumption: includes agriculture and industrial production
and manufacturing, of which approximately 70% is derived from fossil fuels.

With anywhere from 50 to 99 percent dependence on finite fossil fuels, change is inevitable.
Future, more sustainable energy practices will be based on maximizing passive and active solar
energy, reusing and recovering waste energy, and general conservation practices. (Brower, 1992;
Walter, 1992; Daly and Cobb, 1989; Brown, 1981) Many of these changes in energy supply have
implications well beyond the scope of this thesis. Some, however, directly implicate spatial form
and these are the ones which interest this thesis.

The emphasis of this section will be on:

- Solar Energy
- Wind Energy
- Transportation Energy

Other energy initiatives such as Biomass Energy and Cogeneration Power Plants have the potential
to supplement a community's energy supply but their spatial implications are unclear at this time
and therefore will not be discussed in this section.

- Solar Energy

Solar energy can help a community develop a more autonomous energy supply, one which is not
only ecologically more sustainable but one which provides more local return on investment.
Browning and Lovins (1989) have calculated that of every dollar spent on energy in most North
American communities, between 80 and 90 cents leaves the community to subsidize distant supplies. This investment never returns to the community except to increase dependence on that external energy source. An energy policy based on local solar energy supplies would keep this 80 to 90 cents at home and employ people in the community.

Within the last decade numerous projects have realised substantial energy savings by adopting passive and active solar design criteria. Hahn (1991) notes that ecological urban restructuring projects in Europe of 18th and 19th century housing stock has resulted in domestic heat and electrical energy savings of 50 percent. The Rocky Mountain Institute's head office in Snowmass, Colorado has realised 99 percent savings in space and water heating energy and a 90 percent reduction in domestic electricity by employing comprehensive solar design strategies. Brower (1992) estimates overall energy savings of 30-70 percent are reasonable expectations from a well designed passive solar building and that by year 2030, approximately 53 percent of the United States' energy consumption could come from renewable sources such as solar, hydropower, biomass, wind, and geothermal. (Brower, 1992, p.45) Van der Ryn and Calthorpe (1986) presented a solar design proposal for Marin Solar Village in which they anticipated space and water heating savings of 80 percent over conventional systems.

Amory Lovins, one of the world's authorities on energy efficiency predicts even higher savings than Calthorpe, Van der Ryn or Brower. By combining the right sitting, form, and building envelope including efficient windows, with passive design and extremely efficient equipment heat and electrical energy use can be cut by 75 percent or more. (Lovins 1993) Equally important, Lovins argues, is that the cost of implementing such strategies need not exceed the costs of conventional systems, and may even result in lower capital costs for the entire project due to reduced reliance on capital intensive heat, ventilation and air conditioning equipment. (Lovins 1993)

To achieve these savings two basic rules of passive solar design must be followed: orientation and insulation. These strategies represent an archetypal building pattern, traceable back to a time when furnaces and energy utilities did not exist, and society had little choice but to exploit incoming solar radiation as a staple heat source. Ancient Greeecian and Roman cities were organised in grid
patterns oriented along the cardinal points which, among other reasons, maximised incoming solar energy to each building. Socrates wrote,

"In houses that look toward the south, the sun penetrates the portico in winter, while in summer the path of the sun is right over our heads and above the roof so that there is shad." (Solplan, 1993, p.4)

The Romans further enhanced the efficiency of solar gain with the development of window glazings. (Vale, 1991) In areas with warm summers and cool winters attention to siting, masonry construction and the use of overhangs for shading in summer were basic to housing design. This is also illustrated by the adobe houses of the Anasazi, in the American Southwest. Buildings were typically sited within cliff faces to take advantage of the cooling shade provided by overhead rock canopies during hot summer months. In winter when incoming solar energy was desired the lower angle of the sun penetrated directly into the houses. Similar design strategies can be seen in the traditional architecture of the Middle East and Asia.

Unfortunately basic passive solar design strategies are rarely incorporated into new building construction. In particular, suburban communities are often characterized by homes on meandering streets that result less from attention to southern orientation and more to maximising the number of developable lots. Access to inexpensive, nonrenewable energy supplies for heat and electricity helps to marginalize concerns of orientation, insulation and thermal mass. Brower argues that continuing low prices for conventional energy, "tax codes that are biased against capital-intensive technologies, and the failure of markets to account for the environmental impacts of energy use," (Brower, 1992, p.40) act as disincentives to considering many passive and active solar design strategies.

Similarly, active solar designs have been slow to come to market. Early generation photovoltaic (PV) solar panels were expensive and inefficient, and required significant maintenance. This lead to a general rebuke of the technology which continues today despite significant improvements in PV efficiency, reliability and lower costs. (Brower, 1992) Walter (1992) believes this bias will change particularly as costs of fossil fuel energy begin to reflect their "true costs"; the cost of production plus the expenses associated with by-products such as acid rain, greenhouse gases, and loss of forest cover. If these costs are taken into account then the cost of solar power could be
"....as much as 60% below a gas burning plant's costs." (Walter, 1992, p.192)

Two further problems which limit the acceptance of solar energy, particularly active solar strategies, has been the lack of financial support and impenetrable markets. In the mid-1980s, when supplies of fossil fuels increased and oil and gas prices dropped, the incentive for government to continue funding research and development in solar power vanished. In the United States, a world leader in solar research, government funding declined to $114.7 million in 1989, or a drop of “almost 90% below the 1980 level, if inflation is taken into account.” (Brower, 1992, p.22) In 1992 less than 10 percent of research and development into energy research in the United States, went towards renewable sources. (Brower, 1992, p. 28) Difficulties in finding financial support has been exacerbated by markets which are unreceptive, local building codes and inspectors who are ill prepared to review alternative energy based projects, and utility companies have been reluctant to adopt research programmes to improve the efficiency and costs of solar energy. (Brower, 1992; Walter, 1992)

Consequently the price of photovoltaic panels continues to be inflated and demand remains relatively flat. This will likely change as fossil fuel supplies diminish and increase in price, and more money becomes available for research into less expensive and more efficient photovoltaic systems. When combined active and passive solar design strategies have the potential to allow virtual energy autonomy. However, as the intent of this thesis is to focus on design strategies in existence today the emphasis on solar energy design parameters will be on passive solar strategies and their spatial demands on community form. Active solar design will be discussed only as an ancillary energy source.

The following passive solar design strategies establish some site planning criteria for developing solar based communities.

**Orientation**

Orientation is the most critical solar design strategy as it directly implicates solar gain. To maximize solar gain a building’s dominant surface should be perpendicular to, or within 20 degrees either
side of south. Maximum gain occurs between 9 a.m. and 3 p.m. with modest gains at other times of the day. (Crowther, 1992; Brown, 1985) This begins to suggest the preferred building form is long and thin, with the main axis oriented east to west. Knowles refers to this as the “solar envelope”, and argues that solar envelopes oriented along an east to west axis, “contain the most bulk.” (Walter, 1992, p. 88) Knowles argues that an elongated building oriented within 20 degrees of south can be taller and wider than those beyond 20 degrees because they have the potential to generate more energy. As buildings move further off the east-west axis they should become thinner and shorter. Taller buildings should occur along the north side streets and lower ones along the south side to admit winter sun and they should generally begin lower at the corners and gradually rise towards a higher mid-block height.

By association, an east to west building orientation implies that, where topography allows, grided streets oriented to the cardinal points is preferable to meandering streets. Specifically those street patterns which form rectangular blocks along an east west axis provide for maximum solar gain. It has been argued that this attention to orientation can also enhance a community’s legibility;

“Pathways, districts, and directions take on clearer perceptual meaning when the solar envelope becomes a framework for urban development.”(Walter, 1992, p. 88)

Heat energy savings are not the only benefit that comes with improved orientation. An east west orientation allows roof mounted photovoltaic arrays and solar hot water panels to maximize solar gain. Daylighting of buildings is also enhanced which, in turn, reduces the amount of energy used to light rooms through the course of a day. Orientation and solar gain also has the capacity to extend the use of outdoor spaces such as patios, courtyards, porches, decks, balconies, solariums and glass conservatories during colder months.

Therefore the following design parameters can be stated;

The long axis of all buildings will be oriented along an east-west axis to maximise southern exposure and solar gain. Whenever possible these buildings should have sloped roofs which incorporate photovoltaic panels following the same axis to maximise solar gain.

If another orientation axis is selected the roofs should be flat to allow for the placement of photovoltaic panels along an approximate east west axis.
Roofs

Roofs are perhaps the most overlooked resource in a community but are among its most pervasive. The area of a city "under roof" is substantial. Consider that on a standard single family residential lot with a "Floor Area Ratio (FAR)" of approximately 35 to 40 percent of the lot's total area, the roof will invariably occupy an area equal to, and likely larger than, the FAR. In higher density locations, roof coverage may equal 100 percent of the lot's total area. Depending on densities, 25 percent (suburban) to 100 percent (urban) of private land in any given community may be under roofs.

Conventional roofs forsake opportunities to generate energy, moderate the local microclimate, and collect water. Most importantly, conventional roofs eschew the potential energy benefits derived from active and passive solar building techniques, a symbiosis capable of providing most of a building's heat and electrical needs. Current active technology involves two main roof mounted strategies;

- Roof Mounted Photovoltaic Cells - transform incoming solar radiation into electrical energy to be used immediately, stored on site in rechargeable battery cells, or sold back to the energy utility through the existing grid.

- Hot Water Panels - roof mounted panels provide heated water for domestic use or space heating.

Numerous projects throughout Europe and North America have demonstrated that combining passive and active design can provide a minimum of 80 percent domestic heat and hot water, and 50 to 70 percent domestic electrical can be saved by using solar design. (Lovins, 1993; Brower, 1992; Hahn, 1991; Van der Ryn and Calthorpe, 1986) Certain buildings such as the Rocky Mountain Institute in Snowmass, Colorado are able to provide 99 percent of the building's space and water heat energy, and 90 percent of its electrical demands.

The efficiency of active roof systems depends on the roof's pitch or at least the pitch of the panels as well as the building's orientation to south. As discussed earlier the most efficient building envelope is one that is rectilinear with its long axis oriented east to west, perpendicular to south or within 20 degrees of south. The preferred situation is for these buildings to have pitched roofs with
photovoltaic solar collectors mounted along the southern side. The panels must be adjustable upwards to latitude plus fifteen degrees to allow for seasonal changes in the sun’s azimuth, maximize winter solar gain. (Crowther, 1992, p.281) If the building’s long axis moves beyond 20 degrees of south then flat roofs are preferred because they would allow the installation of photovoltaic panels which could be independently adjusted towards south.

Therefore the following parameters can be stated;

Sloped roofs should be used on buildings whose long axis can be oriented perpendicular to within 20 degrees of due south. In these cases south facing pitches should include photovoltaic cells or hot water panels. North facing pitches should be planted with xeriscape plants.

Building axises beyond twenty degree should result in flat roofs which include PV panels which can be oriented due south and xeriscape plants or vegetable gardens.

By combining passive and active solar design strategies buildings become capable of generating most of their own energy. Furthermore this more autonomous existence is accomplished with relatively low levels of technical complexity. This contrasts with modern buildings which rely on elaborate heating, ventilation and air conditioning systems, designed to control the interior climate 24 hours a day, 365 days of the year.

• Wind Energy

One of the keys to a sustainable energy policy is to maximise regional energy production and eliminate appropriated energy resources from another region. This ensures the carrying capacity of a region is not artificially enhanced. While solar energy should constitute the largest proportion of a community’s energy budget as it is in greatest supply, other renewable sources can serve as supplemental supply, particularly during periods of low solar energy gain. Wind energy is the most visible of these alternative sources.

For centuries the wind has been used to pump water, mill grain and, more recently, generate electricity. In the lowland countries of Northern Europe windmills have become landscape icon
along with farms, hedgerows and irrigation canals. Today 2 percent of Denmark’s national energy supply is derived from the wind with aspirations of 10 to 20 percent in the near future. Similarly in the Dutch town of Dearsum, the town’s 150 residents own and operate a wind turbine which supplies most of their electrical energy, and during times of surplus production provides a small income with the sale back to the national utility. Signal lights are mounted on the turbine to indicate to the community demand versus supply, and serves to regulate demand. A green light tells the community the supply of electrical energy from the windmill exceeds domestic use with the surplus being sold to the power utility along the existing grid. A yellow light indicates the community demand is balanced with supply. A the red light indicates supplemental power is being purchased from the energy utility to meet community demand. Last year the community made a profit of $6,800. (Urban Ecologist, 1993)

Wind turbines have been supplying power to Californians since the early 1980s. Between 1981 and 1986 15,000 turbines were built as utility grade power generators. During the same period over 5,000 smaller private wind turbines were constructed elsewhere in the United States. (Brower, 1992) Today more than 16,000 turbines contribute approximately 2.8 billion kilowatt-hours of electricity annually to California’s electrical grid, enough to supply in excess of four million people. (UPI 1993) In Goldendale, Washington, near the Columbia River Gorge, the Pacific Northwest’s first major wind generating power plant is being built. Consistent high winds throughout the year make the site an ideal location for wind generated power. By 1996 140 wind turbines will be capable of generating 50 megawatts of electricity; capacity sufficient to power 9,400 homes.

North America possesses vast areas with the consistent winds necessary for viable wind power generation. The U.S. Department of Energy has identified 37 states with adequate wind resources for commercial wind powered generation plants. (Walter, 1992) The American Wind Energy Association has estimated that perhaps 20 percent or more of the electrical energy demands of the United States could be realistically met by wind power. (Brower, 1992) This calculation includes exclusions of land either too steep, too remote, or environmentally sensitive in nature. In Canada the potential proportion is equally high, if not higher. Along its coasts, in the vast open plains and along the ridge lines of the many mountain ranges numerous sites exists which theoretically
possess the necessary conditions for wind generation.

Turbines are becoming increasingly more cost effective and have the obvious benefit of being environmentally benign. The technological problems of the past have been solved with improvements in efficiency and reliability of wind turbines. Wind farms have the added benefit of being relatively mobile, requiring only months to establish versus years and decades for fossil fuel and hydro power plants. Simultaneously, turbines have proven to be compatible in sharing land with other, typically agricultural uses, a claim not made by conventional systems. Turbines can be erected within and along the edges of fields without disruptions to the farmer. Smaller, less costly turbines have been developed to serve small villages, rural homeowners, and third world applications. Capital costs are recovered in a few years and dependency on larger energy utilities reduced. When hybridised with photovoltaic systems, wind power can offer virtual autonomy from utilities. (Brower, 1992)

Until recently wind energy production compared unfavourably with conventional fossil fuel power plants. Two decades ago the cost of wind power was between 15 and 20 cents/kilowatt hour. Today the direct costs of wind generated energy are now approximately 7 cents per kilowatt hour versus 5 to 6 cents for coal or oil. With lower operating and maintenance costs and no greenhouse gas emissions, wind power is actually cheaper than conventional power supplies when true costing is applied. (Walter, 1992) The traditional problems of daily and seasonal variations in wind speed, the nonconformity of peak production with peak demand, and proximity of source generation to site demand can be mitigated when wind power is used as a supplemental energy source and sufficient battery storage is provided. Therefore the following design parameter can be stated:

If consistent winds exist in the vicinity of the community wind turbines should be erected in open fields on the windward side of the community and linked to the community's power grid.

Opportunities to plant new forest cover which might enhance the velocity of prevailing winds and channel these winds to wind turbines should be explored whenever denuded forests are being reestablished.
• **Transportation Energy**

In North America walking or cycling to work, shops, services, and schools accounts for only 5 percent of all trip. In Europe this figure ranges from a 20 to 40 percent. (Newman and Kenworthy, 1989) The average North American travels 12,500 kilometres per year by car compared to 5,600 kilometres in Europe and 1,800 in Asian. In North America, the average per capita energy consumption for transportation is 56,383 Mega Joules compared with European consumption of 13,280 MJ, and 5,493 MJ in Asia. (Gordon, 1991; Newman and Kenworthy, 1989) These figures emphasise the scale of automobile dependence and the energy intensity of North America's transportation systems.

One of the keys to developing an ecologically based energy policy and a more sustainable form of community is to maximize pedestrian and bicycle circulation for local travel, and public transit options for regional connections. (Deelstra, 1991; Tolley 1990) Emphasising public transportation options and combining integrated land uses makes services and amenities more accessible, reduces energy consumption, atmospheric emissions and groundwater pollutants, and protects agricultural land from being consumed by road construction and development. Multi-modal transportation systems which link local pedestrian and bicycle systems with regional transit systems offer more people more options in travelling to more places. Europe and parts of Asia, where land is scarce and energy expensive, have focused far more attention on issues of public transit than has North America.

It is for this reason that the example of Almere, the Netherlands serves as a good example of what a multi-modal transit system should and can feature. Almere is a collection of three small cities 25 kilometres east of Amsterdam. Construction began in the early 1970s with a mandate to develop an integrated community which included housing, employment opportunities, full services, and recreational facilities. The three cities have a combined population of approximately 70,000 and are expected to grow to 250,000. The communities are organised around a hierarchical transportation system which emphasizes public transit, bicycle paths and pedestrian circulation.
Light Rail
The rail system is part of the national rail network, providing regular thirty minute service to downtown Amsterdam. Each of Almere's communities has a train station at its centre around which a mix of full service commercial and moderately dense residential neighbourhoods are focussed. The highest housing densities and largest proportion of each community's population are located within a 500 meter walk of the station. There is limited surface parking around each station to encourage people utilize the bus lines and discourage driving to the shops.

Segregated Bus Network
After the railway lines and general footprints of each community were located, a series of segregated bus lines were overlayed to link neighbourhoods with the central train stations. Further connections between each community were also established. Automobiles were the last layer of infrastructure located and were fit around the transit lines, housing blocks and community service areas. Consequently 90 percent of all residences lie within a 5 minute walk of the train station or 400 meters of a bus stop. Traffic lights favouring the bus routes occur wherever intersections with automobile roads occur to ensure swift travel for the buses.

Bicycle and Pedestrian Path Network
The network of bicycle and pedestrian paths provide the third and most local transportation option, complementing the rail and bus service. They allow easy access to neighbourhoods, transit stations and other commercial and recreational amenities throughout Almere. The paths are separated from roads to avoid possible conflicts with automobiles. In areas of high pedestrian activity the bicycle paths are segregated and intersections clearly marked. In less congested areas the path is generally shared. At each train station the cyclist has the option of storing their bike in a secure lock-up or taking it on the train.

There is nothing particularly revolutionary about these three systems. They each exist in a variety of forms in a number of cities around the world. In Curitiba, Brazil a dedicated bus network was all the city could afford for public transit. Today it carries 1.5 million passengers per day. (Lerner, 1993) In Adelaide, Australia a dedicated bus line was constructed recently to connect the suburban northeast with the downtown core. While ridership on conventional lines has declined 10 percent,
ridership on the dedicated service has increased 24 percent. (Wayte, 1988)

Advocates of Transit Oriented Developments argue that when public transit is properly integrated into a land use plan that provides for a mix of housing, employment and services within a five to ten minute walk automobile trips can be expected to drop by a minimum 50 percent. (Calthorpe, 1993; Kelbaugh, 1989) It is essential for all communities aspiring to become ecologically sustainable that the transit features similar to those found in Almere become standard practice, and provides the main link to other communities and throughout the region.(Calthorpe, 1993; Newman and Kenworthy, 1992) These features form the following transportation design parameters;

- The community should be organised around a central transit station which sits within a 5 to 10 minute walk of most residences and provides connections throughout the region.

- Intraregional travel is best accomplished on bus lines and bicycle trails which are either segregated from roads or provided separate travel lanes.

- Internal circulation must emphasize pedestrians and cyclists. Automobile circulation should be controlled by traffic diversions such as woonerfs.
3.4 Water

• Introduction

Water is an essential component of all living things, a continuum that binds all ecosystems, sculpts the land and defines plant communities. It is simultaneously global in scale and site specific in characteristic. Water nurtures the forests which purify the air, creates the streams in which salmon spawn and provides us with water to irrigate our gardens. We are linked to water physically through the hydrologic cycle, physiologically through its dominant presence in our bodies and spiritually through its central role in our collective mythologies. It leaves an indelible stamp on us.

Spirn wrote:

"Water is a source of life, power, comfort, and delight, a universal symbol of purification and renewal. Like a primordial magnet, water pulls at a primitive and deeply rooted part of the human nature. More than any other single element besides trees and gardens, water has the greatest potential to forge an emotional link between man and nature in the city." (Spirn, 1984, p.142)

Yet, despite its vital role in all life, city dwellers make little connection between the water they drink and the water they pollute. It enters homes via hidden pipes, pumps and reservoirs and departs along a parallel system of concealed pipes and channels. Surface runoff carries away oil and gasoline residues to rivers, lakes and oceans. Natural drainage courses are paved over and or irrevocably altered. In essence the clandestine movement of water throughout the urban system serves to obscure the understanding of water’s role as an essential component in maintaining regional ecosystem function and ultimately ourselves.

This section addresses how water should be handled in an ecologically sustainable community. Specifically three design parameters which will redefine our relationship with water are discussed:

- Regional Balance
- Surface Drainage
- Grey Water

- Regional Balance

20 million people living in Southern California belies the semiarid nature of the Southern
Californian landscape. The ubiquitous single family houses, lush gardens, swimming pools, golf courses, and the world's most intensive agricultural industry all flourish for one simple reason -- an abundant supply of water. Southern California is swimming in water -- water it does not have. With an average annual rainfall of between 25 to 50 cm very little of the water supply is derived locally. The watershed supplying Los Angeles extends some 2,100 kilometres northeast, to the Rocky Mountains and the headwaters of the Colorado River, and 1,000 kilometres north, via the California Aqueduct to the Sierra Nevadas. (Conniff, 1993)

Though Los Angeles represents an extreme example of water appropriation it is by no means unique. The canals and qanats of Mesopotamia, and Roman aqueducts throughout Southern Europe attest to the extent to which cities have gone to secure water. What distinguishes Los Angeles and most other metropolitan urban systems is the scale of its growth and its concurrent increases in water demands. Even in the Greater Vancouver Region with its seemingly abundant rainfall and local water supply, current population trends indicate the current reservoir capacity for two million people will be reached before 2010 unless conservation measures are mandated (Stephens, Van der Guilk and Heath, 1992).

From an ecological perspective the continued appropriation of water from beyond a region is destructive. It assumes that water can be withdrawn with impunity from undeveloped watersheds. In reality, any withdrawal from a drainage basin alters the ecological systems in that watershed. Minor withdrawals will generally not profoundly alter the ecological matrix, however, large withdrawals will place those same stable ecosystems under a great deal of stress with many plant and animal habitats irrevocably altered. North America abounds with altered drainage basins, of all sizes. At some point, however, there will either be no more water to appropriate as all will have been spoken for by thirsty urban systems, or few natural drainage basins will remain intact.

The stewardship of water is central to the notion of ecological sustainability. The sustainable community must value water as much as other resource, if not more. Its water management strategies must relate to the hydrologic characteristics and capacities of local watersheds. These watersheds represent the building blocks of larger watersheds and are generally altered incrementally by various disparate group, eventually affecting the larger system.
To date few communities have used a watershed perspective in the development of their community. Most assume the water supply is a right of passage into urbanism. However, in Hazelton, British Columbia a watershed approach is being implemented and offers a valuable model for other communities to follow. The community published *Framework For Watershed Stewardship* with the goal of placing water management control within the hands of the community and base those controls on the carrying capacity of the watershed.

The “Framework” establishes a series of strategies and a process to reach this goal based on the management of water and watersheds. The plan involves the creation of a series of watershed authorities which are responsible for the management of the forests, fish, wildlife, flora, minerals, water, air, and soil” within each designated watershed. (Hazelton, 1991, p. 3) The jurisdictional boundaries parallel physiographic, not political, boundaries. The specific controls on development to protect water resources include (Hazelton, 1991):

- **Water Quality** -
  Protection of water quality and quantity shall be recognized as a primary necessity in the planning and implementation of any development or use activity

- **Potable Water License** -
  Any human use in any watershed supplying potable water to a municipality or other local government shall only occur with permission of the potable water license holder, and after a comprehensive water management plan has been prepared.

- **Water Quality Degradation** -
  Any deterioration of water quality caused by human activity in a watershed supplying potable water by license shall be remedied at full cost by the party causing the degradation.

- **Industrial Water License** -
  Industrial water licenses shall be granted only after approvals are obtained from the Watershed Authority. A condition of all industrial water licenses will be a charge for independent monitoring of volume and quality parameters which guarantee minimal environmental impacts.

Other covenants and restrictions exist to protect the integrity of the watershed. From these and other basic environmental planning strategies outlined in the *Framework For Watershed Stewardship* a few design parameters can be stated. Inherent in them is the acknowledgement that water is a shared resource among all the region’s ecosystems and that the urban ecosystem must
minimize its impact on both the volume and quality of the region's hydrologic cycle. It must ensure that the regional water supply remains balanced. Therefore, the following design parameters can be stated:

Calculate the hydrologic potential of the local watersheds including seasonal variations and identify the base level that is required to protect the watershed's ecosystem. If water withdrawals for urban uses exceed this base level water from the urban system, equal in quality must be returned to the point of withdrawal. In essence there must be a balance between the levels of water entering and leaving the urban ecosystem to minimize disruption to other ecosystems.

New developments must map out their water supply and return strategies before commencing construction.

In existing urbanized areas those features which were fundamental to the watersheds ecological vitality but were altered must be identified and targeted for long term acquisition and rehabilitation to restore hydrologic balance.

No new culverting of water courses shall be allowed and a long term strategy should be established to acquire and daylight existing culverted streams.

All subsurface water tables should be mapped and development over sensitive aquifers limited.

*Surface Drainage*

The water management goal of the ecologically sustainable community involves protecting the ecological integrity of the region's hydrologic cycle. The best strategy to accomplish this involves surface drainage which is defined by:

"the use of a system of surface topographic features such as swales, channels, and small ponds to collect and convey stormwater in a manner closely resembling natural watersheds." (Thayer and Westbrook, 1989, p. 154)

Surface drainage allows water to follow the more natural drainage patterns of the local hydrological cycle. It encourages filtered runoff to flow to small ephemeral creeks which in turn feed larger dendritic stream and river systems. Natural stream courses become an important organizing element for the community rather than an impediment. When combined with grey water strategies and reductions in impermeable surfaces, surface drainage techniques can dramatically reduce the
impact of a community on regional hydrologic patterns. Open drainage has the added benefit of making the hydrologic cycle a more visible component of the community. It can also be used to create amenity spaces for adults and children alike, something subsurface pipes could never do.

A distinct advantage of a surface drainage system is the amenity space it can provide. Opportunities for children to play, areas to grow fruit and vegetables, and potential habitat can all be organized around an open drainage system. Of equal value is how the system illustrates the hydrologic cycle. Its visible presence helps reconnect the resident with the flows and associated plant communities of the regional landscape. It is both a physical feature and a psychological tonic and numerous projects in Europe and a few in North America have successfully applied surface drainage techniques.

Valdemarsgade Housing Project
Located in Slagelse, Denmark the Valdemarsgade Housing Project is a recently renovated older urban housing block. Among its many ecological design initiatives, the most compelling is the decision to use surface drainage. Storm water is collected from the housing block’s roofs into an inner courtyard pond where it is either used in the extensive grey water system or recharged into the ground via a stream and recharge bed. It helps irrigate the housing block’s community garden and flows along a stream which forms part of the children’s play area.

Village Homes
Located in Davis, California, Village Homes is a 32 hectare subdivision organized around an open space system which serves as both the community’s principle amenity area and its stormwater drainage basin. A series of swales and ponds allow water to percolate and recharge the subsurface water table. The system provides the community with a variety of open spaces while dispensing with the traditional subsurface drainage systems. Houses are sited on the property’s high ground which defines the site’s internal drainage basins. All precipitation drains away from the houses. Runoff from the community’s interior streets is also handled with surface drainage. The roads are graded towards perimeter gutters where a series of notches in the curbs allow runoff to pass through into dry wells and swales. The water collected in the network of swales flows down to percolation areas where reed beds help filter out oil and fuels that may be carried in the runoff. The
entire drainage system is designed to handle a 10 year storm. It remains connected to the public storm sewer as a safety measure should the open system be unable to absorb severe stormwater runoff. However, to date no runoff has entered the municipal stormwater system. (Thayer and Westbrook, 1989)

The Woodlands
With approximately 7,000 hectares of land The Woodlands, located near Houston, Texas, is an even larger example of an open drainage system organizing community form. It is a suburban housing enclave located in a flat, low lying area with mixed forests and seasonal drainage basins subject to heavy rains and flooding. To ensure the survival of the local forest ecosystem, minimise disruption of water tables and drainage patterns, and prevent subsidence open drainage was chosen over conventional subsurface storm sewers.

Houses and roads are sited based on a series of landscape tolerance guidelines derived from the site’s soil and hydrologic conditions. Consequently roads occur along the high ground or over impermeable surfaces to preserve natural drainage. Curbless roads were selected over a traditional curb, gutter and catch basin systems. The expansive open space includes the community’s three golf courses and is designed to act as impoundment and recharge areas during heavy flooding.

Performance guidelines, called permissible coverage and permissible clearance defined site coverage and site clearing based principally on ecological indicators. Consequently the open drainage system, complete with 100 meter wide drainage easements, 30 meter wide secondary drainage channels, a network of uninterrupted drainage swales, large impoundment and recharge beds, restricted impervious surfaces and curbless roads defines the community’s identity. Unfortunately recent developments and new resident expectations has lead to a departure from open drainage to conventional subsurface strategies. The ecological implications of this are unknown but it is reasonable to speculate the effects will not be positive.
Nevertheless from these and other projects the following design parameters respecting open drainage can be stated;

The drainage capabilities of local soils should be defined to locate permeable and impermeable soils, and potential recharge areas.

Local drainage characteristics should not be effected by the community’s development to maintain the continuity of the hydrologic cycle.

Existing site runoff should be defined to ensure that its location, quality and quantity are not altered.

General site coverage should not exceed 50 percent and existing levels of runoff though altered due to site coverage should be maintained with runoff from roofs or grey water systems.

Roads should avoid the use of catch basins and subsurface drainage systems with runoff either;
- being drained into swales to be carried off to adjacent biofiltration percolation beds and natural drainage systems;
- be drained by swales to nearest solar aquatic facility;
- be channelled into roadside dry wells were oil separators can filter out oil and gas residues and groundwater recharge can occur.

Porous paving, biofiltration reed beds and subsurface recharge areas should be standard details in low traffic areas and parking lots. In higher traffic areas if reed beds cannot adequately filter out surface pollutants swales should carry runoff to nearest treatment facility.

Parking lots should be limited in size and designed to act as detention ponds for periods of heavy rains and high runoff.

Surface paving should be small round or oblong interlocking pavers to maximize potential percolation

Buildings and roads should be located along higher elevations and above impervious soils to minimise disrupting local drainage conditions. In the event displacement occurs site grading and surface runoff should be designed to mitigate any losses to the water volumes flowing through the original system.

Green roofs should be incorporated into all buildings to slow peak runoff.
• **Grey Water**

Water resources are becoming a prized commodity in most urban areas as demand outstrips supply and water must be imported. Even in the Greater Vancouver Regional District with its seemingly abundant average rainfall of 1,055 mm/year summer water restrictions are required to balance a rapidly expanding population and annual per capita water consumption of approximately 450 litres. Metering water consumption and charging for its use is becoming a more common conservation practice in major metropolitan areas such as Boston and Los Angeles. Similarly the installation of low flow faucets and toilets is capable of reducing domestic water usage by 20 to 30 percent (Vale, 1991). To this end the City of Vancouver recently passed a bylaw requiring all new housing include these fixtures. These are measures generally directed at reducing consumption.

A more important strategy involves the reuse of existing water supplies, referred to as “grey water.” In Denmark and The Netherlands where potable water supplies are scarce grey water plumbing is used extensively to reduce external water demands. A basic grey water system collects rainwater from the roof using the eaves and downspouts, and stores the water in a cistern typically located in the basement. In many applications a planted roof is combined to act as the first filtering stage although for most applications this is not required. The water held in the cistern is then available for use in nonpotable situations such as clothes washing machines, garden irrigation and toilets. The appeal of a grey water system is that, with only five to ten percent of total domestic water consumption requiring potable water quality grey water has the potential to reduce domestic water consumption by up to 90 percent. (Vale, 1991)

Grey water systems can be applied to any building and are flexible enough to allow water to be stored in exterior ponds as part of an amenity space or as a children’s play space. The new Institute of Asian Research building on the University of British Columbia campus collects rainwater in a small pond for use in on site irrigation. In Berlin, Germany Block 103 is an inner-city housing block with 332 residential units and 41 shops. It was rebuilt in the 1980’s with a grey water reservoir in the courtyard as the dominant feature of the building. Rain water combines with grey water from sinks and showers into the central pond where a series of biofiltration beds help purify the water for reuse.
It is because of these examples that the following design parameter can be stated:

Grey water systems shall be a compulsory component of all buildings to conserve water. Large reservoir cisterns which can store rain water for future use in toilets and cloth washing machines shall be placed either in the building’s basement or immediately outside the building.

In some situations it may be advantageous to store the water in outside ponds and streams to help animate a courtyard or play areas.
3.5 Waste

- Introduction

Dealing with the waste byproducts of human activity has always presented a problem. Mumford (1961) notes that in 1388 the English Parliament, in response to increasing pollution of water courses, passed an act that “forbade the throwing of filth and garbage into ditches, rivers, and waters.” (Mumford, 1961, p. 290) Cities throughout medieval Europe suffered through plagues and devastating diseases due, in part, to poor sanitary conditions. Outbreaks of cholera and dysentery were, and still are, linked to water supplies tainted by untreated human waste. Yet, until the industrial revolution, waste problems were localized and primarily concerned with the disposal of predominantly organic, sewage and refuse.

More recently, however, increased consumerism has created more complex waste production and disposal problems. Modern society is well ensconced in patterns of purchasing, using and discarding, which creates mounds of waste daily. Waste seems to be an accepted consequence of progress. This, despite the contamination of groundwater by leachates percolating down from landfills comprised of paper, plastic, petroleum, wood, concrete and metal products; despite thousands of tons of carbon dioxide and other greenhouse gases discharged into the atmosphere on a daily basis from industrial smoke stacks and automobiles; and, despite large sewage treatment plants which fail to adequately treat effluent prior to its release into rivers, lakes and oceans.

Compared to natural systems, human waste is an anomaly. Natural ecosystems do not generate waste. The byproducts of one reaction or one organism become the lifeblood for another. The cyclical exchanges and transfers of converted energy and nutrients are essential for an ecosystem to remain diverse, adaptable and stable. In effect the exchange of ‘waste’ is the adhesive which binds the system together. In the urban system, however, byproducts are generally too noxious for further use and or recycling within any system.

In the ecologically sustainable community the concept of waste must be redefined to become part of the circular exchanges of reuse, recycle and reconversion of one by-product into another. Waste
must become a valued resource just as air, water, vegetation, land, energy and materials are. This section discusses waste management issues with profound spatial impacts on community form;

- **Solar Aquatics**;
- **Constructed Wetlands**; and
- **Solid Waste**.

Solar aquatics and constructed wetlands focus on transforming wastewater into an asset for any community. The principle difference between the two systems is spatial. The land requirements for solar aquatics are considerably less than for constructed wetlands, making them more suitable for communities where land is limited. Solid Waste addresses the waste which currently ends up in landfills or incinerators. Managing solid waste is about developing appropriate policies and providing programmes and incentives focusing on reducing consumption and developing only those products which can be reused and recycled. In Germany manufacturers are now being held responsible for the packaging their products are marketed in, even after the product has been sold.

**Solar Aquatic Systems**

Solar Aquatic wastewater treatment is the brain-child of John Todd. Todd’s goal was to develop a technologically simple method for treating wastewater to a tertiary level based on observed patterns in nature. He noticed that within natural ecosystems plants and organisms act as filters and purifiers as their normal biological functions. Solar aquatics borrows these natural filtration capabilities and places them in a formal series of treatment stages. It is a 3 stage treatment process which takes an average of three to five days to completely treat the effluent. (EEA, 1992-#1)

The raw effluent enters preliminary settlement chambers where solids are separated and composted. The remaining liquid effluent enters into a greenhouse to be circulated through a succession of translucent cylinders filled with plants and organism where two principal biological reactions take place. The first series of tanks are responsible for breaking down the effluent through the solubilization and metabolism of complex organics. Aeration and biological activity breakdown organic and inorganic compounds in the effluent into simpler, more soluble compounds, biomass, and CO2 to be consumed by aerobic and anaerobic activity in downstream
tanks. Plant communities within the first tanks tend to be dominated by willows, water hyacinths and starwort supplemented by snails.

As the effluent is transformed it moves into a different phase of treatment, nitrification and nutrient reduction. In this phase nitrifying bacteria, algae and plant species metabolize ammonia and other nutrients while snails and zooplankton metabolize solids. Some heavy metals are absorbed by the plant species within these tanks. As the treatment of the effluent differs from the early phase so does the composition of the plant communities and organisms. In these tanks the plant community is more diverse including tomatoes, nasturtiums, waterlilies, duckweed and pokeweed. There is also the addition of small-mouth bass, suckerfish and bivalves to help develop a food chain capable of reducing the nutrient load of the effluent before it enters the final treatment stage.

The final phase of effluent treatment involves denitrification and pathogen reduction. The effluent enters an engineered marsh where any remaining solids and heavy metals are filtered out, and remaining nitrates and pathogens are consumed by the activity of plants and organisms. Plants are harvested and composted and any pathogens still in the effluent are ingested by organisms, killed by antibiotic releases from plant roots or through the exposure to ultraviolet light. (EEA, 1992-#1)

At the end of the process the effluent is virtually potable and can either be reintroduced into the community water supply or released into the regional hydrologic cycle without any adverse impacts.

There are a number of applications of solar aquatics in the United States and Europe operating under different circumstances. Some service individual housing developments whiles others serve the larger community. In Harwich, Massachusetts, a plant began operating in April 1990 with a capacity 3,600 U.S. gallons of raw sewage per day which represents the product of approximately 50 percent of Harwich's population. After two years of operation the Harwich Treatment plant is proving the success of solar aquatic systems. It has been monitored by federal and state environmental agencies to ensure the outflow effluent meets acceptable sewage standards. The Harwich plant offers a compelling alternative to conventional wastewater systems for a variety of reasons. (Spencer, 1992; Teal and Peterson. 1991)
• Effluent Quality Meets Class 1 Drinking Water Standards
• Powered by Solar Energy
• Lower Capital and Infrastructural Costs
• Compact Facility
• Tertiary Quality Effluent

In addition to Harwich the solar aquatic system has been successfully installed in other locations including: Providence, Rhode Island; Waterbury, Vermont; Boyne River School, Ontario; and, in Kolding, Denmark. The viability of the Solar Aquatic is proven and allows the following design parameter to be stated:

All the community’s waste should be treated in neighbourhood and community based solar aquatic systems unless conditions are right for an engineered wetland to be installed.

The facilities can be designed to serve any number of people although below 50 people it is likely more efficient to install composting toilets.

Solar aquatic sewage treatment facilities require approximately 1m² of greenhouse space per person per day to treat. They require full exposure to the sun and nearby access to a composting area for the solid waste they produce.

Solar aquatic facilities can also be installed on roof tops of individual buildings where grey water and domestic waste could be treated simultaneously.

The facilities should be associated with water reservoirs and ponds to contribute to the community’s local water supplies.

• Constructed Wetlands

Constructed wetlands are a viable alternative to solar aquatics for communities with available land or existing wetlands. The treatment processes are similar with wastewater passing through a series of containment areas where various combinations of plants and organisms process the waste. The critical differences between the two relate to their spatial requirements and the speed with which they process waste. To treat similar volumes of wastewater to comparable levels of quality, solar aquatics require less than 10 percent of the land required for wetlands. This is primarily a function of the greenhouse enclosure providing a more controlled environment for plant and organism growth. This allows the greenhouse system to treat effluent to a potable level in three to five days as compared to a constructed wetland which typically takes thirty to sixty days. In
cooler climates this differential can become considerably more as the plants and organisms in the constructed wetland may become dormant, thereby reducing their filtering abilities.

The third difference, and the compelling reason to favour a wetland system over a solar aquatic system is the potential wildlife habitat and recreational amenity it can provide. Their configuration is not limited by the walls of the greenhouses; they can be shaped to enhance potential wildlife habitat.

There are different approaches to the design of wetland systems. This thesis presents the two most popular; 1. the marsh system as illustrated by Arcata, California’s Marsh and Wildlife Sanctuary; and 2. reed fields common to The Netherlands. Generally the marsh system is more land intensive but offers diverse habitat for wildlife. The reed fields tend to be a more engineered solution and are often developed in tandem with farms to capture and treat runoff from agricultural fields.

**Arcata Marsh and Wildlife Sanctuary**

Arcata is a small community of approximately 15,000 people located along Northern California’s coast. The marsh was constructed in the 1980s on a reclaimed garbage dump and old lumber mill site adjacent to Humbolt Bay. The 70 hectare wetland, in addition to acting as the city’s principal treatment facility, is a designated wildlife sanctuary and recreational amenity. (Stewart, 1988; Price, 1987) Raw effluent enters a primary treatment plant where degritting and the removal of solids occurs. The effluent then passes through a pair of oxidation ponds, a succession of four different marshes, and a chlorination plant before being discharged into the wildlife refuge and the Pacific Ocean.

The marsh treatment facility is proving to have environmental benefits. The treated effluent is virtually potable. The prized oyster beds into which the effluent is discharged have not been altered in any way. Wildlife in the area is thriving and the vegetative growth has the potential to be annually harvested and used to produce a biogass for supplemental fuel in the city’s fleet of vehicles.
Horizontal Reed Fields

Reed fields or reed beds can be broken down into two categories. The first are horizontal reed fields which appear frequently in The Netherlands where, for approximately twenty years they have been treating agricultural wastewater. Reed fields differ from marshes in that their plant communities tend to be more homogeneous and they are more efficient at processing effluent, taking about fifteen days, or roughly half the time required for marshes. They are inexpensive to build and technologically simple to operate. In the Netherlands they are now being used to treat wastewater in recreational areas. (Deelstra, 1991)

Deelstra (1991) and Jones (1991) calculate that the total land base necessary for a reed field capable of handling the waste of 10,000 people would be 7-10 hectares, based on a gross per capita area of 7-10 m² and a net of approximately 5 m². According to Worrall the reed field facility would combine:

- Storm-water and pollution incident overflow treatment areas;
- Artificial riffles to aid oxygenation of the waste water flow;
- Sedimentation in low energy ponds;
- Rafted aquatic macrophytes to act as secondary oil traps;
- Reed beds of different species types and, management regimes to treat organic waste and other pollutants;
- Holding ponds for amenity use;
- Clean-water soakaways for aquifer replenishment;
- Willow beds for total adsorption. (Worrall, 1992-#2, p. 20)

Well-drained sediment beds within the reed fields are crucial to the system’s ability to effectively remove sediments through oxidization. This can be enhanced by terracing the fields and planting the reeds in a gravel bed. Any metals and toxic chemicals not oxidised out of the wastewater in the substrate of the beds are absorbed by the reeds and rushes. (Worrall, 1992-#1; Deelstra, 1991) The adaptability of reeds and rushes to absorb industrial waste is a distinct advantage over engineered marshes whose natural equilibrium is more vulnerable to the toxicity of these wastes.

Vertical Reed Beds

Vertical reed beds, also known as downflow beds, have been successfully used in England to treat wastewater. They differ from horizontal reed beds principally in that they are vertically stacked beds forming a dendritic-like network of beds. The beds are linked by water runnels through
which the effluent flows. The system is more space efficient than horizontal reed fields, requiring a bed area of less than 2m² per person versus the 7 m² for horizontal beds. The cascading effect of vertical reed beds is more efficient in reducing the effluent’s biological oxygen demands (BODs) and suspended solids but less effective in reducing ammonia and nitrates which require calmer waters. Therefore, it is advisable to combine both horizontal and vertical reed beds as is done in Oaklands Park, Great Britain to take advantage of each beds filtering properties. For several years Oaklands Park’s effluent has been treated to higher standards than required by the European Community. (Jones 1991)

In most urban areas finding areas large enough for constructed wetlands is unrealistic. The spatial demands are too great when solar aquatics offer an equally viable alternative on a fraction of the land. However, if the availability of land is not a constraint the following design parameters can be stated:

The wetland system involves four phases of treatment;

- **Phase 1** - Settling ponds or tanks to separate solids from liquids. Solids to be composted.

- **Phase 2** - Vertical reed beds at a spatial allowance of 2m² per person. This phase will reduce biological oxygen demands and suspended solids.

- **Phase 3** - Horizontal reed beds at a spatial allowance of 5-7m² per person. This phase will treat ammonia, nitrates and bacterial activity.

*Note:* Bed thickness for phase 2 and 3 should be .5 meters deep and pitched at 2 percent towards the next pond. The bottom two thirds of the bed should be limestone aggregate. A 1 cm layer of pea gravel should sit atop the limestone with the remaining thickness filled with coarse sand.

- **Phase 4** - Lagoon/Marsh Retention Pond for final treatment at 7m² per person.

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**Solid Waste**

The accumulation of solid waste in recent years has been dramatic. Between 1980 and 1985 the amount of solid waste generated per person in Canada increased by 21 percent. During that same period, only 2 of the 16 members of the Organisation for Economic Co-operation and
Development, Germany and Japan, reduced solid waste production. In 1988 the average American produced 660 kilograms of solid waste. (Brown, 1991, p. 43-44) Society appears to accept this waste as inevitable even though most of it can be recycled or reused. On average paper, paperboard products and food wastes account for 50 to 70% of solid waste; metals, glass and textiles another 20-30 percent; and plastics and other miscellaneous materials the remaining 10-20 percent. (Walter, 1992; Brown, 1991; Vale, 1991) If properly managed all of this material has the capability of being recycled.

Central to any strategy for managing solid waste is a change in the community's policy towards source reduction, "the only option that eliminates the need for disposal, the extraction and processing of virgin materials, and even the reduced energy pollution of recycling." (Brown, 1991, p.47) Source reduction requires, among other educational initiatives, that the price of products reflect their full ecological impacts during the life of their use. To date most products are priced without consideration for the polluted and dispoiled land and water which result from their production and disposal.

Of equal importance is to defer responsibility for handling solid waste to the place where most of it originates, the neighbourhood. Waste generated by a community must be dealt with by and within the community. No longer can waste be carried off to a distant landfill where it remains "out of site, out of mind," insulating people from the ecological impact of their consumer habits. Local responsibility would discourage indiscriminate production of waste and encourage the reuse and conservation of materials and resources. To support solid waste reduction at its source the ecologically sustainable community should consider two initiatives which will have spatial implications.

**Neighbourhood Compost Facilities.**

Each neighbourhood or block should include a permanent facility jointly managed by the community and local residents where food and garden wastes can be dropped off for composting. The facility would be combined with community gardens so the resulting compost could be used in the gardens. Residents could also pick up composted soil for home use. Though many homeowners have begun composting their own wastes few have the time to do so properly. A
neighbourhood location, actively managed by the community would help return nutrients back into the local landscape. Little empirical data exists to define appropriate spatial allowances. However, based on the dimensions of the small compost units now in use in many private homes, an allowance of .2m² per person should be adequate. This figure will likely decrease as the compost facility’s size increases due to increased space efficiency which comes with handling a block of housing or a neighbourhood’s waste.

*Neighbourhood Solid Waste Centre.*

Neighbourhood solid waste centres would handle the non-compostable materials. These would be brought to the facility by residents for separation and possible reuse within the community, or for distribution to the appropriate recycler. Similar neighbourhood centres exist in some Japanese cities where a range of materials, from metal cans to old appliances, from old furniture to building materials are brought for reuse by others. The neighbourhood centre would replace local curbside collection except for items which are too large to carry. The transfer centre would have to be centrally located within a maximum five minute walk of all residents to ensure its accessibility. Like the compost facility the spatial requirements for the solid waste centre is difficult to define. However, a minimum of 1m² per person appears reasonable though this number may also be reduced through efficiency of space when neighbourhood demands are considered neighbourhoods with populations of 500, 1,000 or even 1,500 people.

Therefore the following design parameters can be stated;

- Compost facilities should be located in every neighbourhood of approximately 1,000 to 1,500 people, preferably associated with community gardens. An allowance of .3m² per person is required.

- Neighbourhood solid waste centres should also be included in each neighbourhood at a rate of 1m² per person.

- Both facilities should be no further than a two to three minute walk for all residents.
3.6 Vegetation

- Introduction

The urban system has two significant impacts on local and regional vegetation patterns and ecological function. Within the urban system, roads, buildings and a landscape aesthetic of lawns and ornamental plantings have displaced native plant communities, resulting in fragmented ecosystems and diminished wildlife habitat. On a regional level the continued expansion of urban systems has placed forests and agricultural land under siege and reduced local and regional biodiversity. In general the urban system fails to recognize the vital role vegetation plays in the hydrologic cycle, how its presence can moderate the urban heat island and improve urban air quality, and as habitat for wildlife. (Walter, 1992; Gordon, 1990) Of equal concern is how infrequently the psychological benefits of the urban forest and green open spaces (Kaplan and Kaplan, 1990) effect land use decisions and settlement patterns.

Urban vegetation, as it exists today is dictated by appropriated, nonregional images with little concern for the impact on local and regional biodiversity and wildlife habitat. (Hough, 1990; Spirn, 1984) In many cases these plants do not adapt to local and regional climatic conditions resulting in a variety of maintenance measures, such as irrigation systems and herbicide applications, to ensure survival.

"The horticulture tradition and the picturesque garden, together with the aesthetic that created them, found firm root in North America. Imported to a continent where the clearing of forests, exploitation of virgin timber and soils, and survival were the primary motivations in dealing with the land and where a cornucopia of resource products was the basis for the economy, all that could survive was an artistic doctrine that had no roots in a land ethic. Making gardens was centred on already tamed, man-made environments with scientific horticulture providing the technology. It was totally dissociated as an aesthetic from land management as a biologically sustainable process based on practical necessity." (Hough, 1990, p.134-135)

In the ecologically sustainable community the role of vegetation must hold the same stature as issues of water, energy and waste. It must support ecological function rather than undermine it. In this section three aspects of vegetation are discussed:
Other aspects of urban vegetation which are important such as native plant communities and xeriscape plantings are not discussed in this thesis due to time limitations. They are nonetheless essential if the following strategies are to be successfully implemented.

**Urban Forest**

Moll argues the urban forest can be categorised into four distinct zones, each of which requires a different treatment in order for it to thrive (Moll & Ebenreck 1989);

**Suburban Fringe**

These forests surround the edges of urban expansion where existing forests are fragmented or "perforated" (Forman, 1990) by small individual or clusters of housing. Because the extent of damage is small the indigenous forest, and the ecological function it supports is only partially diminished.

**Suburban Forest**

This is the relatively new forest found in most subdivisions. Exotic and ornamental trees vastly outnumber natural plantings which remain only as conservation belts or as remnant patches within the 5 percent open space requirement. Opportunities for large areas of natural planting exist but most are planted with lawn and ornamental plants. The middle story and understory plant communities of the natural forest are generally removed due to safety concerns even if the forests remain. Ecosystem function is minimal.

**City Residential Forest**

These are forests in older, established neighbourhoods where plantings have had time to mature. Private yards tend to be more heavily planted than suburban areas. They appear at first glance to be lush, productive forests but many are comprised of single species and very few include a middle understory layer to maximise the forest's vertical structure. Ecosystem function is minimal.
**City Centre Forest**

This forest is characterised by trees set in small pits or in pots within the central business district. The trees are in a state of perpetual stress due to extreme microclimate variations, minimal water and air, and a scarcity of space and nutrients. This is the shortest lived of the four zones.

The design and management strategies for each category will differ since their cultural conditions are different. In the city centre forest the most important issues relate to the quality of the soil. Providing adequate space, drainage, aeration and organic matter while minimizing compaction are essential. In the city residential forest the challenge is more rehabilitative -- find ways to add more diversity and vertical structure to the existing forest. Layering opportunities exist in the city residential forest which cannot be included in the City Centre Forest.

Forman (1993, 1990), on the other hand, argues that the evolution of the urban forest is one of progressively less connectivity and diversity. Beginning with the initial stages of tree removal, the forest proceeds through a succession of perforations, dissections, and fragmentation eventually resulting in shrinkage and attrition. Reducing this atrophy in local and regional ecological function is the challenge for the urban forest which must establish its objectives based on maintaining ecological integrity.

**Patches & Corridors**

Ultimately both Moll and Forman seek to improve biological diversity and productivity within the urban forest and between the urban forest and the regional ecosystem. The key to achieving these goals rests with the urban forest’s ability to provide a biodiverse network of patches and corridors throughout the urban system. (Forman, 1993) This translates into corridors which are large enough to provide habitat and interior nesting sites for a variety of species. These corridors must include a variety of plant canopies and vertical structure. (Franklin, 1993) For example, a corridor comprised exclusively of poplars would have a relatively low matrix and minimal habitat value. If however, middle and understory plantings are included and the corridor is given sufficient width the potential biological diversity and productivity would be dramatically enhanced.
These corridors must then be linked to larger forest patches which can provide the principal habitats and nesting sites. These patches must also include a diverse matrix of plant communities to ensure the habitat is diverse enough to support resident populations of wildlife. As is the case with corridors, the more vertical complexity the patch has the more likely the forest will contain viable habit corridors.

Forman (1993) offers the following process which can act as a set of ecological design parameters:

Step 1 - Illustrate existing local and regional patterns and connections including;
- all environmentally sensitive lands and vegetation.
- unique forests and habitats.
- fragmented forest corridors including widths.
- patch size and relative isolation.
- general connectivity.

Step 2 - Illustrate how any particular neighbourhood fits within these local and regional patterns.
- Is it part of an existing or fragmented corridor? If so is it an open or wooded component?
- Is the property within a transition zone?
- Is the property in a unique location in terms of natural features and vegetative patterns?

Step 3 - Establish the primary goals of the forest related to the characteristics noted in step 2.
- is there a need to add species richness?
- should the forest be part of restoring or protecting local hydrologic cycles
- are there special habitat requirements?
- should the forest aide in erosion control?

• Urban Agriculture

As with issues of energy and water supplies, and the handling of waste byproducts, the ultimate goal of any sustainable community is to generate its own food. While complete autonomy is, for most communities, unrealistic much can be done with existing practices to reduce the dependence on imported food supplies.

“If we are to have sustainable, livable cities in our future, it is necessary to create a metropolis that produces much of its food.” (Van der Ryn and Calthorpe, 1986, p. 150-1)

A few local initiatives which can be implemented without major governmental subsidies or expenditures include.
Community/Allotment gardens

These gardens are a neighbourhood scale agricultural initiative. Though allotment gardens idea were popularised during World Wars 1 and II with the notion of the “Victory Gardens” food producing gardens within the urban fabric date back many millenia. Today most cities have some official or unofficial allotment gardens where many urban greenthumbs are able to supplement their food requirements. In the suburbs few allotment gardens exist since individual homeowners have ample land on which to garden. In the future however, as communities densify and the cost of food escalates the allotment garden should become an integral feature of the community’s open space.

There are no specific standards or spatial requirements for these allotment gardens. Most occur on vacant property or along utility right-of-ways. They often begin as individual initiatives without the consent of local government and their size seems determined more by available space then standard sizes. In general the locational requirements of allotment gardens are flexible and can be adapted to the strangest lot configurations as long as there is access to sunlight and water and they are convenient. Hough (1984) cites numerous examples of allotment gardens of varying sizes but concludes little about minimum spatial requirements. Jeavons (1982) on the other hand has calculated that using intensive gardening techniques, a plot approximately 35m² is sufficient in size to provide one person with their annual supply of vegetables and fruit.

Agricultural Urban Forest

The second initiative involves using the urban forest in food production by including fruit and nut bearing trees. The actual proportions of food producing trees has not yet been defined and to do so would seem arbitrary and restrictive. However, if the community aspires to produce much of its own food than the proportion of the urban forest under harvest would be relatively high and coordinated with regional orchard production. To manage the resource the community would employ a full time community gardener who would manage the trees as well as provide input on the allotment gardens. The produce harvested would either be sold in the local farmers markets or offered free to local residents in exchange for community service.
Community Supported Agriculture (CSA)

The third initiative operates at a larger scale than the allotment gardens and offers opportunities for residents to ensure a locally controlled supply of organic produce. In the United States, community sponsored agriculture is emerging as a simple initiative whereby urban residents annually buy shares in local farms in return for a share of the year’s harvest. Any surplus production is generally sold at farmers markets and in local stores. The programme can include greenhouses and cold storage for year round productivity.

The attraction of the CSA is that it is are small scale which it to fit more easily into the urban system. Most CSAs are family run and organic with low energy requirements, an essential requirement for sustainable agricultural. (Berry, 1987) CSAs also provide shareholders opportunities to work on the farm for a few hours each month in lieu of a cash share transaction. An allowance of approximately 30m² of land per shareholder to supply each person with the equivalent of a years supply of fruits and vegetables is adequate.

Between these three strategies the potential exists to supply much of a community’s food demands. (Walter, 1992; Katz, 1986; Hough, 1984) Therefore the following design parameters can be stated;

- Allotment gardens of a minimum of 30m² per person should be located within a five minute walk of any home.

- Vacant land in the community should be operated as temporary sites of food producing.

- Flat roofs should be used for food production.

- The urban forest should include a minimum 25 percent active fruit and nut producing trees.

- Farms adjacent to the community should be considered as prime candidates for community supported agriculture programmes.

• Green Roofs

The final feature of this discussion of urban vegetation is the use of green roofs. Conventional buildings and roofs replace a site’s original vegetative cover with a surface impervious to water and incapable of exchanging air. When combined with other hard surfaces such as roads and parking
lots a large portion of the community’s landscape is no longer capable of exchanging CO₂ with O₂. By replacing these roofs with planted roofs, anywhere from 20 to 60 percent of the community’s hard surface area can be returned to some level of ecological function. Green roofs are becoming a standard detail in building construction in many European cities. In the German cities like Berlin, Hanover, Mannheim and Frankfurt which have policies requiring green roofs in a most new construction. (Roseland, 1992)

Incorporating grass roofs during the design phase is simply a matter of providing structural allowance and drainage as live and dead loads are considerable. Most green roofs in Europe are planted with drought tolerant grasses and perennials on flat or slightly sloped roofs, however, the potential of green roof is much broader than grasses. There exist a number of roof top gardens in North America which decades later are still healthy and growing. Dan Kiley’s Oakland Museum and Arthur Erickson’s Provincial Courthouse incorporate rooftop plantings demonstrate there are few technical constraints facing roof top construction. The potential for green roofs is almost limitless if grey water is available and the architecture is designed to accommodate them. They have the potential to become important agricultural areas in the sustainable community.

With these points in mind the following design parameter can be stated;

All new construction must provide roofs strong enough to support a minimum of 0.5 meters of soil and drainage materials.

Sloped roofs with pitches not facing south shall be planted with a combination of drought tolerant perennial grasses and groundcovers.

Flat roofs shall be planted with the same perennial grasses and groundcovers or if grey water is available, more intensive plantings of trees, shrubs or agricultural crops.

Simply defining the urban forest as a collection of trees along street corridors and patches of forests in parks does not enhance the integrity of the local ecosystem. The definition and role of the urban forest in the sustainable community must be expanded to include all vegetation, public and private. It all constitutes the forests matrix and therefore, if it is to support ecological function, it must be viewed in its entirety. Furthermore, the site specific issue must be viewed within the local and regional context to enhance ecosystem function.
3.7 Housing

"Over 60 percent of Canada's housing units are single-family detached units....Detached houses consume 15 to 67 percent more energy than other common ground-oriented housing options and they accommodate 60 percent fewer people per net hectare than row houses." (CMHC, 1992)

• Introduction

Throughout history the search for secure shelter is basic to human instinct. For most of the last 10,000 years this shelter has generally involved multiple families sharing a building or building cluster. During this century, however, these patterns have changed dramatically. Today the suburban house is the dominant housing type in North America, and though it is a very recent phenomenon, it has altered the land more than any other typology before it. No other pattern has required as much energy or water, or displaced as much forest or agricultural land. From the perspective of ecological sustainability it is an anachronism.

The intent of this section is to identify those spatial parameters for housing which best respond to the basic programmatic features of the ecologically sustainable community -- energy self-reliance, relatively high densities, enhanced livability, protection of ecological integrity and human scale design. The following parameters take as their point of departure from conventional suburban housing, a solar energy mandate. They are not intended to represent a comprehensive discussion of solar architecture, rather they address those features of buildings which affect spatial organisation.

• Building Height
• Building Width
• Building Length
• Adaptable Buildings

Other, less spatial demanding decisions respecting housing exist, however, these are generally building features which operate within the criteria established by these four categories.
Building Height

Discussion of energy efficiency in sustainable design has often overlooked the issue of building height. To date most research has focussed on the single family house, (EMR, 1993) which, as already discussed, is an inappropriate pattern for an ecologically sustainable community. Therefore if multiple family housing is the only alternative for housing urban populations then it is essential to determine if there are spatial parameters, particularly height restrictions, which will ensure an ecological mandate is met. In A Pattern Language, Alexander argues that buildings should not exceed four stories in height;

"High buildings have no genuine advantages, except in speculative gains for banks and land owners. They are not cheaper, they do not help create open space, they destroy the townscape, they destroy social life, they promote crime, they make life difficult for children, they are expensive to maintain, they wreck the open spaces near them, and they damage light and air and view. But quite apart from all of this, which shows they aren’t very sensible, empirical evidence shows that they can actually damage people’s minds and feelings.” (Alexander, 1977, p.115)

The four story limit dominates most of Europe’s older cities. Alexander describes it as “a deep and inescapable property of a well-formed environment.”(Alexander, 1977,p.xiv) The four story rule also dominates the higher density housing found in Transit Oriented Developments (Calthorpe, 1993; Kelbaugh, 1989) and Traditional Neighbourhood Developments. (Krieger, 1991) Nonetheless, while the ‘Four-Story Limit’ makes a compelling argument for height restrictions because of enhanced livability it does not specifically engage issues of ecological design and energy efficiency.

Upon further examination, however, the four-story limit is also a valid consideration for a discussion on energy efficient design. Because heat gain is a function of volume, surface area and orientation, the larger a building gets the larger is its potential passive heat gain. Under similar conditions a four story building will gain more heat than a single family house by virtue of its larger volume and surface area exposed to solar radiation. It would seem logical then that a ten story building would be preferable to a four story building due to its potential passive heat gain. However, the ten story building is dismissed because of its profound impact on the pedestrian scale on which the ecologically sustainable community is based. It is this disproportion which
Alexander argues makes it difficult for buildings higher than four stories to foster the sense of community and street life that a four story building does. The four story limit also appears in Van der Ryn and Calthorpe’s (1986) plan for the Marin Solar Village, a prototypical sustainable community north of San Francisco.

Another ecological concern respecting building height deals with a building’s capacity to supply water and deal with waste on site. Roof area is the prime determinant in defining how much rainwater a can be collected and made available for use within a building. A single story building offers a ratio of roof area to occupants which is four times higher than a four story building, which in turn has a ratio two-and-one-half times higher than a ten story building. Three and four story buildings, though not as water efficient as single story buildings can still supply relatively high proportions of general water consumption using on site grey water supplies. Beyond four stories the building’s capacity to store rainwater and supply for use within the building diminishes. Therefore the following design parameter can be stated;

Residential building heights should be between two and four stories. Exceeding four stories results in significant loss in livability and energy self-sufficiency. Less than two stories results in densities which are simply too low to make public transit and local commercial ventures viable and result in more urban sprawl.

Non-residential buildings can exceed four stories but must demonstrate their plans to maximize energy self-sufficiency.

**Building Width**

The width of a building also effects how ecologically sustainable it can become. Shallow buildings, 8 to 14 meters deep, improve daylight illumination of individual rooms and increase the heat gain properties of the building envelope compared with buildings in excess of 14 meters wide. The result is a savings on energy used to illuminate and heat interior space. This applies equally to residential and commercial buildings as is demonstrated by the NMB Bank building in Amsterdam. This large commercial building has a number of ecological design features but the one which most heavily influenced its physical form was the design parameter requiring each work station to be within 7 meters of a window. This strategy effectively restricted the building to a maximum of 14
meters in width. Combined with a high efficiency building envelope the Bank witnessed a reduction in the energy consumed by its staff, per square foot of building, by more than 90 percent. Natural daylighting is an important energy conservation strategy given that electricity used for lighting accounts for approximately 25 percent of all domestic energy use. (Vale, 1991, p.23)

Narrow buildings exhibit higher heat gains compared to wider buildings because they increase the volume to surface area ratio of a building’s mass. This benefit is best illustrated by comparing two 15 meter high, 20 meter long buildings built side by side with a southern orientation. The only difference between them is that one is 10 meters wide and the other 15 meters. The 10 meter deep building will have an effective volume to heat of 3,000m^2 whereas the 15 meter building will have a volume of 4,500m^2, or 50 percent more space to heat with the same solar gain. Furthermore, wider buildings generally result in central corridors which while not part of the livable space must nonetheless be heated. These corridors virtually guarantee that the more northerly units will have no rooms with any solar gain.

Narrow buildings with operable windows can significantly improve a building’s natural ventilation by encouraging cross flow ventilation. A naturally ventilated building has the capacity, in one hour, to completely exchange its interior air three times as frequently as a similar sized air conditioned building. (Hydes, 1994) This improves indoor air quality and allows for more personal moderation of interior temperatures. When combined with appropriate landscape plantings and high insulation values the need for air conditioning can be virtually eliminated.

Alexander (1977) argues buildings should not exceed 25 feet in width to offer the best opportunities for maximizing daylighting. Van der Ryn and Calthorpe (1986) used a building width of approximately 10 meters in the design of the Marin Solar Village. On the other hand, buildings less than 8 meters deep results in a building too shallow to adapt to changes in building use. Collectively the benefits of narrow building widths leads to the following parameter:

**Residential buildings should be between 8 and 12 meters wide. In commercial buildings which, for specific reasons, may require more floor space depths 15 meters should be the maximum width.**
• **Building Length**

In addition to width and height, length is the third spatial component of a building’s mass which is relevant to this discussion of more sustainable building patterns. It is a discussion concerned less with energy efficiency and more with the impact the length has on community design. Historically long buildings were limited to governmental and religious institutions. It would appear that the act of land assemblage and speculative development that is responsible for much of today’s large scale development was limited to a relatively few higher profile cities.

Although empirical data is scarce, there appears to be sound reasoning behind this. Large long buildings are inherently less flexible than those with small floorplates. For small businesses long buildings are generally too large and expensive to house offices or shops. From a residential and street life perspective long buildings generally offer fewer doorways and stoops. These are a few architectural features which can personalize building entries for residents and offer possible ‘porch-like’ social opportunities. From a visual perspective there is good reason to restrict large buildings, particularly buildings with glass curtain walls. Long street oriented facades tend to repeat details such as window spacings and balconies ad nauseam. This detracts from the visual complexity and texture of the street experience which Jacobs (1961) argues is important for vital streets.

Finally, shorter building lengths allow for more incremental growth and individual variety as each unit consumes modest amounts of land.

• **Adaptable Buildings**

The final parameter governing building design for ecologically sustainable communities is adaptability. While this does not have direct spatial concerns it implicates the ability of a building to adapt to changes in use over time. Considerable amounts of energy and materials are expended in the construction of any given building. Every time a building is demolished and replaced because it can no longer accommodate a desired use the energy embodied in that building is wasted. New materials must be found and new energy spent to construct what often ends up being an even larger building, occupying more of the site. It is a linear cycle of renewal which presumes a limitless supply of energy and materials.
Natural ecosystems are inherently flexible and adaptable to respond to changing circumstances and context. In this respect buildings should exhibit similar characteristics. As family units change and businesses expand and retract, buildings must be capable of responding. Unlike most buildings in the latter half of this century which were conceived as static entities with rigid envelopes, buildings within a sustainable community must be dynamic and flexible. For example, a building no longer viable for a growing business must, if no other businesses wish to use the space after a period of one year, be adapted for another use be it residential, institutional or commercial. Communities cannot tolerate buildings, or floors in buildings, remaining empty for months or years. This practise is wasteful of materials, embodied energy and, if the building requires heating, ongoing energy demands.

Adaptable buildings have a better chance of remaining in the community for a longer period of time. One only needs to walk along the canals of Amsterdam to see how a four hundred year old building can be adapted to contemporary uses while retaining the cultural legacy of ten generations. Adaptability is not only about conserving materials and energy but about preserving community identity. Every time a building is replaced part of the community’s past is changed, and the intergenerational associations disappear.

Therefore the following design feature can be stated;

All buildings must be designed to allow for at least two different uses. For example a building intended for industrial use must be designed and constructed for future conversion to residential uses.

Floor plates of all buildings should be conceived of as temporal, that is they must be designed in such a way that nonload bearing walls can be shifted to adapt to consumer demand.

Modular construction should be used to ensure that adjoining buildings have the potential to adapt to a common use, such as the growth of a local business.
3.8 Spatial Order

• Introduction

In addition to the ecological determinants of energy, water, waste, and vegetation, and the consideration given to appropriate building forms which respect these determinants, there are a few other features of community form which require a brief discussion. They include:

• Density
• Community Size
• Streets
• A Network of Paths

• Density

Cities around the world come in all shapes and sizes. At one extreme is Hong Kong, located on steeply sloped terrain with an average density of 293 people per hectare. It is a city of tall apartment buildings, narrow streets and a crush of pedestrians. Automobiles are expensive to own and operate which explains why there are only 42 cars per 1,000 people. Consequently public transit use is high and gasoline consumption very low (1,987 Mega Joules per person). Houston, on the other hand, sits on level ground with an average density of 9 people per hectare. Its broad streets, endless inner city parking lots and minimal pedestrian activity underscores it as an automobile dependent city. Vehicle ownership is among the highest in the world (603 per 1,000 people) and at 74,510 MJ per person, gasoline consumption is 37 times that of Hong Kong. (Newman and Kenworthy, 1989)

Comparing Hong Kong and Houston demonstrates that density and energy consumption are inextricably linked and inversely proportional. (Newman & Kenworthy, 1989) In higher density communities more frequent and diverse services are within walking distances which reduces energy expended on transportation. Higher density communities also share more building walls which reduces overall demand for heat energy.
Another equally important feature of higher density communities relates to the amount of land they conserve. By definition a denser community houses more people per area of land than a less dense community. For example, if a typical suburban community with a density of 25 people per hectare grew from 500 people and to 2,000 people using the same densities, the amount of land required would also grow, from 20 hectares to 80 hectares, excluding services and roads. However, if that same suburban community chose to increase its density to 80 people per hectare the amount of new land would be 5 hectares, a savings of 55 hectares.

A more specific look at the issues of heat and transportation energy will help define appropriate densities.

**Solar Energy**

Van der Ryn and Calthorpe note that solar design strategies can provide most of the heat energy and supplemental electrical energy, for up to 200 people per net hectare. (Van der Ryn and Calthorpe, 1986, p.82) However, once allowances are made for roads, commercial services, neighbourhood parks, wastewater treatment facilities, the urban forest, and other essential services a community requires this limit would be approximately 100 people per gross hectare.

**Transit**

It has been argued that the ecologically sustainable community is supported by transit and the automobile is relegated to a marginal role, yet for transit to be viable densities must be relatively high. Newman and Kenworthy found that when densities drop below 30 people per hectare transit is no longer viable and automobile dependence is assured. (Newman and Kenworthy, 1989, p.131) Furthermore, they noted that even when densities are between 30 and 50 people per hectare public transit will still require some financial and are limited in the frequency of service. Therefore it appears that in order for transit to be viable densities must exceed 50 people per hectare.

**Historic Perspective**

One final perspective on density relates to the preindustrial community with its compact, pedestrian based, structure. It appears most of these communities had densities of between 100 and 200 people per hectare. (Newman & Kenworthy, 1989, p.79) These are numbers that would be
immediately rejected today as being far too high yet when one visits these communities their human scale, the clarity of their public realm, and immediate access to open space afforded by their compact footprint seems to offset these high densities.

Admittedly one cannot determine appropriate densities for a neighbourhood or community without considering the effects on the life of the community. Increasing densities reduces the proportion of individual open space which, if not adequately addressed, can lead to a host of social problems. However, as the scope of this thesis focuses on ecological concerns which effect spatial form these social issues are not addressed in this review of ecological design parameters. Rather these issues will become criteria during the design application phase of this thesis.

Therefore considering issues of solar energy and transit, the following ecological design parameter can be stated:

- **Provide a mix of housing which achieves an overall net density of between 60 and 100 people per hectare.**

- **To offset this increase in density and an associated loss in individual space a clearly defined open space system must be accessible to all housing**

- **Community Size**

If ecologically sustainable communities are relatively dense and organized around a central transit station the question regarding a preferred size still exists. Alexander (1977) argues that the size of a community should not exceed 5,000 to 10,000 people, comprised of identifiable neighbourhood units of 500 people. He argues this offers the best size for local governance and neighbourhood identity. Beyond 10,000 people, the footprint of the community increases and begins to blur the edges of neighbourhoods and the perimeter of the community. Consequently an individual’s concept of the community becomes blurred, their relationship with other neighbourhoods begins to erode, and they feel more disenfranchised and less willing to participate in local government.
Sale (1980) notes anthropologic evidence suggesting that prehistoric tribes rarely grew beyond 5,000 and 6,000 people. And most cities prior to Christ rarely exceeded 10,000 people. This was true not only in the “Middle East, but in India, China, North Africa and Central America.” (Sale, 1980, p. 185) Sale also notes that Clarence Perry felt the ideal community was between 3,000 and 9,000 people, with an optimum size at 5,000.

Curiously enough when one considers that the catchment area for a transit based community is around 500 meters in radius (5 to 10 minute walk), and that densities supported by solar energy probably do not exceed 100 to 150 people per gross hectare, in order for a community to provide a mix of housing, commerce, employment and open space its highly unlikely its size could exceed 5,000 to 10,000 people and still achieve its mandate. Therefore, the following ecological design parameter can be stated:

For residents of a community to retain their image of their community and for that community to respect the ecological constraints placed on it by solar energy and public transit the community’s population should not exceed 10,000 people and preferably not 5,000 to 7,000.

• Streets

During the last one hundred years, the street has held a certain fascination with planners and designers. Among the many enquiries is Site’s (1889) discussion of the purposefulness of medieval streets, Jacobs’ (1961) argument that streets and sidewalks are a city’s most vital organs, Newman’s (1972) focus on safety and defensibility, and Appleyard’s (1981) research into the sense of community different street characteristics engender. Most recently two anthologies (Anderson 1991, Moudon 1987) have offered a wide range of testaments on the malaise effecting today’s streets and how design can affect positive change in reestablishing their lost vitality. Each raises important issues respecting the street and its role in supporting a strong sense of community.

Unfortunately very few of the enquiries have taken the discussion further and explored what the issues are as they pertain to ecological sustainability. Appleyard (1981) talks about the ecology of the street from an anthropocentric perspective but fails to discuss it from a broader ecological
mandate. Both Hough (1984) and Spirn (1984) discuss some atmospheric and vegetative considerations but neither offer ideas on how one might begin detailing the street to accommodate flows of energy or water, or to enhance biodiversity. Finally Jacobs (1993) recent collection of streets focusses on the form of notable streets from around the world but does address adjacent uses nor their relative ecological merits. Consequently the following information is based less on precedent, and more on observation and speculation. It is interested in whether there are spatial considerations for the street that might maximize solar energy, the movement of water and waste, wildlife habitat enhancement and biodiversity.

Fundamental to the discussion is the belief that an ecologically sustainable community is one which maximizes circular exchanges of energy and materials, and that the role of the street is to support these exchanges. It is analogous to the human circulatory system. Without the network of veins, arteries and capillaries supplying blood to the organs and muscles we could not survive. Similarly streets are the pathways which allow both human and ecological functions to occur. With this in mind there appears to be a few critical features of the street that relate to ecological sustainability.

Solar Orientation

To maximize solar gain a building’s long axis needs to be oriented perpendicular to or within 20 degrees of south. As buildings with this orientation become positioned in the landscape they begin to form a strong east/west axis which the street must support. More specifically a rectilinear block with its long axis oriented east to west provides the highest potential solar gain to all of the community’s buildings. This is the grid pattern used by the Greeks and Romans when space heating and building illumination were dependent on exposure to the sun. It is a street grid which has structured many cities over time. Conversely the meandering suburban street is the least effective street orientation for maximizing solar gain. It results in buildings with little regard for south.

Undoubtedly there are topographical limitations to any grid pattern. Knolls, stream corridors, ravines, steep slopes, and other environmentally sensitive lands all restrict a simple overlay of the grid. Nonetheless the grid, when the land allows, offers the highest solar potential of any street orientation.
Block Spacing

Another energy related issue is the size of development blocks and the on centre spacing of streets. Both Portland, Oregon (Moudon 1987) and Savannah, Georgia (Anderson 1991) offer some insight into these dimensions from the perspective of the pedestrian. Portland's 61 meter block spacing is highly regarded for its walkability because it offers pedestrians four directional choices every 61 meters. Harrison noted that combined with generous sidewalk widths and height restrictions on buildings there is also an increase in open space and light at the street level.

"Downtown Portland has 55 percent open space in its streets and parks, in contrast to 33 percent open space in downtown Seattle and New York." (Moudon, 1987, p.182)

Savannah, on the other hand is organized by a pattern of square blocks based on a 230 meter grid. However, within each of these blocks is a system of smaller blocks, the most common measuring approximately 100 meters by 65 meters. These rectangular blocks are oriented with their long axis east to west. This rectangular organization offers a higher solar gain potential than a square pattern similar to Portland's. Like Portland's block the frequency of intersections in Savannah enhances pedestrian mobility and choice. Recent developments have borrowed some of these spatial characteristics in an attempt to make new suburban communities more pedestrian friendly. Blocks within Duany and Plater Zyberk's 'Traditional Neighbourhood Developments' rarely exceed 70 meters by 185 meters and often include mid block pedestrian connections. (Kreiger, 1991)

Calthorpe (1993) uses a similar rectangular module in his development of Transit Oriented Developments. And Jacobs (1961) notes that the 130 meter grid of Manhattan's East Side is far more lively than the 240 meter long blocks on the West Side.

When bicycle paths are considered it would appear that the ideal block size is rectangular, oriented east to west, with a long dimension of between 75 and 100 meters and 60 to 70 meters north to south.

• Permeability and Drainage

Moudon calculates that from 30 to 60 percent of urban land is allocated to streets excluding freeways, connectors and toll roads. (Moudon, 1987, p.17). In the city of Vancouver and many of its suburbs approximately 25 percent of the land is paved over for streets. (City of Vancouver,
1992) When considered in conjunction with the land covered by buildings, between 60 and 100 percent of the urban system's surface is impermeable to water. This leads to some severe consequences: groundwater tables are deprived of water; rivers, creeks and seasonal streams suffer reduced water flows, some to such an extent that associated plant and animal communities are displaced; and during heavy rainfall increased runoff threatens low lying areas in communities with flooding, while storm sewers overflow forcing both stormwater and untreated sewage to bypass treatment facilities and be dumped, untreated, into adjacent rivers, lakes or oceans.

New strategies must be found to make the street more permeable. Groundwater recharge beds under, and adjacent to street, dry wells and drainage swales must be incorporated. Conventional surfaces such as asphalt and concrete should be eliminated in favour of more permeable surfaces such as cobblestones, loose fitting interlocking pavers, and porous aggregate paving.

Vegetation
The urban forest has many ecological and social responsibilities. It serves as the urban ecosystem's respiratory system, cleansing particulate matter and greenhouse gases released from automobiles. It casts shade across the street which reduces the street's heat absorbing properties and its contribution to the heat island effect. The urban forest provides habitat for wildlife, and helps define and create memorable places for people. With the street occupying 25 to 60 percent of the community's land base, street trees are potentially the largest component of the urban forest.

Supporting these street trees depends a great deal on the street's subgrade. Compacted root zones and low organic matter lead to poor air infiltration and water percolation. These are the limiting conditions for most urban forests. The profile of the street must be redesigned. Soil trenches with a minimum cross-sectional area of 3 m² (Moll and Ebenreck, 1989) must run continuously alongside the street. In low volume traffic areas the rooting zone and recharge areas should extent well beneath the street. Part of the surface runoff entering roadside biofiltration swales should be allowed to percolate into the tree's rooting zone. Direct runoff from streets should be fed to the root zones via oil interceptors. Planting standards must allow roots to extend beneath pavement and ensure soil conditions are matched to the cultural needs of the trees and shrubs. Curbs should be
removed wherever possible to eliminate the problems associated with abrupt elevation changes. (Moll and Ebenreck, 1989)

Widths
There is much discussion regarding the dimensions of the ideal street corridor. (Calthorpe, 1993; Jacobs, 1993; Anderson, 1991; Krieger, 1991; Moudon, 1987) Many have concluded that a two to one ratio of horizontal to vertical psychologically encloses the most comfortable space for people. This would equate to a preferred building height of 10 meters if the street corridor were 20 meters wide from face of building to face of building. While this proportion may create an optimal psychological space it cannot be used indiscriminately. Ecological requirements such as drainage swales or vegetative corridors may preclude such prescribed design guidelines. Similarly, narrow road corridors, complete with trees, may restrict solar gain. However, for most communities this 2:1 ratio does not pose any significant problem for ecological function. In those situations where the corridor must expand for ecological reasons the presence of large street trees along the corridor can maintain the ratio.

With these considerations in mind the major design parameters for the ecological street are;

A rectangular grid is the preferred street pattern, whenever topography allows, to maximize solar gain and provide a coherent urban form.

The preferred on centre spacing of east/west streets should be between 75 and 100 meters.

The preferred on centre spacing for north/south streets should be 60 to 70 meters.

• A Network of Paths
Pedestrian and bicycle circulation need to become the central mode of movement in the ecologically sustainable community. These are the most energy efficient means of travel and the most ecologically benign. Neither emits greenhouse gases to the atmosphere, nor adds to the pollution of ground water. Neither requires the dedication of large paved surfaces on which to travel. Neither exacts a huge financial and social cost to operate. Prioritizing the pedestrian and the cyclist over the
automobile and even over transit should become a fundamental feature of the ecological community.

While pedestrian based cities have been around for centuries and millennia the integration of bicycles is a relatively recent consideration. In this regard few countries have done more to support bicycling than the Dutch. With 14 million people cycling 13 billion kilometres on 12 million bicycles they have some of the most extensive experience with bicycle paths and how to integrate them into the community. (Deelstra, 1991; Tolley, 1990) They have found:

- Path Networks - a dedicated system of paths is the only way to significantly increase ridership. A single pathway is too limiting to encourage use;
- Length of Trip - on trips of 5 kilometres or longer cycle use is limited;
- Accessibility - clear connections to other bicycle paths increases ridership;
- Safety - perceived safety is vital to encourage increased ridership. Dedicated paths dramatically increase ridership;
- Opportunity Costs - if the automobile is perceived as more efficient and costs are even ridership will be low.

Delft Bicycle Network

The City of Delft, in Holland has one of Europe's most comprehensive bicycle networks. It is a hierarchical plan with three interdependent networks. Each network is designed to address specific objectives and serves as a link to the other networks. Deelstra outlines the components:

"The city level network consists of a grid of cycle paths situated approximately 500 meters apart. The paths run directly through the city, and are connected with the regional bicycle-path system. The network is designed for the purpose of linking intensive flows of cyclists with important urban activity centres: schools, university, stations, office and industry areas, sport and recreation areas. Physical barriers (such as canals and railways) call for expensive infrastructural works to avoid detours.

The district level network has two major functions. It connects the various facilities within the district (school, shops, etc.) and collects and distributes bicycle traffic to and from the city level network. The links at this level are spaced 200 - 300 meters apart. The (bicycle) traffic flows on this network are assumed to be less heavy than at the city level and used for shorter distances. The facilities necessary at this level are relatively simple: separated bicycle lanes, small bridges etc.

The sub district level network connects housing areas to local amenities catering for short trips. This particular network is often used by children. The sub district level network is a fine grain system with links at 100 meter intervals, with a simple structure and provisions which can also be used by pedestrians." (Deelstra, 1991, p. 63)
The bicycle network now accounts for approximately 43 percent of all trips in Delft's with pedestrians representing 26 percent, cars 26 percent and public transit 5 percent. (Tolley, 1990)

The savings of energy expended on transportation is considerable as are the infrastructural costs related to new road construction and the provision of parking spaces. In a recent evaluation of the network some more specific observations were made: (Tolley, 1990)

- Segregated bicycle paths in busy areas subject to automobile traffic increased ridership by 40 percent.
- A clearly defined, hierarchical network of paths similar to the three grid layers found in Delft provides cyclists with increased trip options for local and distant journeys. The layered grid in Delft minimizes detours which become disincentives to cyclists.
- A clearly defined, hierarchical network of paths improves individual imageability and cognitive mapping. People are able to orient themselves and develop stronger images of their community.
- Promotion and continued marketing are important in maintaining the profile of the bicycle network among residents.

The bicycle network in Delft represents one of the most comprehensive system of paths in either Europe or North America. From the experiences learned in designing and managing it the following ecological design parameters can be stated:

Develop a network of paths for pedestrians and cyclists based on a hierarchical grid of regional, community and neighbourhood paths.

The First Order of the grid should occur every 100 meters to service the neighbourhood. Local roads can be calculated into the network if traffic calming strategies are used.

The Second Order is the community system which occurs every 200 meters and links individual neighbourhoods together. Similar to the neighbourhood system these community paths can be located on traffic calmed streets. However these second order paths must take priority at intersections with neighbourhood paths and roads. Where traffic calming is inappropriate, segregated lanes should be provided.

The Third Order is the regional path system which occur every 500 meters and provide links to the larger landscape and other communities. Where traffic problems exist the paths should be segregated.

On all shared paths bicycle lanes and pedestrian paths should be distinguished by paving patterns, textures and colours to minimise conflicts.
4.0 CONTEXT
4.1 **Regional Context**

As stated in the thesis introduction the second goal of this thesis is:

To apply these ecologically based design ideas to a suburban community under urban growth pressures in an effort to structure the community’s physical form so as to minimise its impact on local and regional ecosystems.

To evaluate the spatial implications of applying the ecological design principles identified in Chapters 2 and 3 a suburban community in the Township of Langley was selected. However, it is worth briefly reviewing the regional context in which Langley resides to better understand the issues affecting its future.
The Township of Langley sits within the Greater Vancouver Region, a region defined by its unique biophysical setting. It is enclosed to the north and east by mountains, to the west by Georgia Strait, and to the south by its border with the United States. Its mild maritime climate, seemingly abundant fresh water supplies and productive agricultural land make it one of Canada's most fertile and most livable regions. The Fraser River runs through the region to join the Pacific Ocean approximately 30 kilometres west of Langley. The Fraser serves as one of the world's most significant fish bearing watersheds and waterfowl habitats. The region is an ecologically rich and diverse landscape.

The Greater Vancouver Region also happens to be one of North America's fastest growing urban areas. The Government of British Columbia expects the current population of 1.8 million to exceed 3 million by 2021. In excess of 51 percent (610,000 people) will likely reside in the region's currently underdeveloped eastern municipalities of Langley, Matsqui, Abbotsford and Chilliwack and the Cities of Surrey and Langley. Less than 25 percent would reside in the traditional urban areas of Vancouver, Burnaby and New Westminster. (GVRD, 1991)

The eastward redistribution of the region's population also translates into considerable increases in housing development and employment in these eastern locations. The predominantly rural municipalities of Langley, Matsqui, Abbotsford and Chilliwack will be home to 25 percent of the entire region's new housing. Similarly by 2021 one in every three regional jobs is expected to be found in this eastern conglomeration extending to Chilliwack. (GVRD 1991)

Whether these numbers are actually realized by 2021 is less important than the fact that current growth pressures are significant, profoundly effecting the regional landscape. In the last twenty years increased pressure for housing has lead to the development of thousands of single family houses outside the traditional urban areas. These low density developments, with too few residents to support efficient public transit, are leading to ever increasing levels of automobile dependence. With an average of 12 dwelling units per hectare and .75 commuter vehicles per dwelling unit communities in Surrey, Langley, Abbotsford, Maple Ridge and the Coquitlams represent growing commuter problems compared to the City of Vancouver's approximately 45 dwelling units per
hectare and .45 commuter vehicles per dwelling unit. (GVRD 1992-#2) Automobile commuting is increasing twice as quickly as the region's population, reflecting not only the general population increases but also changes in household demographics as nuclear families are being displaced by increasing numbers of two income, childless and single person households. (GVRD 1992-#2)

Suburb to suburb travel is also increasing dramatically, accounting for 62 percent of all automobile commuting. By 2021 this figure is expected to increase to 72 percent. Simultaneously transit's share of the morning commute, currently at 13 percent of all morning peak period trips, is expected to drop to 11 percent unless current patterns of development change. (GVRD 1992-#2)

These expanding populations, low density development patterns and an ever increasing dependency on the automobile are creating significant environmental problems. Noxious emissions from automobiles create severe atmospheric pollution. Increased demand for drinking water related to increased housing development is stressing finite water supplies. Mounds of waste accumulate landfills, while sewage effluent pollutes local water bodies. Biological diversity and ecological productivity are lost as natural vegetation is fragmented by increased road construction and expanding communities. Agricultural land is displaced by expanding urban growth or the conversion to nonproductive uses such as hobby farms and golf courses. Every community in the region faces these problems.

4.2 Local Context - The Township of Langley

The problems facing the Township of Langley exemplify those of the region, and thus provide a good study area for this thesis. The Township's 303 square kilometres sit approximately 50 kilometres east of the City of Vancouver. It is bounded to the north by the Fraser River, to the east by the Municipality of Matsqui, to the south by the United States border and to the west by the City of Surrey. The landscape is a rich mosaic of ecologically significant water courses, productive agricultural lands, remnant forests and cultural resources.

An undulating topography of uplands, valleys and ravines is the result of the forces of numerous rivers and streams, many of which originate within the Township's boundaries. The pervasiveness
Figure 4 - Sensitive Aquifers and Floodplain, Township of Langley

of water is one of Langley’s most defining features. It is in the unique position of being home to several significant rivers and creeks including the Nicomekl, Campbell, Anderson, Yorkson, West and, ostensibly, the Salmon River. These are important fish spawning rivers and serve as important tributaries to the larger regional drainage system. Underlying the Township are four significant and highly sensitive aquifers, the Langley, Salmon River, Fort Langley and Aldergrove Aquifer. These aquifers provide vital water supplies to many rural residents and moderate dry season stream flows.

The rural landscape character is further defined by the predominance of agriculture. Approximately 75 percent of the Township’s land lies within the provincially designated Agricultural Land Reserve, the majority of which has a soil capability of Class 4 or better. The Township’s agricultural industry is the province’s third most productive rural economy behind Matsqui and Chilliwack with a 1986 economic value of $89.8 million. 22 percent of all farms in the Vancouver Region are found in Langley, and are dominated by livestock and poultry farms, fruit and vegetable production, turf farms and nurseries. In addition to the traditional agricultural industries, the horse industry has increased dramatically. Its annual economic impact is estimated to be $40 million resulting in 320 direct full time jobs and 330 full and part time support jobs. (Langley, 1991)

Langley’s rural character also stems from its network of country roads which follow the undulating terrain, pass by open fields, under forest canopies and along the Fraser River. With the exception of a half dozen main arterials, and the TransCanada and Fraser Highways the Township’s roads are narrow and generally free of shoulders and sidewalks giving them a distinct rural flavour.
The Township is also blessed with a rich cultural history. For centuries aboriginal communities located along the Fraser River near present day Fort Langley and took advantage of the abundant salmon and wildlife. A traditional foot trail connected the northern edge of the Township with Boundary Bay along the Nicomekl and Salmon Rivers allowing the aboriginal peoples more opportunities to trade and hunt. More recently Fort Langley and the farming community of Milner mark two of the earliest white settlements in British Columbia and continue today to serve as important legacies in the development of the Lower Mainland. Milner was home to the Hudson Bay Company Farm in middle 1800's and the Fort was an earlier trading and military encampment and at one time served as the provincial capitol.

Presently the Township of Langley is home to approximately 70,000 people with most of the urbanization occurring along the Township’s west border with the City of Surrey. Its average annual population increase is 4.3 percent. In the middle of the Township’s urban corridor lies the City of Langley, which occupies approximately 10 square kilometres and has a population of 20,000 people. The City is the dominant urban presence in the area and is targeted by the Greater Vancouver Regional District as a regional town centre. (GVRD 1990) This means that the GVRD and local municipalities will try to focus development into the area.
**Growth Problems**

Collectively the Township and City are experiencing rapid population growth. Between 1986 and 1991 the Township of Langley was the third fastest growing municipality in the Greater Vancouver Regional District. By 2006 the Township’s population is expected to increase by 50,000 people to 121,000 people. (Langley, 1994) Combined with the City’s projected population, in excess of 200,000 are expected to be living in the Township and City of Langley by 2021. (GVRD, 1991)

With the Township containing some of the largest undeveloped lands in the Greater Vancouver Region urban growth, which is beginning to create serious problems, will only become more pronounced in the coming decade. These problems are diverse and include both environmental and landscape character concerns. Among the environmental issues are:

- Storm water runoff from urban areas and agricultural fields, and leachates from septic fields are creating significant nitrification problems for the Township’s sensitive aquifers, jeopardising Township drinking water.
- Continued fragmentation of forest cover by indiscriminate development is leading to a loss in biological connectivity.
- Indiscriminate wastewater and solidwaste disposal is undermining local ecological integrity
- Development along creeks and streams is resulting in lost forest cover, reduced buffers and a potential loss in vital fish habitat.
- Development on steep slopes subject is increasing the erosion of sensitive soils.
- The conversion of traditional agricultural land into hobby farms is reducing agricultural capacity.

**Langley Tomorrow**

Of equal concern is the loss of Langley’s predominantly rural character. In 1990 the “Langley Tomorrow Program” attempted to identify the community’s values towards the Township and the characteristics residents felt should be protected amidst the forces of change. The principal concerns of the community included: (Langley, 1991)
• The development process should protect the quality of groundwater, streams and rivers;
• Environmentally sensitive areas should be designated and protected through restrictive zoning or purchase;
• Development should be concentrated in the existing communities leaving green, rural spaces between the developed areas to maintain the rural character;
• Mountain views and rural landscapes should be preserved even if it is at the cost of potential development; and
• Unique, narrow and winding country roads should be kept as they help preserve the rural character of the Township.

• Rural Plan

To clarify how these values, particularly those concerning rural character, could be protected the Township initiated the “Rural Plan” in 1990. The plan’s goal was to determine ways of:

“Retaining and/or enhancing the rural character of those areas of the Township designated Rural Residential/ Agricultural in the Official Community Plan. Retention of rural character consists of maintaining the economy, lifestyles, landscape and environmental features associated with rural Langley.” (Langley, 1991)

The result was a plan which addressed land use policies, economic development, recreational opportunities, heritage and landscape protection, transportation and servicing as well as the establishment of special development areas. The “Rural Plan” resulted in a revised “Land Use Plan” which better reflected the current development patterns and concerns than the existing plan.

• Environmentally Sensitive Area Study

A particular noteworthy feature of the Rural Plan’s policies was the desire to “protect the natural environment of the rural area and provide general direction on waste management issues in the rural area.” (Langley, 1991, p. 9) Included in this section was a call for the creation of an inventory to identify environmentally sensitive areas which 95 percent of the residents polled strongly or somewhat strongly agreed should be designated and protected. Consequently, in 1993 the Township initiated “An Evaluation of Environmentally Sensitive Areas (ESA) in the Township of Langley” to inventory those lands which, due to their environmental sensitivity, need to be protected, conserved and selectively managed.
The ESA study established criteria based on abiotic, biotic and cultural features and processes, and analysed data gathered on biophysical and cultural characteristics throughout the Township. The result was that the Township was subdivided into 100 distinct environmentally sensitive units. The units were then placed into one of the following three categories:

- **ESA 1** - Management Areas with the greatest number of ecologically significant features and processes
- **ESA 2** - Management Areas with several important ecological features and processes;
- **ESA 3** - Management Areas with at least one important ecological feature.

The three categories provide a general characterisation of relative sensitivity. According to the Study approximately:

"16,500 ha (45%) of the study area were classified as falling into ESA designation 1, while 2230 ha (6%) were designated as ESA designation 2. About 17,500 ha (47%) of the study area is within the ESA 3 designation. Only about 110 ha of the Townsite, in the NW industrial area, was not given an ESA designation.” (Westwater 1993, p.i)
Since the ESA is the newest of the Townships’s data gathering studies it has yet to be effectively incorporated into the planning and policy action. The authors of the study have recommended the ESA’s management objectives and recommendations be incorporated into the Official Community Plan. The Township is currently exploring ways of incorporating the ESA’s recommendations into the planning and development process. Nonetheless the information gathered is extremely valuable in understanding Langley’s ecological mosaic.

All three of these studies, Langley Tomorrow, Rural Plan and the Environmentally Sensitive Areas Study provide vital information on the expectations of the community and the capability of the land. The data clearly indicates that residents are concerned that the rural landscape cherish is being displaced by urban expansion. These studies reflect the basic questions that must be asked to address these current and future issues. And as a result of the information provided by these studies this thesis has been able to explore an alternative design approach that attempts to protect the Townships’s ecological integrity, its rural character and hopefully provide for a more sustainable future.

4.3 The Study Area - Description & Analysis

• Introduction

Jericho Hill Village is a 140 hectare community on upland terrain in Langley’s Willowbrook district and serves as the specific study area for this thesis. Willowbrook sits along Langley’s western border with Surrey, immediately north of the City of Langley and 1.5 kilometres south of the TransCanada Highway. Its somewhat irregular boundaries are defined by the area serviced by a gravity sewer system which links up to a Greater Vancouver Sewerage and Drainage District pumping station located at 62nd Avenue and 203rd Street. (Langley, 1991) The Official Community Plan has designated Willowbrook as an area for urban and industrial growth. When considered in tandem with the Willoughby district, immediately north of Willowbrook, collectively these lands are among the largest undeveloped lands in the Greater Vancouver Regional District

The majority of Willowbrook’s 615 hectares is located on upland terrain which provides the backdrop for the historic farming community of Milner, the Nicomekl River floodplain and the
Figure 7 - Willowbrook Structural Context Map
City of Langley. The upland section is predominantly rural residential although recent incursions of single family houses in typical suburban subdivisions portend Willowbrook's likely future if development patterns continue unchallenged.

A lowland section, abutting the City of Langley, is developing into a large commercial, office and business park district. It is also home to the Willowbrook Shopping Centre, a regional shopping centre at Fraser Highway and 200 Street. This is consistent with development in the City of Langley and a portion of the City of Surrey adjacent to Willowbrook. An established subdivision is located at 66th Avenue and 200 Street and a few rural residences remain to the north of 64th Avenue and east of 200th Street.

Site Analysis
Willowbrook possesses numerous features and opportunities which are relevant to the design of an ecologically based community. The following section lists these features and the general design responses they elicit.

ESA Designation
Willowbrook carries a designation of 3 in the Environmentally Sensitive Areas Study (ESA), indicating it is among the least environmentally sensitive areas in the Township. This is due to the relative absence of sensitive ecological features. Unlike many of the Township’s urban areas which lie above sensitive aquifers no aquifers underlie Willowbrook. The few environmentally sensitive features which do exist are generally small and tend to occur at the periphery. Nonetheless certain environmental concerns were identified as important to protect:

- Moderately steep eastern and southern slopes prone to severe or very severe erosion.
- Ephemeral streams which feed into the Nicomekl, Latimer and Yorkson Creeks
- Forest cover connecting the headwaters of the Yorkson and Latimer Creeks and Nicomekl River.

Design Response
- The proposed community should be located away from the sensitive slopes to minimize soil erosion and slope instability.
• Ephemeral streams and their riparian vegetation should be protected and enhanced. These stream corridors could become part of a reorganized open space system which Willowbrook currently lacks.

• The vegetative connections between the head waters of Latimer Creek and Yorkson Creek and Nicomekl River tributaries are currently fragmented. The proposed design should enhance these connections by re-establishing forest corridors.

Topography
Willowbrook is divided into a dominant upland section and a lower flatlands section by the erosion prone slopes identified in the ESA Study. The steeper slopes are between 5 and 15 percent with the majority of land varying from between 1 and 3 percent. Most of the upland terrain slopes gently to the south and southwest giving it an almost ideal solar orientation. A high point near the centre of the upland section marks one of the highest points of elevation in the Township. This hill is referred to as Jericho Hill and sits approximately 80 meters above the Nicomekl floodplain, offering panoramic views over Milner to the southeast and the Cascade Mountain range.

The forested eastern slopes are important visual resources in defining the landscape context for the historic Milner farming community and the City of Langley. Unfortunately new house construction is encroaching upon these slopes as developers and residents search for prized and marketable views. Not only are these patterns jeopardising the integrity of these sensitive slopes but they are beginning to alter the historically significant landscape character of Milner.

Design Response
• The design should take advantage of the site’s southern exposure to maximize solar gain.

• The design should minimize encroachment onto the eastern and southern slopes to protect the landscape context defined by these slopes.

Hydrology and Drainage Patterns
Willowbrook contains of four small drainage basins which feed the Nicomekl River and Latimer and Yorkson Creeks. The main ridgeline runs roughly northeast to southwest. A secondary ridge runs from east to west from Jericho Hill towards 200 Street. As noted in the ESA these streams require protection to maintain water quality and seasonal stream flows, and protect wildlife habitat.
These natural drainage patterns are being displaced by suburban drainage strategies associated with the influx of subdivisions and single family houses. This channeling of runoff and increases in impermeable surfaces are altering local drainage characteristics and the plant communities they support. It is possible that in the near future these changes will be severe enough to irrevocable eliminate water flows to the ephemeral streams, and therefore eliminate the streams themselves.

**Design Response**

- The proposed design should employ a surface based drainage strategy, including recharge beds to maintain natural drainage patterns and their dependent plant communities.

- Surface runoff must be filtered using biofiltration beds and oil interceptors to ensure surface runoff contains no noxious elements typically associated with urban stormwater runoff.

- Grey water storage systems and planted roofs should be incorporated into all development to maintain existing peak period runoff characteristics.

**Soils and Geology**

Willowbrook's surficial geology consists of fine textured marine and glacial marine material with moderate subsurface drainage characteristics. These materials are generally stable with the exception of the erosion and earthquake prone eastern and southern slopes identified in the ESA. In terms of the community’s soils the Province of British Columbia’s “Land Capability for Agriculture Langley - Vancouver Map Area - 1985” indicates unimproved class 2, 3 and 4 agricultural soils dominate with no significant areas of class 1 soils. Many of these soils have the potential to be improved by one or two classes, depending upon their existing limitations which generally relate to an excessive amount of water. However, improving a class 4 to a class 2 or 3 for use in more intensive agricultural may actually compromise the role these soils play in the local hydrologic cycle. By retaining water these soils currently moderate storm runoff and reduce peak loading of local creeks and ephemeral streams. Improving their drainage may jeopardise the ecological health of these ephemeral streams.

**Design Response**

- Development should not occur on the geologically sensitive eastern and southern slopes.

- The concept should take advantage of existing unimproved class 2 soils to promote local
agricultural use.

- Class 3 and 4 soils should be disturbed as little as possible as they are important to the local hydrologic cycle.

Vegetation
The presence of vegetation is a prime determinant in creating the Township’s rural character, particularly when it occurs on upland slopes. Unfortunately Willowbrook’s natural vegetation is being displaced by an ever increasing collection of ornamental plants associated with the encroaching suburban development. The fragmentation of the natural forest cover has left only a few, isolated patches of second growth and seral stage forests. The remnant forests are comprised of a mix of deciduous trees with the predominant species being Big Leaf Maple (Acer macrophyllum), Red Alder (Alnus rubra), Poplar (Populus trichocarpa), Birch (Betula papyrifera), and coniferous trees such as Western Red Cedar (Thuja plicata), Douglas Fir (Psuedotsuga menziesii) and Western Hemlock (Tsuga heterophylla).

The most significant remnant forests occur at Tara Farms along the community’s eastern boundary and around the headwaters of the Nicomekl, Yorkson and Latimer tributaries. The loss of forest cover along the eastern slopes and the main ridge line which traverses the community is particularly worrisome as these forests play an essential visual role in defining the Milner agricultural area.

Design Response
- The design concept should include strategies which protect ecologically critical stands of existing forest.
- The concept should seek to re-establish forest cover which is vital as an ecological link to important biophysical features such as drainage patterns and geologically sensitive slopes.
- Wherever possible the concept should use new plantings to protect and enhance the Township’s rural character and historic landscape features.

Existing Infrastructure
Most of Willowbrook’s circulation occurs along small scale country roads. The exception is 200 Street, a divided four lane arterial running north/south through the western half of Willowbrook, linking the City and the TransCanada Highway. 72nd Avenue is a major, east/west local road
connecting 200 Street and the City of Surrey in the west with Milner and Glover Road in the east. As it descends the community's eastern slope towards Milner, it provides panoramic views of Mount Baker and the North Cascade Mountain range to the southeast.

68th Avenue and the southern portions of 202B, 204, 206, 208 and 210 Streets have been constructed on the geologically sensitive slopes identified in the ESA as an environmentally sensitive area. A quick site review found no evidence of slope instability nor erosion. However, experience with roads built on top of sensitive slopes elsewhere suggests this remains a distinct possibility, if not an inevitability, particularly if traffic volumes increase in response to increased development.

Current water supplies come from the Jericho Hill reservoir near 73A Avenue and 204 Streets which is supplied from wells located above the Fort Langley Aquifer, approximately 3 kilometres northeast of Willowbrook. Currently, sewage is disposed of in septic fields with the exception of the industrial and commercial areas which are serviced by sanitary sewers connected to the Greater Vancouver Sewerage and Drainage District system, yet neither service is adequate for the growth expected over the next decade. Considerable upgrading will be required.

While these development costs are generally borne by the developer they ultimately are borne by the residents who move into the communities. Complicating the development of these systems is that they tie into the GVRD infrastructure which is already close to capacity, and in the case of sewage disposal below the environmental levels mandated by the federal and provincial governments.

**Design Response**

- The construction of new roads should be minimised
- Where possible existing roads should be removed, particularly those above geologically sensitive lands
- The concept should offer local solutions to supplying the community’s water and handling its waste
Existing Land Use/Zoning

The Willowbrook Community Plan, adopted by Council in 1979 and amended most recently in 1991, establishes the detailed land use policies, designations and direction for the Willowbrook Community within the framework of the Township’s Official Community Plan. The plan calls for the development of two distinct areas within the Community, upland residential and lowland commercial/industrial/office space.

Figure 8 - Willowbrook Community Land Use Plan

The plan’s primary goal is to develop Willowbrook, “as part of the Langley regional town centre, which also includes the downtown area of the City of Langley and a portion of the City of Surrey along the Fraser Highway and Highway 10 adjacent to Langley. Retail and service commercial activities are encouraged to locate in the southern part of the plan area to concentrate commercial activity and contribute to the development of a regional centre. To reinforce this area as a regional centre, further industrial, business and office development is also encouraged in the area east of 200 Street.” (Langley, 1991, p.6)
TABLE 3: Willowbrook Community Land Use Designations

<table>
<thead>
<tr>
<th>Housing Type</th>
<th>Type of Dwelling</th>
<th>Min. Lot Area/Max. Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suburban Residential</td>
<td>Single Family</td>
<td>1,765 m² (4.44 acre)</td>
</tr>
<tr>
<td>Single Family</td>
<td>Single Family</td>
<td>650 m² (7,000 sq. ft.)</td>
</tr>
<tr>
<td>Residential Density Bonus</td>
<td>Townhouses, Seniors</td>
<td>30 dwelling units/ha</td>
</tr>
<tr>
<td></td>
<td>Housing, Rest Homes</td>
<td></td>
</tr>
<tr>
<td>Multi-Family One</td>
<td>Townhouses, Apartments</td>
<td>44 dwelling units/ha</td>
</tr>
<tr>
<td></td>
<td>Seniors Housing, Rest Homes</td>
<td></td>
</tr>
<tr>
<td>Multi-Family Two</td>
<td>Townhouses, Apartments</td>
<td>74 dwelling units/ha</td>
</tr>
<tr>
<td></td>
<td>Seniors Housing, Rest Homes</td>
<td></td>
</tr>
</tbody>
</table>

- Regional Commercial
- Neighbourhood Commercial
- Business/Office Park
- Industrial/Business Park
- Institutional
- Neighbourhood Park
- Community Park
- Conservation Area

Also included are strategies for upgrading the community's infrastructure. The plan provides for new roads, upgraded water lines, sanitary sewer lines, and revised storm water drainage systems. Additionally, there are four development permit areas, primarily along 200 Street and adjacent to the City of Langley. The plan provides for a population of 15,000 people when fully realized.

Analysis

From the perspective of ecological design the Willowbrook Community Plan fails to address many basic ecological design issues. These are directly related to the current land use concept which provides for a highly segregated plan dominated by single family housing on upland terrain and commercial, industrial and office development on lowland terrain. The problems, however, are not just ecological in scale. The decisions embodied in the Willowbrook Community Plan could have a profoundly negative impact on the landscape character of the Township. More specifically the likely issues include:

Increased Automobile Dependence

This is assured due to segregated land uses, a road network intent on efficiently moving automobiles rather than pedestrians or cyclists, and densities which are too low to adequately
support an efficient public transit system.

**Increased Atmospheric Pollution**
Due in large part to the increased automobile traffic, emissions of carbon dioxide, nitrous oxide and sulphur dioxide emissions will increase and add to an ever growing atmospheric problem in the Greater Vancouver Region.

**Polluted Water Systems**
Storm water runoff laced with oil and gas residues is an inevitable consequence of an automobile dependent community unless a system of biofiltration ponds and drainage corridors are incorporated into the overall drainage plan. The stormwater plan for Willowbrook does not include any significant remedial treatment for surface runoff to reduce the impact of these pollutants on local water systems.

**Natural Drainage Patterns Altered**
The spread of single family houses and roads increase the amount of impermeable surfaces, reconfigure topographical features and alter surface and subsurface drainage patterns. These changes in runoff characteristics in turn effect the local plant and animal communities dependent on the water courses and forest cover.

**Fragmented Forest Cover**
The already scarce forest cover will likely experience further fragmentation and displacement by increased single family housing and its related ornamental planting. This loss of biological connectivity reduces wildlife habitat and biodiversity, two critically important features of a sustainable landscape. (Forman, 1990)

**Roads on Sensitive Slopes**
New arterial and collectors roads are planned along geologically sensitive southern and eastern slopes identified in the Environmentally Sensitive Area Study, increasing the chances for slope instability and slumping.
Imported Energy
Despite a prime southern exposure the Willowbrook Community Plan does not include any direction or provision for exploiting passive and active solar design thereby reducing the amount of energy which must be imported to heat and electrify the homes. The plan also requires considerable amounts of energy be spent on transportation to access the various segregated land uses.

Imported Water
The plan presumes that external water supplies are the answer for meeting anticipated water demands. It offers no direction regarding water conservation such as grey water systems, metered water use and low water usage plumbing fixtures. Unfortunately water supplies in the Greater Vancouver Regional District are close to capacity. If communities such as Willowbrook continue to develop without developing some level of water self-sufficiency and conservation more large scale ecological damage related to the construction of higher and more frequent dams will occur. The current vision for Willowbrook offers no water conserving incentives or direction.

Exported Waste
As was the case with water supplies, the Willowbrook plan relies upon the Greater Vancouver Regional District to handle its wastes exports. However not only is the GVRD’s current infrastructure close to capacity but it operates in contravention of the effluent quality limits established by the federal and provincial environmental ministries. To upgrade existing facilities will require significant capital expenditures which translates into additional costs for the community. From the perspective of ecological design, waste is considered a resource, not an inevitable consequence of human activity. It should be recycled within the community, not exported out. The current plan does not provide for this.

Fragmented Open Space
Less than 10 percent of the Willowbrook plan is intended as recreation open space and conservation. This includes those areas immediately adjacent to existing watercourses, which are to be protected and the requisite community park and local neighbourhood parks. Unfortunately, few if any connections between these spaces exist. What could give structure to the community’s physical form and provide a series of greenways throughout the community currently exists in
Relative Isolation.

**Eroded Community Identity**

The landscape character values identified in the Langley Tomorrow Study and the Rural Plan can be directly related to the Willowbrook plan. The rural character and identity will be compromised by the current Community Plan. Extensive development and the proposal to upgraded certain roads to conventionally engineered dimensions will impact the landscape character of historic Milner and blur the distinction between the limits of the city of Langley and the rural Township. If development trends continue, 200 Street from the city of Langley north to Willowbrook will become one long strip development with all the anonymous qualities associated with strip developments.

**4.4 Summary Of Jericho Hill Study Site**

The 140 hectare Jericho Hill Village Site sits in the middle of Willowbrook’s upland terrain. Jericho Hill sets the topographical foundation for the upland terrain and reaches its high point at the northeast quadrant of the site. The study site is bounded on the west by 200 Street, to the north by 74B Avenue, to the east by 208 Street and to the south by the 75 meter contour line. 72nd Avenue runs through the middle of the site. Current land use is predominantly rural residential on minimum 0.4 hectare lots. Single family houses on smaller 650 m² lots between 202 and 208 Streets south of 72nd Avenues are being developed.

Jericho Hill was deemed the most appropriate site within Willowbrook for the following reasons:

**Solar Exposure**

With 1 to 4 percent slopes to the south and west Jericho hill posses the best site for solar community design within Willowbrook.

**Protection of Ephemeral Streams**

The site is far removed from Willowbrook’s ephemeral streams.
Removed from Geologically Sensitive Slopes

The site does not encroach upon the geologically sensitive soils.

Re-establing Forest Connectivity

The site sits strategically positioned between the remnant forests of Latimer and Yorkson Creeks, Tara Farms and the Nicomekl tributaries. It has the capacity to reconnect these ecologically important features.

Strengthened Community Identity

As one of the high points in the community, Jericho Hill can provide residents of Willowbrook with distant views of the region. And by restricting development to a more compact footprint, adjacent land can be returned to the forest and agricultural uses which define Langley’s character.

Proximity to the City of Langley

Jericho Hill sits within 1.5 kilometres of the City of Langley and its developing regional town centre presence. This close proximity could persuade certain businesses that would otherwise locate within the City to locate in Jericho Hill, within an integrated community. This relationship would also allow a densely populated community to be served by a frequent public transit system, thereby reducing dependence on automobiles.
5.0 CONCEPT PLAN
5.1 Goals

Jericho Hill Village is a mixed use, pedestrian oriented community which begins to demonstrate some of the spatial implications of applying ecological design to a suburban community. The plan responds to site specific environmental concerns as well as the identity issues identified by residents of Langley which were discussed in Chapter 4. The village plan also embodies many of the ecological principles and parameters discussed in Chapters 2 and 3. In general the village plan provides housing, employment opportunities and services for approximately 5,500 people on 140 hectares of rural residential land currently zoned for urban growth. This is a similar number of people to those projections made by the Township for the area of Willowbrook north of 64th Avenue and east of 200th Street. However, the actual village footprint requires approximately 20 percent of the land required for the Township’s plan, 56 hectares versus 300 hectares.

The village plan is organized around the following goals:

- The plan should be able to internally supply 80 percent of its heat energy, 75 percent of its electrical energy and 50 percent of its food.

- The plan should result in a 50 percent reduction in transportation energy, 100 percent conversion all of its domestic waste and a 60 percent reduction in water consumption.

- Develop a strong sense of community identity by designing distinct neighbourhoods, providing for a clearly defining the public and private realm, providing a range of housing options and incorporating community facilities throughout the Village.

5.2 Program

Before the design enquiry could begin a program which could establish the specific land use parameters was needed. After reviewing the Township’s land use plan for Willowbrook, as well as various programmes for mixed use communities, it was decided that the Pedestrian Pocket program developed by Peter Calthorpe and Douglas Kelbaugh (Kelbaugh, 1989) would be used. The pocket transfers well to the Willowbrook context for a number of reasons:

- It accommodates 5,000 to 6,000 people which is consistent with the number of people the Township has projected will live in the area east of 200 Street and north of 68 Avenue.
• The pocket attempts to reduce the heavy burden of commuting by providing a balanced mix of housing, jobs, and services within the community. This allows the community to develop its own economic base and reduce the need to travel to distant services and jobs.

• Willowbrook’s close proximity to the regional town centre emerging in the City of Langley is consistent with the desire to associate the pocket with a larger urban hub. In developing the program for the pocket, Calthorpe and Kelbaugh recognized that not all the amenities available in a larger urban area could be duplicated within the pocket. Therefore the pocket needed a strong association with an urban area. An association which could be serviced efficiently with mass transit. These conditions exist in Willowbrook and specifically in Jericho Hill.

Jericho Hill Village covers 140 hectares with a projected population of 5,500 people. Approximately 60 percent (84 ha) of the area is used in reforestation in an effort to restore the areas fragmented ecological systems. The remaining 40 percent (56 ha) accommodates the following uses;

<table>
<thead>
<tr>
<th>TABLE 4: Jericho Hill Village Land Use Program</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RESIDENTIAL</strong></td>
</tr>
<tr>
<td>Jericho Hill North</td>
</tr>
<tr>
<td>Jericho Hill South</td>
</tr>
<tr>
<td>Jericho Hill East</td>
</tr>
<tr>
<td><strong>COMMERCIAL</strong></td>
</tr>
<tr>
<td><strong>BACK OFFICE/SERVICE</strong></td>
</tr>
<tr>
<td><strong>CIVIC FACILITIES</strong></td>
</tr>
<tr>
<td>Auditorium/Meeting Hall</td>
</tr>
<tr>
<td>Community School</td>
</tr>
<tr>
<td>Recreation Centre</td>
</tr>
<tr>
<td>Fire Hall/ Medical Clinic/Post Office/Churches</td>
</tr>
<tr>
<td>and Library</td>
</tr>
<tr>
<td>Day care</td>
</tr>
<tr>
<td><strong>OPEN SPACE</strong></td>
</tr>
<tr>
<td>Baseball Diamonds</td>
</tr>
<tr>
<td>Soccer fields - full size</td>
</tr>
<tr>
<td>Tennis Courts</td>
</tr>
<tr>
<td>Hard Surfaced Courts</td>
</tr>
<tr>
<td>Community Gardens/Allotment Gardens</td>
</tr>
</tbody>
</table>
This program is an adaptation of the Pedestrian Pocket Program (appendix --) in response to Willowbrook’s close relationship to the City of Langley. The first change involved eliminating the light rail transit station and replacing it with a transit station incorporated into one of the buildings adjacent to the village commons transit hub. The transit service is proposed to be dedicated bus links to the city of Langley and the King George Advanced Light Rail Transit stop in Surrey.

Second was the reduction of “Back Office” office space by 20,000 m². The expectation is that the city of Langley will continue to develop as a regional town centre and will be in direct competition for the same back office functions slowly relocating out of the traditional urban cores.

Another revision involved the housing component of the pedestrian pocket. Single family housing was eliminated as it was deemed inappropriate for an ecologically sustainable community. On a square meter basis single family houses are the least energy efficient and the most land intensive forms of housing. Furthermore they cannot provide the densities necessary to support an efficient transit service. Finally with demographic shifts away from the nuclear family the single family home cannot adapt to issues of adaptability and affordability.

The remaining housing was reprogrammed. Currently the Pedestrian Pocket provides for 1,000 units of residential housing varying from single family detached homes to townhouses and duplexes to apartments. In Jericho Hill since all the housing is attached multistory units with an average module size of 100 m². In most cases this is the minimum unit size although some units will be as small as 75 m². Modules or portion of modules can be added either vertically, with a stairway connection, or horizontally, by adjusting non-load bearing walls, depending upon the needs of the individual or family.

The program was not emphatically applied during the design process. On numerous occasions it was necessary revisit the program depending on what was learned during a particular phase of design. In certain instances the program was changed to test how it might effect the community’s character and its ecological impact. Consequently the program serves more as a general guide of land use but not a fully detailed one.
5.3 Organizing Structure

Jericho Hill Village is seen conceptually as a "fabricated" landscape sitting in balance between the "domesticated" and "natural" landscapes. The principal civic spine of the village meeting hall, library, main religious institution, school, commercial and transit hub sits enclosed by the productive 'sustainable' landscape of the community's main agricultural, and wastewater recovery presence to the west, and the 'natural' successional landscape spine traversing the top of Jericho Hill to the east.

More specifically this structure is the result of six main planning features. Some are ecological in scope while others are civic minded but collectively they balance the community's ecological mandate with its need to provide a strong sense of place. The features are mutually supportive. For example, to protect and enhance natural drainage patterns and forest connectivity the footprint of the community must be kept compact. To accomplish this requires clusters of multiple story housing blocks. Simultaneously, in order that these moderately dense housing blocks are palatable to people with housing traditions rooted in the single family home there must be immediate access to an open space system. Consequently achieving ecological goals while enhancing livability becomes a mutually supportive goal.
Maximize Solar Energy

Virtually all of Jericho Hill's housing units are laid out to maximize solar gain. North of 72nd Avenue, where the terrain slopes gently from east to west, the majority of houses are oriented with the long axis running east to west and the main facade oriented to within 20 degrees of due south. Building separation from north to south averages 25 meters to preserve each buildings access to solar energy in the winter when the sun's azimuth is low while maintaining a desirable level of enclosure. A few buildings are as close as 12 meters while others are as far apart as 50 meters. This variation in building setback is an attempt to overcome some of the limitations of using solar access as an organizational criterion which, if applied exclusively, could result in a regimented site plan of buildings spaced equal distances apart, absent of the design necessary to develop a sense of place.

In the two neighbourhoods south of 72nd Avenue the terrain requires the housing blocks be broken up and staggered. This minimises topographical disturbance while allowing the majority of the buildings to maintain a dominant facade oriented to within 20 degrees of due south.

• Protect Local Water Systems

Respecting the existing drainage patterns is another major force in structuring community form. The community is partitioned into three distinct drainage basins corresponding to the existing watersheds. The northern housing is oriented to allow surface drainage to feed toward the northeast and the headwaters of Latimer Creek. The southwest neighbourhood feeds one tributary
of the Nicomekl while the southeast neighbourhood feeds another. Each neighbourhood is organized so that its surface runoff feeds into a dominant open space where biofiltration and solar aquatic facilities can purify the runoff. Surface runoff and the dominant open spaces ensure that the hydrologic cycle remains visible within the community.

- **Enhance Forest Connectivity**

The village’s compact footprint allows for a major reforestation effort to reconnect the remnant forests of Tara Farm, Latimer and Yorkson Creeks and the tributaries of the Nicomekl. In total approximately 60 percent of the Jericho Hill site is given over to reforestation. Successional forests
encircle the community at its western, southern and eastern peripheries. The forest also traverses Jericho Hill’s main ridgeline, bisecting the two southern communities. This provides a forested connection between the remnant forests along the geologically sensitive southern slopes, over top of Jericho Hill and ultimately connecting up with the headwaters of Yorkson Creek.

- **Preserving Jericho Hill**
  Development is kept off Jericho Hill, its main north/south ridgeline and much of its eastern slope. This ensures a forested hillside continues to provide the background setting for historic Milner, thereby preserving the rural character.

![Figure 13 - The Five Minute Rule](image)

- **The 5-Minute Rule**
  The Jericho Hill Village is organised to allow most residents to live within a 5 minute walk of stores, offices and transit service. The five minute rule (Calthorpe 1993, Krieger 1991, Kelbaugh 1989) appears to be an average time people are willing to spend walking to some destination. Beyond 5 to 10 minutes people generally chose to drive. The five minute rule translates into a catchment area 1000 meters across. Therefore virtually all housing and services in Jericho Hill are contained within a 500 meter radius emanating from the town hall.
5.4 Design Elements

While these six features are principally responsible for Jericho Hill’s structure other important elements are incorporated into the plan giving it the next level of detail necessary to accomplish its goals.

- Energy Flows

As outlined in the introduction to this chapter the energy goals are to minimize transportation energy by 50 percent, heat energy by 80 percent and electrical energy by 75 percent. The transportation savings are derived simply by providing a form of community which is no longer dependent on the automobile. Shops and services are located in both the village centre and the
individual neighbourhoods to provide choices, flexibility and immediate access. By balancing live/work opportunities more of the communities residents will have the option of living and working in the same community. Combined with a strong transit system these measures can reduce commuting by a minimum of 50 percent. (Calthorpe, 1993; Kelbaugh, 1989)

The heat and electrical savings result from passive and active solar architectural strategies discussed in Chapter 3. Long buildings, rarely exceeding 12 meters in width and forming interior courtyards help maximize natural daylighting to every room, thereby reducing the need for artificial light. Further measures such as efficient building envelopes including spectrally selective “superwindows”, efficient electrical and mechanical systems and appliances, and roof mounted photovoltaic panels further reduce the amount of imported electrical energy by 75%. (Lovins, 1993)

Heat savings come from maximizing solar gain and southern exposure, as well as providing for appropriate building envelopes and thermal massing. Additional strategies such as ground source heating allow buildings with an excess heat gain, likely the larger mixed office and residential buildings, to supplement the heat energy requirements of less efficient buildings such as those along a north-south access. In essence the buildings of Jericho Hill become networked and any excess heat gain is pooled for redistribution within the village. Given these measures a heat savings of 80 percent over conventional suburban communities is not unrealistic. (Lovins, 1993; Van der Ryn and Calthorpe, 1986)

• Water

One of the goals of the Jericho Hill Village plan is to realize a minimum 60 percent savings in water consumption compared to a conventional suburban community. Approximately 40 percent can be expected from installing water efficient plumbing fixtures, metering water use and xeriscape landscaping. (Vale, 1991. Further significant savings could come with the installation of compost toilets if they were more universally accepted. However, in Jericho Hill the extra 20 percent plus of savings comes from grey water systems employed in each housing block.
General surface runoff and that collected from roofs provides the majority of the grey water supply. Roofs cover approximately 110,000 m² of Jericho Hill, and with an annual precipitation rate of approximately 1,500 millimetres, have the potential to collect 16,500,000 litres of water each year (1.5m x 110,000m² = 165,000 m³ of rainwater or 16,500,000 litres).

After losses of 20 percent due to evaporation and plant uptake on sodded roofs this figure is closer to 13,000,000 litres per annum. In a community of 5,500 where the daily water usage, even accounting for water conservation measures, is still likely to be approximately 200 litres, (Duancey, 1992) the annual water demand is 401,500,000 litres. While the amount collected from roofs can account for only 3 percent of this annual demand it is 10 times greater than daily demand. Therefore the intent of the grey water system, combined with the solar aquatic facilities, is to maintain a semi-closed loop for nonpotable water supplies.
If designed correctly this system, once the reservoirs are to capacity could operate in balance with demand and meet virtually all the communities nonpotable water needs with only the occasional replenishment required from surface runoff feeding into the grey water system to make up for losses to evaporation, ground water recharge and release out of the system. The net lose to the local drainage system would initially be approximately 7.5 percent until the system is operating and then virtually zero there after. A successional forest recharge zone at the northwest corner of the village provides an outlet for the release of surplus water from the village’s main water reservoir to Latimer Creek.

Other features concerning the flow of water include;

• Ground water recharge catch basins in the streets. These operate similar to septic fields and include oil interceptors to separate oil and gas residues from runoff.

• Surface runoff into drainage swales and biofiltration beds where recharge can occur.

• Buildings and roads account for approximately 30 percent of Jericho Hills developed area and approximately 12 percent of the Village's total 140 hectares. This compares with the city of Vancouver where in excess of 25 percent of its land base is consumed by roads alone. (City of Vancouver, 1992)

• Green roofs are incorporated into all buildings to slow peak runoff, and provide the first biofiltration stage

• Waste Flows
All of Jericho Hill’s wastewater is recycled within the village in solar aquatic greenhouses located at each neighbourhood’s lowest point of elevation and within certain housing developments. In Jericho Hill North the greenhouses are located adjacent to the community’s main grey water reservoir where treated wastewater is stored along with surface runoff for reuse within the community or release to Latimer Creek. Terraced reed beds provide the final stage of filtration prior to the wastewater and surface runoff entering the reservoir. Adjacent to the greenhouses are
community orchards which are irrigated with the treated water. Compost is transferred to the community farm, community gardens, and courtyard allotment gardens. The 750m² greenhouses are sized to handle approximately 60 percent of the waste water generated in Jericho Hill North. The other 40 percent is treated in smaller solar aquatic facilities in the certain housing courtyards. If space were readily available courtyard based treatment would be preferable. However some courtyards would likely be too shaded in the winter to work to capacity therefore these larger treatment facilities are provided.

Figure 17 - Solar Aquatics in Jericho Hill North

In Jericho Hill South and East solar aquatic greenhouses are located at the lowest elevation points in each neighbourhood. These facilities treat the majority of neighbourhood wastewater although smaller facilities are located within certain housing blocks where space permits. The two main facilities are designed to service approximately 60 percent of each neighbourhood’s wastewater.
Where possible solid waste and composting facilities are located at various points within the community, generally associated with community gardens. This allows compostable material to be recycled within the village. Liquid waste can be sprayed on the successional forests to help it become established.

**Food**
Jericho Hill incorporates numerous agricultural operations. The community farm immediately south of 72 Avenue is the largest operation at approximately 6.5 hectares. Its location corresponds with the best class 2 soil in the Jericho Hill study area. Approximately 3 hectares of orchards are scattered throughout the community, with the highest concentrations around the solar aquatic facilities in Jericho Hill North. Five community gardens account for 1 hectare of land. Allotment gardens within the housing blocks account for a minimum of 2 hectares bringing the total agricultural presence to 12.5 hectares.
Using intensive agricultural techniques such as permaculture, 12.5 hectares of land can be expected to produce vegetables and fruit for 3100 people based on a per person allowance of 40m². (Walter, 1992; Wade, 1990; Jeavons, 1982) This represents 56 percent of Jericho Hill’s population. The larger agricultural facilities and those not tended by residents would be managed professionally by full time employees.

**Vegetation**

Jericho Hill’s vegetation strategies are to enhance forest connectivity in the hope that biodiversity will be enhanced while providing the necessary levels of enclosure to define the village. At the larger community scale the reforestation initiatives discussed in Chapter 4 dedicate over 60 percent of the total study area to reconnecting Willowbrook’s various stream corridors and remnant patches of forest.

Within the village, street tree plantings provide connections through each neighbourhood to the larger reforestation effort. On north/south streets the trees are generally large specimens, planted on both sides of the street since their presence will not interfere with solar access. On east/west
streets, however, the trees generally occur only on the south side to preserve solar access for north side buildings. The Greater Vancouver region’s mild maritime climate limits its solar potential relative to sunnier locations such as the Okanogan, therefore, maximising southern exposure is essential and summer shading from trees is less desirable. Shading of windows can be controlled using blinds, awnings or shutters.

Accompanying many of the street trees are middle and understory plantings in the front yards of the housing blocks. These plantings increase the complexity of the urban forest by adding layers to the forest’s structure which in turn provide more habitat options for wildlife. Further forest connections are made between courtyard plantings and the urban forest network. Housing blocks at the outer edges of each neighbourhood do not fully enclose their respective courtyards, thereby allowing the urban forest to connect with courtyard plantings.

Street trees also cast a shade over the street. In open conditions streets act as heat sponges absorbing heat during the day and radiating it back into the air at night. During winter months when ambient temperatures are lower this heat pump is a welcome addition to the neighbourhood microclimate. However, during warmer months this condition can lead to uncomfortably high local temperatures in the evening. The presence of street trees acts as an natural air conditioner and moderator of local temperatures.

One final contribution the street trees make is to provide an enclosing wall and ceiling for the street, thereby strengthening its relationship as a landscape corridor among many landscape rooms. At many of the intersections double rows of trees are planted to further define the space. These contribution can not be overemphasised as qualities of openness and enclosure help people gain a clearer image of the neighbourhood and community.

**Circulation**

Circulation in Jericho Hill occurs on a network of paths and streets which promote walking and limit automobile movement. Pedestrian-only paths and streets account for most of the village’s streets and paths. They offer places for people to walk and children to play. Their widths vary from
a maximum of 20 meters along the main civic promenade to a minimum 2 and 3 meters for paths and sidewalks which weave their way throughout the community. The pedestrian network is loosely organised so that path intersections occur at 60 to 80 meters intervals to maximise the pedestrian's directional choices. Numerous midspan access points offer even more choices and experiences. Where the paths or streets cross specific activity nodes and gathering points plazas are located to accommodate a variety of related uses.

Separated Streets are the second most frequent path and street system and serve as the principal circulation route for automobiles within the village. They provide vehicular access to the individual neighbourhoods and the subsurface parking garages. They are designed to serve as loop roads which carry the automobile from the periphery to the centre and back to the periphery in a manner similar to Radburn. Separated streets are two lanes, 6 meters wide with the 2.5 meter wide parallel parking strips on one or both sides. Their narrow width is designed to reduce driving speeds. They are designed with a drainage swale along the downhill side rather than a vertical curb, to minimise disturbance to the root systems of abutting street trees. (Moll, 1989) These swales carry both
Section - Typical Pedestrian Street

Figure 21 - Typical Pedestrian Street

Section - Typical Shared Street

Figure 22 - Typical Shared Street
surface runoff and surplus grey water from the housing blocks to the main water treatment facilities.

Shared Streets and Alleys represent the third component of the street and path network. They combine local vehicular traffic with pedestrian circulation to minimize the amount of paved surface. They feature a 4 meter wide drive aisle which also serves as a hard surface play area. In the case of alleys an additional 2 meter wide apron leads to the garage and provides space to pull into should two cars be using the alley at the same time. Shared streets extend the 4 meter drive aisle with a 2.5 meter wide parking strip on the north side, and 1.5 metre to 2.0 metre pedestrian path beside the parking strip. Paving patterns and tree plantings direct and slow the automobile traffic. Both the alley and shared street sit .15 to .20 meters above the main automobile routes, and are connected by a small sloped driveway.

- **Civic Order**

  The final design elements of Jericho Hill relate to the village’s civic order which overlay its ecological systems. The village’s main civic spine, a north/south predominantly pedestrian corridor which runs through the middle of the community, links each neighbourhood to the village’s main services. A church/meeting hall and associated public green anchor the northern, southern and eastern ends of the spine. The community’s main meeting hall, the transit hub, a commercial core, post office, library, recreational centre and school punctuate the middle of the spine which is never more than 350 meters away from any home and generally closer than 200 meters. Other public facilities such as community gardens and day cares occur throughout which serves the neighbourhoods. Smaller commercial service centres are located within the southern and eastern neighbourhoods.

  Each neighbourhood is in fact a collection of sub-neighbourhoods with approximately 500 people in each. These sub-neighbourhoods are in turn divided into clusters of housing for between 50 and 200 people to foster a sense of community. The housing blocks form a strong urban wall which helps define the public realm and enclose more private internal courtyards. This form of housing allows residents a choice
Figure 23 - Axonometric of Civic Spine, not to scale
Jericho Hill’s open space system weaves its way into this hierarchical neighbourhood division, ensuring no resident is ever more than 80 meters away from larger features of the system and generally closer than 40 meters. In addition to serving as the community’s ecological superstructure the open space provides for a collection of plazas, playfields, community gardens, meadows, tree alleys, orchards, and connections to the regional landscape, each of which attempts to foster a stronger sense of community identity and to build a better understanding of the region’s landscape.

5.5 Conclusion

The plan for Jericho Hill is an attempt to incorporate an ecological imperative into the fabric of a suburban community with the hope that a more sustainable presence may be realized; a presence which reveals the complexities of nature and strengthens the sense of place. Many of Jericho Hill’s
virtues can be more easily summarised when compared to a conventional suburban development. In Chapter 6, Jericho Hill is compared with another Township of Langley community, Walnut Grove, which is plagued with many of the suburban problems discussed in Chapter 1.
6.0 COMPARISONS
6.1 Introduction

This thesis began with the premise that ecological design parameters exist today which can be readily identified. It was also argued that if these parameters were applied to a suburban context a decidedly different form of community would emerge, one which significantly reduced the impact on local and regional ecosystems. I believe Jericho Hill Village is a testament to that premise.

The ecological merits of the Jericho Hill Ecological Village are most easily summarized when compared to a conventional suburban development. The community of Walnut Grove has been selected for this comparison for a few reasons. First, Walnut Grove is in the Township of Langley, approximately 1.5 kilometres north of Jericho Hill and shares similar development policies with the Willowbrook Community. Secondly Walnut Grove exhibits many of the suburban problems discussed in chapter 1, problems the design for Jericho Hill attempts to remedy. Finally, I am familiar with Walnut Grove from my work assisting the consultant team which recently completed the Township of Langley's Environmentally Sensitive Area Study. I was asked to help map land use changes in Walnut Grove between 1979 and 1992 to determine the rate of land use change and the extent of environmental degradation.

Comparing Jericho Hill Village with Walnut Grove serves another, perhaps even more relevant, purpose: Walnut Grove is a good indicator of Willowbrook's likely future. Walnut Grove was once predominantly agricultural and rural residential, as much of Willowbrook's uplands are now. Walnut Grove is dominated by single family residential housing and low multi-family housing. In Willowbrook's Community Plan the uplands are almost exclusively single family housing. Most importantly, Willowbrook is now being developed with the single family homes found in Walnut Grove. In essence, Walnut Grove offers a window on Willowbrook's future unless, of course, development plans change.

6.2 Walnut Grove - Background

Walnut Grove is comprised of a Town Centre surrounded by seven neighbourhoods, each with their own development plan. The neighbourhoods vary in size and level of services provided but most are dominated by what the Township classifies as Low Density housing (max. 18 units/ha).
Medium (15 to 40 units/ha) and High (max. 70 units/ha) are found primarily around the Town Centre which is Walnut Grove's commercial heart. 88th Avenue is a major four lane, separated collector road which links Walnut Grove with the 200th Street and the TransCanada Highway. Along its western portion is a growing strip commercial development which services not only residents of Langley but Highway 10 travellers as well.

The intensity of development is a relatively recent phenomenon. During the early and middle parts of this century Walnut Grove's landscape was a mix of orchards, field grown agricultural crops and forests. It was not until the 1970s that development began to transform Walnut Grove into the suburban community it is today. Since the 1980s growth has been rapid. Between 1986 and 1991 the population grew by 132.6 percent, rising from 4,535 to 10,549 residents, placing it among the most rapidly growing communities in the Greater Vancouver region. (Langley, 1994)
TABLE #5: Land use changes in Walnut Grove, 1979 - 1992

<table>
<thead>
<tr>
<th>Land Use Category</th>
<th>1979 ha</th>
<th>1992 ha</th>
<th>Change ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>294</td>
<td>72</td>
<td>- 222</td>
</tr>
<tr>
<td>Grass</td>
<td>28</td>
<td>44</td>
<td>+ 16</td>
</tr>
<tr>
<td>Old Fields</td>
<td>136</td>
<td>126</td>
<td>- 10</td>
</tr>
<tr>
<td>Shrub</td>
<td>15</td>
<td>16</td>
<td>+ 1</td>
</tr>
<tr>
<td>Deciduous Forest</td>
<td>58</td>
<td>12</td>
<td>- 46</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>351</td>
<td>204</td>
<td>- 147</td>
</tr>
<tr>
<td>Urban Residential</td>
<td>18</td>
<td>306</td>
<td>+ 288</td>
</tr>
<tr>
<td>Rural Residential</td>
<td>128</td>
<td>69</td>
<td>- 59</td>
</tr>
<tr>
<td>Industrial</td>
<td>69</td>
<td>240</td>
<td>+ 171</td>
</tr>
<tr>
<td>Transportation Routes</td>
<td>68</td>
<td>76</td>
<td>+ 8</td>
</tr>
</tbody>
</table>

Total Area Studied 1165 1165

source: draft copy of the ESA Study

The changes to Walnut Grove’s landscape have been profound. Most notable is an increase in urban residential has increased by 1,700 percent (288 hectares) and industrial/commercial by 350 percent (171 hectares). More critical, however, is what these changes have meant to the productivity of the Walnut Grove Landscape;

**Loss of Agricultural Land**

In the thirteen year period covered by the study, 222 hectares of agricultural land were transformed into residential use, representing a 75% decrease in total available agricultural land. Furthermore, the remaining agricultural land is now more isolated and fragmented into smaller, disconnected parcels by urban growth pressures. Its conversion into housing undermines the economic viability of present and future agriculture, and resigns the community to increased dependence on agricultural imports.
**Loss of Biodiversity**

Fifty percent (193 hectares) of Walnut Grove’s forested land disappeared between 1979 and 1992. The absence of diverse, interconnected, green open spaces within the various housing developments has resulted in isolated, remnant forests; forests which become so fragmented that biological productivity and diversity are lost. This condition is exacerbated by urban forest practices along roads, in parking lots and within institutional developments which are ornamental in nature and fail to provide adequate corridors to support wildlife migration. The predominance of ornamental, nonnative plantings in residential settings further reduces biodiversity.

**Loss of Ground Water Recharge Capacity**

The result of a 1,700 percent increase in housing is a 1,700% percent in impermeable surfaces and consequential loss of permeable surfaces and ground water recharge. Individual properties and strata-title developments have maximized site coverage while minimizing lot line housing, driveways, and wide roadways. Consequently few opportunities exist for percolation and groundwater recharge. While this may seem to be a rather benign practice the net effect is to reduce the amount of water available to the remnant forests and streams. This problem is particularly acute in the low precipitation months of late summer and early fall when stream flows are supplemented by groundwater discharge.

**Loss of Community Identity**

The rural character of Langley is defined by its agricultural patterns and forested lands. Yet between 1979 and 1992 415 hectares of agricultural and forest land were lost in Walnut Grove. This means that in 13 years one third of Walnut Grove’s total land base was transformed. Not only is the scale of the loss substantial but so is the speed of the transformation.

In very general terms the landscape character of Walnut Grove has become one of anonymity and privatization. The anonymity comes from the homogeneity of recent development. It has a sameness which Lynch describes as “all begun yesterday, and completely finished then. There is no crevice through which one can venture back or forward.”(Lynch, 1972, p.60) The privatization comes from the increased construction of housing enclaves that are isolated from the street by large fences. The only public open space system available are the conservation areas around the creeks.
6.3 Jericho Hill vs. Walnut Grove

In many respects comparing Jericho Hill Village with Walnut Grove is like comparing apples with oranges. Walnut Grove covers 550 hectares of land and houses almost 14,000 people with a future population of approximately 23,000 people. Jericho Hill Village on the other hand occupies an area of 140 hectares and accommodates 5,500 people. Walnut Grove exhibits classic suburban qualities of segregated land uses, wide roads, circuitous pedestrian paths, a housing typology dominated by street oriented garage doors and hidden natural systems. In contrast Jericho Hill Village is a mixed use community prioritizing pedestrian circulation, housing which faces and helps define paths and streets and, most importantly, ecological system flows.

Despite these differences some specific comparisons can be made between Jericho Hill and one of Walnut Grove’s similar sized neighbourhoods. Neighbourhood 4 was selected for the comparison as it is of similar size (approximately 68 hectares) and is one of the few neighbourhoods which includes medium density housing. It is located in the southeast corner of Walnut Grove and marks the highest point in the community with gentle slopes to the north and southeast.

Comparing specific land uses is difficult without actually measuring the entire site. However, from site visits and development information on Walnut Grove provided by the Township some basic land use comparisons can be made. The range of categories is limited due to the lack of similarities between each community’s respective programmes. For example, there are no provisions within Walnut Grove’s open space for the production of food or the recycling of water. Its open space is limited in scope, with one area designated as a municipal park and another as a conservation area. Conversely, many of the ecological features found in Jericho Hill take place in the community’s open spaces such as the water treatment facilities or community gardens. In general the open space system in Jericho Hill serves a much more diverse and complex program than the open space found in Walnut Grove. Therefore a general definition of open space was applied whereby all public land not used for roads was calculated as open space. Despite these differences in interpretation the following distributions of land use do begin to illustrate the differences between the two communities.
Figure 26 - Existing Zoning Plan for Neighbourhood 4, Walnut Grove
### TABLE 5: Comparing Land Use/Design Features of Walnut Grove & Jericho Hill Village

<table>
<thead>
<tr>
<th></th>
<th>WALNUT GROVE</th>
<th>JERicho HILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• low density - max. 20 units/ha</td>
<td>38 ha - 749 dwellings</td>
<td>none</td>
</tr>
<tr>
<td>• medium density - 20 to 44</td>
<td>6.5 ha - 295 dwellings</td>
<td>none</td>
</tr>
<tr>
<td>• high density - 45 to 80</td>
<td>none</td>
<td>16 ha - 2,185 dwellings</td>
</tr>
<tr>
<td>Commercial</td>
<td>none</td>
<td>1.0 ha (1.8%)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>none</td>
<td>12.5 ha (22.3%)</td>
</tr>
<tr>
<td>Roads</td>
<td>none</td>
<td>3.5 ha (6.0%)</td>
</tr>
<tr>
<td>Public Open Space</td>
<td>9.0 ha (13.2%)</td>
<td>23 ha (41.4%)</td>
</tr>
<tr>
<td>Total Population</td>
<td>3,100</td>
<td>5,500</td>
</tr>
<tr>
<td>Total Land</td>
<td>68 ha</td>
<td>56 ha</td>
</tr>
<tr>
<td>Net Density people/ha</td>
<td>70</td>
<td>230</td>
</tr>
<tr>
<td>Gross Density people/ha</td>
<td>46</td>
<td>98</td>
</tr>
<tr>
<td>Ratio Road Allowance to Open Space</td>
<td>1.0 m2 to 0.62 m2</td>
<td>1.0 m2 to 6.5 m2</td>
</tr>
<tr>
<td>Road Allowance per person</td>
<td>47 m2</td>
<td>6.4 m2</td>
</tr>
<tr>
<td>Number of Intersections</td>
<td>approximately 25</td>
<td>approximately 125</td>
</tr>
<tr>
<td>(roads and pedestrian paths)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furtherest Distance to Services</td>
<td>1,300 m</td>
<td>350 m</td>
</tr>
<tr>
<td>Furtherest Distance to Open Space</td>
<td>650 m</td>
<td>100 m</td>
</tr>
<tr>
<td>Percent of Lots/Buildings oriented within 20° of south</td>
<td>approx. 15%</td>
<td>approx. 80%</td>
</tr>
</tbody>
</table>

The differences between the two communities are directly related to one deciding to spread across the land horizontally and the other to conserve the land by growing vertically. There is little surprise then that Jericho Hill has three times the net densities of Walnut Grove and twice its gross densities.

**Analysis**

**The Public Realm and Roads**

What is interesting to note is each community’s relative proportion of public open space to roads. In Walnut Grove, for every 1 m² of road allowance there is 0.62 m² of land dedicated for open space use. Conversely, in Jericho Hill, for every 1 m² of road allowance there is 6.5 m² dedicated to the public realm. Another related statistic is the road allowance per person: in Walnut Grove there is 47 m² versus Jericho Hill where there is 6.4 m². These statistics underscore the fundamental differences between the two design approaches. The community which opts for the single family house and automobile dependency sacrifices its public realm and creates a host of
ecological and social problems related to its automobile dependency with the public realm becoming the most visible casualty.

Accessibility

The Walnut Grove neighbourhood plan includes seven ingress-egress points along its 2,200 meter long periphery with 212 B and 216 Streets, and 88 Avenue. This translates into one entrance for every 315 meters of perimeter area. Of these only three are clearly dedicated to the pedestrian. The internal circulation of the neighbourhood is equally anti-pedestrian as the zoning excludes mid-block and end of cul-de-sac pedestrian connections. Approximately 75 percent of the residents live at least 100 meters away from the two neighbourhood open spaces with the furthest residents living 650 meters away.

In Jericho Hill, intersections occur, on average, every 80 meters around the site’s perimeter and closer to 60 meters within the community. The furthest any one resident is from the open space system is 100 meters with approximately 80 percent of the residents living within 50 meters. A central commercial spine and two neighbourhood based service areas provide a shops and services are never more than 350 meters away.

Comparing relative levels of accessibility between the two communities is further illustrated when one considers the proximity of services. Within Walnut Grove no shops or services are provided and no clear pedestrian connections are made between the neighbourhood and the Town Centre to the immediate northwest. Consequently no resident lives within 100 meters of the commercial area and approximately 75 percent of the residents live between 500 and 1,200 meters away resulting in a neighbourhood completely dependent on their automobiles even for local trips. In Jericho Hill Village no resident lives further than 350 meters away from a commercial area with in excess of 50 percent living within 200 meters.

Energy

Walnut Grove’s predominantly north sloping aspect is a handicap for exploiting solar energy as a major source of heat and electrical energy. This is further compromised by a road network which orients approximately 85 percent of the lots and houses beyond twenty degrees of due south. Of
those remaining homes which could take advantage of solar access none are designed with the necessary passive solar building envelope to do so. Other than the residual heat gain and daylighting all buildings experience to some degree, the housing in Walnut Grove generates none of its heat or electrical energy from on site solar energy.

In Jericho Hill approximately 80 percent of the buildings fall within 20 degrees of south with the express purpose of maximizing passive solar gain. The remaining 20 percent are designed with flat roofs to allow roof mounted solar panels to be oriented within 20 degrees.

In terms of the energy used on transportation it is clear that without any internal services or work opportunities, or close proximity to a larger urban area where employment might be found residents of Walnut Grove consume far more energy for transportation than those people residing in Jericho Hill Village, perhaps in excess of twice the amount. (Calthorpe, 1993)

Permeability

The implications of developing an automobile dependent, single family housing community are further revealed when one considers that almost 87 percent (59 hectares) of Walnut Grove is consumed by roads and housing versus 35 percent (19.5 hectares) in Jericho Hill. On average, Walnut Grove’s houses and related hard surfaces cover a minimum 50 percent of their property. When combined with the actual surface area of roads and sidewalks found in the community (approximately 60 percent of the road allowance) than at least 52 percent (35.5 hectares) of Walnut Grove is paved with impermeable surfaces is. The consequences of this impermeability include a significant reduction in infiltration and ground water recharge, and the lost contributions made by subsurface water tables in regulating low flow summer stream conditions.

In Jericho Hill, roads, sidewalks and buildings cover approximately 18.7 hectares (33 percent) of land. However, the net effect of these impermeable surfaces is considerably less due to the subsurface recharge beds which are located under the roads and the many infiltration areas incorporated into the surface drainage system. The intent of this recharge strategy is to approximate the site’s natural infiltration patterns and minimize disturbance to subsurface drainage systems.
**Water, Waste and Agriculture**

Jericho Hill is organized to respect local drainage patterns and recycle the flow of water throughout the community, thereby reducing the community's need for imported water. The most dominant feature of this system is the water reservoir in Jericho Hill - North which is fed by treated surface runoff and wastewater from the solar aquatic greenhouses. When combined with the grey water storage capacity of each building the village has a water reservoir capacity in excess of 16,500,000 liters. This represents a storage capacity ten times greater than the community's daily requirements and help the village achieve at least a 60 percent reduction in imported water.

Jericho Hill Village also provides solar aquatic facilities which allow for all of the wastewater generated by village residents to be recycled or composted within the community. In Jericho Hill 12.5 hectares of land are dedicated to agricultural production with a capacity to supply 3,100 people with an annual supply of fruit and vegetables.

Walnut Grove, on the other hand, provides neither water storage facilities nor waste treatment facilities. It is 100 percent dependent on imported water and 100 percent dependent on shipping its waste out of the community. Additionally there are no facilities dedicated to agriculture despite Walnut Grove's traditional role as an important agricultural hub for Langley.

**Vegetation**

The final comparison between the two communities lies with the role vegetation plays in the respective communities. In Jericho Hill the vegetation serves as an important green connection through the community from one edge to another in support of wildlife habitat and migration throughout the region. The urban forest also helps moderate the village's micro-climate by casting shade across all north south streets to minimize potential heat gain. Finally the forest helps to define landscape paths and rooms, and unify various parts of the village.

In Walnut Grove there has been little if any thought given to the role the vegetation plays. Very little native vegetation remains and among the plant material that is planted very little of it has any
relationship with the local or regional patterns. In general the vegetation is devoid of both ecological relevance and regional context.

6.4 Conclusions

The differences between Jericho Hill Village and Walnut Grove are profound. From an ecological perspective Walnut Grove is designed without concern for local and regional ecological integrity. It represents the common mistake made in the planning and design of communities during the last few hundred years: Cities and towns exist as separate entities from the larger landscape. It is clear this is not the case as we have come to learn that cities and towns have enormous impacts on local, regional and global ecosystems.

What Jericho Hill Village demonstrates is an approach to organizing a community to minimize its impact on the landscape and if possible to develop symbiotic relationships between the village and the local landscape.
7.0 CONCLUSION
7.1 Introduction

Jericho Hill Village represents one possible scenario resulting from an ecologically-based, community design process. Its spatial organization has, in its attempt to maximize self-sufficiency, taken on a distinctly different, if not antithetical quality to that of a conventional suburban community. Exploring opportunities to generate heat, conserve water and waste, grow food, and increase biodiversity has created a community with very few of the features associated with the contemporary suburb.

The most notable and perhaps most controversial difference is the absence of the single family home. Early in this thesis it became clear that for a community to achieve basic levels of sustainability the single family house had to be abandoned as the archetypal housing pattern. As discussed in chapters one and two the social problems spawned by the single family house -- live/work imbalances, automobile dependency, anonymity and placelessness -- have also resulted in severe ecological problems such as the reduction in biodiversity, polluted water bodies, lost agricultural production, and increases in atmospheric emissions. Therefore, the single family house has been replaced with a variety of multiple family housing units that, while not satisfying those seeking a suburban house, will create the densities necessary to allow many of the other ecological design principles to be realized. Multiple family housing has the added benefit of providing affordable housing for the dominant nonnuclear family unit, an illusive virtue for the single family house. The conceptual plan for Jericho Hill Village also demonstrates how issues of energy and water conservation, waste recycling, urban agriculture and biodiversity can not only be incorporated into a design response but that these can enhance the form, function and image of the community.

The specific features of the plan do not profess to be a template for all ecologically based communities. Its grid-like organization, while maximizing solar gain, is realized only as the existing terrain allows it. The open space network is organized along natural drainage patterns specific to Jericho Hill. Reforestation is designed to reconnect remnant forests that have been fragmented by indiscriminate development. Each of these issues respects the design parameters set forth in chapter three, yet each is adapted to the context. In essence Jericho Hill’s form is guided by
design principles but rationalized by site conditions.

It is this ability to respond to and embody local context in the shaping of the community that may be the most important characteristic of an ecologically based design approach. If people can understand and respect the idiosyncrasies of local and regional ecosystems, and in particular their vulnerabilities, possibilities for developing more sustainable communities become real. If one knows very little about the function and features of local ecosystems, as is the consequence of current suburban design, the likelihood of ecologically sustainable communities being realized is virtually nil.

7.2 Prime Determinants

During the planning and design of Jericho Hill Village I realized the ecological design parameters discussed in chapter three -- energy, water, waste, vegetation, housing, and spatial organization -- could not be applied as uniformly as I had originally thought when the parameters were being defined. Early on in the design process it became clear that addressing the community's energy and water flows would have to take priority over other parameters as these two establish the structure on which other ecological features can operate.

Energy

The use of energy to support the many activities found in a community is inevitable. Energy is essential in heating and lighting our houses, cooking our food and carrying us from one area to another. What differentiates the conventional community from the ecologically sustainable community is the source of that energy. In the conventional suburb the form of energy is typically fossil fuel or hydro electric power, both of which are products of solar energy, but not solar energy directly.

In the ecologically sustainable community direct solar energy is the only renewable source of energy that is produced on a daily basis in the quantities necessary to meet the majority of a community’s needs. In addition, direct solar energy is the only energy source that is not
appropriated from another system and the only source whose use is free of adverse byproducts. Therefore attempting to maximize solar gain establishes fundamental guidelines for the placement of buildings and streets. The result is that solar energy becomes a prime determinant of the community’s physical form.

Water

Water is an equally important, and perhaps more dynamic consideration, in determining spatial form. Though water flows are not bound by the same orientation demands that come with maximising solar gain, the role of the hydrologic cycle in shaping and supporting local and regional ecosystems is undeniable. In any landscape its presence supports a range of plants and organisms. In the conventional suburb the understanding of the hydrologic cycle as an important ecological feature is rarely incorporated into the decision making process that determines the community’s layout. This results in the indiscriminate alteration of local drainage patterns, and surface and subsurface water courses. The consequences may be slow to materialize but eventually supplies of potable water become scarce, local plant and wildlife communities disappear and the natural systems that support human activity are lost.

Alternatively the emphasis in the ecologically sustainable community is placed on minimal disturbance of local surface and subsurface drainage patterns. In the case of Jericho Hill Village this lead to the separation of the community into three drainage basins that aligned with the existing drainage patterns. Subsequent decisions dealing with surface runoff and grey water reinforced these strategies and attempted to protect preexisting drainage characteristics. Thus it is the first responsibility of the open spaces system to protect the local hydrologic patterns.

In retrospect this revelation that energy and water become prime determinants of community form is consistent with the basic organizing principles structuring natural ecosystems, where the absence or abundance of solar energy and water define the character of the system. This does not imply the other design parameters discussed in chapter three -- waste, vegetation, housing, and spatial order -- are unimportant determinants of form. Rather they should be understood to be critical in establishing specific features of the community within the restrictions placed by the response to energy and water.
A good example of this is a wastewater facility such as a solar aquatic system. Its requirements are simple: it should be placed downhill from the majority of waste producing sites in a sunny location and include the appropriate plants and organisms to treat the waste. The system is most effective when it is located within or near the community's drainage courses to more easily capture and treat wastewater prior to its release into the hydrologic cycle. The siting and spatial requirements of the solar aquatic facility is determined by and adapted to the community's basic structure.

Another example of this hierarchical relationship between the prime and secondary determinants can be illustrated by the possibilities offered by urban agriculture. There are endless examples of people fortuitously reclaiming derelict land, easements, rights of ways and even rooftop tops to grow fruits and vegetables. The locational requirements are quite flexible as long as water is available, the site is sunny and the soil is adequate. Small scale allotment gardens and orchards have the capacity to be adapted to a variety of settings. This flexibility makes the siting of urban agriculture less critical at the outset than maximising solar gain or maintaining local drainage patterns.

Understanding the prime determinants is essential for any community design approach aspiring to be ecologically sustainable. Energy and water represent the inescapable constraints of any given site and cannot be substituted for. Unfortunately the unwillingness of planners, designers, managers and residents to accept this truism is why the urban system is failing. It is a delusion that has no basis in ecological reality and is ultimately proving to be self-destructive. The conceptual plan for Jericho Hill Village offers an approach to the planning of a suburban community based on these parameters. And while the solution presented is by no means the quintessential model it does offer some legible alternatives to the status quo.

7.3 The Issue of Place

It is not enough to understand cyclical orientation and participation in purely organisation or technical terms. People must be enabled to again experience them personally. This means, ecological urban restructuring is above all a creative task. It is important to get beyond the reduction of functional or aesthetic aspects of the city as the expression of a linear and sectoral understanding of design. Since most of the natural and cyclical relationships of architecture, urban planning and technical systems can no longer be experienced sensually, sensitivity and responsibility wither away and indifference as to what is bad and good in life rises."

Ekhart Hahn, 1992.
The scope of this thesis has been limited to defining ecological design parameters and applying them to the design of a suburban community. As has been noted elsewhere a design process that attends to issues of energy, water, waste and food will fundamentally influence the form of the community. However, it is unlikely that such a process will independently succeed in realizing a more sustainable community unless it can engender a “sense of place” among its residents: unless it can foster the necessary sensibilities that will lead residents towards a more sustainable existence.

The question of how well any design process addresses a “sense of place” is a complex one, well beyond the scope of this thesis. However, what can be said about the Jericho Hill Village concept plan is that it embodies many of the qualities that place theorists have noted as essential in the creation of place. Norberg-Schulz (1980) argues that place emerges when built form allows people to concretize their existential relationship to the landscape they inhabit. Relph (1976) suggests that the fundamentals of placemaking lie in the ability of a location’s physical and psychological qualities to define that place as a centre of human existence. Heidegger believes that sense of place emerges when a person is placed in a setting in such a way that it reveals the external bonds of his existence and at the same time the depths of his freedom and reality.

Jericho Hill Village and the ecological design parameters that organizes it help to reveal local ecological features as not only simple functional features but as narratives of the way natural systems are integrated with human systems. The ecological design parameters help to concretize the many natural system flows is such a way that they become apparent and recognizable to residents. For example, the passage of water through the community not only serves to protect the integrity of local ecological function but, when skillfully integrated into the fabric of the community, can reinforce a resident’s visceral relationship with the water and the larger systems it is connected to.

There are other reasons to suspect the proposed plan for Jericho Hill Village is more likely to engender a sense of place among its residents than a conventional suburban plan. Beyond the mixture of uses it offers and the more legible public and private realm defined by its spatial order defines, the process envisioned for implementing it includes the following features, each supportive of the development of a “sense of place”.
System Based Design Process
Jericho Hill Village is the result of an organic, system based design process. Its organization mirrors natural ecosystem function and attempts to maximize self-sufficiency in energy, water, waste and food. This is an approach that leads to a design that is diverse, adaptable and intimately connected to local and regional ecological function. Every part of Jericho Hill is part of larger and smaller systems, interconnected by a series of energy transfers, flows, cycles and networks. The design assimilates inputs and outputs of energy, water, waste, air, and food from the smallest act of building through to the community's relationship with the region. The system-based design clearly embodies and reveals the local context in its spatial organization.

Time and Change
If a sense of place is to emerge one must be able to relate to concepts of time and change. With a system based design approach seasonal changes and cycles of ecosystem function become much more apparent. It is a process that helps to relate the influences of time and change upon the landscape, the community and the resident. Past, present and future concepts of time are reflected in the ecological systems operating within the community throughout the year, making them more readily apparent and anticipated. This contrasts with the static concept of time most suburban communities embody.

Incremental/Small Scale
The concept plan for Jericho Hill Village illustrates a fully built community of approximately 5,500 people. As a plan it does not reflect the inevitable growth and change it will go through as it matures. In reality it would take years of incremental change to realize the form shown in the plan. Developing ecologically sustainable community must be based on incremental change and growth. It must avoid rapid change as this reduces diversity and adaptability, and erodes the continuity necessary for a sense of place to emerge. Incremental change allows time to respond and adapt to changes in context and circumstance in a similar manner found in natural systems.

Regional Identity
Creating a sense of place begins with the development of a relationship with the landscape in which one resides. The more one responds to the local context the more likely it is a sense of place will
emerge. Jericho Hill Village is derived from the application of a number of ecological design parameters to an existing set of local landscape characteristics. The design begins to describe and reinforce the areas context through the flow of water, the reconnection of remnant forests, and the design’s response to the area’s rural character. In essence the design for Jericho Hill responds to local and regional characteristics, and celebrates the idiosyncrasies of the regions natural systems and in the process reinforces regional identity.

7.4 Implementation

The observations on the placemaking qualities found in Jericho Hill are, of course, speculative. One cannot be sure that any would actually be realized until the plan is implemented. Thus the question of implementation remains. It is one thing to spend two years considering the design features of an ecologically base suburban community. It is, however, a completely different problem considering what some of the opportunities and constraints might be in attempting to implement such a design.

Conventional Development Process

Perhaps the most obvious constraint to implementing such a proposal is the inertia of the current approach to developing communities. Suburban communities look, operate and feel the way they do for a variety of reasons, not the least of which is the unwillingness of planners, designers and residents to explore alternatives. In the early 1970s when Michael and Judy Corbett were proposing to develop Village Homes in Davis, California, the financial institutions and development bylaws were unprepared for their ideas on energy and water conservation. The system had not seen a similar proposal and therefore created layers of red tape that slowed, and ultimately, compromised the final design. It appears little has changed. Many financial institutions are unwilling to provide a mortgage on alternative construction techniques. Similarly, local building codes and building inspectors are poorly prepared to evaluate subdivision plans and buildings that do not conform to their conventional bench marks.
Official Community Plans

The lack of interest in using basic ecological concerns as organizing principles can be traced back to most community planning documents. An example of this is the Willowbrook Community Plan produced by the Township of Langley. The purpose of the plan is to provide:

"(a) the basis for long range orderly development of the community;
(b) a guide for day-to-day decision making in the development process for the area and investment decisions of individuals;
(c) the basis for preparation, adoption and amendment of land use regulating bylaws; and,
(d) the basis for the preparation and adoption of a capital works program."

The plan goes on to discuss the general concept and offers the following three goals for the plan:

"1. To encourage commercial, business, office and industrial uses as well as residential accommodation in the Willowbrook area to promote development of a regional centre in conjunction with downtown Langley
2. To provide for adequate services and public facilities.
3. To provide an aesthetically pleasing environment and protect significant natural features."

The purpose and goals in the Willowbrook Plan are commonly found in official community plans and neighbourhood plans in other cities and municipalities. These are documents focused entirely on the development potential of their communities not limitations for development. The plans generally speak of "orderly development" without any mention about how the proposals will address issues of energy, water, waste, food and vegetation. This is why, from the perspective of ecological sustainability, the development process and the documents guiding it are inherently flawed. In failing to recognize that development is ultimately dependent upon local, regional and more distant resources, and the health of the ecosystems that produce these resources, the current development process deludes itself in to believing ecological concerns are subservient to development concerns when the opposite is true.

Economic/Cultural Expectations

Associated with the constraints of the current approach to development are its underlying economic and cultural expectations. The development of standard suburban subdivision reflects short term,
investment decisions. This speculation on real estate leads to the rapid development and sale of property in an attempt to maximize profits. It is rare that the person developing the land will reside on it and it is even more rare for this development process to result in a thoughtful discussion respecting the future of the community and its impact on the land. It is a process reinforced, if not perpetuated, by cultural expectations of private property ownership and single family houses. Thus as long as the single family house holds the esteemed position in the human psyche it does, absolved of its adverse impacts on regional ecosystems, proposing more ecologically sustainable alternatives will be an uphill battle.

It would seem impossible to reconcile aspirations of ecologically sustainable communities with current approaches to development. Short term investment, either as time or money, does not reflect the influences of time affecting natural ecosystem function. Physical changes to a landscape can happen quickly but changes in fundamental ecosystem functions are much slower to materialize, and when they do become apparent they are often manifested as systemic problems rather than single issue problems. This is why any and all development must better understand that any action has a consequence, good and bad, for local and regional ecological function as well as community identity. Until this reality is embodied in the development process and the development process can look beyond its myopic mandate there is little chance for change.

Enabling Factors
Undoubtedly the idiosyncrasies of the status quo represent considerable impediments to an ecologically based design approach. However there are a number of emerging factors that suggest an alternative approach might be well received. First the change in family demographics discussed in chapter one, from the traditional nuclear family to a smaller, more diverse family unit is beginning to undermine the appropriateness and equally important the affordability of the single family house. These disparate family units have different programmatic needs that cannot be fulfilled by the traditional suburb.

Another important change is the transformation of the work place. Information based industrial development is not bound by the same locational requirements that conventional industry required. In addition management structures are becoming more flexible, offering people more options to
work at home or in satellite offices closer to their home.

Few incentives for finding alternative solutions in the development of communities are more compelling than the emerging constraints being placed on communities by their water and waste systems. Rapid population growth, particularly within the Greater Vancouver Region, is stressing the current infrastructure’s ability to supply potable water and carrying away waste. Many of these systems are at or near capacity. Upgrading them with conventional solutions is proving to be too expensive for most communities and alternative approaches are being sought.

Another important enabling factor has been the increase in environmental regulations during the last few years. As people become aware of the many impacts their activities have on ecosystems policies are being written that restrict emissions and control certain forms of development. While these are at present incomplete they do establish a necessary precedent of prioritizing ecological concerns above traditional concerns.

There are other positive signals that suggest an ecologically based design approach could take root including the ever increasing costs of fossil fuel energy, improved efficiency of building envelopes and photovoltaic panels, and waste recycling opportunities. There are also indications that more people are willing to compromise their personal goals to protect their environment and that people are generally becoming more sympathetic to environmental issues.

7.5 Future Work and Expectations

Before an ecologically based community design approach is likely to happen there are a number or areas of study not addressed in this thesis that will likely have to be addressed.

Cost Comparisons

The first involves the development of a series of cost comparisons between a conventional development approach and an ecologically based approach. The costing would have to include a life cycle assessment of both to better reflect the complete costs involved. There is no doubt that on
A per unit basis the multiple family housing used throughout Jericho Hill is considerably cheaper to construct than single family houses. The increases in densities would also result in fewer roads being required per person and more shared services. Since infrastructural costs can account for up to 40 percent of development costs there is little doubt an ecologically based community can offer considerable cost savings during construction and development. The question is how much and to what extent. These are basic questions which need to be answered if the ecologically based design is to be demystified and more universally accepted.

**Policy Recommendations**

This thesis does not provide specific policy statements similar to those found in conventional planning documents partly to help limit its scope but also in response to my perception that policy statements have only a limited capacity to foster good design. A case in point is that conventional suburban development has been subject to a litany of policies and, while the policies may have been well intentioned they have failed to generate vibrant communities. Nonetheless, as an interim measure, it is likely that specific policies empowering an ecologically based design process must be written to help change the status quo. Policies have become the lexicon of the development industry and until that changes they will continue to play an important role in describing what can and cannot be done.

**Pilot Projects and Financial Incentives**

On an annual basis design competitions and pilot projects are developed throughout Europe to test out new approaches to architecture and community planning. Often these projects are the collaboration of government and private interests. What they succeed in doing is to provide a tangible precedent for an alternative idea that people can walk through, touch, evaluate and improve. Unfortunately, these competitions and pilot projects are rare in North America, which explains why so few innovative ideas on energy efficient design, water conservation, or waste recycling are disseminated throughout the continent.

The absence of these ideas reinforces, and is reinforced by the reluctance of financial institutions, industry and government to sponsor the construction of prototypes. What should occur is the joint sponsorship of pilot projects by public and private interests as well as a provisions for monitoring
the results and integrating what is learned into mainstream practices or more than likely altering mainstream practices to better support the idea. There are many smaller projects than Jericho Hill Village that could occur. For example a stretch of road in an existing community could be rebuilt with the goal of maximizing ground water recharge and providing the best possible habitat for the street trees. Different techniques would be used and evaluated. Another project might include the redevelopment on an urban block into a mixture of uses that maximizes self-sufficiency in energy, water, waste and food.

Future Design

Another area for future study could involve a further evaluation of the ecological design parameters and their influence on physical form. The concept plan for Jericho Hill Village represents a preliminary proposal for an ecologically sustainable community but it requires further refinement. Its exploration into how water, waste and energy can be effect community form is incomplete. There needs to be more attention paid to how well these parameters can engender a sense of place and the specific design dimensions they require in order that ecosystem function can be supported.

Architecturally the challenge is to explore how multiple family housing can become more energy self sufficient while providing the necessary levels of public and private separation. For community planners and landscape architects the focus should be on how the proposed open space enhances local and regional ecosystem function. For engineers there must be new solutions for the community’s infrastructure that protects ecological function.

Ultimately, however, the likelihood that ecologically sustainable communities will emerge depends not on the design resolution of a few design professionals, but on the acceptance of the idea by the general public. It is the individual resident that must be committed to the idea and responsible for its implementation. With this in mind perhaps the most important area for future work is in educating people in the problems of the status quo and the opportunities of alternative approaches.

“In the long run the proper ethical view surely sees man as part of nature and man’s role as one of living together with other species in some reciprocal relationship, concerned for them, helping them and the entire ecological system to change and develop in some selective direction”.

Kevin Lynch, 1972
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Appendix 1 - Case Studies

During the research for this thesis numerous projects from Europe and North America provided valuable information on the spatial implications of ecological design. The lessons learned in these projects contributed significantly to the development the ecological design parameters established in chapter three. I had the opportunity to visit most of these sites and for those I was unable to visit I was able to acquire good documentation of their features. The following is a brief annotated list of the projects.

Denmark

• Torsted Vest, Horsens
Located along Horsens' western boundary this new subdivision will eventually provide 700 units of housing combined with a mixture of services. The project was begun in 1991 with completion due in 1999. To date Torsted Vest is the most comprehensive community in exploring ecological considerations as an organizing tool. The mixture of housing is sited to maximize natural air circulation and protect lowland areas. There is housing that is autonomous from any community services, that explores passive and active solar architecture, and that is adaptable buildings. Other relevant features are grey and black water strategies, urban agriculture and a cogeneration system,

• Egebjerlgard, Ballerup
A mixed use development of approximately 700 units, 15 kilometers west of Copenhagen. The project was started in 1986 and is expected to be complete in 1994. It demonstrates passive and active solar architecture, clustered housing, grey water techniques, live/work opportunities, a large percentage of public open space, and urban agriculture.

• Valdemarsgade, Slagelse
Valdemarsgade involved the renewal of a block of derelict buildings in downtown Slagelse in 1993. The inner city project integrates a range of ecological design initiatives within 148 resident units. The project’s main features are passive solar architecture, energy conservation, water and waste recovery, food production, and wildlife habitat enhancement.
• Slagelse
The original centre of Slagelse has been designated a “green city” (Grøn By) by the Danish Government and the European Community. The designation supports green initiatives throughout the inner urban core such as a cogeneration plant, solar energy projects, water and waste conservation, traffic calming and green spaces. Many of these have been realized such as the Valdemarsgade project.

• Copenhagen
There are far too many examples of ecological design related strategies in Copenhagen to list here. They include innovative housing strategies that address energy and water concerns, pedestrian and bicycle networks, mixing of uses and human scale design.

• Fredensgade/Hollændervej, Kolding
This inner city renewal of a derelict housing block is notable for its attempt to deal with water and waste onsite. It includes grey water and solar aquatic facilities as well as passive and active solar architecture. It is scheduled for completion in 1995.

• Blangstedgard, Odense
This subdivision began as a design competition to provide 600 units of housing in 1987. The project provides interesting examples of multiple family housing, many of which include passive and active solar design features. The circulation system prioritizes pedestrians and cyclists, and the open space system retains much of the areas rural character.

England
• Letchworth
Letchworth is the only authentic example of Ebenizer Howard’s “garden city”. As such it provides an interesting example of community land trust ownership. Its mixture of uses, clustered housing and active agricultural industry are among its many virtues as a somewhat autonomous community,
• Welwyn Garden City

Welwyn was to have been the second true “garden city” but due to circumstances it developed without the community land trust ownership. Consequently it demonstrates fewer of Howard’s ideas than Letchworth. Nonetheless it has a commendable human scale, it is serviced by a regional train and local bus system and provides significant open space for its residents.

• Milton Keynes

Beyond the separated pedestrian and bicycle path systems from automobile traffic, the naturalized plantings along easements and some allotment gardens Milton Keynes has few redeeming qualities that can be used as precedent in defining ecologically sustainable communities. As one of Great Britain’s most notable new towns from the 1950s and 1960s I had expected Milton Keynes to be more forward looking, yet the automobile dominates this place.

Germany

• Block 6 - South Friedrichstadt, Berlin

An engineered marsh dominates the inner courtyard of an urban renewal housing project. The project was intended to treat and recycle grey water from approximately 100 housing units to reduce the project’s water demands on the city. While it has not been as successful as the designers had hoped it is an interesting development with potential for future applications.

• Block 103 - Luisenstadt, Berlin

Block 103 is typical inner-city housing block in Luisenstadt Quarter of Berlin. As part of the 1987 International Building Exhibition(IBA), the 332 residential units and 41 shops were rehabilitated using a broad range of ecological design initiatives. One of its principal water conservation strategies was to replumb the building to accommodate a grey water system.

• Block 70, Luisenstadt, Berlin

This urban infill project of approximately 200 units is organized around a courtyard that is planted with native to enhance biodiversity and wildlife.
• Berlin
There are hundreds of projects throughout Berlin which offer a variety of interpretations of ecological design. Many deal with grey water recycling techniques, passive and active solar design, material recycling and the renewal of old building stock by the residents. The city has numerous building codes requiring basic levels of ecological performance and has integrated a fairly extensive bicycle path system. The open spaces in Berlin are also noteworthy for the volunteer succession that is occurring in abandoned and derelict sites.

• Erlangen
Notable for its extensive bicycle system that was overlayed and integrated into the existing urban fabric.

• Hanover
Hanover is an important location for passive and active solar architecture in Germany. Numerous buildings have been developed that explore different energy options.

• Documenta Urbanica, Kastle
This is a small subdivision in southwest Kastle that serves as a demonstration project for different passive and active solar architectural techniques.

• Munich
Munich offers excellent examples of urban planning that supports pedestrian and bicycle circulation. It also successfully demonstrates urban growth centres that are linked to each other and the city core by an extensive public transit system.

• Saarbrucken
In 1992 Saarbrucken received an environmental award from the United Nations sponsored Rio Summit for their cogeneration power plant that supplies much of their domestic energy as well as the industry where the power plant is located. It is also notable for some of its open space initiatives and its examples of passive solar architecture.
• Stuttgart
Stuttgart has been purchasing open space throughout the surrounding hills to protect the region’s air circulation. The prevailing winds and outflow of air from the surrounding forests was found to play an important role in reducing the urban heat island effect and thereby reducing the need for air conditioning and the energy required to power these units.

The Netherlands

• Almere
Almere is located east of Amsterdam and provides good examples of new town planning supported with a variety of public transportation options. The role of the open space for recreation and ecological function is also notable.

• Bijlmermeer
The notable feature of this apartment building complex located east of Amsterdam is the attempts as natural plantings. A series of successional planting strategies was used to enhance biodiversity and wildlife habitat.

• Amsterdam
Amsterdam provides endless examples of adaptive reuse of buildings, human scale design and a bicycle path system integrated into the old city fabric.

• NMB Bank Building, Amsterdam, The Netherlands
This 50,000m² building is home to approximately 2,000 employees. The employees were involved in the site selection and building design development as required under Dutch law. The building demonstrates that substantial energy savings and improved interior environments can be achieved independent of building size. The building is oriented along an northwest - southeast axis, and demonstrates principles of passive solar architecture, daylighting, heat exchange and healthy interior environments.
• Delft

The bicycle network in Delft is one of the most extensive in Europe and serves as a good study of what works and how it can be integrated into an existing urban area.

• Ecolonia, Alphen aan den Rijn

Ecolonia is a subdivision of 101 demonstration homes built between 1992 and 1994. All the houses had to meet a general program for conserving energy and utilizing environmentally aware materials. The homes were then separated into 9 categories with more specific programmatic objectives. The development offers some interesting passive and active solar design solutions as well as water conservation techniques, flexibility and interior air quality.

Sweden

• Solbyn, Dalby

Solbyn is a 50 unit housing cooperative built in 1987. The housing units are oriented to maximize solar gain. The housing development demonstrates passive solar architecture, compost toilets, a common building, root cellars, allotment gardens and orchards and onsite daycare.

• Skarpnack, Stockholm

This new town centre includes approximately 3,000 housing units in a suburb south of Stockholm. It offers some interesting examples of courtyard based, four to seven story housing, with live/work opportunities.

• Stockholm

Stockholm serves as a good study of a planning approach that attempts to focus mixed use growth in specific suburban areas that are linked to the city and to one another by public transit. The basic intent is to increase transit use, reduce automobile use and per capita energy consumption, and preserve regional open space and natural systems.
• Tusenskonan, Vasteras
This 70 unit four and five story housing development is organized around an inner courtyard. The project demonstrates techniques for grey water recycling complete with a courtyard stream and pond, urban agriculture, domestic waste separation and ventilation and heat recovery systems.

United States
• Rocky Mountain Institute, Snowmass, Colorado
This 372m² building houses 21 employees and is one of the most energy efficient buildings in the world. Its design demonstrates the potential for passive solar design to achieve energy savings of 99 percent savings in space and water heating energy, 90 percent reduction in domestic electricity, and a 50 percent savings in water use.

• Village Homes, Davis, California
This 32 hectare subdivision is organized around an open space system that is both the community’s amenity area and its the stormwater drainage basin. The project, built in the mid 1970s, establishes an important precedent in North America of passive solar architecture combined with surface drainage, ground water recharge, urban agriculture system and natural vegetation.

• The Woodlands, Houston, Texas
Woodlands is a suburban housing enclave outside of Houston located in a low lying area susceptible to seasonal flooding. Ian McHarg was involved in the design which is notable for its open drainage system that was chosen over subsurface storm sewers. Houses and roads are located along the high ground or impermeable surfaces to preserve natural drainage. It demonstrates the potential for surface drainage even within a large scale application.

Canada
• Boyne River School, Toronto, Ontario
Boyne River School serves as an outdoor school/natural science centre for the Toronto School Board. It sits in a woodland near the Niagara Escarpment. Because of its remote location the school is designed to be autonomous from municipal services. Attention to passive solar design
techniques allows the building to supply most of its own heat. Photovoltaic panels and a wind turbine located on a nearby hill provides most of the electricity. And a solar aquatic wastewater treatment system occupies a room of 50 m² within the school building and treats the waste from approximately 250 students and teachers.

• Lebreton Park, Ottawa
Lebreton Park is a .55 hectare park surrounded by medium density housing blocks. At the very heart of the park sits a stormwater retention pond. When dry the pond’s hard, yet permeable surface allows for variety of play and community activities to occur. However, during heavy rains water that does not percolate through the park’s grassed areas drains to the pond. A catch basin and weir control the height of the pond and the rate of percolation. Depending on the volume of water collected the pond might reach a depth of .5m and remain for up to 3 days (Hough 1984).

• 2211 West 4th Avenue, Vancouver
This mixed use commercial and residential building is notable for its use of ground source heat recovery that when combined with basic passive heat gain provides the large building complex with most of its heat.
Appendix 2 - Pedestrian Pocket Program

The following program was used as a guide for programming Jericho Hill Village. It is the program established for use in a design competition that took place at the University of Washington in March of 1988 (Kelbaugh, 1989). It accommodates 2,500 to 3,000 people or roughly half a full sized pedestrian pocket.

<table>
<thead>
<tr>
<th>Light Rail Station</th>
<th>10,000 square feet minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back Office</td>
<td>500,000 sf</td>
</tr>
<tr>
<td>Service Office</td>
<td>150,000 sf</td>
</tr>
<tr>
<td>Neighbourhood Retail Facilities</td>
<td>60,000 sf</td>
</tr>
<tr>
<td>Commercial Parking</td>
<td>1,000 stalls</td>
</tr>
<tr>
<td>Apartments</td>
<td>400 units</td>
</tr>
<tr>
<td>Townhouses/Duplexes</td>
<td>400 units</td>
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<tr>
<td>Single Family Detached Houses</td>
<td>50 units</td>
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<tr>
<td>Elderly Congregate Living Facilities</td>
<td>150 units</td>
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<tr>
<td>Day-Care Facilities</td>
<td>2 @ 7,500 sf</td>
</tr>
<tr>
<td>Civic Facilities</td>
<td>25,000 sf</td>
</tr>
<tr>
<td>Parks and Recreational Facilities</td>
<td>12 acres</td>
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