DECISION SUPPORT TECHNIQUE FOR SUSTAINABLE COMMUNITY DESIGN:
Developing a Sustainable Community Design Evaluation Methodology

by

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ABSTRACT

The meaning of an architectural work is borne out of the whole, from a vision that integrates the parts. It is in no way the sum of the elements. However, because of our limited capacity to retain and process multiple information of **the whole**, it is sometimes disaggregated so that it could be better understood from its parts. Perception and cognition orders our understanding of physical phenomena. Our understanding of the richness of a design lies in the vitality of the images it arouses. If we are to experience architectural meaning and sense in community design, it is vital that the effect of the design should find a counterpart in the world of the viewer's experience. Where human spatial experience can be appropriately simulated, the need thus arises to model its impact and record the result in a scientifically consistent and reliable manner in order to appropriately assist decision-making.

The determination of consumers' receptivity to sustainable community design alternatives using scientific methods of analysis poses great challenges to researchers in the design profession. Different approaches have been suggested. This research is a contribution to the continuing investigation of an appropriate method for design investigation that will help to inform the quality of design decisions.

This research proposes a new approach to analyzing design data for decision support. The paradigm shift involves the decomposition of community design into features that could be formally (scientifically) evaluated using the Fuzzy Group Decision-Making (FGDM) approach. It presents a disaggregate approach to analyzing consumers' receptivity to sustainable community design alternatives. A hypermedia visualization interface based on the creation of **virtual** community scenarios is used to present design data to 3 subject-groups for assessment, in both laboratory and Internet environments.

An experimental test, using FGDM provided a scientific basis for the evaluation of survey results from larger subject-groups. The framework for a decision model is developed for project-based application. This research demonstrates the use of FGDM as a reliable decision modelling technique using disaggregated design data. The greatest strength of FGDM is that it is appropriate for capturing the inexactness or fuzziness that is inherent in the definition of goals and criteria where variables are defined in linguistic terms.

DEDICATION

To my wife: Cecilia Tinuola; and my children: Ronke, Oluseyi, and Bimifoluwa.

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The successful completion of every work of research depends on the contribution of many parties whose names may not feature anywhere else in the final product. However, the fact that they are not listed as authors or co-authors does not diminish their invaluable contribution to the research.

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CHAPTER 1

THESIS BACKGROUND

1.1 Introduction

The definition of sustainable community is as varied as the disciplines and backgrounds of the authors who define it (Rees and Roseland 1981, Perks and Clark 1996, Gurstein 1995). There is agreement in the literature that sustainability, ecologic architecture and livability are intertwined. This research, however, adopts the definition of sustainable community design presented by Perks et al. (1996) and the definition of livable community design presented by Appleyard (1981) to develop the parameters for the community design proposal used for consumers' receptivity testing. These definitions are presented below.

Perks et al. (1996) define sustainable community design as:

> *"A community that considers choice, convenience, and diversity. A compact form which has more people together to support having services and places close to the home. An environment that is healthy... with energy-conserving home designs and site planning... an ecological approach to the use of land and natural resources... streets designed for walking in safety and comfort... and every neighbourhood developed with its own special character and identity."*

Appleyard, (1981) defines a livable community as:

> *"...a community whose street is a safe sanctuary for children playing, walking or cycling to local schools, bus stops, shops, playgrounds or parks... It is a community in which communal life is possible... a neighbourly territory where residents feel a sense of belonging and a sense of pride and responsibility..."*

This thesis presents the parameters for sustainable community design that are developed from literature (Lynch 1981, Lennard 1995, Alexander 1977, Kelbaugh 1989, Hough 1984, Newman 1980, Pressman 1981, Jacobs 1961, Rees 1988, Appleyard 1981). Furthermore, a sustainable community design proposal is presented for Whyte Ridge Community -- a local suburban community in the City of Winnipeg. The design proposal is based on established sustainable community design parameters, which are developed from 154 sustainable community features proposed by Perks et al., and the works of several other authors.

Consumers' receptivity to these parameters was tested with experimental 2D sketches and 3D renderings of alternative testing scenarios in a virtual environment, using live subjects. The "conventional"[1] and "sustainable"[2] design scenarios for Whyte Ridge community, based on disaggregated community features, were presented for participants' assessment using a hypermedia visualization interface. This interface was used for testing consumers' receptivity to sustainable community design. The data obtained from this survey were used to complement a web-based survey using the same data. Correlation of sustainable community design receptivity data was made for the various subject-groups to establish final preference pattern using Fuzzy Group Decision-Making (FGDM) technique.

Issues considered in the alternative sustainable community design include: choice, convenience, diversity, proximity to community core, community compactness, efficient use of natural resources and urban space, environmental health, safety, decreased pollution, and the establishment of a sense of place.

1.2 Problem Statement

Recent research on the potential for designing sustainable communities has led to the development of a wide variety of community design alternatives and the deliberate manipulation and experimentation with a wide range of design criteria. In order to assist the decision making process that precedes any application of these sustainable community design concepts, the potential users (i.e., community residents) should have the means to understand the impacts of such concepts on an experiential level.

Decisions about the choice of one design concept over another require an understanding of the perceptive reality of these concepts to a user. Although Virtual Reality (VR) technologies cannot examine all of the sustainable community design criteria, many of the criteria may be appropriately tested in a VR setting (Bertol and Foel and Foel 1997). It is the objective of this research to identify and isolate such criteria, and to develop a methodology for carrying out the test and evaluating the outcomes.

[1] A scenario that depicts a traditional suburban community.
[2] A scenario that depicts a community design using sustainable principles.

This research seeks to answer two basic questions:

- If a suburban community were designed to incorporate goals, ecological-planning criteria, and technological features associated with achieving sustainable development, would people want to live there?
- Does design representation technique affect consumers' understanding of design intent, and hence the choice of design alternative that they make?

1.3 Goal of Research

The goal of this research is to develop a procedure for assessing sustainable community design alternatives in a virtual environment, and to develop a methodology for evaluating the results. The concept of "virtual space", in this research, refers to the use of a hypermedia visualization interface (HVI) to conduct a cyber-survey of alternative design scenarios through the Internet, and to present data to subjects in a laboratory environment.

1.4 Significance of Research

The nature of judgments that are often made in the assessment of visual data and the formulation of sustainable community design criteria falls within the category of decision problems which exemplifies the vagueness and non-specificity inherent in human formulation of preferences, constraints, and goals. Qualitative data such as this can only be effectively modelled using a modelling technique that would capture these imprecisions. FGDM was used in this research to obtain a realistic outcome from the evaluation of qualitative data obtained from an assessment of graphic and linguistic data. This is a new line of research that presents the potential for increasing the reliability of outcome from assessments using qualitative data by allotting threshold values to judgement criteria. Increased reliability of results from a decision model based on qualitative data means a better quality of decision advice provided to a decision-maker, and hence better decisions by the decision-maker.

The hypermedia visualization tools developed for this research have strong potential for the type of market research that would seek to test innovative ideas, design schemes and ranges of choice in housing or community services, pricing and costing, consumer-industry trade-off decisions, and for conducting the user-participant planning-and-design process. These direction-finding processes in community and municipal planning, urban development, and transportation planning, could regularly deploy the procedure and technology with considerable effect for conducting participatory planning and for educational purposes. The tool would especially be useful for focus group-type research, and for comprehensive statistical research.

1.5 Scope of Research

This research is limited to the development of a hypermedia interface that could be used to assess graphical data and model the impact of design representation technique on consumers' choice of a preferred design alternative. The theoretical and practical basis for determining consumers' receptivity to sustainable community design alternatives are developed and examples of its application presented from research and from a survey of householders in the City of Winnipeg.

This research does not attempt to provide policy recommendations for implementing the conclusions reached from the survey. It is outside the scope of this research to develop hypermedia visualization software for application in comparative design testing scenarios.

1.6 Outline of Research Methodology

Presented below is the outline of methods and procedures used in this research. The methods and procedures are discussed further in order to clarify our realm of engagement, and define the direction of the research.

- The development and definition of design features to be used as variables in the design program.

    To develop a foundation for this research based on current work, sustainable community design features were compiled and defined after completing a literature search of the concept of sustainability and the impact of community building on design solutions. This helped to define the boundaries of our engagement.

- The establishment of a proof of concept for sustainable community design parameters.

  Design proposals were made and presented to a jury of designers, to test the validity of the research approach and demonstrate that the features compiled could be explored and assessed in the virtual space. The conceptual framework for assessing sustainable community design was presented for internal critiquing. The final list of features and the method of presenting them were then compiled and analyzed.

- The development of an experimental design proposal for a local community to validate the use of established parameters.

  Four sites were considered and analyzed for testing experimental design solutions for sustainable community design. These are: (a) William Whyte Community in the North-end of the City (b) Wildwood Community in the Fort Garry area, (c) South Point Douglas in the midtown area of the North-end and (d) Whyte Ridge Community in the Fort Richmond area of the City. The midtown sites were rejected because the goal of the research was to explore alternative "sustainable" design alternatives for a suburban community. Whyte Ridge was chosen because it fit into the definition of a conventional community with defined boundaries and indicators of the trend of developer-driven consumerist designs that inundate contemporary urban landscapes in North America. Experimental design solutions for the site were made and critiqued by an internal panel of design jury, and the program's committee.

- The development of a hypermedia visualization interface for presenting graphic data for assessment.

A hypermedia visualization interface was developed for the project. The Web-based interface was developed to allow cyber-participants in the assessment of features. The final design solution for Whyte Ridge was accessed through the hypermedia visualization interface. Three levels of surveys were carried out. The first "expert" survey involved 11 design professionals drawn from different locations in the City for a Web-based survey. The second involved a panel of 24 householders in the City, who were invited to a controlled setting to assess design alternatives, projected on a large screen. The third was a parallel Web-based survey of 25 householders from within and outside Whyte Ridge community.

- Analysis of results from the survey and development of the sustainable community design evaluation procedure for determining consumers' receptivity design alternatives.

The data obtained from the survey were analyzed for decision support using the Fuzzy decision model. The goal of using this technique was to capture the uncertainty and imprecision that usually results from the linguistic evaluation of visual data.

- Testing the validity of the procedure and reporting the outcome.

The procedure for developing the decision support technique was subjected to further tests to validate its conclusions. The objective was to determine variance between expected and final outcomes, and to explain the gap between them. The outcome from this exercise led to suggestions for avoiding some of the shortcomings of the procedure in future research.

1.7 **Analytical Procedure**

After the review and analysis of relevant literature, two alternative design scenarios were developed for the purpose of comparative design assessment. The design scenarios were reviewed by a survey panel of householders who live within and outside the site.

1.7.1. Data Analysis Procedure

In this research, sustainable community design parameters were disaggregated into component performance features. The intent was to isolate each feature such that an assessment of consumer preference for alternative design scenarios, which exhibit some design characteristics of the feature, was possible. Three categories of sustainable community design parameters were considered. They include community design, ecologic design and street design parameters.

1.7.2. Data Capture Procedure:

The first stage of the tests involved the use of a descriptive-explanatory procedure based on "before design intervention" (i.e., Whyte Ridge as is) and "after design intervention" (i.e., the proposal for a sustainable Whyte Ridge) scenarios for the test site. A hypermedia interface was developed to present the "before design intervention" and "after design intervention" designs for each feature, for participants' assessment.

Photographs and video images of the existing community and rendered 3D and VR of design proposals for the same community were presented. The images were hyper-linked with text frames that define the feature under consideration. A second text frame contained assessment questions for determining the degree to which the participant would prefer to have the feature reflected in the community in which he/she lives. Links were provided to QuicktimeVR and/or animation files of each feature to allow users to explore the designs in the virtual space. A preference assessment frame was included to allow cyber-subjects to score their preference for each design scenario, using a rating scale or a "Yes/No" radio button.

An alternative survey strategy was to invite 32 participants in two groups of 16 each into a controlled environment where design scenarios that were made available on-line would be projected on a large screen for better visual immersion. An advantage of this in-house presentation was the enhancement of a sense of immersion that was not possible when data was viewed on-line on an independent basis. Secondly, access to design data would be faster and not dependent on the Internet access rate possible on individual participants' PCs (personal computers). Third, it would be easier to provide more information, through presentations, to the participants such that participants' response could be based on detailed understanding of the questions asked.

The second stage of this procedure involved the decomposition of descriptive pairwise preference information into weighted quantitative data. A matrix of fuzzy relations was established between the set of alternative design scenarios and the set of descriptive performance constraints developed for the assessment of the visual data. The preference dataset was subjected to rigorous analysis to determine data based and media-based responses using the fuzzy modelling procedure (see details of analysis in chapters 3 and 6). A modified Saaty's rating scale of preference was used to score consumers' preferences before applying the Fuzzy Group Decision-Making technique to further evaluate the data.

1.7.3. Sample Size:

Sixty subjects (comprising design professionals, householders and renters) participated in 3 survey groups. The composition includes an 11-member subject-group of design professionals, a 25-member Web based subject-group, and a 24-member "in-house" or laboratory-based subject-group invited to the Computer laboratory of the Faculty of Architecture at the University of Manitoba. The laboratory-based subjects participated in a 3-hour session of computer-generated virtual sustainable community design proposals and questionnaire completion.

1.8 Decision Making Techniques

The complexity of community design problems requires that a multidimensional approach be used to adequately represent the issues involved. In almost all problems the multiplicity of criteria for judging the alternatives is pervasive. In many decision problems, the decision-maker wants to attain more than one objective or goal in selecting the course of action while satisfying the constraints dictated by environment, processes and resources (Hwang and Masud 1979).

Presented below is a discussion of the decision-making techniques used in this research. The application of FGDM to real live problems is discussed in Chapter 3.

1.8.1. Fuzzy Group Decision Making Technique

Consumers' preference for the inclusion of certain design features in their prospective home is a decision-making problem. Decision is broadly defined to include any choice or selection of alternatives. Probabilistic decision theories have modelled decision making under conditions of risk. Fuzzy decision theories attempt to deal with the vagueness and non-specificity inherent in human formulation of preferences, constraints, and goals. The formulation of sustainable community design criteria falls within this category because of the nature of judgments that are often made in the assessment of visual data.

The Fuzzy Sets technique is a method for solving a decision problem where decisions are made under uncertainty (Zimmerman 1990, Zadeh and Kacprzyk 1992). Chapter 3 is devoted to the discussion of theoretical and practical applications of the Fuzzy Group Decision-Making technique.

1.8.2. The Analytical Hierarchy Process (AHP)

The practice of decision-making involves attaching weights to alternatives, all of which fulfill a set of desired objectives. The problem is to choose the alternative which most strongly fulfills the entire set of objectives (Saaty 1980). Saaty's Analytical Hierarchy Process permits the inclusion of subjective factors in arriving at a recommended decision.

The decision-maker must however, make judgments about the relative importance of each decision criteria and then specify a preference for each decision alternative relative to each criterion (Anderson et al. 1994). The output is a prioritized ranking indicating the overall preference for each of the decision alternatives.

1. Saaty's Rating Scale

Saaty used a 1 to 9 rating scale to map the degree of preference stated by the decision-maker. The scale is amended in this research to eliminate the intermediate values and retain only the ordinal values that will make the evaluation of subjects' assessments easier. Saaty's rating scale is presented below:

Verbal Judgment of Preference	Numerical Rating
Extremely preferred	9
Very strong to extremely preferred	8
Very strongly preferred	7
Strongly to very strongly preferred	6
Strongly preferred	5
Moderately to strongly preferred	4
Moderately preferred	3
Equally to moderately preferred	2
Equally preferred	1

2. Methods for Pairwise Comparisons

Some of the methods proposed by Saaty, for carrying out pairwise comparisons in a survey of this nature include:

- Direct questioning of the people who may or may not be experts, but who are familiar with the problem;
- Specifying alternatives in advance such that all the variables are not necessarily under the control of each of the parties involved in affecting the outcomes of the alternatives.
- Working with an understanding that expressed preferences are assumed to be deterministic rather than probabilistic.

Where several people are involved in the survey or panel, they can assist each other in sharpening their judgments and also divide the task to provide the judgments in their areas of expertise, thus complementing each other. A major advantage of Saaty's pairwise comparisons is that it enables the analyst to improve consistency using as much information as possible.

3. Problems with Measurement and the Judgment Process

In spite of its advantages, Saaty's method has severe limitations with measurement and the judgment process that makes its sole application to this research inappropriate. Some of the problems are discussed below.

- *Measurement*: It is difficult to ascertain the consistency of the measurement criteria.
- *Providing greater stability and invariance to social measurement*: Social measurements are subjective. It is therefore difficult to provide greater stability and invariance to such measurements.
- In any real life situation, it is difficult to set up the right conditions for people to structure their problems, and provide the necessary judgment to determine their priorities.
- *The "Primary Effect":* Judgments are always provided for every comparison scenario. It is difficult to determine whether providing these judgments will bias the outcome toward what is examined first.
- *The "Recency Effect":* There is an inherent weakness in human behaviour to more vivid recollection of what is presented last. This may affect the judgment provided in favour of what is presented last.
- In any group survey, there is the danger of having a domineering subject who will have an opinion on everything and, because of his/her temperament, tend to influence the decision of the less assertive members of the group. Such out-of-role-behaviour, in which people assume the role of others and provide judgments for them without full appreciation of the people they represent, tends to bias the outcome.
- *Personal bias*: Where members of the group have a personal bias, the outcome of the survey from the group would be slanted in favour of the bias exhibited in the group.

Saaty (1980) argued that the influence of these drawbacks is diminished if more time is taken with repeated interaction and people are cautioned about personal bias. Pairwise comparisons enable the decision-maker (DM) to improve consistency by using as much information as possible. The preference ordering of Saaty's method is modified and used in this research.

1.9 **Basic Concepts and Terminology**

Discussed below are some of the words and terms used in this research. Most of the terms are used in multiple criteria decision-making literature.

1.9.1. Attributes:

Attributes are the characteristics, qualities or performance parameters of alternatives. Multiple attribute decision problems involve the selection of the "best" alternative from a pool of pre-selected alternatives described in terms of their attributes (Hwang and Masud, 1979).

1.9.2. Objectives:

Objectives are directions for better performance as perceived by the decision-maker. They are reflections of the desires of the decision-maker (DM) and they indicate the direction in which the DM wants the organization to work. For multiple objective decision making problems, it involves the design of alternatives which optimize or "best satisfy" the objective of the DM.

Hwang and Masud (1979) explained this with an example of a development plan for the government of a developing country. The objectives of the government in devising an acceptable plan could be: to maximize the national welfare; to minimize dependence on foreign aid; or to minimize unemployment.

1.9.3. Goals:

Goals are things desired by the decision-maker expressed in terms of a specific state in space and time. While objectives give a desired direction, goals give a desired (target) level to achieve. In most literature, this distinction gets blurred and the two words -- objectives and goals -- are used interchangeably. They will also be used interchangeably in this review.

1.9.4. Criteria:

Criteria are standards of judgment or rules to test acceptability. A multi-criteria decision-making problem includes either multiple attributes, or multiple objectives or both. They are used to classify problems in general terms to make them easy to analyze.

1.9.5. Optimal Solution:

An optimal solution to a Vector Maximum Problem (VMP)[3] is one that results in the maximum value of each of the objective functions simultaneously. Since it is the nature of multiple-objective decision-making problems to have conflicting objectives, usually there is no optimal solution to a VMP.

1.9.6. Preferred Solution:

A preferred solution is a non-dominated solution (that is, a solution chosen by the decision-maker, through some additional criteria, as the final solution). It lies in the region of acceptance of all the criteria values for the problem. It is also known as the best solution.

1.9.7. Satisficing Solution:

A satisficing solution is a reduced subset of the feasible set, which exceeds all of the aspiration levels (goals) of each objective (Sheppard, 1983). Satisficing solutions, argued Hwang and Masud (1979), need not be non-dominated. This type of solution is credited for its simplicity that matches the behavior process of the decision-maker whose knowledge and ability are limited.

1.9.8. Vector Maximum Problem

A Vector Maximum Problem (VMP) is a problem that consists of n decision variables, m constraints and k objectives; where any or all of the functions may be nonlinear.
The mathematical definition of a multiple objective decision problem such as this is:

Maximize: $[f_1(x), f_2(x), \ldots, f_n(x)]$
subject to: $g_j(x) < 0,\ j = 1, 2, \ldots, m$
where: x is an n dimensional vector.
$f_i(x), g_i(x)$ are non-linear functional variables

[3] A decision problem where the functions $f_i(x), g_j(x)$, are nonlinear

1.9.9. The Concept of Evaluation:

All rational decision making, whether by individuals or groups, involves some form of evaluation. Evaluation can take an almost unlimited range of forms and levels of sophistication, depending upon the decision involved, the decision-maker, and the characteristics of the courses of action contemplated. Evaluation may be termed the relative and absolute assessment of the worthiness of a particular course of action or planned expenditure, and worthiness can be assessed in a number of ways by either determining to whom a plan is worthwhile or when the plan will be worthwhile.

Evaluation is the activity of examining the goals, assessing the relative desirability of each action, and summarizing the key issues to be considered by interested parties in reaching decisions (Hwang and Masud 1979, Sheppard 1983).

1.9.10. Choice:

Choice is the activity of reaching a conscious decision as to which of the alternative actions (if any) to implement; choice takes as input the results of evaluation.

1.9.11. Virtual Reality (VR):

Virtual Reality is a computer-generated world involving one or more human senses and generated in “real-time” by the participant's actions. The participant, rather than the viewer or user, in a virtual environment is the perceiver and creator at the same time. Its success depends on a sense of "presence" - the perception that the participant is actually present in the virtual environment. The participant must feel a sense of immersion (Bertol and Foel 1997).

CHAPTER 2
THEORETICAL BACKGROUND

2.1. Literature Review

The review of literature was carried out to determine visually assessable sustainable community design features, the characteristics of conventional suburban communities, and decision modelling techniques. The product of this review is presented below.

2.1.1. Sustainable Community Design:

The concept of sustainability is based on the two principles of *conservation* and *bioregionalism.* The goal of conservation is to ensure a more prudent and responsible management of non-renewable earth resources. The concept of bioregionalism attempts to develop the awareness that all life forms are interdependent (Smales and Green 1996, Rees and Mathis 1996). Sustainability involves respect and reverence for "life" itself.

Kremers (1995) defines sustainability as a process wherein responsible consumption is practiced in order to minimize waste and interact in balanced ways with natural environments and cycles. He presents six objectives for sustainable community design. These objectives are: (a) modelling the ecosystem with an environmental understanding; (b) assessing the socio-economic context of each site; (c) establishing acceptable limits to change; (d) designing all facilities within social and environmental thresholds; (e) monitoring site factors throughout construction; and (f) re-evaluating design solutions between development phases. He concludes that sustainable community design serves as a rallying point for creating greater awareness for the built environment and its long-term viability

Kelbaugh (1997) argues that sustainability alone is an insufficient objective unless it is combined with the restoration of damaged and deteriorating systems. This extends the realm of sustainable community design beyond prudent utilization of existing resources to the meticulous management and restoration of these non-renewable resources, based on an understanding of the human 'societies' that the design is intended to serve, and the earth's resources that will make the habitation possible.

Urban designers, architects, and planners, among other professionals, have been formally involved in reshaping urban environments based on the concept of sustainability. The need for professional involvement in sustainable community design has been more acute since the growth of concerns about the negative impacts of conventional urban design approaches on the quality of lives and community-building in the suburbs (Duany 2000, Kelbaugh 1989, Calthorpe 1993).

One of the intents of design is to reorder resources to better serve people. Design relates to nature in a state of constant tension because, by its very nature, design is 'interventionistic'. When the damages that arise from the negative impacts of development are not mitigated through proper environmental understanding, the state of the natural system and its resources begins to deteriorate. It is the role of theory to define these impacts, and to develop a methodology for understanding and mitigating the impacts of design on the site, its 'contents' and its context. The determination of relevant parameters for sustainable community design developed for the Winnipeg project was based on this understanding.

2.1.2. **Characteristics of Conventional Suburban Communities**

The typical suburban community is usually planned almost exclusively for one type of home and economic class, the high or upper middle income class in single family detached housing. Shopping, work, and entertainment are located elsewhere, possibly at a considerable distance from the community. In most cases, there is an absence of schools close by, partly because too few families live close together to make the location of schools viable. Furthermore, there are too few choices in the type and size of housing, to encourage the type of intensity and mix of social classes that would give a community the required vibrancy (Perks and Wilton-Clark 1996).

The homogeneous structure of suburban communities has resulted in a number of problems. These problems could be summarized as follows. The first problem is the dominance of single family detached housing in traditional communities, which has resulted in high urban land consumption and a waste of land and material resources. A second characteristic is the limited variety of house types, and the high cost structure of housing, which has resulted in declining affordability for a sizable proportion of the population, and a shrinking demand. Third, there is the high maintenance input of money and resources for homes and properties because of the lack of building layout compactness.

Fourth, most suburban communities are plagued by feelings of isolation by residents especially those communities in which there is no place to work or socialize within the community. Fifth, because of the separation of work and home, residents are forced to travel greater distances between home and work and other centres of interest. This leaves too little time for family, community and social life. Sixth, the increased distances between home and work have led to increased commuting and automobile dependency. Seventh, there is persistent traffic congestion on suburban highways as a result of commuting to work and activity centres. Governments have reacted to this phenomenon by building more and bigger roads, but this approach has only served to increase the amount of automobile usage and cause more congestion.

Eighth, acute air pollution (which is a direct result of the ever-growing number of automobiles on urban highways), soil pollution, water pollution and wildlife habitat degradation has led to worsening environmental conditions. Ninth, there is increased per capita energy consumption because of the lack of compactness at the core and increased demand for fossil fuel consumption to run automobiles, to provide infrastructures, and to generate power. Tenth, there is suburban sprawl, which has also resulted in increased land consumption and increasing costs of extending municipal infrastructures and services.

2.2 Goals of Sustainable Community Design

There are three major goals of sustainable community design: (1) to maintain community compactness and diversity, (2) to ensure ecologically sensitive site planning practices, and (3) to develop communities that will promote community identity and a sense of place (Perron et al. 1998, Perks and Wilton-Clark 1996). These goals and the strategies for achieving them are discussed in detail below.

2.2.1. Compactness and Diversity:

A major goal of sustainable community design is to achieve compactness of community form, and to maintain a diversity of housing and households, jobs, shopping, shopping and business services, neighborhood styles, and environments, in the community.

A compact community can be maintained through reduced lot sizes and increased number of units per acre. This would make home buying affordable and attract a diverse range of households and people into the community (Lynch 1981, Perks et al. 1996, Jacobs 1960). Accessibility and convenience for people are ensured through easily accessed transportation and services, and by providing paths and pedestrian areas in their planning and design.

Strategies for achieving this include: (1) provision of homes for large and small households, senior population, non-family households, single parent families, shared households, and people of all income levels in each neighbourhood; (2) provision of diverse housing types: detached housing, row houses, duplexes, small low-rise apartments, townhouses and multiplexes. The houses should be designed for expansion, family growth and other adaptation over time. (3) Intensifying residential development density. Increased community density helps to reduce land and resource consumption, and it facilitates better waste management. (4) Provision of dwelling clusters and low density detached houses throughout the community. (5) Ensuring that houses are placed within easy reach of shopping, places of work, and entertainment in order to reduce automobile dependency.

2.2.2. **Ecological Approach to the Use of Land and Natural Resources**:

The primary goal of sustainable community design is to create a friendly, healthy environment with energy- and water-conserving home designs and site planning. Its objectives are to create a community that produce less wastes by recycling unusables, process and reuse storm water, and manage sewage at the local or community level. In a sustainable-designed community, there is infrastructural support for storm water management and water recovery. There are natureways, civic places, walking and cycling networks, community "greening", and streets designed for walking in safety and comfort; and there are gardens and greenhouses for local food production in the community.

Some of the ways for attaining this goal of sustainable community design include: (1) creating open space landscapes, and preserving the topography and ecology of the site; and (2) blending housing developments with watercourses, topography, vegetation patterns, and wildlife habitats. Others include: (3) weaving housing subdivisions around protected landscape patches and watercourses, where they exist; (4) developing tree nurseries for urban "greening", and providing food-growing gardens and farms; and (5) providing and encouraging community power co-generation and district heating, on-site storage of storm water for irrigation, recycle and drop-off stations for recycling and composting.

2.2.3. A Community Core that Promotes Sense of Identity and Place.

A sustainable community is a community in which materials and architectural standards are in line with cultural and environmental realities of the community. The elements and fabric should have meaning and value to residents.

Methods for achieving this include: (1) Providing community centres and ensuring that each community has a designed core or town centre. (2) Creating open spaces that are directly connected to residential streets. (3) Locating schools, shopping, entertainment, and work places within a five-minute walk from homes (Perks and Wilton-Clark 1996, Bargh and Lehrman 1995). (4) Developing each neighborhood with its own special character and identity.

2.3 Decision-Making Techniques

2.3.1. Introduction

Design problems, because of their complexity and qualitative nature, require a multidimensional approach to adequately represent the issues involved. In multi-criteria decision problems, the decision-maker wants to attain more than one objective or goal in selecting the course of action while satisfying the constraints dictated by the environment, processes and resources (Hwang and Masud 1979). In some cases, design objectives are apparently non-commensurable; that is, they are Vector Maximum

Problems (VMP)[1].

One method of solving VMP is to optimize one of the objectives while appending the other objectives to a constraint set so that the optimal solution would satisfy these objectives, at least up to a pre-determined level. A second method is to optimize the super-objective function created by multiplying each objective function with a suitable weight and then adding them together.

In determining the effectiveness of alternative strategies, some problems may arise with weighting and ranking of alternatives. Even where a panel of experts is assembled to assess various areas of objective attainment as an input to the decision-making process, considerable problems still arise in the process of weighting the various viewpoints, and in determining a good decision (Hwang and Masud 1979, Saaty 1980). Particular problems arise where two objectives are in conflict, in which situation information would be required on the difference in importance between the two objectives.

2.3.2. **Judgment**

This is the oldest and most tried method for decision-making. Judgment may be in the form of "pure intuition" or a "professionally-based decision". The professionally-based decision method is based on the judgment of an informed professional architect/planner, an engineer, or an economist using technical data related to the feasibility and expected payoff of a policy decision or an investment project (Aboul-Ela 1981). Decisions made using this method may be based on recommendations of peer reviews, professional panels, or a structured reporting format.

Judgment can also be used together with one or more analytical techniques to enhance its systematic application and the inclusion of objective measures. Lusk (1979) developed an eigenvalue priority assignment model that was found useful in the systematic evaluation of decision alternatives, where the evaluation criteria may have subjective as well as objective measures. Zadeh (1965) also developed another method called the fuzzy set for use in the multi-criteria decision-making process. These methods could be used as a means of providing the final decision-makers with a more consistent and comprehensive alternative scenario evaluation. Fuzzy Sets modelling technique has

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[1] See definition of VMP in Section 1.9.5.

been developed for different types of applications by Zimmerman (1990) and Klir and Yuan (1995).

2.3.3. **Multi-attribute Utility Function**

In this method, the utility functions for each criterion or attribute are assessed and then a multi-attribute utility function, which can be additive of multiplicative, is obtained. The alternatives are then ranked according to their multi-attribute utility. Mathematically, the non-commensurable criteria (VMP) are converted to the form:

Maximize: $U(f_1, f_2, ..., f_k) = U(f)$

such that,

$$g_j(x) < 0, \quad j = 1, 2, ..., m$$

where, $U(f)$ is the utility function of the multiple objectives.

$g_j(x)$ is a matrix of criteria being assessed.

The rationale for using $U(f)$ is the assumption that the decision-maker (DM) must have some utility associated with the objectives. The utility function would then take into consideration the decision-maker's preferences.

The major advantage of this method is that if the utility function {U(f)}has been correctly assessed and used, it will ensure the most satisfactory solution to the decision-maker.

There are some disadvantages of this method. First, the determination of the utility function for even a simple problem is difficult. Second, the decision-maker is required to articulate preference judgment in an information vacuum (Hwang and Masud 1979). Third, like the single objective utility functions, the multi-attribute utility functions suffer from intransitivity of time and state. Fourth, Multi-Attribute Utility Function is impractical where many decision-makers are involved, as is often the case with the evaluation of sustainable community design alternatives.

A major criticism of this method is that uncertainty is assumed to occur in two stages:

first in the estimation of outcomes (scores) for each proposal, and second in the assessment of utility functions for each attribute where techniques such as lottery indifferences are used.

2.3.4. The Eigenvalue Priority Assignment

This model contains an ordinal scale developed by Saaty (1980), and is used to relate the pairwise evaluation of alternatives. The ordinal numbers are recorded in a judgment matrix, and each matrix is abstracted by computing the eigenvector associated with the maximum eigenvalue of that matrix. The resulting vector determines the relative values of alternatives.

Lusk (1979) describes the selection process as follows. If there are "**n**" alternatives and "**m**" criteria for which judgments must be rendered, there will be "**m**" decision alternative judgment matrices, each of size "$\mathbf{n} \times \mathbf{n}$", and one criteria judgment matrix of size "$\mathbf{m} \times \mathbf{m}$". The "**m**" eigenvectors developed from the "**m**" decision alternative matrices are then called to reflect judgmental intransitivity, and in conjunction with the eigenvector developed from the criteria judgment matrix used to develop the priority weights assigned to the "**m**" alternatives.

Saaty (1980) used elementary pairwise comparisons between activities to derive a scale of priorities for them. He used a scale of 1 to 9 for expressing the degree of importance of one member of a pair over the other.

Although the technique is an important contribution to the modernization of judgment by evaluation technique, Aboul-Ela (1981) argued that the requirement for a large number of questions an individual must answer in order to obtain the [n(n-1)]/2 judgments makes its application problematic.

Therefore, the technique would require further development of its rating scale and question size requirements in order to allow professionals and the public to participate in the evaluation process. However, some of the attributes of this method are used with other methods to obtain a better evaluation methodology.

2.3.5. Mathematical Programming Method

Mathematical Programming Method considers decision-making as the process of selecting a possible course of action from all alternatives available to the decision-maker. It sets out to determine an optimal solution, that is, that alternative which satisfies the requirements of constraints of the problems while attaining the specified objectives to a predetermined level that is as high or higher than that of any other alternative (Hwang and Masud 1979).

Mathematical approaches to solving multi-criteria decision-making problems have been presented in books and monographs. Although, the methods for various Multi-Criteria Decision-Making problems are widely diverse, these methods share the following characteristics:

- A set of criterion judgments;
- A set of decision variables; and
- A process of comparing alternatives.

Multiple Criteria Decision-Making problems can be classified into two major categories:

- Multiple Attribute Decision-Making (MADM), and
- Multiple Objective Decision-Making (MODM).

Multiple Attribute Decision-Making usually has a limited number of predetermined alternatives, and the alternatives have associated with them a level of the achievement of the attributes that may not necessarily be quantifiable. The final decision is based on the achievement of the attributes. The final selection of the alternative is made with the help of inter- and intra-attribute comparisons that may involve explicit or implicit trade-offs.

Multiple objective decision making, on the other hand, is not associated with problems in which the alternatives are predetermined. Its goal is to design the 'best' alternative by considering the various interactions within the design constraints which best satisfy the decision-maker by way of attaining some acceptable levels of a set of quantifiable objectives.

The common characteristics of these methods are that they possess:

- A set of quantifiable objectives,
- A set of well defined constraints, and

- A process of obtaining some trade-off information, implicit or explicit, between the stated quantifiable objectives and also between stated and unstated non-quantifiable objectives.

These methods are more related to design problems, rather than the selection problems on which multiple attribute decision making methods focus.

The following three steps are essential to the development of multiple-objective decision making methods:

1. The stage at which the preference information needed is determined;
2. The stage at which the type of information needed is determined; and
3. The stage at which the major methods for each classification are developed.

In multiple criteria decision-making problems, there are four possible stages at which decision-making information is needed from the decision-maker. The first is the stage where no articulation of preference information is needed from the decision-maker. Second, the stage where 'a priori' articulation of preference information is needed. Third is the stage where progressive articulation of preference information is required. Finally, the stage at which 'a posteriori' articulation of preference information is needed from the decision-maker.

In this research, it is impossible to quantify the objectives discretely for the purpose of measuring the performance of attributes. Therefore, a more appropriate method would be that which measures the grades of preference in the attainment of specific design goals.

2.4 Design Representation Techniques

The past few years have witnessed a major transformation in the media used by architecture as a discipline and as practice, from representation to design. This shift is most evident in the use of computer-related technology for drafting and visualization purposes. Traditionally in architectural design, the communication of knowledge and information had been done through signs made of ink on paper. These include the 2-dimensional (2D) representation of a 3-dimensional (3D) artifact such as a building, and communication of design idea with the use of sketches.

Computer aided design (CAD) is now utilized for drafting, surface or solid modelling system dealing with 3D shapes. It is also employed as an electronic pencil, in which the task of representing 3D objects becomes extremely efficient. Added to the use of CAD applications for developing electronic models, it has received extensive use as design visualization tool, especially for rendering and animation.

Although renderings have the potential for greater aesthetic quality, virtual reality (VR) represents the ultimate interactive walkthrough, because the viewer not only passively looks at video footage of animation sequences, but can also interact in real-time with the path of motion and the direction of sight.

One of the tasks of architecture is the creation of a man-made environment in which specific functions are performed and where social interaction takes place. This task assigns a certain character to a built form thus transforming an architectural artifact into a place. Digital architecture, on the other hand, does not exist in physical material. It is not permanent. The sense of immersion created in VR is only illusionary since the solidity of enclosure is different from what is perceived by the observer. However, the VR environment in which the representations completely surround the visual universe of the participant, represents the most sophisticated example of digital architecture. Presented below is a discussion of design representation techniques.

2.4.1. **Orthographic Projections**

An orthographic projection is the representation of an object on a plane of projection when the lines of sight from the eye to the object are perpendicular to the plane of projection. Four factors need to be considered: (a) the point of sight; (b) the lines of sight; (c) the plane of projection; and (d) the object.

It is obtained by finding the points at which the lines of sight pierce the plane of projection, and connecting them in the proper order. This method is especially useful for visualizing details of joints and connections in three-dimension. It is deficient for visualizing objects in a dynamic state, since it is a representation of the object in a static form.

2.4.2. **Axonometric Projections:**

An axonometric projection involves three forms of pictorial drawings: (1) isometric, (2) dimetric, and (3) trimetric drawings. The first type is the most commonly used while the other two are rarely used by hand, but are extensively used in computer generated drawings in which the object can be rotated until the most descriptive view is achieved.

In isometric projections, the lines are foreshortened in a mathematical proportion (30°-60° angle). This can be obtained graphically by any one of four methods: rotation; auxiliary views; direct orthographic projection from properly placed orthographic views; and by the use of an isometric scale. Computer-generated 3D objects are sometimes constructed in this form before they are rendered in sequences and animated.

2.4.3. **Perspectives**

A perspective is the form of a pictorial drawing that most nearly approaches the picture as seen by the eye. Because of the accuracy of its picture to the way the eye perceives the object, it is used more often as a design visualization tool. Dobrovolny et al. (1984) observed that when a person looks at an object, the eye focuses the visual rays from the object so that the picture is formed on the spherical rear surface of the eye known as the retina. Although this method has a lot of potential for evoking an accurate perception of static objects to the observer, it is deficient for representing the interaction of objects and viewer in a dynamic state.

Until the development of perspective, the main representations used in architecture were plan and elevation. Perspective representation offered a means to explore architectural space, providing its most complete visual simulation. The development of perspective brought about an identity relation between vision, nature, and geometry. The first theories on perspective centred on the idea of a man-made world of buildings, monuments, people, animals, and landscapes, simplified, decomposed, and described through geometric entities such as lines and points. It established a mapping between the physical world and the geometric universe.

In the 17th century Descartes posited that a point, line, or surface could be coincident to numbers. This reduction of images to points, and points to numbers or coordinates through mapping leads to virtual reality in the computer age. This representational history was realized with difficult processes and media: from graphite, ink and colour pigments to the phosphorous or liquid crystals of the computer screen.

The construction of perspective involves vision, the physical world, and its representation. The physical 3D world can be described through Euclidean geometry. However, the geometry that better explains perspective principles as geometrical properties of vision is Projective geometry. From Leon Batista Alberti's treatise on painting: "Della Pittura" to modern day VR, the matrix principles of transformation of 3D coordinates into 2D perspective projections still provides the foundations for any realistic computer visualization of 3D objects.

The key axiom in Alberti's treatise is that the size of a represented object decreases proportionally with the orthogonal distance of the actual object from the observer. Filippo Brunelleschi demonstrated the validity of perspective in representing architectural scenes with the painting of the Cathedral of Florence. This experiment represented a sort of renaissance virtual reality (Bertol and Foel 1997).

In perspective rendering, the bridge between representation and reality is connected to the bridge between reality and ideas. Perspective also brought about the issue of the validity of geometric interpretations of nature. Its introduction and geometric value demonstrated that Euclidean geometry was not sufficient for the complete understanding of reality.

2.4.4. **Computer Modeling**

Bedard et al. (1992) define computer-based design as a search process to find a solution that satisfies a set of constraints defining the problem context. He classifies the basic problem types as (a) parametric, (b) configuration, and (c) conceptual or preliminary. These models use constraints, either explicitly or implicitly, for evaluating design parameters, and for formulating and generating design alternatives.

Because of the nature of community design, architectural judgment is required in order to optimize the various conflicting subsystems. Community design judgments could be method-oriented. This is a rational and evolutionary process embedded in professional contexts and using professional criteria. It could also be process-oriented. The major phases being those of analysis, synthesis, and evaluation of the design project.

However, decision making is not synonymous with thinking patterns, it is an outcome of such patterns (Goldschmidt 1992). Design cognition is thus included here, as a means of understanding and evaluating design processes.

When designing for users, two issues should be considered:

- How best to represent knowledge about human response; and
- How that knowledge can best be introduced into the design process.

Steinfeld (1992) proposes two basic approaches to representing knowledge in evaluative and predictive methods. The first approach is to provide a checklist of norms or rules for the design. The second is of provide a model of behaviour. This modelling approach to knowledge representation and the conversational approach to knowledge integration combine synergistically in a concept described as 'the artificial user'.

2.5 Virtual Reality (VR) System

"A VR system consists of a computer-generated model, a stereoscopic display, a device to interact with the computer-generated world, and the software that orchestrates all the components" (Bertol and Foel 1997). It is a computer-generated world involving one or more human senses and generated in **real-time**[2] by the participant's actions. The participant, rather than the viewer or user, in a virtual environment is the perceiver and creator at the same time. Its success depends on a sense of "presence" (that is, the perception that the participant is actually present in the virtual environment). The participant must feel a sense of immersion.

VR sophistication ranges from low-end systems, which display a monoscopic perspective view of the simulated world with very basic movement capabilities through its environment, to high-end systems, with tracking devices that can detect a participant's head and limb movements. The display device in high-end systems has the capability of providing stereoscopic images in an immersive environment. Some of the VR system components are discussed below.

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[2] The almost instantaneous response time between the time data are fed into a computer and the time a solution is received.

2.5.1. Tracking Systems

Conventional tracking systems for communicating a participant's position and movements include magnetic trackers, created with coils of wire, to optical tracking systems, based on infrared LEDs (light-emittent diodes) mounted on a ceiling for flight simulations, and ultrasonic tracking systems that are based on ultrasonic transducers and microphones.

2.5.2. Control Devices

1. ***Keyboard and Mouse:*** The most primitive devices for a virtual world. They use the arrow keys to assume the function of navigation in directing the viewpoint of the participant forward or backward, right or left, and up or down. The mouse can be used in a slightly more advanced way than the keyboard to control the participant's movement. It can be expanded to a 6-degrees-of-freedom (DOF) option that allows interaction with the virtual environment using six degrees of freedom in the participant's hand movement.
2. ***Wired Glove:*** This allows the participant to communicate with the virtual environment with hand gestures. Wired gloves can be used for CAD/CAM and other applications.
3. ***Wand:*** Wands allow the selection of a command in the VR environment by pointing in the direction of a selection area. In a site planning simulation, pointing to a certain area in the site and clicking on a button will implement the navigation toward that position.
4. ***Tread Mill:*** This navigation device provides the optimal navigation system for architectural environments that are best evaluated by the action of walking.
5. ***Biological Signals:*** Devices based on myoelectric signals that recognize muscular activity. The VR software then transforms this body movement into an action in the virtual environment.

2.5.3. Visual Display Systems

1. ***Head-mounted Display*** (HMD): The use of HMD provides a complete immersion of the participant in the virtual world. The essential components of an HMD include a display image source and an optical system. (Barfield-Furness 1995). It also incorporates a tracking system to detect the position and orientation the head, and thus the eyes of the participant.

2. ***Binocular Omni-Orientation Monitor*** (BOOM). BOOM is another type of head-worn visual device that uses a counter-weighted boom to eliminate the weight and ergonomical problems of HMD. Because this tracking device for detecting the position and orientation of the participant is more accurate than conventional HMD's, the time delay between head movement and image generation and display is dramatically shortened.

3. ***Projections:*** Projected displays represent the alternative to head-worn devices. The projection screen becomes a window open on the virtual world. The scale of representation is close to the human scale.

4. ***Cave Automatic Virtual Environment*** (CAVE): CAVE is one of the most sophisticated VR applications. The high resolution of the projected images and the large scale of its immersive theatre provide the optimal envitonment for scientific evaluations.

5. ***3D Glasses:*** 3D glasses add stereoscopic viewing to the images displayed in the computer monitor or on the projection screen. Stereo glasses come with ultrasonic head tracking and require stereo read signals for synchronization.

6. ***Retinal Display:*** Virtual Retinal Display (VRD) projects a computer-generated image on the retina of the participant's eye. In this system, no real image is ever produced. What is seen is an image that is directly on the retina of the user's eyes.

2.5.4. **Haptic Systems**

Haptic systems are used to provide the sensations of the feelings of touch and vibration, provided by cyclic movements. In this system, electronic signals are converted in the activation of tactile sensations to generate the sensation provoked by "grabbing" an object in the real world. One example of this system is ***Force-feedback***. Force-feedback can be used to create the sensation felt by a participant when an object is grabbed, or if an object collides with static objects such as walls, floors, ceilings, etc. Force-feedback is incorporated in digital gloves and robotics arms, and used for both high-end and low-end VR applications.

2.5.5. **Audio Systems**

Sound systems in VR map three-dimensional space of the virtual world to different sound sources that have been assigned specific 3D locations. Current VR systems usually provide monophonic sound, which can be complementary to the visual rendering but does not provide a realistic simulation of sound perception (Bertol and Foel 1997: 113).

The VR system developed for this research involves only the use of projected displays and computer-generated displays with the aid of control devices such as keyboard and mice. The computer monitor domain was used for cyber-participants because they cannot have access to the display equipment that is available in the Faculty of Architecture. A trade-off was made between the attainable level of immersion and the flexibility of being able to complete the survey in the comfort of their homes, but it was discovered that this would not have significant impact on the outcome of the research (Chapin 1996, Bertol and Foel 1997).

2.6 Sustainable Community Design Features

Discussed below are 34 visually analyzable features from the 154 design features presented by Perks et al. (1996). The discussions are limited to the definition of the features and how they can be implemented within the context of sustainable community design. The discussion was made under 7 design categories or design parameters. The categories include: (1) building ecology, (2) landuse and landscape ecology, (3) community design, (4) energy, (5) water and sewage, (6) transportation, and (7) waste recycling.

2.6.1. Building Ecology

1. Natural Ventilation:

Natural ventilation provides both comfort and health to indoor environments. When an indoor environment is naturally ventilated it results in both capital cost and energy savings and reduces the need for mechanical ventilation and air conditioning systems. It serves to maintain acceptable indoor air quality by replacing indoor air with fresh indoor air. It provides thermal comfort, and cools the building at night by allowing the building to act as a heat sink during the day (nocturnal ventilative cooling).

2. Daylighting:

Opening up a building to maximum daylighting helps to reduce the energy demands of a building and to create healthier interior environments. Electric lighting accounts for approximately 25 per cent of the total electrical energy used in buildings. A goal of sustainable home design is to reduce the electric lighting requirements wherever possible. As a design feature, the use of daylighting within a building produces a more pleasant and stimulating atmosphere for its inhabitants.

Generally, south, east and west facing windows can be controlled for good daylighting while north-facing windows can provide uniform daylighting without controls. Because different wall orientations receive different amounts of sunlight throughout the day and throughout the seasons, optimal window design will differ for each orientation as will the lighting controls. Daylighting strategies must consider heat gain, glare, variations in light availability and solar penetration. These are addressed through aperture size and spacing, use of shading devices, type of glazing materials and their surface reflectance characteristics.

3. Atria and Solaria:

Atria are open or glazed top-lit interior spaces within or between buildings, varying in size and configuration. Atria have been incorporated in northern climates to provide mediating spaces – to bring the natural environment within the proximity of building inhabitants. Solaria are glazed smaller-scale rooms typically attached to dwellings at grade or on balconies.

Atria and solaria are multi-functional and they provide a range of functions from providing daylighting and cost-efficient passive solar heating to providing a transitional space between indoor and outdoor environments. They are subject to daily and seasonal variations in temperature and solar exposure and require solar controls to provide comfortable living space.

4. Smaller Unit Sizes (Perks and Wilton-Clark 1996, Alexander 1977):

Smaller unit sizes are designed to make more efficient use of interior spaces while retaining solar and ground access. In turn, these are linked with smaller lot sizes that help to create more compact, efficient and affordable residential development. Net densities for smaller unit sizes range from 7 to 14 units per acre.

The benefits include: lower impact on the natural environment, more compact and accessible neighbourhoods to promote sense of community, potential for public transit integration, reduced infrastructure expenditures, reduced costs for materials and construction, and reduced servicing, maintenance energy expenditures (life-cycle costs).

5. Low Rise Cluster (Alexander 1977, Newman 1980):

Low-rise cluster dwelling units are also responsive to the changing social and demographic profiles of household arrangements. These include townhouses, row houses and condominiums with or without direct access to private yards. These housing types have been growing in number as land costs increase and as people seek new ways to build community. Low-rise clusters are flexible, and may help to achieve some level of landuse efficiency. The organization of low-rise clusters is adaptable to urban as well as to rural settings. Net densities for low clusters range from 14 to 36 units per acre.

2.6.2. **Landuse and Landscape Ecology**

1. Preserving Buildings and Cultural Environments:

Preserving buildings of value is an important method of recycling the built environment while, at the same time, enhancing a community's sense of culture, history and place. It is a method of tracing and documenting a community's history and evolution. Preservation is important for reducing building material waste and providing multiple-use spaces, for community involvement in public institutions and for educational or interpretive purposes.

2. Neighbourhood Gardens:

In sustainable communities, areas of land are set aside for food production for the local neighbourhood. These allotments contribute to residents' nutrition, they contribute to the reduction of household costs, and they engage the residents in productive activity, in education, and in community support. These gardens can transform unproductive, vacant lots into productive areas. However, they should incorporate organic techniques, such as manure from compost sites.

3. Greenhouses:

Greenhouses extend the season for local food production year-round. Greenhouses support the local economy, reducing expenditures on imported goods, and offering community employment opportunities. They take advantage of alternative energy sources (solar) and they provide a source of compost materials.

4. Community Agriculture:

Parcels of community land should be dedicated to the production of food as opposed to industrial, recreational or residential development. These landscapes are important for energy and nutrient cycling. It should incorporate organic farming techniques in order to decrease food import costs and provide opportunities for local employment. Community agriculture includes livestock and grains, vegetables and fruit production as a way of increasing the cycling of energy and nutrients. Excess produce is used as animal feed and animal waste is utilized as organic fertilizers.

2.6.3. **Community Design**

1. Residential Intensification and Sprawl Reduction:

Residential intensification supports the creation of new living accommodations within existing neighbourhoods and communities. It has the potential to revitalize urban and suburban contexts and accommodate a diverse population that includes the young, the elderly and the disabled. The intent is to make suitable use of under-utilized and vacant buildings and sites. It helps to achieve more efficient use of land and infrastructure, create a sense of community, reduce energy demands, reduce real estate and housing costs, and, reduce development demands on new lands.

The goal of sprawl reduction is to limit low-density suburban development on the periphery of towns and cities. The objective is to balance developed and undeveloped lands through an integrated approach within a well-defined and limited development area.

A sustainable growth strategy for the suburb recognizes rural and natural functions and land uses together with urban functions such as transportation, employment, the availability of mixed use areas, housing and other integrated components of community design. It attempts to protect undeveloped lands through a planning and design strategy that considers growth as well as the carrying capacity of the land.

2. Streetscapes and Spaces between Buildings (Calthorpe, 1993):

Sustainable community design encourages streetscapes that support pedestrian traffic in addition to vehicular movement. Streetscapes provide protection from the `elements' and encourage outdoor interaction among residents.

Pedestrian oriented development provides a separation between pedestrian and vehicular traffic by using plantings and other buffers to define the boundary between two traffic networks. Streets are designed to accommodate pedestrians and cyclists. Road widths are reduced for vehicular traffic wherever possible such that vehicular speed is reduced. In addition, variation of architectural detail, building form and siting as well as landscape elements are necessary to provide visual interest and a positive sensory experience for pedestrians (Lennard 1995).

3. Sense of Identity and Place (Alexander, 1977):

A community's sense of identity stems from an understanding of context - of its natural surroundings and the related processes of settlement. The careful planning and design of community places is dedicated to the consideration of local aspects as well as global issues that influence the particular region and are expressed in its collective built form.

Creating 'places' requires the recognition of the geographic and cultural characteristics of the site and the need for social integration. More specifically, sustainable communities strive to preserve existing ecosystems that support wildlife habitat, the bio-diversity and natural beauty of the site, to preserve and restore historic sites and buildings, and embrace changing societal values and technological advancements in a manner consistent with the established 'genius loci' (Lennard 1996).

4. Condensed Lots:

The use of condensed lot configuration has increased in suburban communities because of the need to: (a) use land more efficiently, (b) reduce the costs of infrastructure, and (c) promote a stronger sense of community. Condensed lots typically increase single family detached housing lots from 4 dwelling units per acre to 8 dwelling units and above per acre, while retaining the privacy and livability common to detached housing.

Methods for achieving this include the use of reduced frontyards and setbacks, incorporating two storey, rather than one-storey buildings in parts of the community, reducing the building 'footprint', and carefully landscaping undeveloped buildable residential land. Undeveloped land can thus be used as nature reserve, community gardens and/or open space and parks.

5. Related Clusters:

Cluster development is a flexible residential planning concept that can take a number of forms and is adaptable to a range of household types with related social, economic and ecological benefits. The concept, which is based on an aggregated housing form of varying composition and scale, is cross-cultural and has been used over many centuries.

In the 1970s, cluster developments were promoted in North America as "Planned Unit Developments" (PUDs). Related clusters, which typically can achieve 20 dwelling units per acre or more, are an aggregated housing form that are designed to make more efficient use of land resources, reduce energy consumption, and integrate building life-cycle management. They are also designed to provide increased solar access and wind protection, reduce local environmental impacts, reduce infrastructure, and create a sense of community and social integration.

6. Mix of Housing Sizes and Types:

The sustainable community integrates housing of mixed sizes and types appropriately within the overall community design to respond to a range of household and tenure types that reflect societal needs. Integration, as opposed to segregation, is an objective of sustainable communities. The goal is to accommodate individual and community needs and aspirations, by providing structures that promote this accommodation.

Housing types such as single family, detached, cluster, town houses, low rise apartments, secondary suites, shared housing, collective living, work/studio, and care/service housing, which are common to urban settlement, are merged in the overall community design. The structure of the community is such that higher density housing types are located toward the centre of the community and lower density housing types toward the periphery. Mixed housing encourages community diversity and provides an opportunity for closer social contact among a wide range of community residents.

7. Shared Facilities and Common Buildings:

The sustainable community promotes interaction among residents through the use of shared facilities and common buildings. These can include neighbourhood-recycling centres, senior and youth centres, daycare facilities, workshops and hobby spaces, and shared cooking or dining facilities.

Community arrangements that support shared facilities and common buildings vary from condominium associations to housing cooperatives and co-housing developments. Community owned and operated amenities help to reduce individual reliance on consumer products and thus reduce the cost of living while providing a higher quality of life.

8. Social Spaces:

Social spaces encourage informal contacts between individuals and groups in both indoor and outdoor settings. They are seen to be important to the advancement of individual and societal well being. Essentially, these spaces are those that are associated with the public or semi public realms of urban settlement. In a sustainable community, social spaces are planned and designed to promote community interaction and facilitate the programming of neighbourhood events and functions. They are open to the public wherever possible to foster civic values in the community and beyond. They include common rooms and shared facilities as well as local gathering places such as community recreational facilities.

9. Mix of Households and Tenancy Types:

Demographic and socioeconomic diversity is an important ingredient for realizing sustainable communities. Diversity is realized through the mix of household types which includes singles, couples, single and dual parent families, and extended families. In a sustainable community, housing is planned and designed to accommodate residents of all ages and orientation including the young, elderly, and the disabled.

A variety of tenancy types should be provided to reflect the socioeconomic diversity of a community and to advance social integration. These include privately owned housing types, condominiums, rental housing, apartments or suites, co-operative housing, and co-housing. An important goal is to provide a range of affordable housing types without sacrificing related amenities for the whole community.

10. Mixed Uses in the Community:

Diversity is key to sustainable land use. A sustainable community endeavours to promote multi-functional rather than mono-functional settlement patterns by providing compact urban centres with a broad range of services and amenities in close proximity to each other. These amenities and services include commercial and retail shops, schools and daycare, health care, and live and work housing units.

Mixed-use developments should be enhanced by compact design. A compact core with mixed-use developments reduces the tendency for a deserted core after business hours, by providing sources for continuous activity on the street. Increased street activity enhances real and perceived safety needs (Jacobs 1961, Alexander 1971). Providing for the needs of a community at the neighbourhood level reduces the need for vehicular and public transport, thereby decreasing demands on infrastructure and energy resources while promoting pedestrian accessibility and a sense of community.

2.6.4. **Energy**

Conserving energy by recycling the by-product of energy generation to provide alternative heating source for households is at the heart of sustainable community design.

Discussed below are some of the techniques and strategies for achieving efficient and sustainable energy supply and distribution for a community.

1. District Heating:

District heating refers to the practice of generating steam or hot water heat at a central location and then distributing it through a series of pipes to homes and businesses within a local district. District heating can provide economies of scale not possible through individual heating sources (i.e. the home furnace). By twinning district heating facilities with local electricity generating plants, low emission standards can be set when compared to the emissions that are generated by each process alone.

2. Area Zoning/Cold Buffer:

A buffer is created between the exterior and interior temperatures when the outside entrances of a dwelling are separated from the main interior living spaces with vestibules and atria. This buffer can reduce energy consumption by minimizing the heat lost or gained through direct contact with the outdoors.

Generally, the areas to be closed off occur at the periphery of the building, especially around the fireplace. The compartmentalization of living spaces allows for the subdivision of components necessary for comfortable living conditions, while at the same time minimizing energy expenditures. By compartmentalizing the different living areas within the home a zoning system is set up which will limit the amount of energy used to heat or cool living areas that are not in use.

3. Co-generation:

Simultaneous production of heat energy and electrical or mechanical power from the same fuel in the same facility is possible through co-generation. Waste heat from the steam generated in an industrial process may be used to produce electricity. Steam from electric power generation may also be used as a heating source.

Co-generative heat production is an example of the constructive use of the by-product of one energy process as a resource for another. Co-generation is now feasible at the local neighbourhood scale due to the availability of low temperature district heating derived from natural gas fired engines (Perron et al. 1998).

2.6.5. **Water and Sewage**

Water recycling and reuse for non-potable domestic purposes helps to reduces the cost of water usage to individual homeowners. Sewage treatment and recycling reduces the volume of greywater that is channeled through municipal sewer mains for treatment or disposal. In the following section some strategies for water and sewage recycling are discussed.

1. Storm Water Retention

Storm water retention ponds are utilized primarily as a way of easing the pressure on the street sewer drain system during a heavy rainfall. The ponds typically hold water throughout the year, collecting water during a storm and releasing it slowly after the peak flow has subsided. This slow release, typically over a period of days, reduces the need for storm sewers to be sized for maximum potential peak flow. It thus helps to reduce infrastructure costs (Perron et al. 1998).

The water can be used for irrigation and to provide urban habitat for migrating waterfowl. It may also marginally increase the moisture levels in the city through evaporation. This will contribute to the development of many sites within the community into aesthetically pleasing active or passive recreation areas that complement housing development.

2. Permeable Surfacing

Much urban land is covered with generally impermeable surfaces such as concrete, asphalt or built structures. Rain, surface water and runoff are often channeled to catch-basins and drained away through closed pipe land drainage systems. In low traffic areas, gravel roadways and pads or turfstone -- concrete blocks with spaces to allow for vegetation to grow through -- can be employed to inject moisture into the soil. This will help to replenish ground water supplies and distribute nutrients usually lost in the urban environment. Whereas geotextile fabric, with dense plantings on slopes, can prevent soil erosion and still allow water to soak into the earth; the use of hard surfacing will only drain water to other areas.

2.6.6. **Transportation**

The structure of a community's streets, and the connection or separation between different types of traffic patterns in the community, contributes to the efficiency of traffic movement and the safety of the streets. Some of the strategies for sustainable transportation planning and design are presented below. They are discussed in detail with illustration in a paper submitted for review by the *On-Line Planning Journal* of the University College, London in the United Kingdom.

1. Street Design:

One of the goals of sustainable community design is to reduce the dependence on automobiles and encourage alternative modes of transport. The key to this approach is to integrate transportation with land use planning and focus on 'accessibility' rather than on 'mobility'. In a sustainable-designed community, street widths are narrow, pedestrian-friendly and connected.

Increased numbers of intersections are encouraged within a denser urban fabric. Services and community amenities are made accessible within walking distance. To achieve this, community amenities such as local grocery stores, parks and recreation areas, bus stops and transit centres, commercial and retail markets, educational facilities, and social and cultural centres should be provided at a maximum of 5-minute walking distance (approximately 450 metres) from residences (Calthorpe 1993).

2. Reduced Street Width:

The size of an urban block and the connectivity of the street network in relation to the intensity of land use, determine the width of interconnecting roads. A clear strategy for achieving this is to reduce the amount of land dedicated to streets (lanes) and street rights of way in residential and other urban areas. By reducing the number of lanes dedicated to vehicular traffic, land could be recovered for pedestrian paths (Calthorpe 1993).

Reduced street widths can make streets more intimate in scale and provide more space for landscaping, cycling and for sidewalks. Street widths in conjunction with design speeds and number of lanes should be minimized. At the same time pedestrian and cyclist safety should not be compromised. Street lanes could be reduced from 3.75 metres to 2.5 or 2.75 metres and parking lanes could be reduced from 3 metres to 2.5 metres. Vehicular travel speeds should be reduced from 50 km/h, for example, to 30 km/h. There is evidence in the literature that there is no significant time gained by traveling faster than 30 km/h within a community (Appleyard 1981, Lynch and Appleyard 1976).

3. Reduced and Consolidated Parking:

A goal of the sustainable community is to reduce automobile dependence and accommodation vis-à-vis the parking lot. Parking lots come at a significant cost in terms of land and material resource depletion, maintenance, and pollution. Parking lots should be consolidated to reduce the disruption of public space and visual blight. Easy access and availability of free parking discourage ride sharing and transit use and add to traffic congestion (Appleyard 1981, Perron et al. 1998).

4. Public Transportation:

Public transportation is a very important component of a sustainable community. It helps to reduce congestion and improve traffic flow, reduce air and land pollution, reduce infrastructure expenditures in terms of energy, construction and maintenance, and reduce the dependence on non-renewable resources.

Public transportation should be encouraged through the development of efficient, frequent, safe and accessible public transportation services. Public transportation systems should help to guide or to determine the structure of a sustainable community. Additionally, proposed community planning and design should include public transportation options such as buses and light-rail systems together with vehicular, bicycle and pedestrian modes of transit.

5. Pedestrian Network:

Pedestrian networks serve as the primary link to all community functions including residential areas, places of employment, commercial areas, recreational areas, schools, civic institutions, public spaces, and squares among others. Pedestrian paths and sidewalks should be incorporated on all streets. They may be complemented with pedestrian only or with pedestrian and bicycle paths through the community.

Pedestrian networks should be designed to be safe, secure and comfortable and to contribute to the aesthetic character of a community. They should help guide or determine the structure of a sustainable community, over and above the needs of vehicular traffic and should be linked with the public transportation system. Pedestrian pathways should be clearly defined and sheltered by built form, landscaping and lighting.

6. Bicycle Network:

Bicycle networks serve as a vital link to all community functions including residential areas, places of employment, commercial areas, recreational areas, schools, civic institutions, public spaces, and squares among others. By reducing the number of lanes dedicated to vehicular traffic, land could be recovered for bicycle paths. They should be designed to be safe, secure and comfortable and to contribute to the aesthetic character of a community.

Bicycle networks should help to guide or to determine the structure of a sustainable community, over and above the needs of vehicular traffic, and should be linked with the public transportation system. Bicycle networks can be integrated with pedestrian and vehicular modes of transportation, although segregated bicycle paths should be considered as well.

7. Universal Access:

The goal of providing universal access in a community is to make it inclusive rather than exclusive. All public areas and transportation systems should be accessible to everyone all of the time. This includes public spaces, buildings, products and services. Integrating universal access in all forms of transportation is a goal of sustainable community design.

Universal access relies on lighting, signage, auditory signals, surfaces and barriers to help orient and direct individuals. It must also recognize a broad range of users including the physically and mentally handicapped, as well as the young and the old.

All buildings and public open spaces in a sustainable-designed community should be easily accessible to all members of the community. Attention should be directed to the planning and design of external areas, parking and pedestrian ways, stairs, ramps, lifts, signage, emergency exit routes, interior spaces, and street furniture. Disabilities vary including mobility, and visual and auditory dexterity, among others. Disabilities generally increase in correlation with age. This phenomenon is reminiscent of the Canadian demographics. A commitment to "barrier free" design demonstrates an inclusive attitude, acknowledges interdependency of people within the community, and fosters the spirit and strength of an integrated community.

8. Traffic Calming:

Traffic calming is a design strategy to reduce and to slow down all forms of traffic within residential areas in order to provide a larger measure of safety for residents of all ages. It is also a way of making streets more attractive and a way of increasing the quality of life in the community. This concept was developed in Europe. In Holland, it is called a 'woonerf', which denotes 'living yard'. The woonerf is a shared street, in which pedestrians have the right-of-way and vehicles have to respect the human setting dedicated to walking, cycling and children playing (Appleyard 1976 p. 191).

Typically, the design includes the elimination of curbs, changes in paving, and the incorporation of bollard barriers, shrub and tree planting, and street furniture. Traffic calming design strategies should be integrated throughout a community, otherwise they tend to divert and increase vehicular traffic on adjacent streets.

9. Minimize Noise Disturbance:

Noise is generated primarily by vehicular traffic along surrounding arterial roadways and along roadways within a community. Rail and air traffic can also contribute to the problem of noise in the community. In all cases, measures should be taken to prevent or reduce noise levels in a community through careful planning and design. Optimally, noise-generating sources should be isolated away from communities as in the case for rail and air traffic.

Noise reduction strategies include: (a) the location of arterial roads to the periphery of a community and away from residential areas, and (b) reduction of vehicular speeds and access within a community. They also include: (c) careful orientation of housing and built form, and (d) construction of berms, acoustic fences or extensive planting between arterial streets or rail lines that are adjacent to the residential community.

2.6.7. **Waste and Recycling**

The success of sustainable living in a community depends on the commitment of its residents to waste recycling and composting practices, and the sorting and reuse of reusables. Some strategies reviewed in the literature are presented below.

1. Waste Separation Area in the Local Community:

Depots should be provided for separation of recyclable items that will be picked up in bulk at a later date. Items may be put aside for reuse or items currently not being recycled may be stored until they are needed. Communities should also implement centralized collection areas within walking distance from residences, thus reducing energy requirements associated with the removal of recycled products.

2. Household Separation and Composting:

Reuse of any packaging in the household, such as jars, boxes and bags, and the separation of any recyclable items into their different categories for pick-up from the household reduce the need to repurchase these items. Vegetable waste from the kitchen and garden are added to the household compost pile.

Community based compost areas should be established for dealing with leaves, grass, etc. Local recycling stations should be developed to encourage local redistribution of household products such as appliances, furniture, etc.

CHAPTER 3
DESIGN INTERPRETATION

3.1 Methods of Design Interpretation

Simon (1983) defines design as an intellectual activity that produces artifacts. It is a decision-making process, which requires thinking activities that result in analytical, creative, evaluative, communicative, and executive skills and modes of action. It is a multi-professional activity that is conducted in a world of practical realities to make best decisions. It requires compromises and optimization of conflicting subsystems. Therefore, it is impossible to design using rational, logical methods except for particular building parts or units, which lend themselves to such approaches.

Design may also be considered as a process of transformation of presentations from one form of abstraction to another (Oxman, 1992). Oxman's model for design interpretation in a knowledge-based design system maps among formal, typological, and performance descriptions. Formal descriptions include the graphical descriptions (coordinates), geometrical descriptions (geometrical elements and their attributes), and topological descriptions (the relations between elements). Typological descriptions pertain to the attributes of the type. Performance description concerns the performance attributes of the various elements.

In the process of design generation and evaluation, reasoning supports design interpretation. In order to interpret and produce new statements of knowledge from design descriptions, interpretive knowledge is required. The role of interpretation in design is to derive the properties of each alternative or successive forms of the design that may not be explicit in the design description through structured representations.

Approaches to design interpretation include the use of models. A model is simply a representation of the relevant characteristics of a reality (Arsham, 2000). It is a means of expressing certain characteristics of an object, or system (Echenique 1975). The question that the model is designed to answer will determine the selection of variables and the antecedent conditions for its operation. How the actual selection of relevant characteristics is appraised and verified is largely a technical matter. In modeling, theory provides the empirical or normative premise or foundation on which practice is based.

The seven steps listed below are crucial to the model calibration process (Krimerman 1969, Arsham 2000).

- The existence of an object, setting, or system that is of interest;
- An intention, clearly expressed, enabling the selection of appropriate characteristics of the object, setting, or system;
- The development of a theoretical basis for expressing and selecting appropriate characteristics for the object, setting, or system;
- A process of observation and abstraction enabling the reality in question to be observed in relationship to selected variables;
- A process of translation, enabling the creation of a suitable conceptual framework for organizing factual information; and
- A process of testing and making conclusions about the congruence between the model and reality, that is, the "calibration" or the fitting of some previously determined regularity to the specific circumstances of the locale under scrutiny.
- The revision of assumptions based on observed deviations of model assumptions from reality during the testing process.

Echenique (1975) observed that a model could stand as a theory to the extent that it is a system of ideas that is held as an explanation for the phenomenon or group of facts. Hesse (1986) argued that one could distinguish between kinds of models according to their predictive powers. Theoretical models, she observed, are idealizations and are weakly predictive, whereas analogue models based on empirical data are not. Lowry (1997) concluded that the model builder is concerned with the application of theories to a concrete case with the aim of generating empirically relevant output from empirically based input. In the following sections, the theoretical foundations for the visual analysis and the procedures for design evaluation are briefly described.

3.1.1. **Descriptive Model**:

The principal purpose of a descriptive model is the explanation of phenomena in the domain of interest. A descriptive model can be used to reveal much about the underlying structure of the building or urban environment in order to reduce the apparent complexity of the observed world to a coherent and rigorous framework. To obtain a good descriptive model of an object or situation, the ratio of input data to output data must be small; the conformance of model output to direct observation must be high; and the model should be generally applicable (Lowry, 1997).

3.1.2. **Predictive Model:**

The purpose of a predictive model is to give a forecast of the temporal disposition of the phenomenon under study. It can be extrapolative (one in which the spatio-temporal change is represented by a continuation of past trends), or conditional (one in which the mechanism of cause and effect governing the change process is specified in the general form). The advantage is that the process of change, or a significant portion of it, is endogenously specified. It does not solely rely on the translation of past events into the future.

3.1.3. **Explorative Model:**

This is usually designed to allow the discovery, by systematic speculation, of realities other than the one at hand, which may be logically possible. It is applied to design situations, as case studies, for re-examining conventional practices.

3.1.4. **Planning Model:**

Planning models incorporate prediction, usually of the conditional kind, but are extended to allow for the evaluation of predicted outcomes in terms of goals. The components of planning models include the specification of alternative programmatic or design interventions throughout some course or courses of action. It involves the development of a predictive model, allowing the consequences of choosing any specified alternative to be revealed. The scoring or ranking of the consequences, revealed in the process of developing a predictive model, are carried out according to some matrices of goal achievement. In this type of model, a mechanism for making the choice of the alternative that yields the highest score must be available to decision makers.

Planning models have some problems of interpretation because they seem to be extensions beyond empirically based explanatory theory. They incorporate goals presumably based on normative positions, which are largely precluded from the idea of explanatory theory. They also seem to draw information from other sources that may not be scientifically based. Planning models tacitly assume a rational behavior pattern. Outcomes are evaluated in terms of goals, and therefore a reasonable correspondence must be struck between an expression of outcome and the expression of a goal.

3.2 Representation Techniques and Decision Making

Presented in this chapter is a discussion of the decision modelling procedure used in this thesis. The procedure discussed in this chapter is a detailed version of a paper that has been accepted for presentation at 3rd International Conference on Ecosystems and Sustainable Development: ECOSUD 2001. The paper has been edited for relevance to the objectives of this thesis. The analytical procedures discussed have been validated through other works of research (Klir and Yuan 1995, Zimmerman 1990, Zadeh 1965).

3.2.1. Introduction:

The design professions have always relied on visual simulations to explore and communicate thoughts and ideas (Zeisel, 1995). He observed that design is difficult to describe because it includes many intangible elements such as intuition, imagination, and creativity. Because the characteristics of physical phenomena are visual, images are used to represent the information distilled by the designer (Wanger et al. 1992). However, most of the images used in the sketch design phase are three-dimensional, since human beings have a predisposition to interpret in a three-dimensional context. The use of relevant representations is crucial to helping observers understand visualized objects. It has been argued that highly sophisticated visualizations could provide a level of understanding not always achievable in simpler systems (Robertson and Abel 1993).

Decision-making is not synonymous with thinking patterns, it is an outcome of such patterns (Goldschmidt, 1992). However, since design cognition is a means of understanding and evaluating design data, the more realistic is the design metaphor, the more accurate will be the judgment that results from design evaluation. Because urban spatial experience is dynamic, the methods of representing this reality should be able to capture and simulate the essence of this dynamic experience. In this thesis, urban design features are isolated and presented in alternative design scenarios using a combination of 2-dimensional and 3-dimensional imagery, QuicktimeVR and computer animation technology.

Furthermore, the determination of consumers' receptivity based on the experimentation with different combinations of sustainable community features is a multi-criteria decision-making problem (Perks and Clark 1996, Hwang and Yoon 1981, Hwang and Masud 1979, Klir and Yuan 1995). The final decision, based on the degree to which the combination of features under consideration has been satisfied by the decision alternatives, may be difficult to measure using a classical (crisp) decision-making approach. This section focuses on the Fuzzy group decision-making approach proposed by Zadeh (1965), Zimmerman (1990), and Klir and Yuan (1995). A modified version of Saaty's rating scale is used to quantify consumers' preferences from a comparison of three design scenarios (Saaty, 1980). The quantified scoring of preferences was rigorously analyzed using the fuzzy procedure proposed by Klir and Yuan (1995).

In this decision analysis, an appropriate procedure for informed decision-making includes (Zimmerman 1990):

- A modelling technique that appropriately represents the set of community design scenarios, which incorporates varying degrees of sustainable community design features;
- A set of decisions to be made;
- A relation, indicating the expected outcome from the selection of the combination of features, and;
- A utility function, which orders the outcomes according to their desirability.

The precise ordering of outcomes based on the visual assessment of design data is difficult. The decision of a preferred set of solutions consisting of a set of design features that a consumer prefers for the community in which he/she lives is made under uncertainty. Therefore, the Fuzzy decision making model is proposed as the most appropriate method for capturing the imprecision involved in selecting an appropriate combination of features that will satisfy the consumer. Perks and Clark (1996) carried out a consumer-receptivity survey using a combination of twenty-seven "sustainable" design features for the Edgemont community in Calgary. They used a descriptive procedure based on a pairwise assessment of the existing community and a proposed 'sustainable' alternative.

A similar procedure is developed in Winnipeg using a combination of descriptive and predictive modelling approaches. The test site for the Winnipeg experiment is the Whyte Ridge community – a suburban community similar to Edgemont in Calgary. The objectives of this section are to develop a decision-making-procedure based on a survey of consumers' receptivity of sustainable community design alternatives, and to discuss the advantages and limitations of the approach used as a contribution to the techniques for analyzing decisions that are based on design problems.

3.2.2. The Winnipeg Study

In the Winnipeg study, sustainable community design parameters are disaggregated into component performance features. The intent is to isolate each feature such that an assessment of consumers' preference for alternative design scenarios, which exhibits similar characteristics of the isolated feature, is possible.

In this experiment, three categories of sustainable community design parameters are considered. The categories do not contain an exhaustive list of features that can be classified as "sustainability features." They are adopted for this research because they provide a broad characterization of design categories for sustainable community design. In addition, they represent a sample of sustainable community design parameters that can be analyzed using visual metaphors. The categories include:

1. ***Community Design***

- *Land-use and Housing*: This includes features such as lot sizes and configuration, residential intensification, types and sizes of housing, and the use of common buildings as connectors.
- *The Core*: Includes measures such as availability of mixed use spaces, social spaces, and streetscapes at the centre.
- *In-between Spaces*: This involves the attention paid in design to the availability of connecting outdoor spaces such as circulation, social, and recreational spaces.

2. ***Ecologic Design***

- *Waste Management*: This includes the location and visibility of recycling centres and depots as incentive for community residents to recycle.
- *Water and Wastewater Management*: Includes measures such as opportunities for greywater reuse, stormwater recycling, and rainwater recycling in the community.
- *Energy*: This includes the availability of opportunities for power co-generation and district heating facilities in the community.
- *Local Food Production*: Includes opportunities for operating district gardens and community farms for local food production.

3. ***Street Design***

- *Circulation Network*: Includes measures such as pedestrian, bicycle, and vehicular networks and the separation of different types of traffic to enhance safety.
- *Rights-of-way*: This includes an assessment of the width of community streets at the arterial, collector, and local street levels.
- *Universal Access*: It includes an assessment of streets and public areas in regard to accessibility for all residents, especially the disabled, children, and seniors.

These parameters are used to define the analytical premise for our consumer receptivity test. Randomly selected subjects scored their design preferences based on a comparison of empirical design data and alternative design proposals.

3.2.3. Sampling Method, Sample Size and Test Procedure:

A structured modelling process is at the heart of scientific decision-making. The sampling method and the procedure for carrying out the test are important for reliability of results. Bias in data may arise due to the method of sample collection, or from the data structure itself. In this thesis, care is taken to ensure that data based bias is minimized. Below is a discussion of the procedure.

1. Sampling Procedure

A stratified random sampling procedure was used for the pre-test and final surveys (Ezeala-Harrison 1996). The benefits of using the random sampling method are discussed in Vichas (1983). In the first survey, expert subjects were randomly selected from a directory of design architects, engineers, planners, and developers in the City. This is reminiscent of an Internet-based Delphi panel. The objective of the expert survey was to establish the necessary framework for our analytical procedure and to determine if there was a significant deviation or newer facts than were obtained from the Calgary study to make our approach worth pursuing. The initial outcomes obtained revealed significant deviations that tended to validate our assumptions about the robustness of our analytical technique. The outcomes and conclusions are presented in Section 3.2.5 and 3.2.6.

The subjects for the final survey were randomly pooled from a telephone listing of householders in the Whyte Ridge area. In each of the surveys, the participants were contacted by phone to introduce the survey and request their participation in the survey. Only the respondents who agreed to participate in the survey were invited. The written invitation detailed the objective of the test and the web site address for a personal data questionnaire that each would-be subjects were expected to complete. This first information was used to sort the subjects into geographic, demographic, professional, and home-ownership categories.

2. Sample Size

Representativeness and adequacy of sample are the hallmarks of a good survey (Ircha, 1997). Green (1988) and Linstone (1975) argued that the sample size used in surveys, including questionnaires, must be representative and adequate. While Jones and Twiss (1978) suggest between 10 and 100 participants, Delbecq (1975) argues that 10 to 30 participants are sufficient for a homogeneous group. The number of subjects required for this type of survey varies from 10 to 100. Eleven design "experts" were selected to complete our pre-test (expert) survey questionnaire, and 50 householders of different professional and demographic backgrounds were pooled from a directory of householders within and around the Whyte Ridge site, for the final survey (see Section 5 for details of the testing procedure). The data obtained from the pre-test survey are analyzed using the Fuzzy decision analysis (FGDM).

3. Test Procedure

The test was a three-tier procedure. The first stage involved the development of 3 design alternatives for the community, and the preparation of a questionnaire based on 'a priori'-determined sustainable community design features. This stage also involved the development of a web-based hypermedia interface for assessing the design data. The second stage involved the conduct of a pre-test survey to assist in developing a strong theoretical foundation for the use of the decision making procedure. The third stage involved conducting a final survey with more subjects than the first to provide the required degrees of freedom and increased reliability of outcome.

4. Hypermedia Interface Development (http://www.umanitoba.ca/faculties/architecture/eco-whyteridge):

The hypermedia interface presented a split-screen pairwise display of design scenarios for each feature for each subject to view and score his/her assessment, based on a modified Saaty's rating scale (see Table 3.2.1). The interface development served as a precursor to the descriptive procedure that was used for our consumer receptivity test.

An alternative design scenario for the Whyte Ridge Community in Winnipeg was developed and embedded in graphic frames with explanatory text links. The design abstractions for each of the 22 features considered in our survey are provided in 2D and 3D formats. Photographic representations of the features were also presented to increase subjects' understanding of the issues being explored. QuicktimeVR and animation sequences were provided to assist subjects to explore some of the features in virtual space. Links were provided to text frames that contain a list of assessment questions for determining the degree of users' preference for any one of the pairwise-presented design scenarios in the community in which they live.

The VR link was provided in order to allow users to explore alternative scenarios of the features presented in virtual space. A sample of the Web interface depicting some of these features are presented below (See figs. 3.2.1 – 3.2.3.).

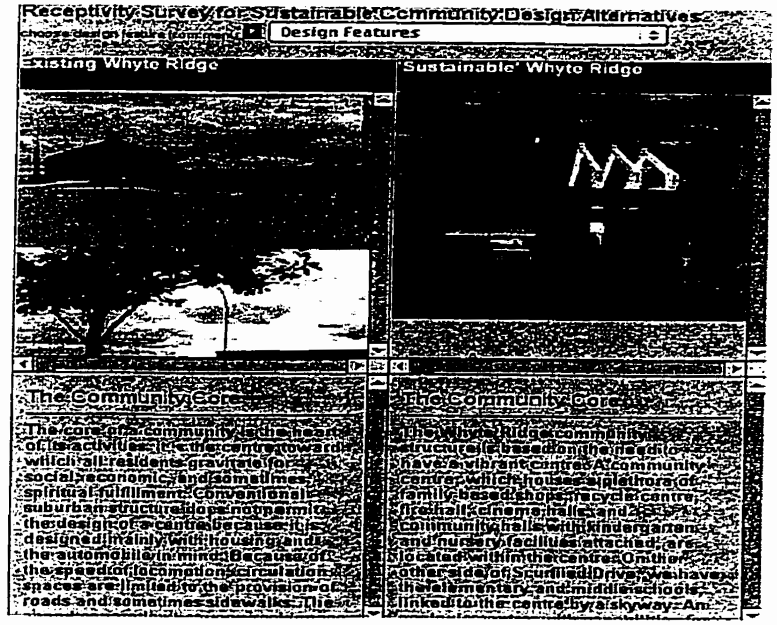

Fig. 3.2.1: **The Core**: The Community Core

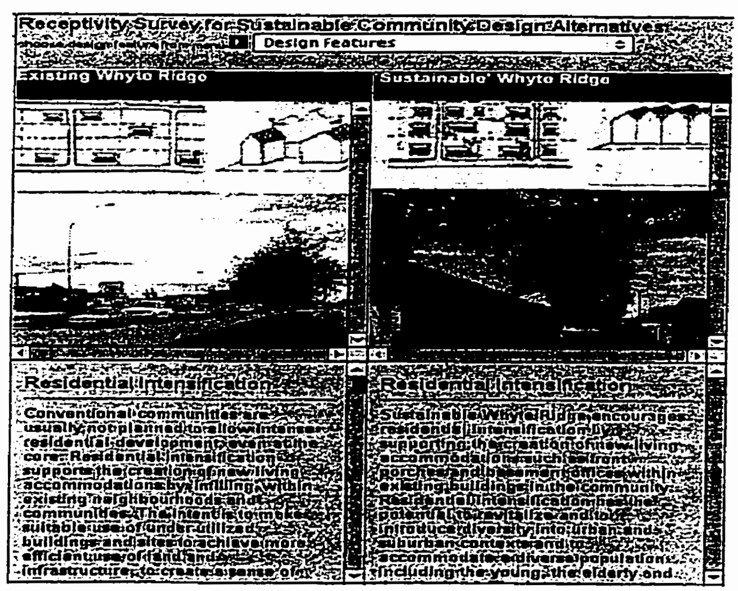

Fig. 3.2.2: **Residential Intensification**: Increasing Residential Density at the Core

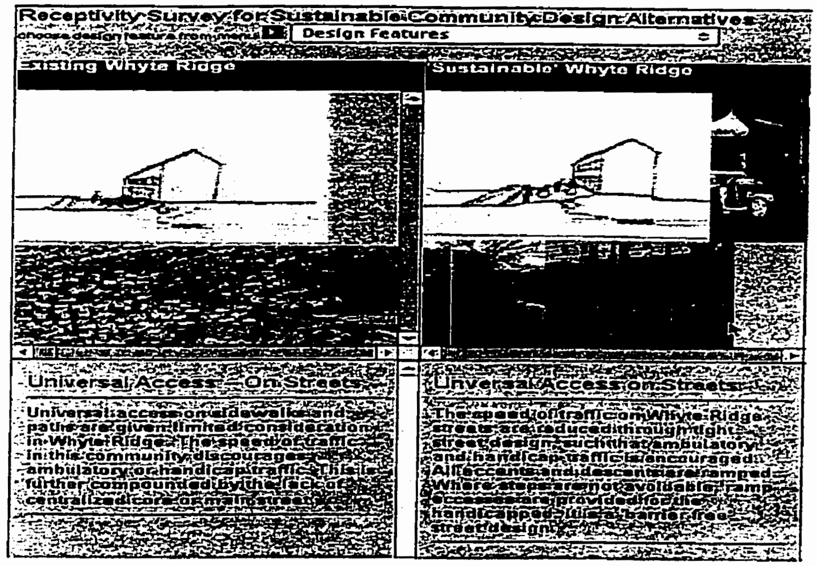

Fig. 3.2.3: **Universal Access:** Access to Public Areas and Buildings

5. Web-based "Expert" Survey:

The "expert" survey stage involved the use of a randomly selected group of 11 design professionals (3 architects, 4 urban designers/planners, 2 landscape architects, and 2 engineers), for a web-based assessment of 'a priori' stated design features and the completion of a survey questionnaire. The data used for this analysis were derived from the pre-test survey results.

An objective of the research was to determine the applicability of the fuzzy procedure to qualitative design data. The outcome of the evaluation of the data from the survey was used to establish the weights and hierarchies for the sustainable community design parameters.

In the survey, respondents were given the web site address developed for the consumers' receptivity survey. The web site contained information about the procedure for completing Web questionnaire. The data from this survey were dynamically retrieved through a CGI scripting tool known as "Gform". The "Gform" scripting protocol provided the capability to dynamically retrieve participants' response to questionnaires from a default *cgi-bin* as soon as respondents activate the "submit" button at the end of each question.

6. Analysis of Data:

The third stage of this procedure involved the decomposition of descriptive pairwise preference information into numeric data, from the preference ratings collected from subjects. The data set from the expert survey was subjected to rigorous analysis to determine group preferences using the Fuzzy Group Decision-Making procedure. The same procedure was used for analyzing the data from the final survey.

The Fuzzy Group Decision-Making technique was used to analyze the allocation of preference values by "expert" subjects. The fuzzy technique, by revealing the degrees of preferences of individual subjects, assists decision-makers to determine the most preferred criterion by the sample, and the degree of preference for each decision criterion. A hierarchy of criteria and decision alternatives, based on their weights (eigenvectors), was then established. Saaty's eigenvector procedure was used to determine the priority rating for three representation techniques.

Saaty's scale was modified because proper discrimination between its nine-point ratings was found to be too cumbersome for survey participants. Its cardinal ratings were found to be appropriate enough for capturing the extent of consumers' preference ordering because of the distinctiveness and clarity of the 5-point rating system. This observation agrees with arguments in the literature that although a 7-to-10-point scale seems to gather more discriminating information, respondents do not actually discriminate carefully enough when filling out questionnaire to make their use valuable. The use of a 4- or 5-point scale was thus recommended as a more appropriate option (Arreola 2000, Frary, 2000, Galloway 1997). The rating parameters are presented in Table 3.2.1.

Table 3.2.1: **Preference Scale used for the Pairwise Assessment of Design Features.**

$f(d_i, d_j)$	Preference for feature d_i with respect to d_j
1	Equally preferred
2	Moderately preferred
3	Strongly preferred
4	Very strongly preferred
5	Extremely preferred

Table 3.2.2. **Glossary of Notations**

$d \in D$	Element d belongs to crisp set of decision alternatives D
r_{ij}	Matrix
$\langle d_1, d_2, ..., d_n \rangle$	Ordered *n-tuple* design alternatives $d_1, d_2, ..., d_n$
D^2	Cartesian product $D \times D$
$R(D, D) \subset D \times D$	Relation on D by D is wholly contained in a D *by* D matrix
$\sum$	Summation
$[D, D] \rightarrow [0, 1]$	Function from $[D, D]$ to $[0, 1]$
$\min(a_1, a_2, ..., a_n)$	Minimum of $a_1, a_2, ..., a_n$
$\max(a_1, a_2, ..., a_n)$	Maximum of $a_1, a_2, ..., a_n$
R	Set of all real numbers
N_n	Set of $\{1, 2, ..., n\}$ natural numbers
R^+	Set of all positive real numbers
Crisp Set	Classical (nonfuzzy) set
$[0, 1]$	The closed unit interval in a fuzzy set that represents the extreme boundaries of the values assigned to the total denial or affirmation of the membership grade of the given fuzzy set. The value, "x is a member of a" (denoted by $x \in A$), with boundary values $[0, 1]$, is not necessarily a *true* (with value 1) or *false* (with value 0) scenario, it is a representation of the linguistic term "it may be true only to the degree that x is a member of A."

3.2.4. **Fuzzy Group Decision Making Analysis: Theoretical Basis and Application**

The formulation of sustainable community design criteria falls within the category of decision problem where the vagueness and non-specificity inherent in human formulation of preferences, constraints, and goals are present, because of the nature of judgments that are often made in the assessment of visual data. A discussion of the theoretical basis for applying the Fuzzy Sets theory and a sample application to the research data obtained from one of the consumers' receptivity surveys is presented. Some of the terms and symbols used in this discussion are also defined in Table 3.2.2.

1. Theoretical Underpinnings of Analytical Procedure

Fuzzy sets are sets with boundaries that are not precise (Zadeh, 1965). The membership of a fuzzy set is not a matter of affirmation or denial, as in probability statistics, but a matter of degree of membership. Probability theory requires a high degree of randomness. It is applicable to problems that are clustered around the two extremes of complexity and randomness scales. However, most life problems are somewhere between these two extremes.

It has been argued that probability theory is only capable of representing one of several distinct types of uncertainty, that is, the types with known probability distributions (Zadeh 1965, Yager, 1979, Zeleny 1991, Klir and Yuan 1995). 'A priori' data, as well as the criteria by which the performance of man-made systems is judged, are far from being precisely specified or having accurately known probability distributions (Zadeh, 1962). The Fuzzy Sets theory introduces concepts for bridging the gap by dealing with the imprecision, non-specificity, vagueness, and inconsistencies that characterize most qualitative data.

In a condition of risk, when the only available knowledge concerning the outcomes of a decision-making problem consists of their conditional probability distributions (one for each action), the decision-making problem is an optimization problem of maximizing the expected utility of outcomes. However, when the probability of outcomes is not known, or may not be relevant, and outcome could only be characterized approximately, decisions are said to be made under uncertainty or "fuzziness" (Klir and Yuan, 1995).

For example, let us assume that we have a decision problem involving the determination of the sustainability of a number of community design alternatives from the consumers' point of view. This is a multi-criteria decision problem in which each member of n individual decision-makers (consumers) is assumed to have a reflexive, antisymmetric, and transitive preference ordering $P_k \in N_n$ which totally or partially orders the set of design alternatives.

where: P_k is the fuzzy preference ordering by each decision-maker (DM);
$N_n = \{1, 2, ..., n\}$ denotes the set of n natural numbers representing each DM's preference ordering; and
n denotes the number of DMs involved in the decision-making problem.

An analytical technique that can effectively capture these orderings is the Fuzzy Sets procedure. The Fuzzy Sets technique is a method for solving a decision problem in which decisions are made under uncertainty (Zimmerman 1990, Zadeh and Kacprzyk 1992). Shimura (1973) extended the use of Fuzzy Sets for constructing an ordering of alternatives by individual decision-makers on the basis of a pairwise comparison of decision alternatives. In this research, each DM's assessment was based on a rating scale of 1 to 5 (see Table 3.2.1 above), made by an individual for all pairs of alternatives in a given set of design alternatives D. Shimura's formula was modified to reflect the characteristics of the survey data. The modified equation is presented below.

$$F(d_i, d_j) = \frac{f(d_j, d_i)}{\max\left[f(d_i, d_j), f(d_j, d_i)\right]}$$

$$= \min\left[1, f(d_j, d_i) / f(d_i, d_j)\right] \ldots\ldots\ \ldots\ldots\ldots\ldots (1)$$

for each pair $\langle d_i, d_j \rangle \in D^2$, and $F(d_i, d_j) \in [0, 1]$ for all pairs $\langle d_i, d_j \rangle \in D^2$

where: D^2 is a fuzzy binary relation $R(D, D) \subset D \times D = D^2$;

and: $F(d_i, d_j)$ denotes the relative preference grades given by an individual to d_i with respect to d_j

$f(d_i, d_j)$ denotes the preference grade given by the individual to d_i with respect to d_j, and

$f(d_j, d_i)$ denotes the preference grade given by the individual to d_j with respect to d_i

Explanation: The equation above simply states that the relative preference grade given by an individual for design scenario d_i with respect to d_j is the lowest value between 1 and a fuzzy set of values which describes his preference for d_j over d_i divided by his preference for alternative d_i over d_j (see Table 3.2.3 below).

When $F(d_i, d_j) = 1$, d_i is considered at least as attractive as d_j, the function F, which is considered as a membership function of a fuzzy relation on D, has for each pair $\langle d_i, d_j \rangle \in D^2$ the property: $\max[F(d_i, d_j), F(d_j, d_i)] = 1$. This presupposes that, for each pair of alternatives, at least one must be as attractive as the other alternative. This often arises when comparing an alternative with itself. Therefore, for each $d_i \in D$, the overall relative preference grade can be represented by the equation:

$$P(d_i) = \min_{d_j \in D} F(d_i, d_j) \quad \text{.....................} \quad (2)$$

where: $P(d_i)$ denotes the overall preference for alternative d_i, and $\min_{j \in D} F(d_i, d_j)$ denotes the minimum of all preferences for d_i with respect to d_j

The preference ordering of alternatives in $d_i \in D$ is then induced by the numerical ordering of the grades obtained in $P(d_i)$.

When decisions are made by more than one person, the goals of individual decision-makers may differ such that each places a different ordering on the alternatives. Secondly, the individual decision-makers may have access to different information upon which to base their decisions. The imperfection introduced by the differences in access to information on the data being assessed results in differing outcomes from an evaluation of the same data. Increased knowledge and understanding of data may also account for this difference. This may arise due to the experience of individual decision-makers with the type of data presented rather than from inconsistencies in the data structure. Blin (1974), and Blin and Whinston (1973) proposed a fuzzy group decision modelling approach to fully capture and resolve the imprecision in a subjective data set such as this.

In order to deal with the multiplicity of opinions, Blin and Whinston (1973) defined the social preference for the group S as a fuzzy binary relation with membership grade function $S: D \times D \rightarrow [0,1]$. This function assigns the membership grade $S(d_i, d_j)$, indicating the degree of group preference of alternative d_i over d_j. The aggregate of individual preferences is then determined by computing the relative popularity of alternative d_i over d_j. This can be obtained by dividing the minimum preference grades of persons preferring d_i over d_j and the minimum preference grades of persons preferring d_j over d_i, by the total number of decision makers, n. Equation 3a expresses this aggregation.

$$S(d_i) = \frac{\sum_{i=1}^{n} P(d_i)}{n} \quad \text{.............................(3a)}$$

where: $S(d_i)$ denotes the relative popularity of d_i

$\sum_{i=1}^{n} P(d_i)$ denotes the sum of overall preferences for alternative d_i, and

n denotes the size of sample.

The most preferred alternative, therefore, is the alternative that maximizes the overall relative popularity, that is,

$$\min_{d_i \in D} S(d_{ij}) = \min_{d_i \in D} \sum_{i=1}^{n} P(d_i) \quad \text{....................(3b)}$$

Equation 3b above is only sufficient for determining the social preference S of all decision-makers when one design parameter is considered. However, the determination of group preference in regard to the sustainability of different design scenarios for a design feature is a multi-person and multi-criteria decision problem. Since the number of criteria is finite, and the number of considered alternatives is also finite, we thus require a procedure for constructing one global preference ordering. Therefore, if $D = \{d_1, d_2, ..., d_m\}$ denotes the set of design alternatives for which n decision-makers stated their preferences, and $C = \{c_1, c_2, ..., c_n\}$ denotes the set of design criteria that were considered in the assessment. The basic information involved in the multi-criteria decision making can be expressed by a $m \times n$ matrix of the form:

$$R = \begin{matrix} & c_1 & c_2 & . & . & c_n \\ d_1 & r_{11} & r_{12} & . & . & r_{1n} \\ d_2 & r_{21} & r_{22} & . & . & r_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ d_m & r_{m1} & r_{m2} & . & . & r_{mn} \end{matrix} \quad \text{.......................(4)}$$

The entries r_{ij} of R express, for each $i \in N_m$ and $j \in N_n$, the degree to which decision-maker P conforms to the required profile in terms of criterion c_i.

Prior to determining the r_{ij}s the multi-criteria decision problem is converted into a single-criterion decision problem by finding the global criterion $r_j = h(r_{1j}, r_{2j}, ..., r_{mj})$, such that for each $p_j \in P$ there is an adequate aggregate of values $r_{1j}, r_{2j}, ..., r_{mj}$ to which the individual criteria $c_1, c_2, ..., c_n$ are satisfied (see Klir and Yuan 1995). The function h is the aggregating operation that produces a meaningful expression, in terms of a single fuzzy set, of the global preference ordering of the decision-makers. The aggregating operator used for the data represents the weighted average presented below:

$$r_j = \frac{\sum_{i=1}^{m} w_i r_{ij}}{\sum_{i=1}^{m} w_i} \quad j \in N_n \quad \text{.......................(5a)}$$

where: $w_1, w_2, ..., w_m$ are weights that indicate the relative importance of features $c_1, c_2, ..., c_m$ to the sample, such that $w_i \in [0,1]$ for all i, and $\sum_{i=1}^{m} w_i = 1$;

r_{ij} denotes the degree to which decision-maker P_i conforms to the required profile in terms of feature c_i.

Since the matrix R contains fuzzy numbers $\tilde{r}_{ij}$ on R^+, and weights are specified in terms of fuzzy multiplication, the weighted average $\tilde{r}_j$ is calculated with the formula:

$$\tilde{r}_j = \sum_{i=1}^{m} \tilde{w}_i \tilde{r}_{ij} \quad \text{......................} \quad (5b)$$

where: $\tilde{r}_j$, denotes fuzzy numbers $[0,1]$[1], which expresses the degree to which the design parameter c_i has been satisfied by the design alternative $d_j (i \in N_m, j \in N_n)$,

$\sum_{i=1}^{m} \tilde{w}_i \tilde{r}_{ij}$ denotes the sum of all weighted degrees to which criterion c_i has been satisfied by the design alternative $d_j (i \in N_m, j \in N_n)$ viewed as a matrix representation of a fuzzy relation on constraint C by design alternatives D.

2. Application to Data:

We discuss the application of the fuzzy technique to the data obtained from an initial test sample of 11 design "experts". The choice of three subjects is intended to demonstrate and present the procedure used in this research. The final outcome represents

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[1] $[0,1]$ is a fuzzified set of values that represents the extreme boundaries of a decision-maker's preference grade. In Fuzzy Sets, the value "x is a member of A" $(x \in A)$, with boundary values $[0,1]$ is not necessarily a true (with value 1) or false (with value 0) scenario, but that it may be true only to the degree that x is a member of A.

an application of the procedure to the total sample. Three representation techniques were provided for the sample for assessment. One of the scenarios displayed an animation sequence and QuicktimeVR representation of each of particular design. Two other scenarios presented 2D and 3D scenarios of the design feature. FGDM analysis for 3 out of the 11 test-sample is presented in the Table 3.2.3.

The notations below apply to the assessment of our design alternatives:

d_1 denotes Option 1 (Animation/QTVR representation of a design feature)
d_2 denotes Option 2 (2D representation of a design feature)
d_3 denotes Option 3 (3D representation of a design feature)

The pairwise comparison of representation techniques produces ratings that in the matrix relation give the reciprocal of the values for the pair of alternatives compared when a reverse comparison is carried out. For example, when we consider the pairwise comparison matrix for subject #1, we discover that the value of the subject's assessment of d_1 with respect to d_2 is 4. This signifies that subject #1 very strongly preferred d_1 with respect to d_2. However, the subject's assessment of d_2 with respect to d_1 will automatically return a value of $\frac{1}{4}$, being the reciprocal of his/her assessment for d_1 with respect to d_2.

Table 3.2.3: **Given Preference Grades by Sample Subjects**

Subject #1

$f(d_i,d_j)$	d_1	d_2	d_3
d_1	1	4	5
d_2	$\frac{1}{4}$	1	4
d_3	$\frac{1}{5}$	$\frac{1}{4}$	1

Subject #2

$f(d_i, d_j)$	d_1	d_2	d_3
d_1	1	3	4
d_2	$1/3$	1	$1/5$
d_3	$1/4$	5	1

Subject #3

$f(d_i, d_j)$	d_1	d_2	d_3
d_1	1	4	$1/4$
d_2	$1/4$	1	$1/5$
d_3	4	5	1

Applying equation (1) and (2), the outcomes for three subjects are presented in Table 3.2.4 below.

Table 3.2.4: **Relative Preference Grades of Sample Subjects**

Subject #1

$F(d_i, d_j)$	d_1	d_2	d_3	$P(d_i)$
d_1	1	0.063	0.04	0.04
d_2	1	1.00	0.063	0.063
d_3	1	1.00	1.00	1.00

Subject #2

$F(d_i,d_j)$	d_1	d_2	d_3	$P(d_i)$
d_1	1	0.11	0.063	0.063
d_2	1	1.00	1.00	1.00
d_3	1	0.04	1.00	0.04

Subject #3

$F(d_i,d_j)$	d_1	d_2	d_3	$P(d_i)$
d_1	1	0.063	1.00	0.063
d_2	1	1.00	1.00	1.00
d_3	0.063	0.04	1.00	0.04

When we apply equation (3a), the result is presented below.

Figure 3.2.4: **Result Obtained from Analysis of Three Subjects' Preference Ratings**

$S(d_1) = (0.04 + 0.063 + 0.063)/3 = 0.06$

$S(d_2) = (0.063 + 1.00 + 1.00)/3 = 0.69$

$S(d_3) = (1.00 + 0.04 + 0.04/3 = 0.36$

Applying equation (3b) we have, $\min_{d_i \in D} S(d_i) = 0.06$. This implies that the alternative preferred most by 3 subjects from our sample was option 1 (Animation/QTVR representation of a design feature). The relative rankings did not change appreciably when computed for the whole sample. The choice that was preferred most was still option 1. This design option represents the animation or QuicktimeVR representation for the provision of a vibrant core with mixed residential types.

Saaty's eigenvector procedure was used to assign preference grades, and to develop a priority matrix for the three sustainable community design parameters defined in Section 4. This matrix was based on subjects' stated preferences for the inclusion of the features of sustainable community design in a community in which they wish to live. It was developed from a parallel preference survey for the design features in each design parameter. A summary of the outcome is presented below.

The notations below apply to the assessment of the pairwise-compared design alternatives:

C represents a set of fuzzy preference ratings for the sustainable community design constraints:
C_1 denotes Community Design parameters
C_2 denotes Ecologic Design parameters
C_3 denotes Street Design parameters

$$C = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_3 \end{array} \\ \begin{bmatrix} 1 & 3 & 2 \\ 0.33 & 1 & 0.50 \\ 0.50 & 2 & 1 \end{bmatrix} \end{array}$$

Using Saaty's eigenvector analysis, the data were normalized by dividing each pairwise score by the column total to determine the relative weights of the design parameter based on subjects' assessment.

$$C = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_3 \end{array} \\ \begin{bmatrix} 0.55 & 0.50 & 0.57 \\ 0.18 & 0.17 & 0.14 \\ 0.27 & 0.33 & 0.29 \end{bmatrix} \end{array}$$

$$\tilde{w}_i = \begin{bmatrix} 0.54 \\ 0.16 \\ 0.30 \end{bmatrix} \text{..........} (6)$$

where: $\tilde{w}_i$ denotes the fuzzy weights or relative importance of each design parameter, and

C is a $m \times n$ matrix of subjects' preference ratings for each design parameter.

The pairwise-comparison data were checked for consistency and the consistency ratio (CR)[2] was found to be 0.009. This value is within the acceptable range of $0 \leq CR \leq 0.10$ for the consistency of pairwise-compared data (Anderson et al. 1994: 669). Therefore, the degree of consistency exhibited in the pairwise comparison matrix for design parameters is acceptable, and the data are consistent.

The expression for our decision support model is given as:

$$SCD = f[(CDP + EDP + SDP) + (CMP + ESP + ...)] \quad \text{................(7a)}$$

where:

SCD denotes Sustainable Community Design

CDP denotes Community Design

EDP denotes Ecologic Design

SDP denotes Street Design

CMP denotes Community Management, and

ESP denotes Economic Structure

The interpretation of expression (7a) is that the sustainable community design alternative chosen by a particular community is a function of the inclusion of parameters such as community design principles, ecologic design principles, street design principles, and other factors. The other factors include demographic, social, organizational, and economic variables that are beyond the capability of design to visually represent and effectively analyze using judgments based on dynamic human experience of spatial relationship. Therefore, the decision support model that derives from $\tilde{w}_i^{x}$ would adopt only the values attached to CDP, EDP, and SDP. Using the weights $\tilde{w}_i^s$ in (6) the model is thus of the form:

$$SCD = [0.54(CDP) + 0.16(EDP) + 0.30(SDP)] \qquad (7b)$$

Model (7b) suggests that, if sustainable community design were limited to the factors listed under community, ecologic, and street design parameters, design energy and resources would be most efficiently devoted to these parameters, based on the weights attached to each design parameter. Essentially, the community design parameter that obtained the greatest weight should receive an attention commensurate with its relative weight in the design of a sustainable community for the people-group surveyed.

The global priority rating for the total sample based on the three design parameters was determined by applying (6) to the outcome of the fuzzy priority matrix of subjects' preference for each design alternative with respect to the design parameters. The following fuzzy matrix was obtained from the evaluation of each subject's global priority rating of presented design alternatives based on provided design parameters. It was developed as a 3×3 matrix of fuzzy relation on $d_i \in D$ by $\tilde{C}$.

$$\tilde{R} = \begin{array}{c} d_1 \\ d_2 \\ d_3 \end{array} \overset{\begin{array}{ccc} \tilde{C}_1 & \tilde{C}_2 & \tilde{C}_3 \end{array}}{\begin{bmatrix} 0.56 & 0.59 & 0.66 \\ 0.12 & 0.07 & 0.27 \\ 0.32 & 0.34 & 0.07 \end{bmatrix}} \qquad (8)$$

that is:

$$\tilde{C}_1 = \begin{array}{c} d_1 \\ d_2 \\ d_3 \end{array} \begin{bmatrix} 0.56 \\ 0.12 \\ 0.32 \end{bmatrix}, \tilde{C}_2 = \begin{array}{c} d_1 \\ d_2 \\ d_3 \end{array} \begin{bmatrix} 0.59 \\ 0.07 \\ 0.34 \end{bmatrix}, \tilde{C}_3 = \begin{array}{c} d_1 \\ d_2 \\ d_3 \end{array} \begin{bmatrix} 0.66 \\ 0.27 \\ 0.07 \end{bmatrix}$$

where: $\tilde{C}_1, \tilde{C}_2, \tilde{C}_3$ represents design constraints and d_1, d_2, d_3 represents design options,

$\tilde{R}$ denotes a fuzzy matrix relation on d_1, d_2, d_3 by $\tilde{C}_1, \tilde{C}_2, \tilde{C}_3$.

---

[2] CR is a measure of data consistency.

Instead of the simple summation of relative preferences, an aggregating framework, which is compatible with the objectives of evaluation are required (equations 4 & 5a). The fuzzy overall priority-rating equation (5b) is applied and the result is presented below.

$$\tilde{r}_j = \begin{array}{c} \\ \\ \end{array}\overset{\begin{array}{ccc}\tilde{C}_1 & \tilde{C}_2 & \tilde{C}_3\end{array}}{\begin{bmatrix} 0.56 & 0.59 & 0.66 \\ 0.12 & 0.07 & 0.27 \\ 0.32 & 0.34 & 0.07 \end{bmatrix}} \times \overset{\tilde{w}_i}{\begin{bmatrix} 0.54 \\ 0.16 \\ 0.30 \end{bmatrix}}$$

$$\tilde{r}_j = \begin{matrix} d_1 \\ d_2 \\ d_3 \end{matrix} \begin{bmatrix} 0.59 \\ 0.16 \\ 0.25 \end{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots(9)$$

where: $\tilde{r}_j$, denotes a parametric family of partitions within an infinite set of fuzzy values in the interval $[0,1]$, which expresses the degree to which the design parameter c_i has been satisfied by the design alternative d_j in linguistic terms, and

$\tilde{w}_i$ denotes the fuzzy weights or relative importance of each design parameter.

3.2.5. **Discussion of Results**

The decision support technique discussed in this research developed a hierarchy $\tilde{w}_i$ for ranking different categories of sustainable community features in order of importance. For example, the community design parameter (which includes features such as the patterns of land-use and housing, availability of a community core, and the design of in-between spaces), was given a weight (eigenvector) of 0.54 by the sample. The eigenvector attached to this parameter signifies the rating of its importance as a sustainable community design feature to the sample. This is higher than the weight (0.16) attached to the importance of ecological design practices (such as waste management, water and wastewater management, energy conservation, and local food production) by the sample. It is also higher than the weight (0.30) attached to the inclusion of street design features by the sample. Other factors, such as increase in initial cost of housing, the overall impact of design features on lifetime cost of building, and the location of community in the city, were not considered in this analysis.

Design representation technique 1, which represents displayed representation of design features using animation sequences or QuicktimeVR, received the highest overall priority rating (0.59). The technique representing features in 2-dimensional form received the lowest rating of 0.16, and the 3-dimensional display of features, received a rating of 0.25. This validates the hypothesis that the closer the images displayed to users' perceptive reality of actual , the more accurate will be the assessment received from such assessment.

The eigenvector analysis helped us to determine the fuzzy relative preference grades for each design criterion. It revealed which design criterion has higher assigned importance by the sample. The outcome from this level of analysis is useful for assisting decision makers such as architects, real estate developers, homeowners, planners, and governmental agencies responsible for housing, to determine what sectors to allocate more resources to, for an ecologically balanced and marketable residential development. Finally, the decision-support model attempts to define parametric hierarchy, together with the intra and inter-parameter relationship for sustainable community design.

3.2.6. **Conclusion**

This section demonstrates the use of Fuzzy Group Decision Making technique (FGDM) for determining consumer receptivity to design features using values from imprecise data from an expert survey sample. FGDM is used to determine the relative importance of design features to consumers. The procedure made possible the objective comparison of consumers' preferences within and across parametric lines. It provided the weighted priority ratings for each design parameter. The prioritizing of design parameters therefore made it possible for greater design energy to be devoted to design features that each community believed to be most important in its pursuit of a sustainable and livable community.

The robustness of this model can be improved by adding cost factors to the data, such that responses can be evaluated across socio-economic classes. The inclusion of organizational factors such as community management and resource management strategies will also contribute to the robustness and reliability of the final model. It may require a larger sample size than was used for the preliminary test to possibly increase the reliability of outcome. Larger sample sizes were used in the final surveys, and FGDM was used to analyze the results of the rating scores obtained from the pairwise-comparison of 3 representation techniques by the survey sample (see Chapter 6 for detail discussion).

Other statistical techniques such as analysis of variance (ANOVA) and Principal Components Analysis (PCA), can be used to measure variation in responses between the different statistical groupings. These techniques will, however, not provide the robustness that is possible with the FGDM technique.

Conducting web-based surveys with a high content of dynamic graphics, such as QuicktimeVRs, animations, and VRMLs, require fast download capability from end-users. One of the problems faced in the Web-based segment of the survey concerns the Internet access speed available to potential subjects. This was a major factor in the selection of the sample. It is believed that the improvement and affordability of web-access technology will remove this limitation in future surveys of this nature.

CHAPTER 4

EXPERIMENTAL DESIGN FOR WHYTE RIDGE COMMUNITY

4.1 Background

The Whyte Ridge community is a 900-acre suburban community located in the southwest of the City of Winnipeg. Similar to most conventional suburban residential developments, it is designed exclusively for single family homes. This homogeneous development pattern has the upper middle income group as its target market. The mean family income for the residents of this community is between $80,000 and $135,000 per year.

The development is located to the southwest of Linden Woods, which is a residential development similar to Whyte Ridge. It was developed solely to cater to the needs of the growing upper middle income class of the City of Winnipeg.

Fig. 4.1.1: Map of Winnipeg City showing the site

4.1.1. Description of Site (see Table 4.1.1):

Kenaston Boulevard bounds the site on the east, while McGillivray Boulevard bounds it on the north. On the west, Brady Road runs southwards, parallel to the CPR rail track, which connects Fort Garry Industrial Park with the Genstar cement plant in the Tuxedo Industrial Area. Several commercial developments have taken place in the Tuxedo Industrial Park since the inception of this design project. They include an IGA grocery store, Wal-Mart, Canadian Tire store, Esso and Petro Canada gas stations among others.

The main access to the community is from Scurfield Drive. This road forms a loop around an ornamental lake on the western part of the site that connects with Fleetwood Road. Scurfield Drive is a four-lane divided highway from the entrance to the community through Kenaston Drive to Whyte Ridge Elementary School, where it becomes a two-lane collector at the intersection of Scurfield and Columbia Drive.

The site is essentially flat but gently slopes toward the southeast. The landscape resembles an old prairie wheat farm with a few stands of trees, low prairie shrub, and grassland vegetation.

There are three parks on the site, two of which are fully developed. The third is yet to be developed. There are two ornamental lakes located on the southeast and northwest of the site. Adjacent to the third open space, in the north central portion of the site is a 10-acre site for the community centre. The first phase, consisting of a community office building and a hockey rink, has been completed.

The only commercial use in the community is a Shell Gas Station, which is located at the entrance of the site on Scurfield Drive[1]. It is located adjacent to the only place of worship on the site. Toward the northeast corner of the community is the Petro Canada gas station – adjacent to the intersection of McGillivray and Kenaston Boulevards.

There are 2200 residential plots. Some of these lots are in residential clusters designed either in loops or in linear arrangement along neo-traditional curvilinear

[1] Several commercial uses have been developed around the site since this report was written.

roads. There are about six identifiable residential typologies with a maximum of about three-and-half floors (with or without basements).

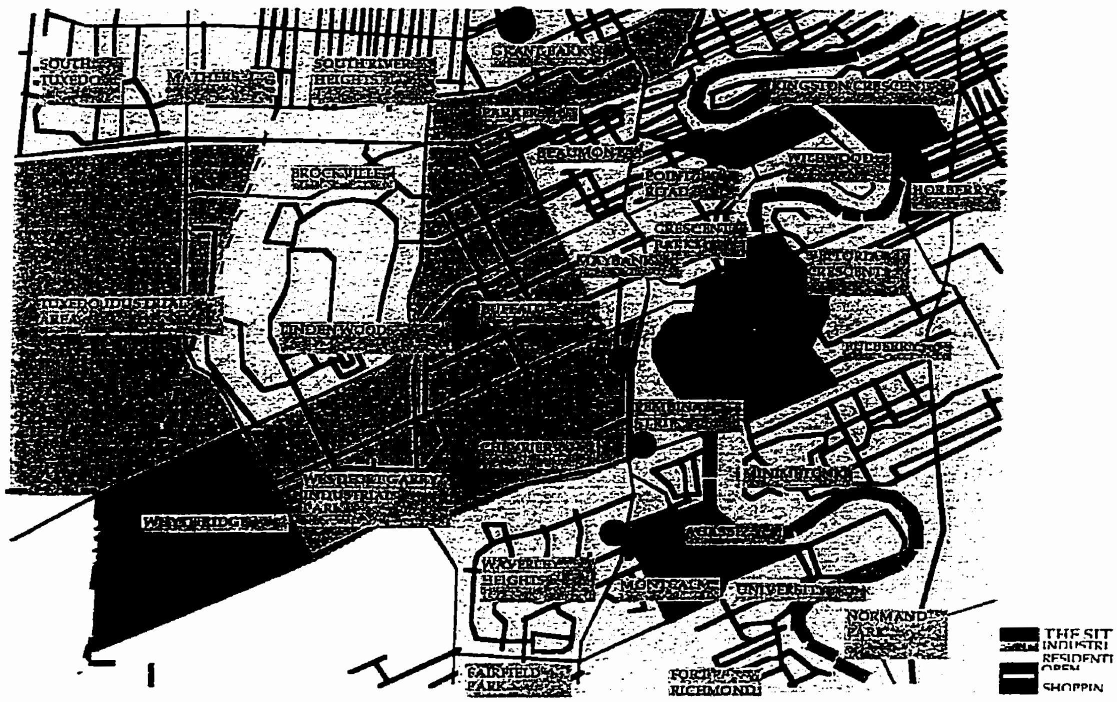


Fig. 4.1.2: **Site Context**

The community is designed almost exclusively for automobile users. Pedestrian sidewalks are restricted to major arterial roads, and there is virtually no other pedestrian sidewalk along residential and local roads. Social contact at the cluster level is difficult because of the exclusive nature of residential hold planning in which each allotee has direct access to a road, facing away from other lots. The absence of shopping and other commercial uses at the core also makes the constant use of the automobile necessary.

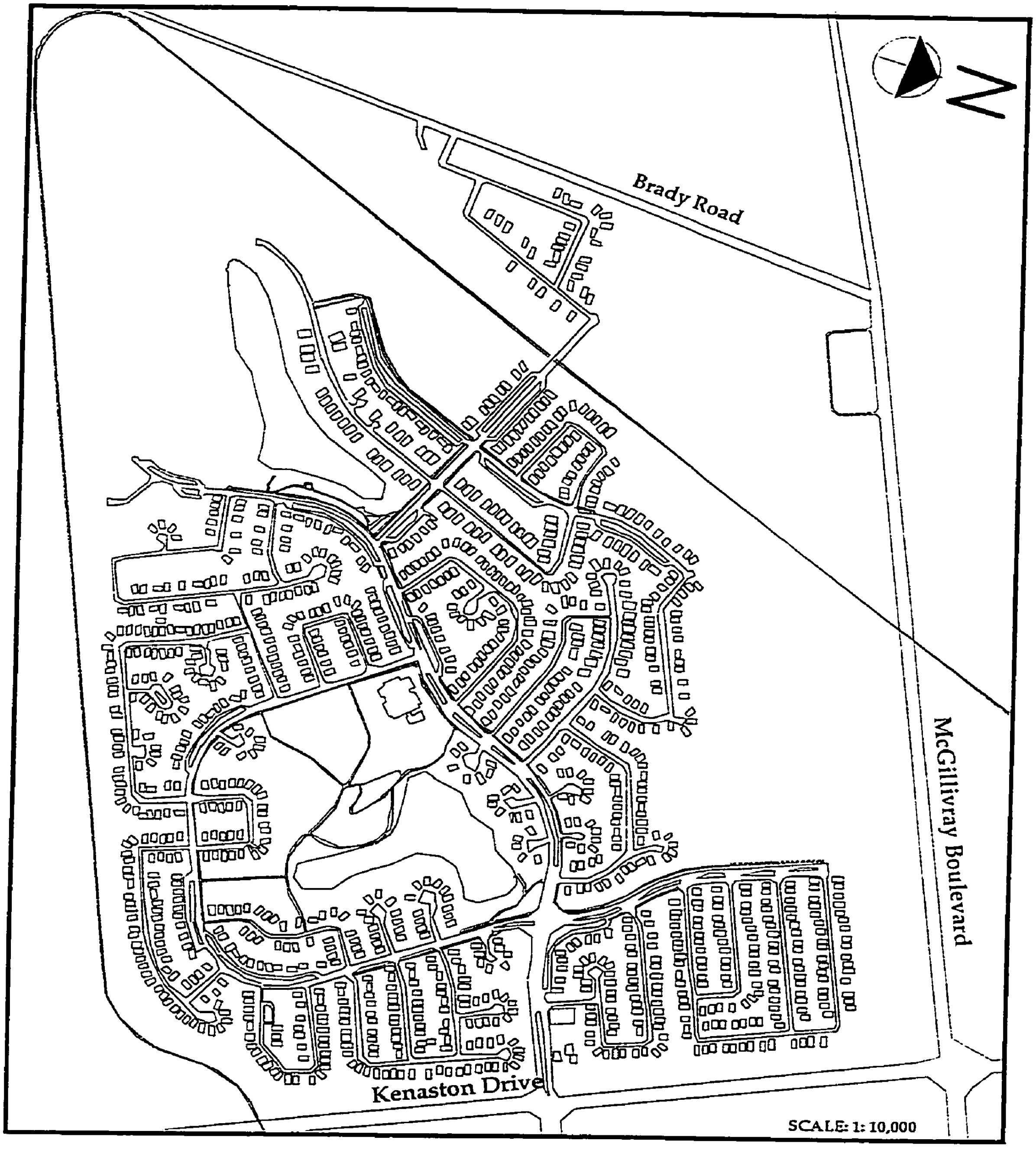


Fig. 4.1.3: **Existing Developments on Site**

Table 4.1.1 **Site Data - Existing Condition**

1. Size of Site
- *Length*: 2148.84m (7080' or 2.16 km.)
- *Width* 1694.69m (5560' or 1.69 km.)
- *Area*: 3,641,617.60m^2 (364.16 ha. or 899.83 acres)

2. Topography:
- Relatively flat terrain
- Slopes gently toward the southeast

3. Types of Building
- Single family housing
- Elementary School
- Commercial and Institutional use at the Scurfield Drive entrance
  - Gas Station
  - Place of Worship

4. Site Planning
- Single entrance and exit point to and from community
- Site for Community Centre is under phased development and location is not central for easy accessibility from all parts of the community
- Loops, and linear planning for housing development
- Ornamental lakes possibly for passive recreation
- 4-lane boulevard-type entrance with wide right-of-way
- Maximum height of buildings is 3 1/2 floors
- Limited spaces within the community for meaningful social contact
- A southwest-northeast rail line divides the community and serves as a potential source of noise pollution.

4.2 Case Studies

The precursor to realizing the design of a new architectural phenomenon is to study existing phenomena or projects that are similar and could help to shed some light on the structure and elemental composition of the proposed phenomenon, and its performance requirements. Most of the existing sustainable community design projects concentrate only on single building projects and the relationship between elements and fabric to achieve an environmentally friendly whole. The literature of finished work on the development of whole communities is limited to small neighbourhoods and single-block projects. In most of the available whole community cases, such as the Edgemont Community in Calgary, the projects are still at the proposal stage.

4.2.1. **McKenzie Towne, Calgary Alberta**

1. Introduction

McKenzie Towne is a 970-hectare (about 2400 acres) residential community located at the southeast periphery of the City of Calgary. The site is a relatively flat prairie dryland. The target number of residential units was 10,000 dwellings at build-out, and it was intended to accommodate 28,000 people and nine school sites. The net residential development area is 1,650 acres. The first neighbourhood opened in summer 1995.

2. Building Ecology

The building sites and architecture for the community are controlled by detailed written and graphic codes, administered by the developers. Massing, materials and architectural detailing are closely regulated. However, there is yet no technological innovation in housing designs to achieve water or energy conservation, to use recycled materials, or to provide for waste and refuse handling and recycling in the home.

3. Land Use Planning

The layout of greenways and their connectivity are subordinated to neighbourhood configurations and street geometry. Land use planning does not follow natural ecological patterns or gradients already established on the site. Schools and playing fields are located in the greenways. The site's major open space network together with the school make up 375 acres, about 16 percent of the site, a proportion that is not significantly different from most conventional subdivision projects in Calgary.

Residential land use is predominantly single-family detached housing. The eventual net residential density may reach 6 dwelling units per acre. The town centre is proposed to have mixed use buildings and multi family housing in higher proportion than the neighbourhoods.

4. Community Design:

The town plan and urban design character are neo-traditional. It has a grid street system, a town centre or main street laid out in a formal axis and terminated by a major civic space at each end. It also has a village-scale square in each of the 13 neighbourhoods, and an extended open space system arranged along two intersecting cross-town axes. School sites and playing fields are located in the greenways, equidistant between two neighbourhood squares and fronting on connector roads

5. Transportation:

Public transportation in McKenzie Towne is a bus system, with a substantial proportion of neighbourhood's population located within 450 metres of the transit stops. Cycling options are well provided for along residential streets and greenway paths. Streets, with the location and massing of fronting homes, are designed be attractive for walking and as "outdoor rooms".

A Light Rail Transit (LRT) line is proposed for construction by the year 2016. Off-street parking lots are minimized in favour of on street parking throughout community. Traffic calming in residential areas is helped by the use of reduced turning radii and short street blocks.

4.2.2. **Windsong Co-housing Community, Vancouver BC** (Perron et al. 1998)

1. Introduction

Co-housing is the name of a type of collaborative housing that attempts to overcome the alienation of modern subdivisions in which no one knows his/her neighbors, and there is no sense of community. It is a development in which each household has a privately owned residence but also shares extensive common facilities such as kitchen and dining area, children's playroom, workshop, guest room, office space, gardens and laundry facilities. Although individual dwellings are self-sufficient and each has its own kitchen, the common facilities, and particularly the shared meals, are important aspects of community life both for social and practical reasons. Shared activities are optional. Residents choose this form of housing out of personal preference.

Co-housing began in Denmark in the late 1960s, and spread to North America in the late 1980s. The typical co-housing community has 20 to 30 private single-family homes along a pedestrian street or clustered around a courtyard. Residents of co-housing communities often have several optional group meals each week in a "Common House", which also has shared facilities for playing and dancing. In most cases residents are fully involved in the design and management of the project. Consensus decision making is a key part of the co-housing culture.

In the co-housing model, future residents create their own custom-designed neighbourhoods. Sustainable principles, such as efficient use of land, transportation alternatives, and organic gardening are usually included. Other principles, such as preserving the natural habitat, sharing resources and bulk purchasing, financial diversity and inclusiveness, may also be applied. Effective waste and water management, waste reduction, recycling and composting, energy efficiency and the use of alternative energy sources, use of solar energy, and material choice based on analysis of embodied energy, toxins and recycled products are sometimes practiced.

2. The Context

WindSong Co-housing Community is made up of 106 people, 34 townhomes and a 5,000-sq. ft. Common House on a 6-acre site with organic community gardens. It has 4 acres of green space traversed by a creek. The residency structure in the community is diverse. The professional classification of the residents ranges from architects to doctors, academicians, and journalists.

The Windsong Co-housing, in the Walnut Grove area of Langley, British Columbia is about 50 kilometres from the Vancouver City centre. The Walnut Grove area is a quickly developing rural area with a mixture of single family and townhome neighbourhoods. It is in close proximity to elementary and secondary schools and is within a 5-minute driving distance from the Langley Fine Arts School.

There are several walking trails on the site and it is a 5-minute drive from Darby Reach Regional Park, which offers riverside camping and forest trails. Windsong is also close to commercial services. The extensive commercial sector of Langley City is about 10 minutes drive away from the site.

3. Design Concept

There are 34 townhomes in the community arranged in two long rows facing each other across a pedestrian street. The Common House is located midway between the north and south ends. The streets are covered by glass roofing that enables the residents of the community to move about in an enclosed covered space. This is a significant factor in this West Coast maritime climate, with precipitation all year round. Vehicular parking space is almost entirely at sub-grade level throughout the site.

The Common House includes a kitchen, dining room and fireside lounge, a playroom with loft, a children's outdoor play structure and sand box, an arts and crafts room, workshop, laundry, community office, multi-purpose room, T.V. room, guest room and three washrooms.

The private homes are in 3 sizes: 1-bedroom plus den, 3-bedrooms on two levels and 4-bedrooms on three levels. Homes on the eastern side have decks looking into the creek side forest and field. Homes on the western side have upper atrium decks and/or private back decks and yards. Kitchens face on to community streets. Living rooms and master bedrooms are toward the rear of the buildings. Front entry doors are on the main street, while many of the homes have basement entrances. The community has diverse tenancy types and family sizes, ranging from babies to seniors with couples, families, singles and single parents.

There is a good representation of all ages in the community. Some of the social and communal spaces and activities include several book clubs, an organic diners club and lots of recreational spaces for walking, cycling and playing tennis.

4.2.3. **Eco-Village, Ithaca** (New York)

1. Introduction

Ithaca is on the southern shore of Cayuga Lake and surrounded by the hillsides of Cornell University and Ithaca College. It is located in the heart of New York State's Finger Lakes Region. In addition to its scenic gorges and waterfalls, and the Commons (New York State's premier pedestrian mall), Ithaca is known for its educational institutions. It has a population of about 30,000.

EcoVillage in Ithaca is a community that is dedicated to exploring and modeling innovative approaches to ecological and social sustainability. The community created a unique habitat that includes co-housing, organic agriculture, cottage industries, an education center, and natural areas. This habitat was created by preserving and restoring over 80 percent of the residential components that comprise of 3-5 tightly clustered co-housing communities, which surround a village green.

The community is on a 176-acre site of farmland and woods overlooking the City of Ithaca to the east and bordered by Coy Glen Nature Preserve to the west. Fifty-five acres of the site are permanently preserved through a conservation easement.

2. The Design Concept

The focus of the co-housing design in Ithaca is the Common House, which also provides space for play, meetings, guests, offices, crafts, root cellar, and laundry. The dining room in the Common House overlooks a one-acre pond, fields, and mountains to the south. The housing consists mainly of detached dwelling units with compact and functional floor plans that include 1-bedroom units (922 square feet), 3-bedroom units (1300 square feet), and 4-bedroom (1642 square feet) units.

EcoVillage operates the West Haven Farm, which has been a source of vegetable supply to the community for over 6 years. The farm operates under the Community Supported Agriculture (CSA) model, which is a new relationship between farmers and consumers. It brings people into closer contact with their food source and provides more community support for farmers.

3. The Design Criteria for EcoVillage

All facilities are designed to be wheelchair accessible and have a separate "grey water" and sewerage waste piping. The design criteria for residential and common space are presented below.

- **Residential Space**

1. Wherever feasible buildings are earth-sheltered.
2. Dwelling units are connected by sunspace-enclosed walkways. The design strategy for dwelling units was proposed to incorporate the following sustainable practices.
   - Provision for aquaculture and intensive gardening;
   - Provision for "greywater" recycling;
   - Passive solar heat storage;

- Provision for future wind-generated resistance electric heating or wind-driven heat pumps;
- Aesthetic "lounge" or an indoor park-like atrium; and
- Access to outside at each dwelling unit.

3. There are about 50 dwelling units in multiples of about 600 square feet (20'x30') each with bath and kitchen.
4. Dwelling units are in flexible modules and are easily connectable or detachable (via doors) to reform into combinations of 1, 2, 3 or 4 units to accommodate changes in 'family' size.
5. The overall structure is compact to maximize heating efficiency.
6. Scenic vistas are provided, through sunspace/walkways, from each dwelling unit
7. Covered access is provided to an underground car park

- **Common Space**

The design strategy for the common space include:

1. Connecting common space to residential units via sunspace/walkways.
2. Providing a Main Room (dining/assembly space) for 125 persons, capable of being used as a planetarium.
3. Locating the kitchen adjacent to main room to prepare food and serve 125 persons. The kitchen was to have:
   - Walk-in cooler and/or walk-in freezer;
   - Easily accessible "root cellar"/pantry; and
   - Easily accessible delivery area, and access for waste/compost removal.
4. Providing 3 stalls of men and women's lavatories.
5. Providing a laundry room with space for sorting/folding and ironing
6. Providing a small child/infant care/playroom with access to enclosed outside play area.
7. Providing a library/reading/quiet study space.
8. Providing a shop or project space with large door outside access.
9. Providing a "Health Spa" or Wellness Center with:
   - Exercise Room (400-600 sq. ft.);

- Sauna (for 10-20 persons);
- Massage Rooms (2 or 3);
- Hot tub/Whirlpool (for 10-20 persons) located in "tropical garden" sunspace setting; and
- Small (200-300 sq. ft.) men's and women's locker/shower rooms.

Source: Eco-Village Times, June 5, 2000 (http://www.ecovillage.ithaca.ny.us.html) and (http://www.ecovillage.ithaca.ny.us/frog.html).

- **Rationale Underlying Design Criteria**

The rationale for developing the design criteria is based on the provision of four basic functional spaces: the provision of flexible compact dwelling units, connected enclosed sunspace walkways, hemispherical dining and assembly space, and a health spa or wellness centre.

A. Dwelling Unit Size and Flexibility of Combination:

As persons go through various stages of life development, the amount and complexity of required living space changes. The design strategy was to provide the option of combining or disconnecting adjacent units (in 600 square foot increments) to accommodate these changes in a "family" structure. An overriding consideration was such that older persons would remain integrated into the community throughout their latter years.

B. Connected, Enclosed Sunspace Walkways:

These features were intended to provide:

- Protected or sheltered movement between dwelling units and the common space;
- Space for enclosed aquaculture and passive solar heat storage;
- A pleasant indoor "park-like setting for gathering, socializing, relaxing and spiritual renewal (particularly in winter).

C. Hemispherical Dining/Assembly/Ritual Space:

This feature was intended to provide:

- A lofty, esthetically pleasing space for gathering, meals and ritual;
- The ability to serve as a planetarium/theater for multimedia presentations.

D. Health Spa / Wellness Center:

This space was proposed for:

- Group relaxation;
- Exercise and body conditioning;
- Massage practitioners' practice.

4.2.4. **Ecolonia, Netherlands** (van Vliet 1998)

1. Introduction

Ecolonia is located in 'Alphen aan den Rijn', Netherlands (the Kerk en Zanen district). The residential community was developed by the 'Bouwfonds Woningbouw ' - a building fund society of Dutch Municipalities, and supported by 'Novem' - the Netherlands Agency for Energy and the Environment. It is bounded on the west by a slow-traffic route from the city centre to the educational park called Archeon. The community was built between 1991 and 1993.

2. Building Ecology:

The energy conservation goal was to reduce energy consumption in the community by at least 25 percent. The building strategy was to ensure an integral life cycle management for developments in the community and ensure quality improvement to the nature of Dutch suburban development.

3.. Landuse and Landscape Ecology

Prior to construction, the site was a reclaimed area of moorland, with a waterway running along one side of the site. The dwellings are clustered around the central pond that was used to maintain subsoil conditions and as a wetland habitat. The pond functions as a retention pond for surface runoff from the community and a variety of aquatic vegetation filter stormwater pollutants.

4. Community Design

The concept plan for Ecolonia was based on an urban development strategy that fosters a relationship between residents and their environment. The ideas were based on the principles of natural expansion in which a community will accommodate the needs of the residents at a human scale. The planning and design team was headed initially by a Belgian architect commissioned by the Bouwfonds Woningbouw to produce the site plan.

5. Energy

An important planning objective for the community was to showcase a number of techniques that effectively demonstrate energy conservation strategies. The diversity of housing typologies demonstrates several effective techniques ranging from solar water heaters to maximizing heat storage. The more general conservation strategies include:

- Orientation of the building for maximizing solar collection;
- Improved insulation through better building envelope design; and
- Implementation of space-heating systems that have a low environmental load and high efficiency.

6. Water and Sewage

At the centre of the community site plan is a retention pond. Water is conducted to the pond through mole drains where it is purified by a variety of wetland species, such as reeds and cattails. These vegetative filters assist in the break down of pollutants conveyed from road surfaces and chemical residues, which in some cases are leached from lawns and gardens.

7. Transportation

One of the design goals for Ecolonia was to reduce the amount of automobile-based transportation. A local centre (Winkel centrum) to the north provides a range of shops within a 10-minute walking distance to the regional rail station. The town centre of *Alphen aan den Rijn* is about 15 minutes walking distance away from the regional rail station.

Ecolonia is an enclave away from any thoroughfare. The result of its sheltered location is low noise levels and improved safety. Within Ecolonia, cycling and walking are the main modes of transportation. Vehicular routes are designed for slow residential level speed.

However, there is no clear separation between the different types of traffic in the planning and implementation of the transportation system. There are no marked parking bays or separate areas for cyclists and pedestrians. Because of the lack of separation between the different types of traffic, areas designed for play and common areas often used for parking.

8. Waste and Recycling

Another design objective for the community is the minimization of waste and the need to recycle materials used in the construction process. Design decisions took into account the choices of types and quantities of construction materials and construction techniques. The process included consideration of the systems intended for use by the residents in the post-construction phase, and future uses, and the use of materials with low embodied energy, which helped to minimize the amount of waste and the impact of construction on the environment.

4.3 Sustainable Community Design Features

4.3.1. Introduction

Discussed below are sustainable design features considered in this research. They provide the basis for the consumers' receptivity survey that formed the bedrock of the decision analysis developed in this research. It has been developed in part for publication in the *On-Line Planning Journal* of the University College, London.

The homogeneous structure of conventional suburban communities, as discussed in Section 2.1.2, results in a number of problems, such as the dominance of single family detached housing and high urban land consumption, and a limited variety of housing types. Other problems include the high cost of housing in suburban communities, feelings of isolation by suburbanites, intense commuting and auto-dependency, and sprawl. The design of a sustainable community strives to maintain a balance of physical and ecological considerations with the purpose of developing an inclusive and vibrant, yet ecologically sensitive community.

4.3.2 Community Design

In most conventional suburban communities the planning and design of the land-use is not properly adapted to local climatic conditions. Buildings are not sheltered from severe weather. Land-use planning and housing design in a sustainable community are adapted to local macro- and microclimates. Buildings should be sheltered from aggressive climatic influences and there should be enough intensity at the centre to sustain a viable commercial and social life and to promote sustained use of public space. Design features that fall into this category include lot configuration, residential intensification, types and sizes of housing, common buildings, the design of a community core, mixed uses at the core, and availability of social and recreational spaces.

4.3.2. Ecologic Design

1. Water, Wastes, and Wastewater Management

The Calgary research (Perks et al) showed that more than 30 percent of the water used in a community can be recycled and reused for household cleaning and irrigation. A sustainable practice aims at minimizing the use of water by recycling and reusing greywater and stormwater, and by re-channeling rainwater for domestic use.

At the heart of a community's sustainability is its effectiveness in managing wastes. Canada rates higher than the U.S. in per capita waste generation. The major reason is that wastes are not recycled. Landfills are being expanded continually and reusable materials are getting incinerated and wasted. Practices such as this will eventually put a stress on the natural resources that are used to produce these materials. Design features such as availability and location of recycling centres within the community, opportunities for greywater and stormwater recycling, and the design of housing units to allow for rainwater recycling, fall within this category.

2. Energy

About 33 percent of housing budget are expended on power and heat consumption. An energy-efficient building will cut its maintenance budget by 33 percent. A goal of sustainable suburban community design is to reduce the cost of power generation and the dependence on the use of fossil fuels. Sustainable energy features include the provision of co-generation and district heating plants to supplement the City's hydro electric power supply..

3. Local Food Production

The capacity of a community to locally produce its food impacts the amount of money it spends on food items that could be produced locally and the energy wasted on commuting to regional malls. Availability of land for community farms and allocation of land for community gardens at the neighbourhood level, are some of the features that enhance local food production.

4.3.3. Street Design

1. Street Hierarchy

Streets should be designed as a place of interaction rather than a mere link between two locations in the community. Traffic networks should be designed to be narrow, pedestrian-friendly and connected. More intersections should be encouraged, within a denser urban fabric. Maximum distances for essential destinations should be established to encourage walking or cycling. In most situations a 5-minute walk, approximately 450 metres, is the most desirable walking distance that would discourage the use of vehicles for such trips. Street design features include the development of traffic systems such as pedestrian, bicycle, and vehicular networks; and the reduction of street rights-of-way for arterial, collector, and local streets.

2. Universal Accessibility

The intention of providing universal access in communities is to make them inclusive rather than exclusive. The idea is that everyone should have continuous access to everything including public spaces, buildings, products and services.

Integrating universal access in all forms of transportation is a goal of sustainable community design. Universal accessibility design features include the design of the street to accommodate every type of traffic (vehicular, pedestrian, bicycle, and wheelchair), and the incorporation of barrier-free design features into public building design.

All buildings and public open spaces should be easily accessible to all members of the community. More specifically, attention should be directed to the planning and design of external areas, parking and pedestrian ways, stairs, ramps, lifts, signages, emergency exit routes, interior spaces and furnishings.

A commitment to "barrier free" design demonstrates an inclusive attitude, acknowledges interdependency of people within the community, and fosters the spirit and strength of an integrated community.

4.4 The Design Proposal

This section presents the discussion of the proposal for Whyte Ridge. The discussion focuses on the planning and design concepts for the site, and the development of the design program.

4.4.1. Planning Concept

The site planning for the community was based on established parameters for sustainable community design. These parameters were used to determine functions and to assign appropriate spaces. The objective was to achieve adequate population diversity by providing units that are affordable to all economic and demographic groups. This would also allow increased density and encourage more intense social activity, which would help to sustain transit.

Twenty-five percent of the site (225 acres) was allocated to open spaces and ornamental lakes and storm-water retention ponds. These open spaces are either at the unit, cluster, neighbourhood, and community level. Twenty percent (180 acres) was devoted to civic/public use. The remaining 55 percent (or 495 acres) of land was allocated to the seven types of residential developments proposed for the community (see details in Section 4.4.2 subsection 4).

The proposal presents a compact community with higher residential density at the centre. It accommodates about 5,800 residential units consisting of single family dwellings (50% or 247.5 acres), attached housing (30% or 148.5 acres), and multi-family housing (20% or 99 acres).

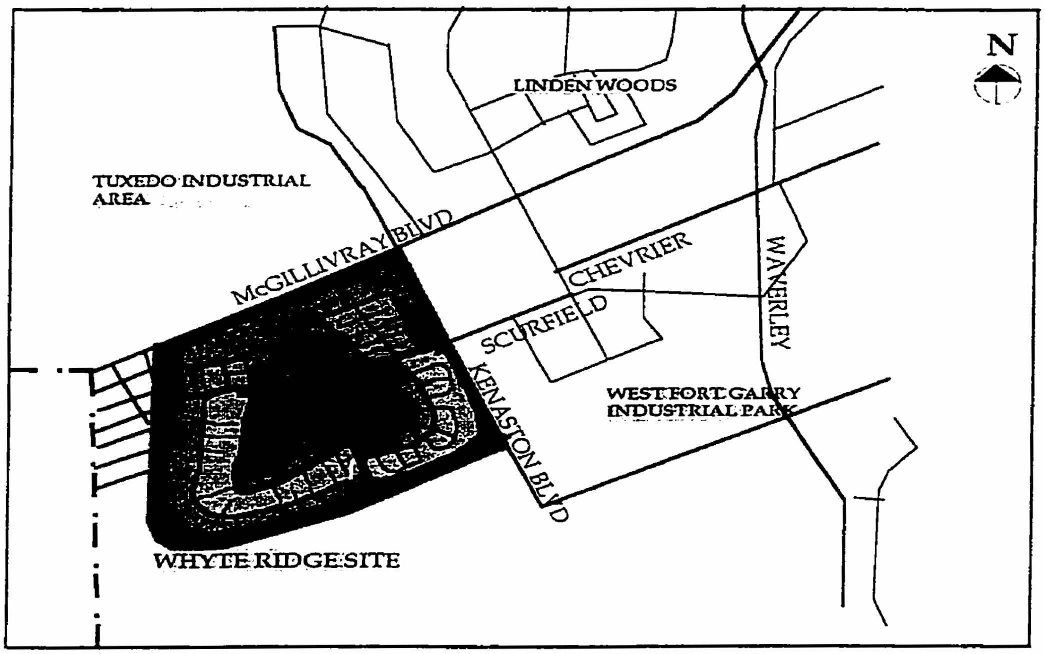


Fig. 4.4.1: **Proposed Design Concept and Context**

1. Three-Node Neighbourhood Cores

There are three neighbourhood cores with neighbourhood level recreational areas. A continuous 'green' corridor links the mini-cores to the main core (the centre of community activities). In each of the neighbourhoods, there are residential units of varying types. Some of the units have spaces that could be used for home-offices and daycare services.

The building clusters in the new development are more compact than in the existing Whyte Ridge. The clusters have 20 percent more internal spaces and 25 percent more external open spaces. To enhance interaction across the street line, and reduce vehicle speed, the new development has reduced a right-of-way and a reduced building-to-building setback.

The residential types are more diverse than in the existing community. There are three types of single family residences, the 4-bedroom, the 3-bedroom, and the 2-bedroom units. These units account for 50 percent of residential development on the site. In addition, attached dwelling types, consisting of townhouses, duplexes and multi-family apartment buildings, are provided at the core of the community.

Fig. 4.4.2: **Site Concept – Development**

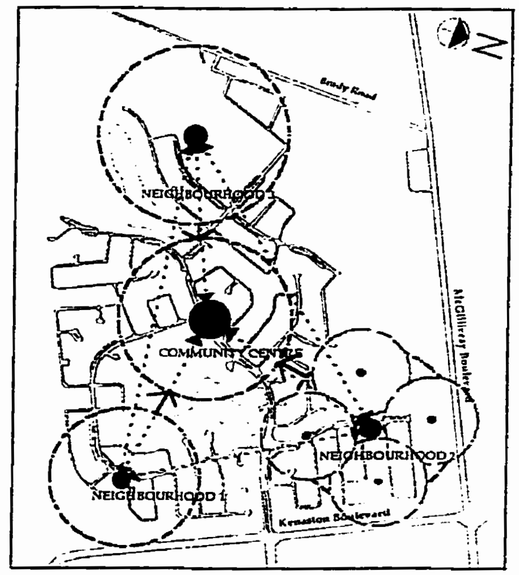


Fig. 4.4.3: **Site Concept -- Transportation**

The centre of community activities was designed to serve as the social magnet of the community. It is intended to be a centre of activities for all age groups of residents in the community. It has a multi-purpose hall that accommodates such functions as:

- Community meetings
- Day-care services
- Shopping/commercial functions
- Postal, fire and police services
- Community-based work establishments
- In-door sporting activities

It has an internal and perimeter transit corridor with nodes that are about 10 minutes walking distance apart. This corridor is designed for residents, regardless of age, to have access to public transit no more than 5 minutes walking distance (or 450 metres) from their residences. To facilitate quick access to transportation, dedicated bus lanes are provided in the internal transit corridor. Sheltered bus stops or transit nodes are also provided.

A major objective of sustainable community design is to provide a secure pedestrian traffic environment, free from any interference from automobiles. The roads within the community are reduced to a maximum of three lanes in the internal transit corridor where there are dedicated bus lanes. All local and residential roads are single-lane roads.

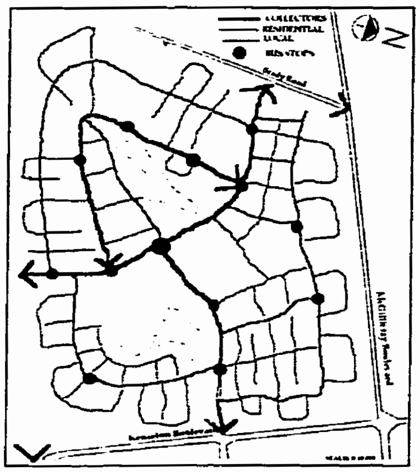


Fig. 4.4.4.: **Site Concept -- Pedestrian Network**

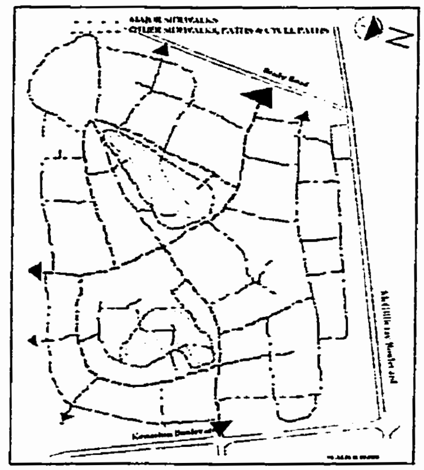


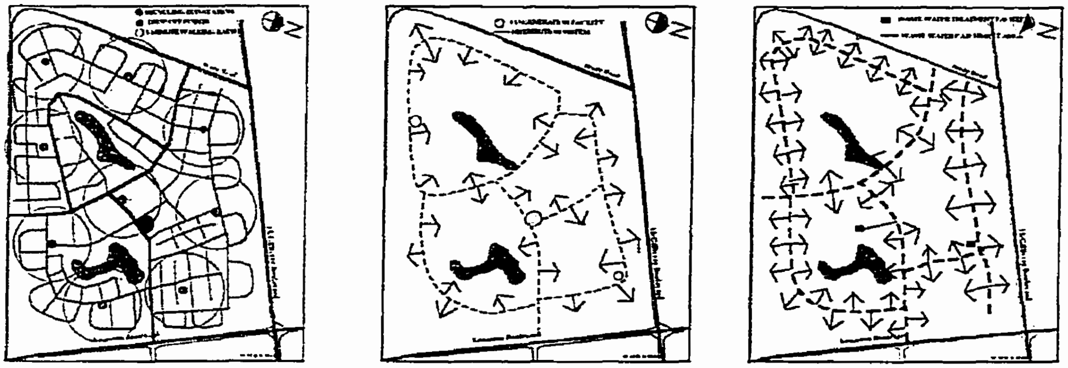
Fig. 4.4.5: **Site Concept -- Vehicular Network**

Universal access is provided to all public areas, so that those on wheelchair are not deprived access to any of its public areas. To increase pedestrian access and security, the design devoted attention to providing clear separation between pedestrian and vehicular accesses. There are streetlights to illuminate all streets at night. These lights are connected to the community co-generation station to reduce hydro bills. There is a network of cycle tracks which links each neighbourhood to the community parks and the perimeter parkway. These tracks could also be used as snowmobile tracks in the winter months.

The success of a community designed with sustainable principles depends on the provision and maintenance of infrastructures that support ecologically sound practices. Therefore, spaces are provided for:

- Recycling centres and depots;

- Storm water storage and recycling;
- Biological sewage treatment and recycling to community gardens;
- Neighbourhood level eco-generation and community heat system; and
- Community greenhouse for plant nurseries, in the community.



District Heating Network **Recycle Centre and Depots** **Waste-water Treatment Network**

Fig. 4.4.6: **Ecologic Planning Proposal**

4.4.2. **The Design Program**

The sustainable Whyte Ridge Community combines suburban features with traditional urban features, based on the parameters established for sustainable community design. This includes the interface of a compact form with ecologically based design strategy. The design strategy involves a neighbourhood design, which has unique architectural character such that residents have a sense of place and community identity.

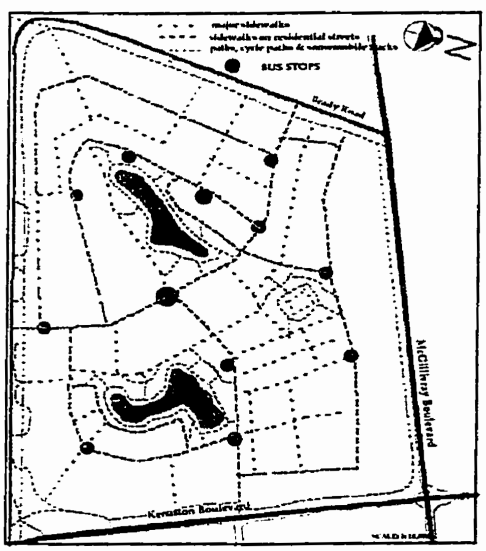
This section focuses on five major components of the design. They include (1) general site planning, (2) the community core or civic centre, (3) the residential areas, (4) transportation planning, and (5) open spaces and their hierarchy.

1. *General Site Planning*

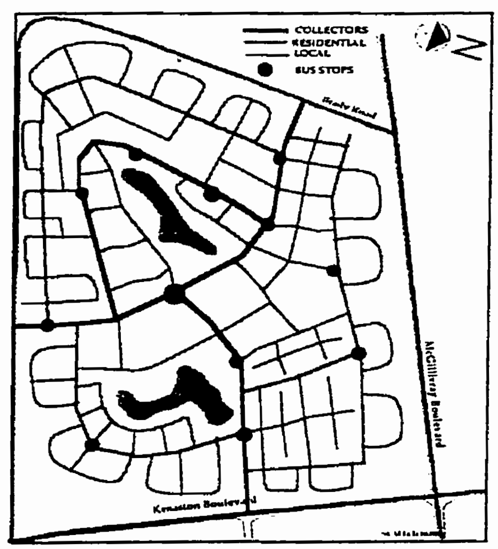
- 3 mini-cores of residential neighbourhood focused on the community core
- Tri-Neighbourhood mini-Cores
  - Neighbourhood recreational areas;
  - Home offices;
  - Residential uses.

2. *Transportation Planning*

- Minimize four-way intersections
- Give priority to pedestrians
- Slow down vehicular traffic
  - Use multiple connections in street design
  - Limit speed to 40 km/hr. on local streets, and 50 km/hr. on collectors
  - Limit street width to 2 lanes
  - Use street parking to slow down traffic
  - Incorporate traffic calming devices
- Street Design
  - Minimize destination distances: (to parks and recreation facilities, bus stops and transit centres, centres of community activities and educational facilities).
  - Minimize allowable rights-of-way
  - Adapt traffic network to collective transport
  - Provide dedicated public transit lanes where necessary.
- Provide sheltered pedestrian networks
- Provide cycle networks
- Provide universal access to all public areas and buildings
- Reduce and cluster parking



Pedestrian Circulation Network



Vehicular Circulation Network

Fig. 4.4.7: **Traffic Network**

3. *Community Centre/Civic Square*

- Multi-functional activity centre with
  - Commercial uses
  - Recreational uses
  - Institutional uses
    - Schools and playground
    - Religious buildings/spaces
    - Fire station/community police station
    - Postal agency
    - Community recycling centre

4. *Residential Areas*

- Residential Use Types
- Single family housing (50% of residential development)
  - Type 1 (1 to 2 persons per unit)
  - Type 2 (3 to 4 persons per unit)
  - Type 3 (5 persons and above per unit)
  - Density: *4 - 6 units per acre*
- Attached housing (30% of residential development)
  - Side - by - side duplex units
  - Townhouses (cluster of 3 to 4 units)
  - Density: *10 - 15 units per acre*

1. Multi-family housing (20% of residential development)
  - Single-loaded walk -up apartments (maximum of three and half floors)
  - Double loaded walk-up apartments (maximum of three and half floors)
  - Density: *15 - 25 units per acre*

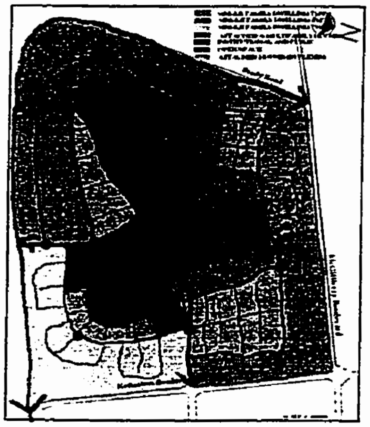
5. *Hierarchy of Open Spaces*

- Unit level backyards, front porches, and patios/solaria
- Cluster level shared open spaces
- Neighbourhood parks

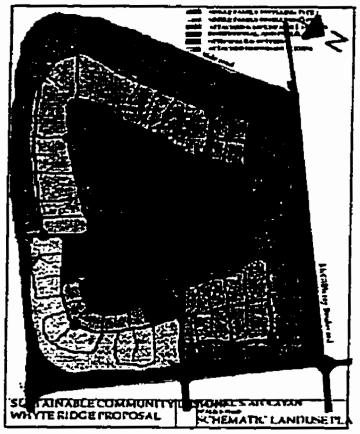
- Community parks
- Community 'green' buffers

6. *Ecologic Features Provided*

- Community wastes recycling
- Community power and heat generation
- Eco-lake for freshwater and storm-water recycling for irrigation and recreation
- Community Garden and Greenhouse for plant nurseries and food production



Site Concept 1



Site Concept 2

Fig: 4.4.8: **Design Concept**

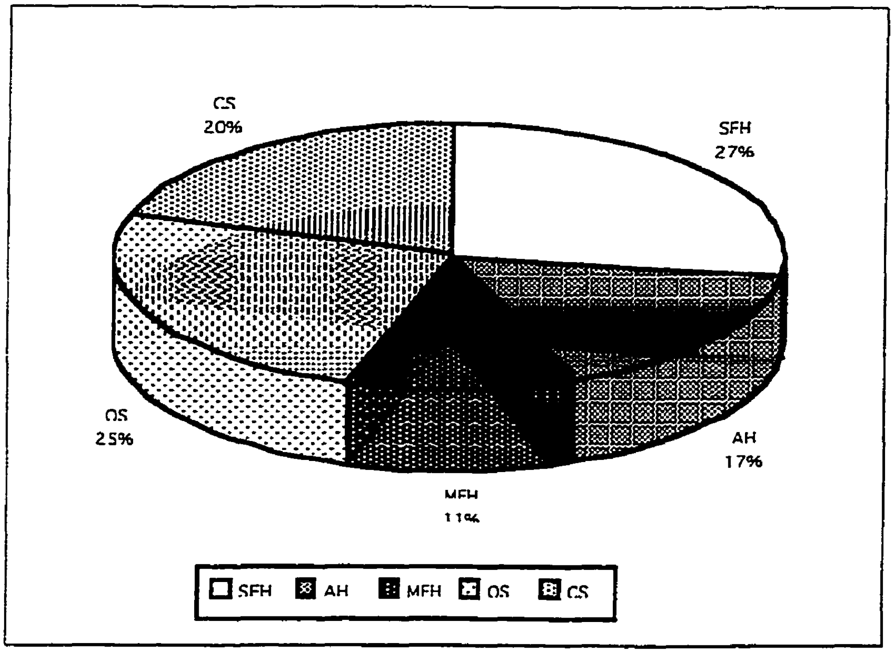
Table 4.4.1: **Space Allocation Data**

- Open Space (unit, cluster, neighbourhood, community) = 25%
  - 225 acres
- Community/Public Space = 20% (40% open, 60% built-up)
  - 180 acres
- Residential Development
  - Single Family Housing = 27.5%
    - 247.5 acres
  - Attached Housing = 16.5%
    1. 148.5 acres
  - Multifamily Housing = 11%
    - 99 acres

Table 4.4.2: **Space Allocation per Residential Type**

Types of Use	Allocated Acreage
Single Family Housing	**247.50**
Attached Houses	**148.50**
Multi-family Houses	**99.00**
Open Space	**225.00**
Community/Public	**180.00**
TOTAL ACREAGE	**900.00**

Fig. 4.4.9: **Space Allocation**



LEGEND

SFH: Single Family Housing

AH: Attached Housing

MFH: **Multi-Family Housing**

OS: Open Space

CS: Community/Public Space

Types, Density, and Number of Residential Units

- Single Family Housing Density: 5 units/acre = 2,000 units
- Attached Housing Density: 14 units/acre = 2,000 units
- Multi-family Housing Density: 20 units/acre = 1,800 units
- Estimated number of housing units = 6,000 units

Table 4.4.3: **Number of Units per Residential Type**

Residential Types	Number of Units
SFH1	400
SFH2	1,200
SFH3	600
AH1	1,200
AH2	800
MFH1	1,500
MFH2	300
TOTAL # OF UNITS	5,800

LEGEND

SFH1: Single Family Housing Type 1

SFH2: Single Family Housing Type 2

SFH3: Single Family Housing Type 3

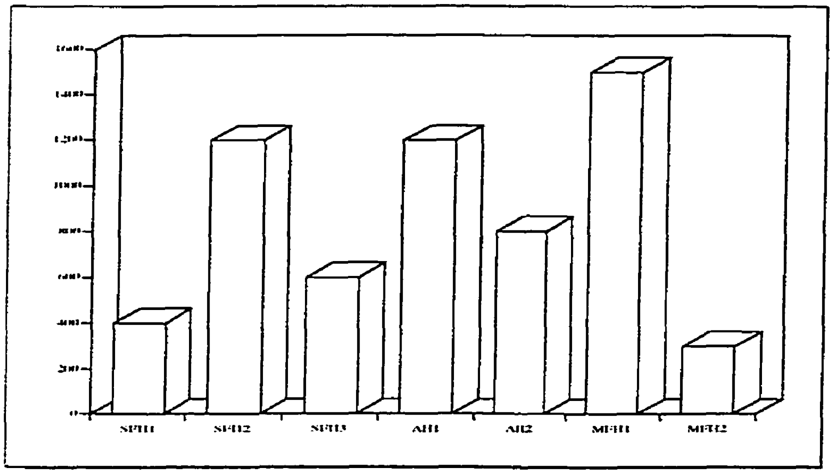
AH1: Attached Housing Type 1

AH2: Attached Housing Type 2

MFH1: Multi Family Housing Type 1

MFH2: Multi Family Housing Type 2

Fig. 4.4.10: Number of Units per Residential Type



Residents per Residential Types

- Single Family Housing

  Number of persons:

  Type 1 (20%) = 400 units i.e., 800 persons @ 2 persons per unit

  Type 2 (60%) = 1200 units i.e., 4800 persons @ 4 persons per unit

  Type 3 (30%) = 600 units i.e., 3000 persons @ 5 persons per unit

- Attached Housing

  Number of persons:

  Type 1 - Duplexes (60%) = 1200 units i.e., 4800 persons @ 4 persons per unit

  Type 2 - Townhouses (40%) = 800 units i.e., 4000 persons @ 5 persons per unit

- Multi-family Housing

  Number of persons:

  Type 1 (80%) = 1500 units i.e., 4500 persons @ 3 persons per unit

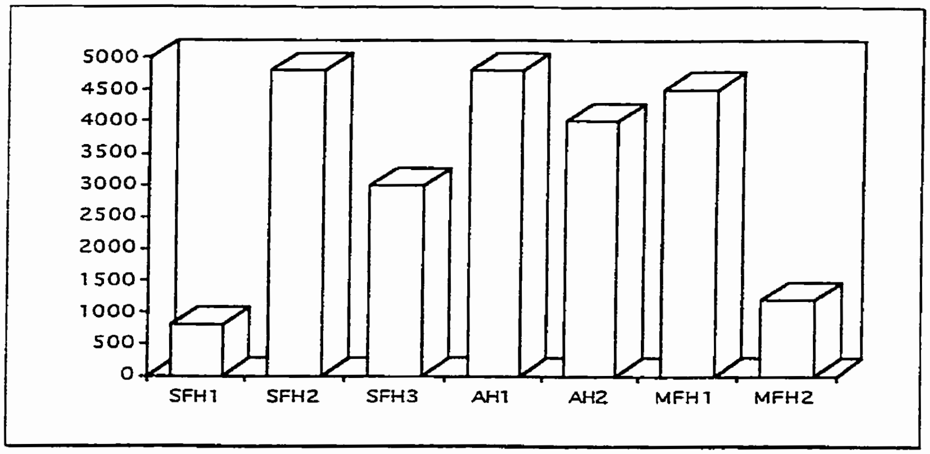
  Type 2 (20%) = 300 units i.e., 1200 persons @ 4 persons per unit

- Estimated total number of residents = 21,000 - 27,000 persons @ 3.5-4.5 persons per unit

Table 4.4.4: **Number of Resident per Residential Type**

Residential Types	Population
SFH1	800
SFH2	4,800
SFH3	3,000
AH1	4,800
AH2	4,000
MFH1	4,500
MFH2	1,200
TOTAL POPULATION	23,100

Fig. 4.4.11: **Number of Resident per Residential Type**



LEGEND

SFH1: Single Family Housing Type 1

SFH2: Single Family Housing Type 2

SFH3: Single Family Housing Type 3

AH1: Attached Housing Type 1

AH2: Attached Housing Type 2

MFH1: Multi Family Housing Type 1

MFH2: Multi Family Housing Type 2.

4.4.3. **The Community Core**

The core is designed as the main street or 'downtown' of the community. It is the focus of activities and the social magnet for all age groups and economic strata in the community. The core is a multi-functional activity centre with commercial, recreational, institutional, and medium density residential uses. Institutional uses in the centre include schools and playgrounds, places of worship, a fire station, a postal outlet/post office, a community police station, and a community recycling centre.

The residential units consist of duplexes (side-by-sides), townhouses/row-houses, and multi-family single- and double-loaded walk-up apartments. The maximum number of floors for the low-rise apartments is four storeys.

All residential units are connected to the centre and the community's open spaces and parks by a network of pedestrian walkways, and cycle paths. The transportation planning is geared toward the minimization of delays and hazards for pedestrians. To achieve this, the traffic network strategies adopted include:

- Minimizing of four-way intersections
- Slowing down vehicular traffic by:
  - Using multiple connections in street design;
  - Limiting street width to a maximum of 2 lanes;
  - Using street parking in designated areas to slow down traffic;
  - Incorporating *traffic calming* devices.
- Maintaining a compact street design by:
  - Minimizing destination distances from residential areas to the core. Destination distances at the core (to bus stops, recycling depots, shopping) are limited to a maximum of 5 minutes walk (450 metres).
  - Minimizing allowable rights-of-way
  - Adapting traffic network to collective transport by having dedicated public transit lanes

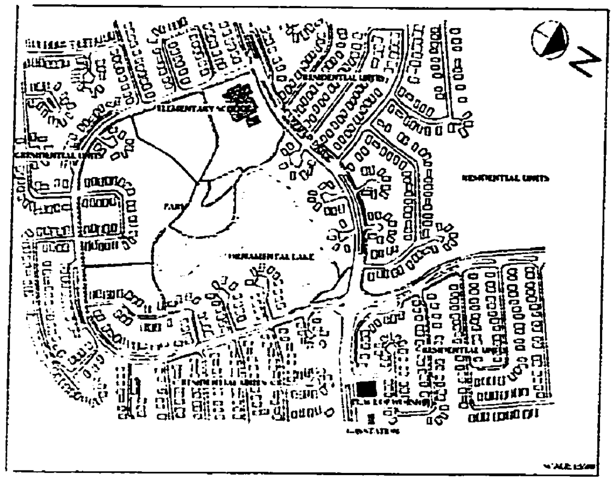


Fig. 4.4.12: **Layout of Existing Core**

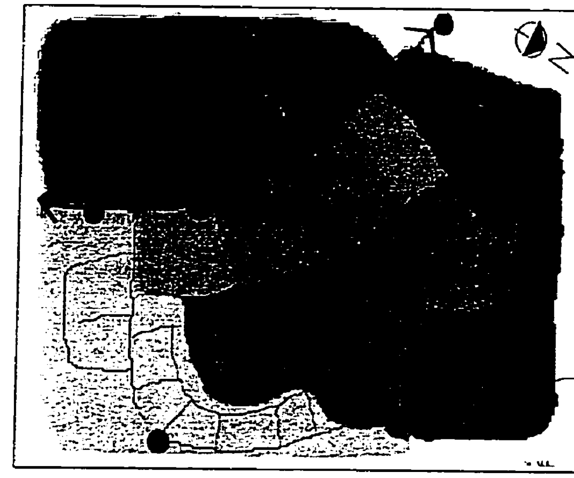


Fig. 4.4.13: **Planning Concept**

Fig. 4.4.14: **Northwest view of Core**

Fig. 4.4.15: **Rendered view street layout at the Core**

- Providing public transportation
- Providing sheltered Pedestrian Networks (skylink between the community centre and other institutional buildings in the community.
- Providing cycle networks
- Providing universal access to all public areas and buildings
- Reducing the size of land allocated to parking by clustering parking in designated areas.

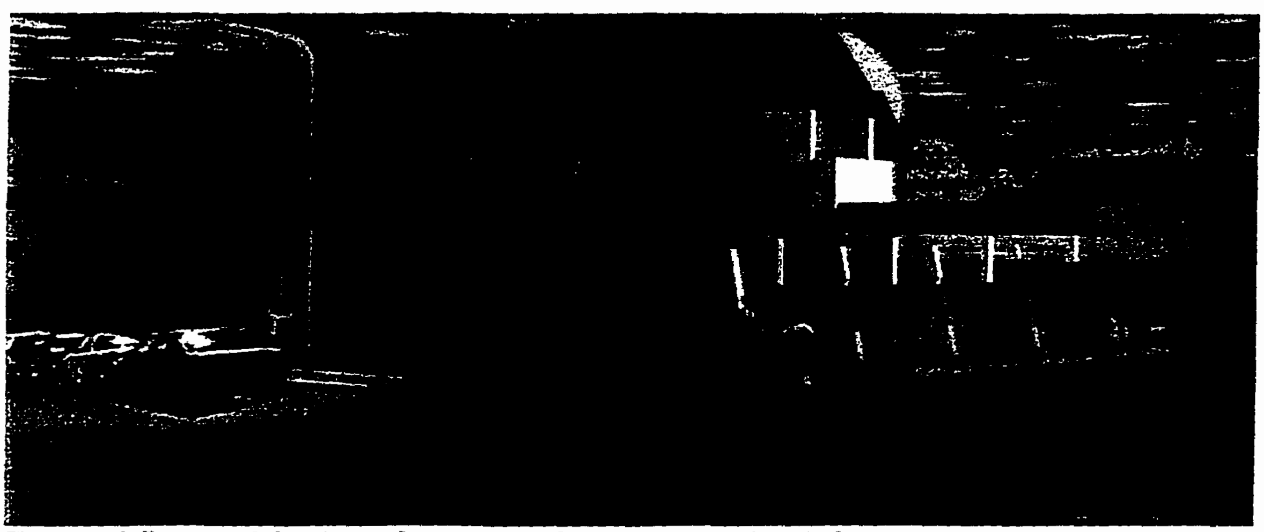


Fig. 4.4.16: **Increased density and access to public transportation shelters**

Part of the multi-functional structure of the core was the design of open spaces and parks for outdoor recreation. Open spaces were hierarchically structured from the unit level backyards or patios, to cluster level shared open spaces, neighbourhood parks, and Community Park. In order to reduce noise pollution from highways and rail tracks that surround the site, a community 'green' buffer was designed as green natureway throughout the perimeter of the site.

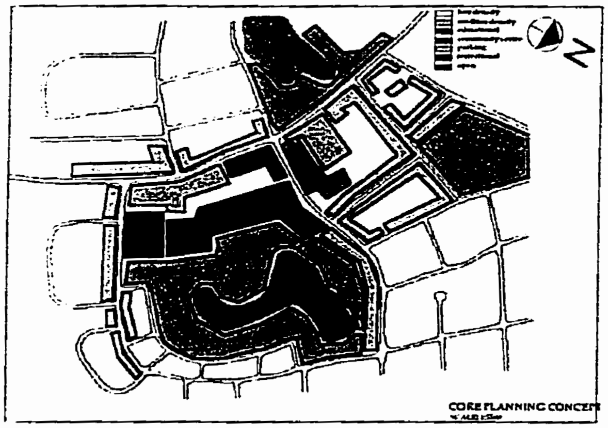


Fig. 4.4.17: **The Core - Design Concept**

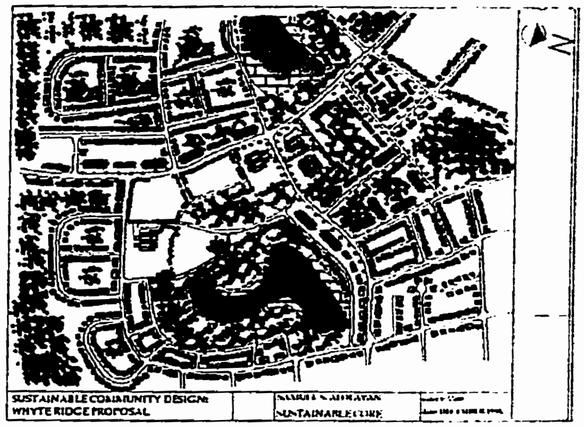


Fig. 4.4.18: **Layout of Proposed Core**

Throughout the site, there are designated spaces for waste recycling, community gardens, and greenhouses for plant nurseries and food production. The community power and heat generation plants are located in the ecologic building, which also functions as a resource centre for the community's ecological programs. Greywater recycling building was located beside the central ecological lake on the site.


Fig. 4.4.19: **View of Greenhouse and Ecologic Lake**

The goal of this design exercise is to present a research argument for using established parameters for sustainable community design to evaluate the sustainability of a conventional suburban community in the City. Established parameters would then be used to carry out an evaluation of design alternatives, such that the result of the research could be used to assist in the design of new suburban communities. The objective of producing reliable graphical imagery of community features for a survey on consumers' receptivity to sustainable community design alternatives was attained with this design project. The second objective of determining which of the features are testable in the VR environment is addressed in Chapters 5 and 6. The last objective of validating the use of this tool to assist in establishing consumers' receptivity to sustainable community design features is also addressed in Chapters 5 and 6.

CHAPTER 5

THE HYPERMEDIA VISUALIZATION INTERFACE DESIGN AND TESTING

5.1 Design Algorithm

The goal of the hypermedia interface is to present design information to Web-based participants in a clear and dynamic form so that data obtained could be used for the analysis of consumers' receptivity to sustainable community design alternatives in the City of Winnipeg. The procedure for developing the hypermedia interface used for the survey is presented in Table 5.1.1 and shown graphically in Figures 5.1.1 and 5.1.2.

Table 5.1.1: **Algorithmic Design Procedures**

1. Prepare necessary design data
2. Prepare HTML[1] frames to fit design categorization
3. Input data into HTML frames
4. Manipulate data to achieve desired output
5. Input values of output data based on interrogation
6. Log final answer in default e-mail address
7. Store data in bin for processing
8. Retrieve data from file for processing
9. Analyze data using preferred analytical procedure.

The HTML programming format for the hypermedia visualization interface (HVI) was based on the need to present design scenarios in pairwise format. The pairwsie split-screen format enabled participants to compare both the graphic output and the text explanations in order to make an informed judgment. Design categories were explained in the introductory Web page of the frame-based interface. Database interrogation was made possible through a function call that activated a network of frames containing the information in the drop-down menu.

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[1] Hypertext Mark-up Language: "Hypertext" refers to the way links on web pages cross-reference other pages, while a markup language consists of a set of text commands which, when interpreted by software (Netscape Navigator or Internet Explorer, for example), result in a visual document.

Figure 5.1.1: **FLOW DIAGRAM OF HVI DESIGN AND SURVEY PROGRAM**

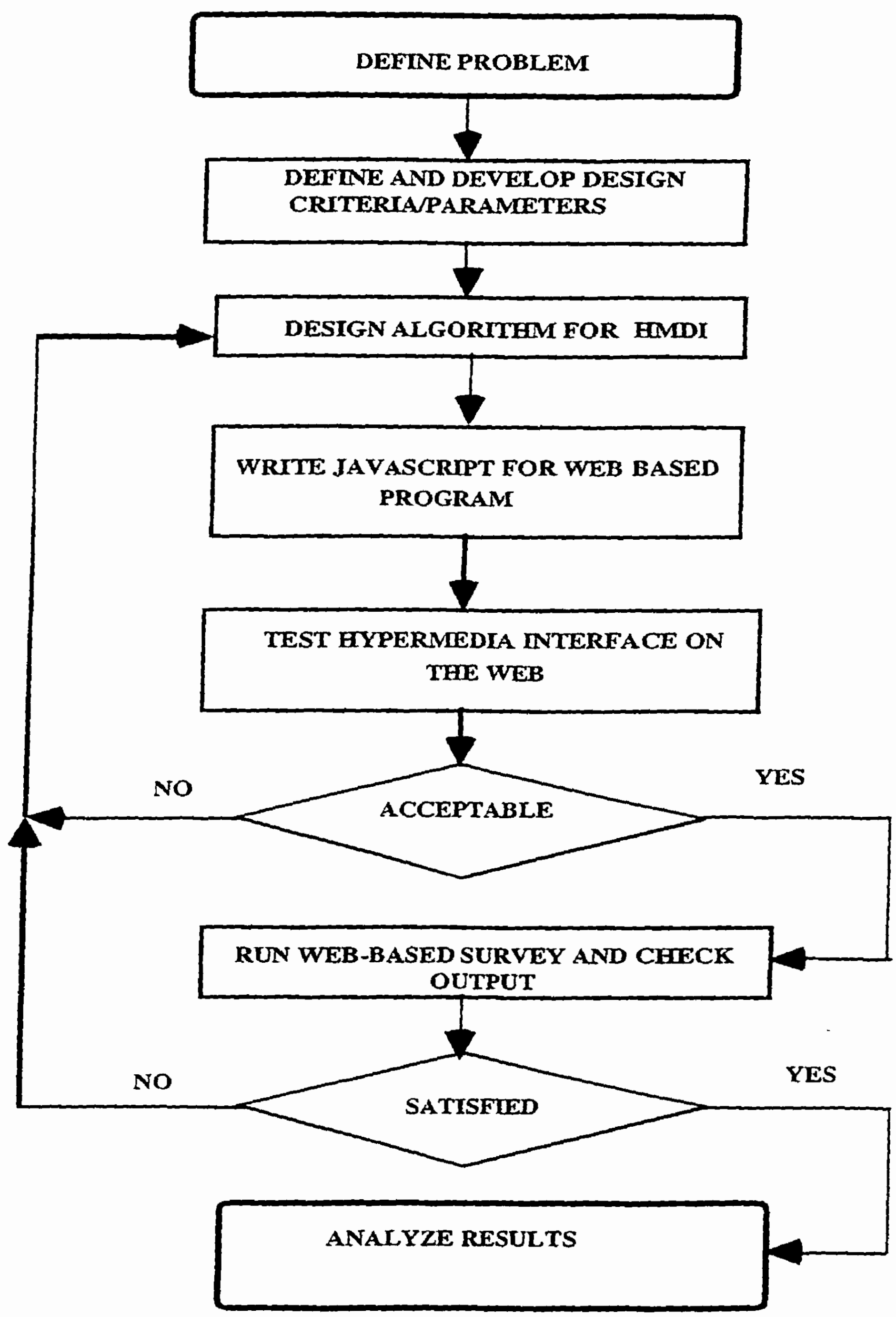
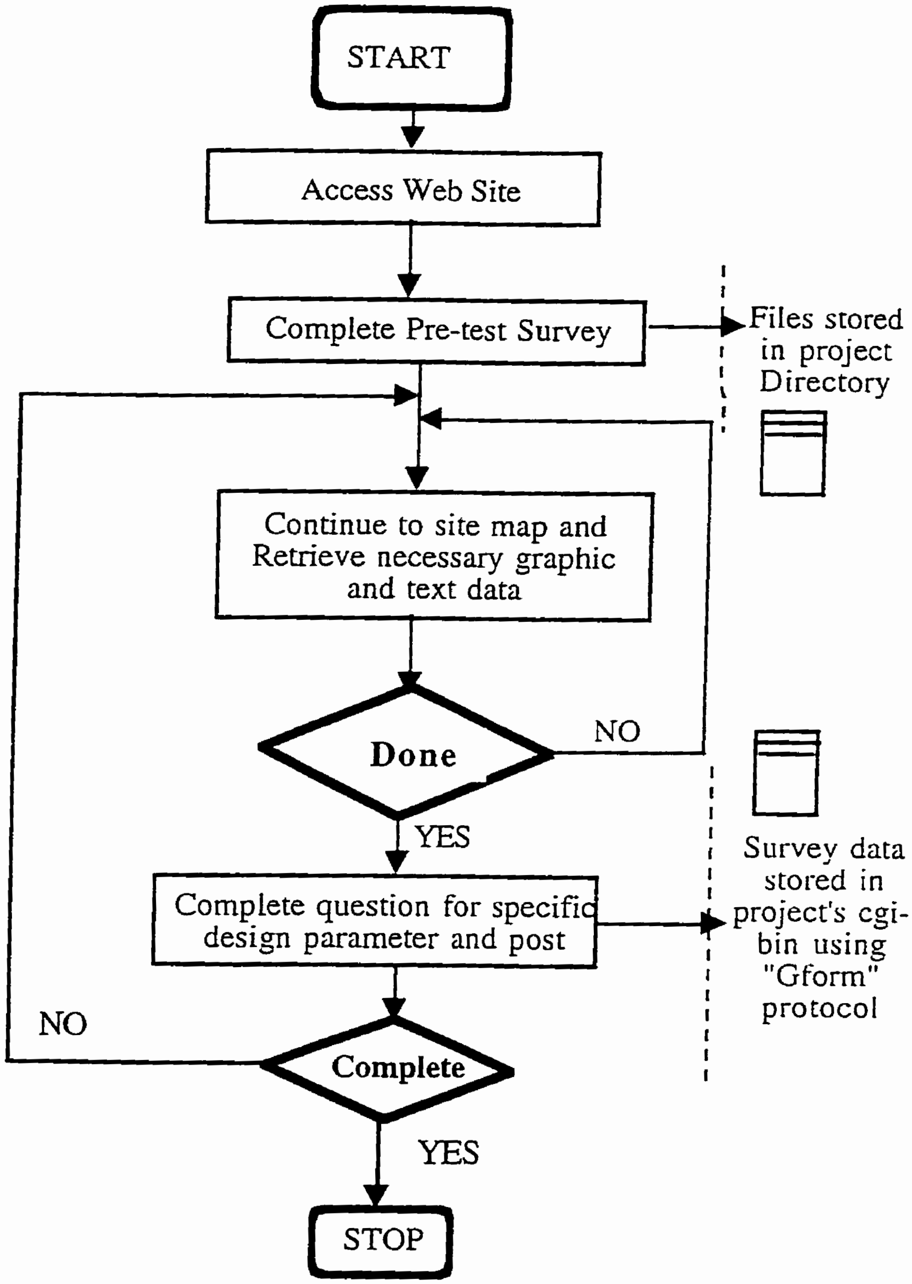


Figure 5.1.2 presents a diagrammatic illustration of the procedures for hypermedia visualization system.

Figure 5.1.2: **WEB BASED HYPERMEDIA VISULAIZATION INTERFACE SYSTEM**



5.2 **Interface Design Structure** (see Figs. 5.2.1 - 5.2.2)

The structure of the system was based on the need to present both graphical images and explanatory texts for each sustainable community design feature contiguously, and to present the questions beside these explanations, so that respondents have all the information they require to make an educated assessment. This presentation is only possible with the use of HTML frames, where child-frames could be nested inside parent frames, and each of the frames would contain all information required for assessing specific features. A detailed explanation of the procedures for developing the interface follows.

5.2.1. Explanation of Procedures

The first step of the hypermedia visualization interface development involved the preparation of design data in HTML interchange format and converting explanatory texts into HTML formats, then saving the texts as separate files in a directory created for the Web site.

Figure 5.2.1: **The Design of Web Site's Introductory Page**

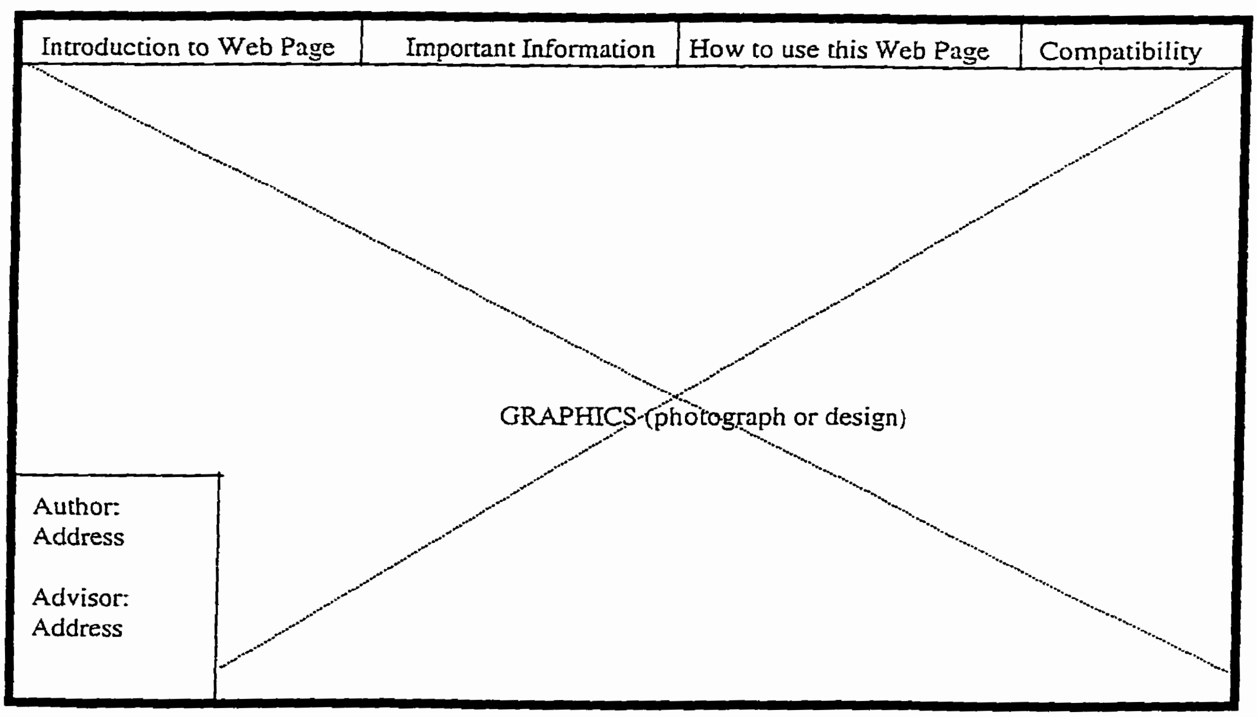


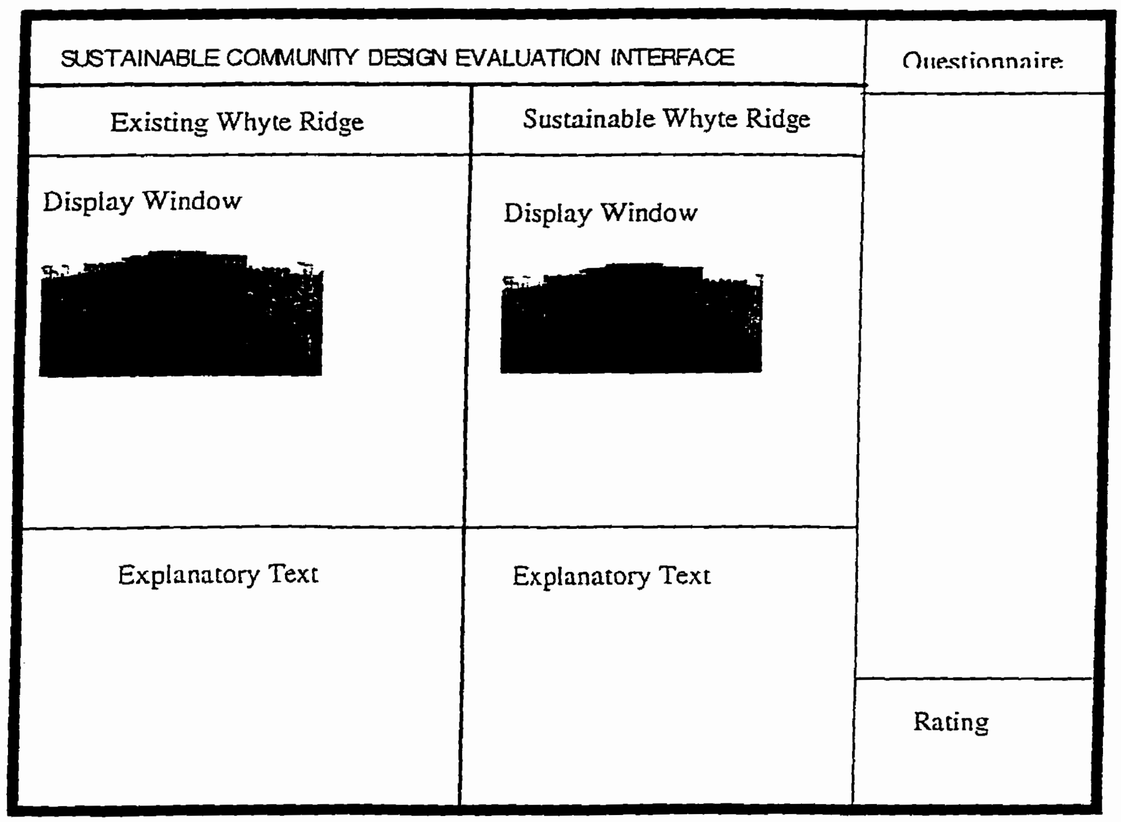
Table 5.2.1: **Layout of Menus and Sub-Menus**

SELECTED PROJECT	GLOBAL PARAMETER	DESIGN FEATURES
Existing Whyte Ridge		
Sustainable Whyte Ridge	***Community Design***	Land Use and Housing
		Residential Intensification
		Types and Sizes of Housing
		Common Buildings
	The Core	Mixed Use
		Social Space
		Street Network
	In-between Spaces	Circulation
		Social
		Recreational
	Ecologic Design	Waste Management
		Conspicuity/Design
	Wastewater	Greywater Re-use
		Storm water recycle
		Rainwater recycling
	Energy	Co-generation
		District Heating
	Local Food Production	Community Farms
		District Gardens
	Street Design	Circulation Networks
		Vehicular/ Bicycle
	Right-of-way	Arterial
		Collectors/Local
	Universal Access	Street
		Public Areas/ Buildings

Table 5.2.2: **Sample Menu Calling Procedures**

Conventional →	Community Design →	Landuse and Housing →	Lot Configuration
	Ecologic Design	Community Core	Residential Intensification
	Street Design	In-between Spaces	Types and Size of Buildings
			Common Buildings
Sustainable →	Community Design →	Landuse and Housing →	Lot Configuration
	Ecologic Design	Community Core	Residential Intensification
	Street Design	In-between Spaces	Types and Size of Buildings
			Common Buildings

Figure 5.2.2: **Hypermedia Interface Frame Structure**



The graphic files for each design feature in the hypermedia interface are saved in JPEG format -- an interchange file format that makes the embedding of graphic files in HTML files possible (see figure 5.2.2). The objective of the frame design is to present a split-screen-display of alternative design scenarios in a way that direct comparison and assessment can be made by participants. The objective of adopting this presentation format was to give participants as much information as possible in order to make an objective assessment of the design feature under review.

The right frame of the interface displays questions based on the graphic and text display in the frames containing "existing Whyte Ridge" and "sustainable Whyte Ridge" scenarios. The intention is to present the question and a predefined response rating for each question on the same large frame, such that the frame containing the ratings was embedded as a child frame to the questionnaire frame, in the frameset.

Dreamweaver 3.0[2] was used to develop the web interface. The graphic inserts were prepared in Photoshop and saved as separate JPEG files. In each of the 55 questions contained in 10 individual frames per frameset, data manipulation was achieved through the use of a drop-down menu.

Figure 5.2.3: **Drop-down Menu**

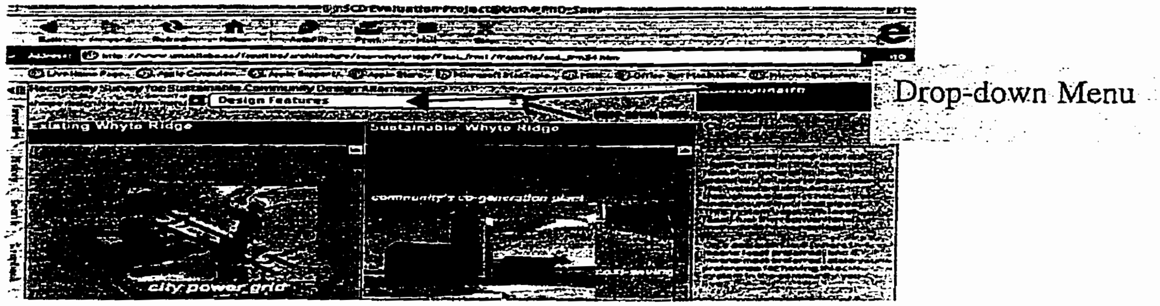
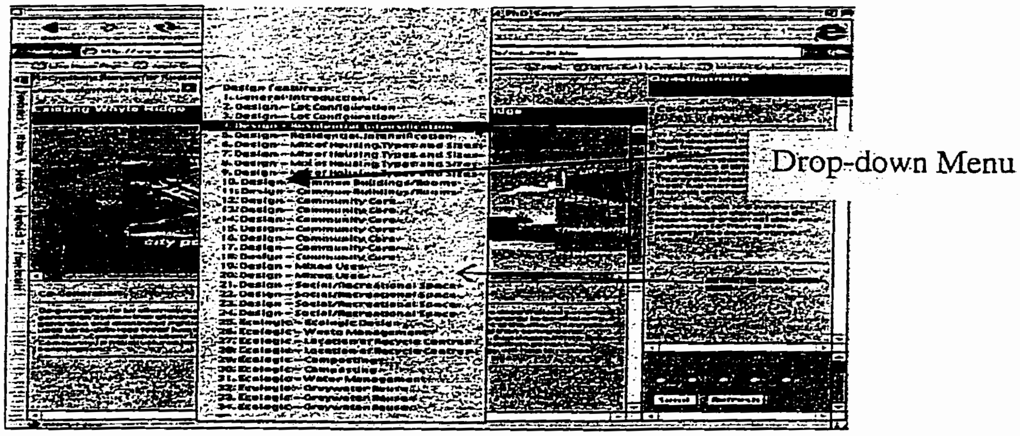


Figure 5.2.4: **Activated Drop-down Menu**



In addition to the drop-down menu, a site map was created to make navigation through the questions easier for participants. Because of the change in its colour cues, the site map makes it easier for participants in the Web based survey to track questions that have been answered. This helped participants to optimize the time spent on the questionnaire and made their tasks easier.

[2] Dreamweaver3 is a Web development software produced by Macromedia Inc. in San Francisco, CA.

5.2.2. Development of Graphical Imagery

The graphical images embedded in HTML codes were developed using CAD software such as VectorWorks[3], and 3D modelling software such as FormZ[4]. The plans and elevations were developed using VectorWorks. VectorWorks is a computer aided design and drafting software, used for designing buildings from layout plans to detailed drawings and 3D projections. It was used to develop alternative plan proposals for design features and to produce the site plan and detailed plans for the community core.

The development of conceptual 3D models for the core was done using FormZ. FormZ is a robust 3D modelling software that allows the designer to conceptually lay out building configurations for a site. Individual buildings could then be modelled, rendered and saved in separate layers and imported into the project's main layer as a template. All images created in FormZ have a depth dimension. The designer must categorically define the depth dimension when developing the conceptual models for each unit of the general plan. When completed 3D models of different aspects of the site are imported and assembled in the general plan layer, the dimensional parameters attached to each model by the modeller are imported with it.

FormZ has a texture mapping capability such that texture maps could be attached to models to produce photorealistic images. This is one of the greatest strengths of FormZ. The texture maps and shadow casting that could be obtained with this software are better than is possible with most 3D modelling software such as Virtus Walkthrough Pro[5], and 3D Studio[6].

The greatest advantage of FormZ is its versatility and ease for creating virtual environments. It does not require any cumbersome conversion of design from vector to raster images in order to produce QuicktimeVR rendering or animation sequences of specific scenes. In FormZ, all the designer is required to do is to define a direction of view and path or direction of movement for animation rendering. QuicktimeVRs of scenes are easily rendered and texture, shadow, and opacity specifications attached to scenes before rendering in FormZ.

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[3] VectorWorks is produced by Deihl Graphsoft, Inc., CA.
[4] FormZ is produced by Auto.des.sys Inc., CA
[5] Virtus Walkthru Pro is produced by Virtus Corporation
[6] 3D Studio is produced by Autodesk, the producer of AutoCAD.

Selected 3D views from the design layout were rendered to conform to the pattern of survey interrogation. The rendered views represented a match between pre-defined sustainable community features and the portion of the designed core that most appropriately represent the feature. Well over 250 views were rendered and matched with design features. This process was used to test and eliminate which views are not very relevant to the investigation. At the end of the image-matching and selection process, 3D views that illustrate each of the features were sorted and QuicktimeVRs and animation sequences of the views were produced. The static and dynamic images produced were attached as links to relevant features in the hypermedia visualization interface.

5.2.3. Development of Text Files

Explanatory texts and questions for each feature were prepared and saved as word documents. These documents were then converted to a format that was HTML-readable. HTML files were set up for all features and saved as a sub-folder in the frame folder. This process made it easy to link text files to framesets that were developed at the initial stage of this process. Appendix C presents a summary of questions contained in the text files and the reference numbers that were attached to each question in the hypermedia interface frame files. Fifty-five questions, subdivided into the three main categories for the investigation were developed. Participants were encouraged to answer all questions, to the best of their understanding of the feature under review. When the questions are answered and posted, the responses were dynamically saved into the candidate's e-mail directory and they were sorted in the order in which the questions were queued onto the server.

5.3 **Database Interrogation**

Table 5.2.2 presents the database interrogation procedure. Two procedures are used for frame-access by the system. The procedures include the use of drop-down menus complemented with a hyper-linked site map (see Fig. 5.2.8) to facilitate end-users' navigation through the site. The title for each question was inserted as a menu item on the drop-down menu list. The pull-down and data retrieval routine was implemented with a JavaScript jump-menu code, which activates a function call on all hyperlinked frames in each of the framesets attached to the menu title on the list. The procedure follows a "click-and-access" routine, in which every click of the mouse on an item calls all URLs[7] that are hyperlinked to the list item.

Figure 5.2.5: **Text File Attachment**

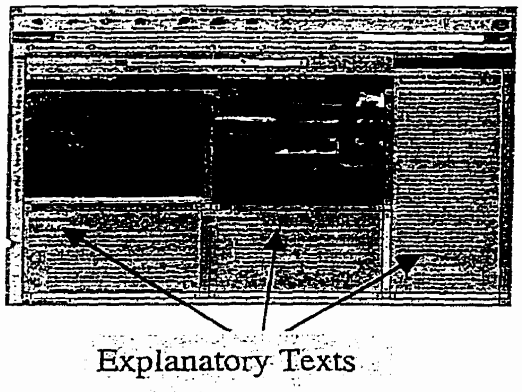
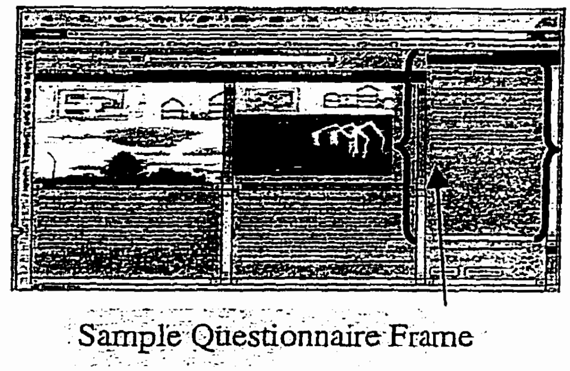


Figure 5.2.6: **Questionnaire Frame**



Each frame contained nested graphic and/or text files in a URL that were displayed in the Web browser whenever the list item is queried with a click of the mouse. Dreamweaver made it easy to link multiple HTML pages in any frameset such that a single URL reference was required to call all the information in the frameset. This made it easy to display multiple files embedded in different frames in the same frameset. The advantage of this display method is that the information required by end-users or participants is displayed at the same time (see Figs. 5.2.3 and 5.2.4).

Presenting all required information side-by-side on the same page as shown in Fig. 5.2.7 helped to minimize the bias that could arise because of the freshness of recent information displayed for a participant's judgment of a preferred alternative. The recency-effect of layered information could skew the response obtained from respondents in favour of what was most recently displayed (Saaty, 1980). The interface structure used in this research ensured the avoidance of such bias.

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[7] Unique identifiers called Uniform Resource Locator used by Web browsers to keep track of what is at either end of a link.

Figure 5.2.7: **Sample Interface Split-screen**

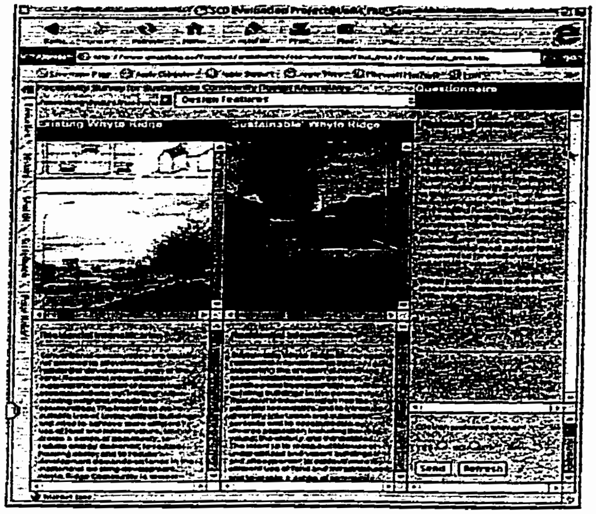


Figure 5.2.8: **Site Map Interface**

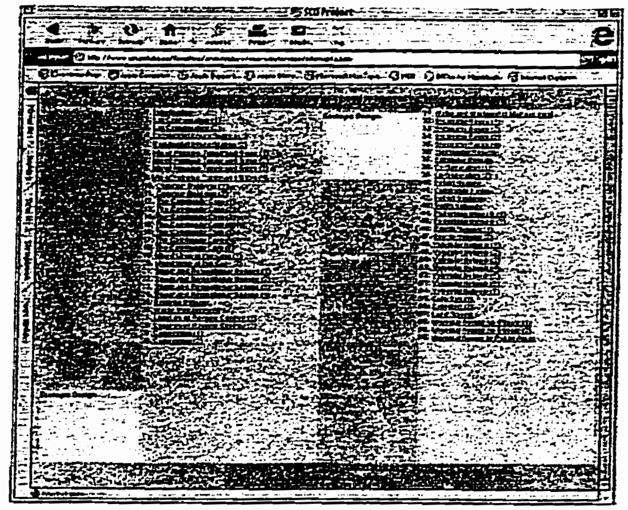


Fig. 5.2.9: **Sample Main Page Display**

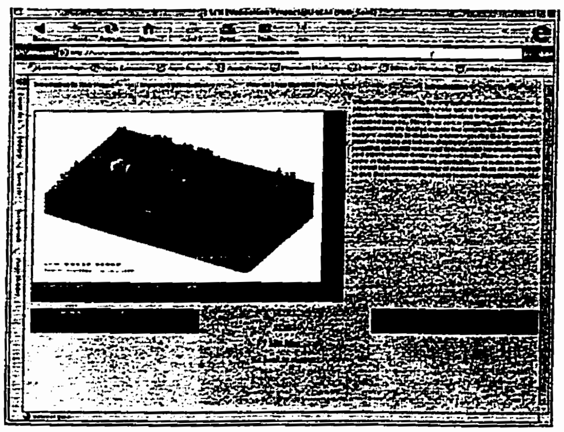
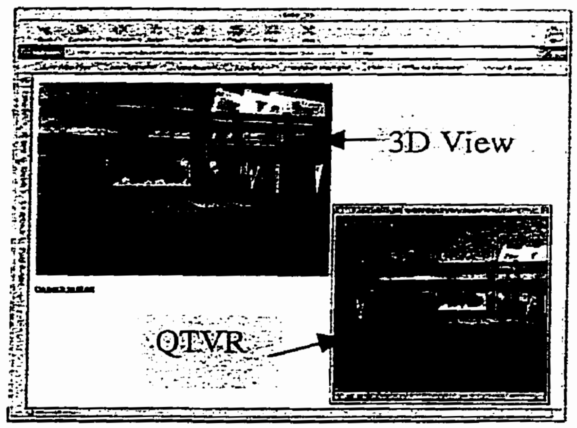


Fig. 5.2.10: **3D View and QTVR of View**



The main page of the interface contained a 3-dimensional computer model of the project site. The model was subdivided into 24 rollover[8] images that were hyperlinked to 3-dimensional views and QuicktimeVRs (that is, a 360° interactive panoramic display), of each 3D image (see Figs. 5.2.9 and 5.2.10). The objective of this presentation method was to give each participant the opportunity to explore the rendered 3-dimensional representations of the site in virtual space. It was argued in chapter 3 that simulating consumers' dynamic experience of a designed space enhances the quality of assessment

[8] Rollover is an image-swapping event in which an image changes when a mouse pointer is placed on it or when it is clicked on.

that is obtained from participants in a receptivity survey and improves reliability of judgment and the data obtained from such judgment. It was thus essential to ensure that subjects were able to carry out a virtual exploration of represented feature before making a final judgment about which alternative presented a more sustainable approach.

5.4 Web Site Access

Access to the site is made through an index page that provided links to the personal data page and all the framesets that a participant would require for completing the questionnaire. Sample desktop views of these introductory pages are shown in Figs. 5.2.11 and 5.2.12.

Figure 5.2.11: **Index Page**

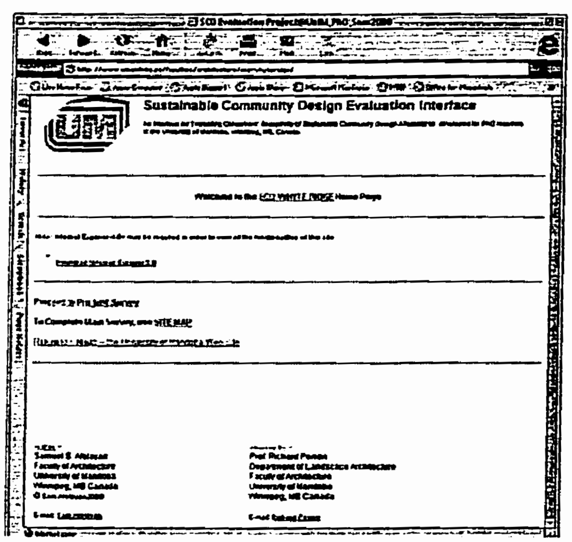
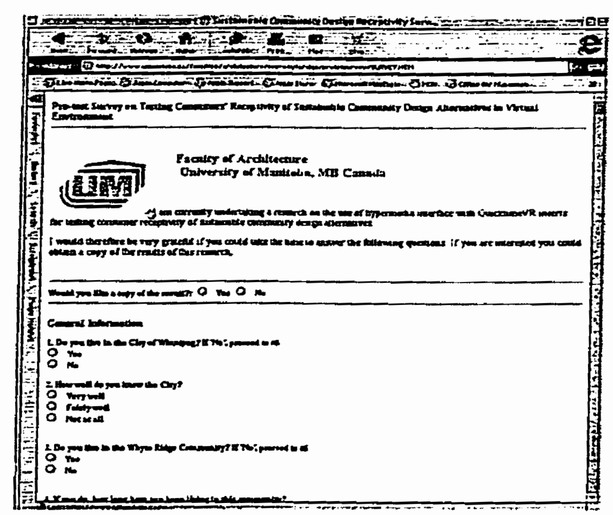


Figure 5.2.12: **Personal Data Page**



5.5 Data Retrieval: The Gform Protocol

5.5.1. Introduction

The dynamic data retrieval protocol for this interface is called "Gform" (Seifert 1995). Gform is a generic Web form handling utility protocol developed at Swinburne University in Australia. It uses a CGI scripting routine that takes advantage of HTML file comments enclosed by '<!--' and '-->'. To handle this form, a script or program is required to interpret the input values specified as 'cgi-bin/handler'. Gform uses all input type tags defined in HTML v2.0 such as:

5 **TEXTAREA** - which assigns a variable with all the entered text including linefeeds.

6 **SELECT** - SELECT returns a single value from a list of options.

7 **SELECT MULTIPLE** - where a comma-separated list of the selections is returned.

8 **CHECKBOXES** - which returns the value of the checkbox if it is selected. Otherwise "null" is returned.

9 **RADIO BUTTONS** - RADIO BUTTONS returns the value of the selected radio button. Otherwise "null" is returned.

Gform has three types of commands. The first type of command handles text and variables, the second defines a delivery method, and the third is an optional reply URL that is sent to the user after the form is submitted. The syntax for this can be summarized as shown below:

<!--gform <"text|$(var)">|<[**reply** ="URL"]|[**deliver** =[**print** "queue"]|[**mail** "address" [**subject** = "subject"]]|[**file** "path"]]>**-->**

where:

- **bold** text is a keyword that must be entered.
- Text between "<>" brackets indicates required data.
- Vertical bar "|" reads as an 'exclusive or'
- Square brackets "[]" enclose optional data.
- "Text" is a series of alphanumeric characters and $(var) is a variable. Any number of variables and text can be freely mixed.

Variables are identified by a '**$**" sign and maybe enclosed with brackets so that the programmer does not need to have a space between it and any text immediately following it. A variable should match with the name given in the input specification. It could also be a CGI environment variable. Gform variables are case insensitive. Only CGI environment variables are case sensitive.

A typical line in a form could be:

Enter your name:<INPUT TYPE="text" name="Sola">

The variable name is given by '**name**' and is called '**Sola**', and the corresponding gform line will look something like;

<!--gform "The person's name is: $(Sola)\n"-->

$(Sola) is then replaced by what the form user entered and the result is delivered according to the given delivery method(s).

5.5.2. Methods of Data Delivery.

Information from a submitted form can be retrieved in 3 ways. It could be sent to a default e-mail address, to a printer, or to a text file. Any combination of delivery methods can be used. Two combinations of delivery methods were used in the survey for this research. They involved a combination of e-mail address and text file delivery methods.

Where the results are to be retrieved via e-mail the protocol will be written as shown:

<!--gform deliver=mail "address@project.site.ca"-->

The "**<!--gform** " lines together with the text and variables that are specified, will be sent to "**address@project.site.ca**" via e-mail with the variables containing the entered values.

To get the results appended to a file the script is written in the form:

<!--gform deliver=file "/path/of/file"-->

To send the results directly to a printer the routine is of the form,

<!--gform deliver=print "tornado"-->

Where *tornado* is the name of a printer connected to the system. For BSD type UNIX, *tornado* corresponds to an entry in the '/etc/printcap' file. The disadvantage of printing directly is that the results are sent as straight text and not in properly formatted postscript.

5.5.3. Reply URL

After the user has submitted the form, the form creator has the option of specifying a URL to send back. This is done by using the 'reply' command. In the consumers' receptivity to sustainable community design survey, a simple "Thank You for Your Participation in this Survey" was sent.

For example:

<!--gform reply="/thanks.html">

5.5.4. CGI Environment Variables.

If a variable specification in a **<!--gform** line does not match any variable in the INPUT specification, Gform will interpret it as an environment variable. If it is not an environment variable, it returns the "**null**" value. See the sample of Gform codes written for the Web-based survey attached as Appendix D.

5.6 Data Processing

The processing of the Web-based survey used for this research followed a three-step procedure. The first step involved sorting of respondents according to the personal information data provided in the personal data questionnaire. The second step involved matching responses from individual respondents with the questions and recording them on a data record sheet. The third step involved inputting data in a spreadsheet program for analysis.

5.6.1 Personal Information Data

A Pre-test Survey page was created to facilitate the sorting of respondents according to the information required in the survey. The information requested from participants included:

- Where they live;
- How well they know the City of Winnipeg;
- Whether they live in Whyte Ridge;
- Whether they are renters or owners of the place they live;
- Respondents' genders;
- How well they can read and interpret architectural drawings;
- Age group classification;
- Professional or employment status;
- Experience with the use of computer;
- The Internet connection speed of their computer, for Web access.
- Respondents' Home Page address if they wished to have their Web page linked to the site.

This information made it easy to classify participants' responses according to their demographics, the understanding of architectural drawings, and use of computers. It also allowed a mapping of the patterns of response with respondent's economic and demographic data for the purpose of analysis.

5.6.2. Data Sorting

Data obtained through one of the Gform delivery methods described in section 5.5.2 were sorted in the order of the questions in the hypermedia visualization interface. This was possible because identifiers for each of the questions were embedded in the 'NAME' field of the Gform protocol, such that when data were delivered, they were delivered with the identification parameter embedded in the codes. This facilitated the process of data sorting and ensured that no data were 'orphaned' during delivery.

A record sheet was prepared to record responses from individual respondents, and was saved in separate folders based on the order in which the electronic survey forms were submitted. In order to successfully track responses to individual questions, each question was prepared as separate HTML files. For example, where six questions are asked under a particular design feature, the feature was sub-divided into six separate HTML files and a response frame was prepared for each of the questions. This procedure made matching responses to particular questions easy.

5.6.3 Data Analysis

Recorded raw data from the assessment of features were input into Microsoft Excel for processing and analysis. Once the data had been input, it was easy to perform analytical operations, such as determining the mean, variance, standard deviation, t-tests, and single factor ANOVA, on the data using statistical packages like SPSS[9].

For this research, a mathematical programming procedure, called Fuzzy Group Decision-Making technique, was used for analyzing the data obtained from the survey on clarity of representation techniques in conveying design intent. It was argued in Chapter 3 that the qualitative nature of design data makes the use of this analytical technique necessary. The chapter is devoted to the discussion of the theoretical foundation and application of this decision-making technique.

5.7 Hypermedia Interface Optimization

The Web-based hypermedia visualization interface was tested using different browsers to confirm that all the functionality of the site could be viewed in the different browser environments. Few anomalies were observed in this process, some of which had to do with the inflexibility of the Web programming software used for the interface design to present similar interface output in different browser environments. A detailed discussion of the problems encountered is presented below.

5.7.1 The Frame Structure

The need to organize the data in frames made it difficult to insert navigation buttons into any single frame in the interface. The reason for this difficulty was that embedded navigation buttons only hyperlinked the specific frame to which it was inserted. To overcome this difficulty, a site map was developed. The framesets were then linked to the table of contents on the site map, making it easy for respondents to track the questions that have been answered, as well as presenting all information in an undistorted frameset.

Secondly, scroll bars were provided for all frames in the frameset to allow respondents to scroll downward or sideways where presented data could not be viewed at a glance. This was especially useful for graphic and text files that could not be fully displayed in a single window-display due to the variability of display monitor sizes or the window display configuration by different end-users.

5.7.2 Graphic Display

The display of the graphic contents in the framesets, for the survey questionnaire was limited to 2-dimensional and 3-dimensional architectural drawings and photomontages. This was necessary because of the size of graphic files and the slow download-time problem for participants with low modem capacity. However, it was noted that the quality of embedded graphical data did not change drastically from the observed quality of the source data, unless in situations where there was need to stretch graphical data for good visual cognition. To ensure that graphical data were displayed in the required format, they were inserted into HTML files using a dimensionally coordinated layering procedure that presented embedded data by order and location, in the target frame.

5.7.3 Text Display

A procedure similar to the one described in 5.7.2. was adopted for display of text files. Horizontal and vertical sliders were used to facilitate navigation through text files because frames tended to constrain the area of texts that were visible at a single display. With the sliders, participants were able to scroll downward or sideways, to read the entire text. No major problem was observed with presentation of text frames, since text files were initially converted into HTML-readable formats and saved as HTML files.

5.7.4 Data Retrieval

Perl (Practical Extraction and Report Language), a CGI scripting procedure, was experimented with at the initial stages of the hypermedia visualization interface

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[9] A statistical package for analyzing data in social sciences

development. Perl is excellent for developing interactive sessions, such as chat-rooms or forums on the Web. It allows multiple-users to comment on graphical display, while the comments are dynamically displayed for every user connected to the site in real time.

However, because of the programming time overhead, it was found to be inappropriate for the simple transaction required for the Web survey. The extensive functionality achievable with Perl was not required for our survey because it was decided at the beginning of the project to limit the capability to data submission and retrieval.

Gform was found to be an appropriate and easy scripting procedure for performing easy data retrieval functions. The difficulty with Gform was that individual HTML files had to be scripted as separate pages of forms and a Gform code written for retrieving the data contained in each page. This is often a cumbersome procedure that included defining, naming, and referencing the data required, and writing them in separate pages of HTML codes.

The initial program for our survey did not contain such detailed referencing, thus most of the data obtained from the questionnaire could not be used. In the final hypermedia visualization interface used for the survey, detail referencing was thus provided to every question in the form before the revised program was uploaded onto the server. The data obtained from the survey were sorted and subjected to mathematical and statistical analysis in format useful for our decision modelling technique.

CHAPTER 6
DECISION ANALYSIS FOR CONSUMERS' RECEPTIVITY TO SUSTAINABLE COMMUNITY DESIGN ALTERNATIVES

6.1 The Consumers' Receptivity Survey

The foundation for the decision analysis proposed in this thesis was the development of questionnaires, the administration of a survey, and retrieval of data on sample consumers' responses to issues of sustainable community design, based on presented text and graphical information. Three levels of survey were conducted to determine the receptivity of consumers to sustainable community design alternatives in the City of Winnipeg. The survey provided a scientific basis for modelling householders' decision-making process, and assisted in establishing the pattern of consumers' behaviour with regard to sustainable community design issues.

6.1.1. Introduction

The survey started with researching sustainable community design features to determine features that would be included in the questionnaire. Three broad categories of design parameters were identified. These broad categorizations helped to define our realm of engagement. They included:

- Community design parameter;
- Ecologic design parameter; and
- Street design parameter.

These parameters were disaggregated into specific performance features that were found to be inherent in the broad categories. Graphic illustrations were used to explain each feature in 2D, 3D, animation, and QuicktimeVR formats.

It was decided at the beginning of the exercise to develop two platforms for the survey -- a Web-based and an "in-house" or laboratory-based platform -- using a hypermedia visualization interface (HVI). The web site for the survey was developed over a period of 2 months (i.e., May and June, 2000). The questionnaires for both the Web-based and "in-house" surveys were also developed during this period. Both questionnaires went through an approval process from the Faculty of Architecture's Ethics' committee.

6.1.2. Survey Procedure

The three surveys were based on a three-tier procedure. The first stage involved the development of a design alternative for the Whyte Ridge community in Winnipeg. Whyte Ridge falls into the category of a conventional suburban community that the survey was designed to critique. Two sets of questionnaires that were based on *'a priori'*-determined sustainable community design features were developed -- one for the two Web-based surveys and the other for the "in-house" or laboratory-based survey. This stage also involved the development of a Web-based hypermedia interface for assessing the design data.

The second stage involved the conduct of a Web-based "expert" survey to assist in developing a strong theoretical foundation for the use of the Fuzzy group decision-making procedure. The third stage involved conducting a laboratory-based survey with an adequate number of subjects to provide the required degrees of freedom. In this stage a parallel Web-based survey was conducted with similar questions, to provide greater degrees of freedom for parsing survey data and to increase the reliability of the outcomes.

6.1.3. Sampling Procedure for the Surveys

A stratified random sampling procedure was used for the Web-based and "in-house" surveys. In the Web-based "expert" survey, participants were randomly selected from a directory of design architects, engineers, planners, and developers in the City. This procedure is reminiscent of an Internet-based Delphi panel (Saaty, 1980). The same procedure that was used for the selection of participants for the laboratory-based survey was adopted for the second Web-based survey.

Participants for the "in-house" or laboratory-based survey were randomly pooled from the telephone listing of householders in the city, especially those living in Whyte Ridge and surrounding areas. In each of the surveys, would-be participants were contacted by phone to introduce the survey, and request their participation in the survey. Only the respondents who agreed to participate in the survey were given letters of invitation to either the Web-based and/or laboratory-based survey. The written invitation detailed the objective of the survey and the Web site address for a personal data form that participants were expected to complete. The information obtained from this form was used to sort the subjects into geographic, demographic, professional, and home-ownership categories.

6.1.4. Hypermedia Interface Development (http://www.umanitoba.ca/faculties/architecture/eco-whyteridge):

The hypermedia interface presented a split-screen pairwise display of design scenarios for each feature such that subjects could view the display on the user-interface and score their preference, based on a modified Saaty's rating scale. The interface development served as a precursor to the descriptive procedure that was used for the consumers' receptivity test.

Alternative design scenarios for the Whyte Ridge Community in the City of Winnipeg were developed and embedded in graphic frames with explanatory text links. The design abstractions for each of the 22 features considered in the survey were presented in 2D and 3D formats. Photographic representations of the features were also presented to increase subjects' understanding of the design features. Animation and QuicktimeVR images of selected views were provided to assist subjects to explore some of the features in virtual space. Links were provided to a text frame that contained a list of assessment questions for determining the degree of users' preferences for any one of the pairwise-presented design scenarios. A detailed description of the procedure for developing the hypermedia interface is presented in Chapter 5.

6.1.5. The Web-based Surveys:

In the Web based surveys, respondents were given the web site address developed for the consumers' receptivity survey. The Web site contained information about the procedure for completing both the personal data form and the survey questionnaires. Participants were assisted in their understanding of the Web site through personal contact by the candidate to provide any additional information requested regarding the Web-based hypermedia visualization interface. The data from the Web-based surveys were dynamically retrieved using a CGI scripting procedure known as "Gform". "Gform" scripting is an Internet form, data-retrieval protocol that provides the capability to dynamically retrieve data submitted for completed questionnaires. The script was written to permit dynamic delivery of submitted data into a default e-mail address and a text file in the project's *cgi-bin* directory as soon as respondents clicked the "submit" button at the end of each question.

6.1.6. The "In-house" or Laboratory Survey:

The initial selection criterion for the "in-house" survey was based on the need to have an equal number of "in-site" and "out-of-site" participants who would be representative of the city's demographic and professional groups. Invitation letters were sent to 25 householders from the Whyte Ridge Community and 25 householders from locations in the Fort Richmond area of Winnipeg. Restricting participants to those in locations close to Whyte Ridge was necessary in order to achieve a good level of consistency based on subjects' understanding of the site. The expectation was that at a 65% turnout, the 16 participants per group proposed for the survey could still be obtained.

The attendance from householders in Whyte Ridge was well below the projected 16. Only 2 (8%) of the householders invited from this survey node made it to the CAD laboratory venue where the survey was carried out. The remainder of our participants decided to participate in the Web-based survey. In sharp contrast, 22 (88%) householders from the non-Whyte Ridge areas made it to the survey location. This gave us a total of 24 participants at the survey location.

In the survey, participants were taken to the CAD laboratory of University of Manitoba's Faculty of Architecture for a presentation and computer-based participatory exploration of "existing" and "sustainable alternative" proposals for Whyte Ridge. The procedure for the survey included a general presentation and briefing session, at which time participants were introduced to the object of the survey. This was followed by the completion of "general attitude" and "representation technique" questionnaires based on questions and graphic representation of features that were projected on a large screen. There was a 15-minute coffee break for interaction and clarification of points from previous presentations before participants were taken to the computer laboratory for personal exploration of the proposed design scenarios in virtual space.

6.1.7. Data Evaluation:

The data obtained from Web-based and "in-house" participants were evaluated by decomposing the descriptive pairwise preference information into numeric data on the basis of preference ratings retrieved from participants' submissions. A break down of the categories of survey questions and the outcomes are presented.

1. General Attitude Survey

The goal of the general attitude questions was to test participants' understanding of sustainable community design issues, and to explore how receptive they were to these issues. This test helped us to introduce the concept of sustainable community design to our subjects and to prepare them for the technical questions that they encountered in the main survey. The general attitude survey was in two parts. The first part (see Appendix E) was devoted to general questions on sustainability, while the second part (see Appendix F) was a text-only questionnaire which attempted to pose questions similar to the ones presented in the Web-based surveys (without the graphical display for conventional or sustainable design scenarios). The criteria for the ratings are presented in Table 6.1.1.

Table 6.1.1: **Rating Scale for General Attitude Questions**

Attitudes	Ratings
Strongly Disagree	1
Disagree	2
Not sure	3
Agree	4
Strongly Agree	5

The following notations apply to the designations given to subtitles in the spreadsheet:

QstN denotes chronological numbering attached to the questions,
Ratg denotes rating score,
RatgSum denotes summary of persons, who gave the feature this rating,
TotSamp denotes total number participants in the sample,

The intent of using this type of rating was discussed in Chapter 3. A balanced rating scale is required for surveys so that the data obtained would not be skewed in a single direction. A balanced rating scale also makes the use of statistical methods of analysis easier, reduces data-borne bias, and increases reliability of outcome.

Presented below are the tabulated results from the general attitude questions:

Question 1: Communities that are compactly built are more sustainable than communities in which the buildings are widely spaced out.

Table 6.1.2. **Table of Response to Question 1**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
1	1	2	24	8.33%			
	2	3	24	12.50%		20.83%	
	3	1	24	4.17%			4.17%
	4	9	24	37.50%			
	5	9	24	37.50%	75.00%		

Question 2: The presence of open social spaces in a community contributes to the livability of the community.

Table 6.1.3. **Table of Response to Question 2**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
2	1	0	24	0.00%			
	2	4	24	16.67%		16.67%	
	3	0	24	0.00%			0.00%
	4	7	24	29.17%			
	5	13	24	54.17%	83.33%		

Question 3: Communities with compactly built residences that are connected by common dividing walls tend to enhance community interaction than communities with single family houses on separate lots.

Table 6.1.4. **Table of Response to Question 3**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
3	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	1	24	4.17%			4.17%
	4	9	24	37.50%			
	5	13	24	54.17%	91.67%		

Question 4: Communities with more "green" areas (such as trees, lawns, shrubs etc.) tend to be more livable than communities with more paved areas and fewer green spaces.

Table 6.1.5. **Table of Response to Question 4**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
4	1	2	24	8.33%			
	2	2	24	8.33%		16.67%	
	3	0	24	0.00%			0.00%
	4	10	24	41.67%			
	5	10	24	41.67%	83.33%		

Question 5: Where energy generation unit is centrally provided and shared, the overall energy consumption in the community is reduced.

Table 6.1.6. **Table of Response to Question 5**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
5	1	2	24	8.33%			
	2	4	24	16.67%		25.00%	
	3	6	24	25.00%			25.00%
	4	5	24	20.83%			
	5	7	24	29.17%	50.00%		

Question 6: Communities with a mixture of housing types tend to be more sustainable than communities with fewer types housing units.

Table 6.1.7: **Table of Response to Question 6**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
6	1	1	24	4.17%			
	2	1	24	4.17%		8.33%	
	3	6	24	25.00%			25.00%
	4	10	24	41.67%			
	5	6	24	25.00%	66.67%		

Question 7: Communities that have shopping, meeting, and work areas at a distance of less than ten minutes walk from residences tend to be more livable than communities that do not.

Table 6.1.8: **Table of Response to Question 7**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
7	1	1	24	4.17%			
	2	0	24	0.00%		4.17%	
	3	1	24	4.17%			4.17%
	4	6	24	25.00%			
	5	16	24	66.67%	91.67%		

Question 8: Communities with different categories of residential units tend to attract more diverse types of tenants.

Table 6.1.9: **Table of Response to Question 8**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
8	1	0	24	0.00%			
	2	2	24	8.33%		8.33%	
	3	0	24	0.00%			0.00%
	4	6	24	25.00%			
	5	16	24	66.67%	91.67%		

Question 9: A community that is designed to respect the ecology of the area in which it is sited tends to be more livable than a community that is not.

Table 6.1.10. **Table of Response to Question 9**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
9	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	2	24	8.33%			8.33%
	4	10	24	41.67%			
	5	11	24	45.83%	87.50%		

Question 10: Where public areas are universally accessible, the character and quality of the community is enhanced.

Table 6.1.11: **Table of Response to Question 10**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
10	1	0	24	0.00%			
	2	2	24	8.33%		8.33%	
	3	1	24	4.17%			4.17%
	4	4	24	16.67%			
	5	17	24	70.83%	87.50%		

Question 11: The relationship between the height of buildings and the width of the street affects our understanding of the quality of a community street.

Table 6.1.12: **Table of Response to Question 11**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
11	1	0	24	0.00%			
	2	3	24	12.50%		12.50%	
	3	6	24	25.00%			25.00%
	4	9	24	37.50%			
	5	6	24	25.00%	62.50%		

Question 12: A community that has the potential to expand and rearrange itself is more sustainable than a community that no room for growth and expansion.

Table 6.1.13: **Table of Response to Question 12**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
12	1	0	24	0.00%			
	2	4	24	16.67%		16.67%	
	3	1	24	4.17%			4.17%
	4	8	24	33.33%			
	5	11	24	45.83%	79.17%		

Question 13: Universal access to public areas in a community encourages people of diverse physical ability to use such public areas.

Table 6.1.14: **Table of Response to Question 13**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
13	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	2	24	8.33%			8.33%
	4	6	24	25.00%			
	5	15	24	62.50%	87.50%		

Question 14: The streets in communities with safe sidewalks tend to be more intensely used by pedestrians than communities where there are no sidewalks.

Table 6.1.15: **Table of Response to Question 14**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
14	1	0	24	0.00%			
	2	3	24	12.50%		12.50%	
	3	1	24	4.17%			4.17%
	4	4	24	16.67%			
	5	16	24	66.67%	83.33%		

Question 15: The more universally accessible a community is, the more intense is the use of its public areas.

Table 6.1.16: **Table of Response to Question 15**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
15	1	0	24	0.00%			
	2	2	24	8.33%		8.33%	
	3	2	24	8.33%			8.33%
	4	3	24	12.50%			
	5	17	24	70.83%	83.33%		

Question 16: Where building interiors have direct access to sunlight, energy use is minimized.

Table 6.1.17: **Table of Response to Question 16**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
16	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	0	24	0.00%			0.00%
	4	6	24	25.00%			
	5	17	24	70.83%	95.83%		

Question 17: A community where there is opportunity for recycling wastes tends to be more ecologically friendly.

Table 6.1.18: **Table of Response to Question 17**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
17	1	1	24	4.17%			
	2	0	24	0.00%		4.17%	
	3	0	24	0.00%			0.00%
	4	7	24	29.17%			
	5	16	24	66.67%	95.83%		

Question 18: The quality of material used for construction in a community determines the life and durability of its buildings and infrastructures.

Table 6.1.19: **Table of Response to Question 18**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
18	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	0	24	0.00%			0.00%
	4	4	24	16.67%			
	5	19	24	79.17%	95.83%		

Question 19: People tend to have a better feeling of enclosure where public places are surrounded by continuous walls of buildings that are not penetrated by roads on every side.

Table 6.1.20: **Table of Response to Question 19**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
19	1	0	24	0.00%			
	2	2	24	8.33%		8.33%	
	3	6	24	25.00%			25.00%
	4	10	24	41.67%			
	5	6	24	25.00%	66.67%		

Question 20: A community with recycling depots and drop-off areas that are easily accessible to residents tends to recycle better.

Table 6.1.21: **Table of Response to Question 20**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
20	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	0	24	0.00%			0.00%
	4	9	24	37.50%			
	5	14	24	58.33%	95.83%		

Question 21: A community that has opportunity to for reusing wastes tends to have reduced garbage per resident.

Table 6.1.22: **Table of Response to Question 21**

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
21	1	1	24	4.17%			
	2	2	24	8.33%		12.50%	
	3	3	24	12.50%			12.50%
	4	9	24	37.50%			
	5	9	24	37.50%	75.00%		

6.2 **Findings from Surveys**

Presented in this section is a spreadsheet summary of questions posed in the surveys and results obtained from the participants. The output is presented in a question-and-result format so that the results could be easily correlated with the questions posed.

6.2.1. Introduction

Three subject-groups were surveyed to determine the receptivity of consumers to sustainable community design alternatives. The first survey used the design experts' subject-group as its target and the questions posed were similar to questions posed in the non-Web survey. The second was a Web-based survey of householders in Whyte Ridge and non-Whyte Ridge areas of the city. The third survey was a laboratory-based survey. The procedure for this survey is discussed in sections 6.1.5. and 6.1.6.

Some of the questions vary in detail, based on the platform in which it was to be presented. For example, Web based questions were accompanied with more explanatory texts than laboratory questions. This was because the author was present at the laboratory presentation to explain and clarify difficult technical languages and issues contained in the definition of design features, and thus it was deemed unnecessary to provide the same level of explanatory text detail as was provided for Web subjects.

6.2.2. Consumers' Receptivity to Sustainable Community Design Alternatives

Presented below is the analysis of the sustainable community receptivity survey conducted using three subject-groups on the Web-based and laboratory-based platforms.

The questions together with a table of responses from the three subject-groups are tabulated for ease of comparison.

Earlier research by Perks and van Vliet (1994) had indicated that positive responses to sustainability features are sensitive to the local planning context and innovative character of the delivery system. It also indicated the sensitivity of consumers' to factors such as costs, individual or household incomes, and to convictions about the environment and social aspects of community. The questions were therefore structured to deal with costs relevant to spatial design and environmentally responsible technology.

The factor of costs appeared in topics such as waste management, property and house design, and the provision of regenerative utilities. It was discovered that this approach would allow respondents to evaluate the costs associated with the provision of these "sustainable" amenities, as they would do in real life community choice issues. The detailed information allowed them to make the necessary trade-offs that are similar to those normally made in real life decision-making about the choice of a place to live.

Table 6.2.1: **Summary of Consumers' Preferences by Subject-Group**

Question 1:

Residential Intensification: *Residential second units are customarily located in the upper level of a garage, in the attic, or at the basement level. They have to be self-contained for bathroom and cooking facilities. By renting out a second unit, a family could purchase a home that would otherwise be unaffordable. The "second unit" could be used as a self-contained guest suite or for home offices for people working out of their homes.* Would you be willing to live in an area where Residential Second Units are allowed?

Allow Second Residential Units in Community	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	12	80%	19	83%	5	83%
No	3	20%	4	17%	1	17%
Respondents	15		23		6	
Total Sample	25		24		11	

Question 2:

Residential second units are customarily located in the upper level of a garage, in the attic, or at the basement level. They have to be self-contained for bathroom and cooking facilities. By renting out a second unit, a family could purchase a home that would otherwise be unaffordable. The "second unit" could be used as a self-contained guest suite or for home offices for people working out of their homes. Would you wish to own a home in a community where you could have a residential second home?

Attaching Second Residential Units	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	11	100%	19	83%	6	86%
No	0	0%	4	17%	1	14%
Respondents	11		23		7	
Total Sample	25		24		11	

Question 3:

Mix of Housing Types: *Living in a community with a mix of detached dwelling units and attached units such as, apartments and townhouses will cost about 30% less than in a typical suburban development with single family dwelling only.* Would you consider living in a community with a mix of different types of housing units?

Living in Attached Housing	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	5	50%	9	39%	3	60%
No	5	50%	13	57%	2	40%
Respondents	10		23		5	
Total Sample	25		24		11	

Question 4:

Mix of Household and People: Would you be inclined to choose a home in a community made up of a diversity of households, families and people of differing age, income status, and cultural lifestyle? Assuming your home was located in an area of some 2 or 3 residential street blocks, where all of the homes are designed for people of similar household status and "market bracket" as yours?

Diverse Household in Community	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	9	90%	12	57%	6	86%
No	1	10%	8	38%	1	14%
Respondents	10		21		7	
Total Sample	25		24		11	

Question 5:

Would you be inclined to choose a home in a community made up of a diversity of households, families and people of differing age, income status, and cultural lifestyle? Assuming your home was located in an area where the household status and "market bracket" of people are varied, but the street presentation of each home is similar in architectural character and appearance?

Demographic Diversity	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	8	73%	16	70%	5	71%
No	3	27%	6	26%	2	29%
Respondents	11		23		7	
Total Sample	25		24		11	

Question 6:

The Community Core: *To support a community core with work, shopping, recreation and entertainment uses, integrated with residential suburban developments, the overall density of the community would have to be higher than it is in conventional community.* Would you favour a community with a Community Core?

Mixed Use Core	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	15	88%	15	75%	7	100%
No	2	12%	4	20%	0	0%
Respondents	17		20		7	
Total Sample	25		24		11	

Question 7:

Neighbourhood Centre: A neighbourhood centre would offer some retail and business services. It would comprise largely of 2 or 3 storey attached building forms. Would you favour having such a development within a 5-minute walking distance from your home?

Mixed Use Neighbourhood Centres	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	11	100%	22	96%	7	100%
No	0	0%	0	0%	0	0%
Respondents	11		23		7	
Total Sample	25		24		11	

Question 8:

Landscaping: Consider that the initial cost of a home is about 1% higher but there are attractive maintenance savings of about 75% and 60-70% less in labour time. Would you favour a residential landscaping option with hardy drought-resistant plants species over conventional non-resistant species?

Landscaping with Hardy Plants	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	9	100%	11	50%	4	80%
No	0	0%	10	45%	1	20%
Respondents	9		22		5	
Total Sample	25		24		11	

Question 9:

Using permeable pavement surfaces for driveways and patios maintains subsoil water balance, makes the yard cooler in summer, and looks better than asphalt. It may add up to $300 in initial cost. Would you be in favour of using this type of surfacing in the community you live?

Use of Permeable Paving Surfaces	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	11	85%	18	78%	6	100%
No	2	15%	5	22%	0	0%
Respondents	13		23		6	
Total Sample	25		24		11	

Question 10:

Recycle Centres: Do you favour a more local opportunity and community-organized facilities like "neighbourhood collection points" and "eco-station" for recycling waste in the community you choose to live?

Community-organized Recycling	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	9	90%	20	87%	4	67%
No	1	10%	3	13%	2	33%
Respondents	10		23		6	
Total Sample	25		24		11	

Question 11:

Would you be inclined to regularly recycle your household discards if a collecting point was located within 2 to 3 minutes walking distance from your home?

Household Level Recycling	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	6	100%	21	91%	5	71%
No	0	0%	2	9%	1	14%
Respondents	6		23		7	
Total Sample	25		24		11	

Question 12:

Composting Centres: *A home equipped for convenient recycling and composting does not cost more. It conserves resources and saves on garbage collection and landfill costs.* Would you be inclined to choose a home that was designed and equipped for easy sorting and composting given that such a home would cost about $300 more in initial cost than conventional building?

Composting Centre in Community	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	8	100%	21	91%	6	86%
No	0	0%	2	9%	1	14%
Respondents	8		23		7	
Total Sample	25		24		11	

Question 13:

Suppose that the home you choose is equipped for convenient sorting and composting, would you recycle and compost more or less reusable wastes and discards?

Sorting Reusables and Discards	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	8	100%	20	91%	6	86%
No	0	0%	2	9%	1	14%
Respondents	8		22		7	
Total Sample	25		24		11	

Question 14:

Greywater Reuse: *Re-using water for toilet flushing or garden irrigation costs between $0 to $1200 more than conventional system, but conserves 50% or more of water piped into the home. The additional system cost would be recouped in 5 years through savings on your water bill.* Would you be inclined to choose the "water re-use" system over the conventional system?

Choosing Water-Reuse System	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	6	67%	21	95%	5	71%
No	3	33%	1	5%	1	14%
Respondents	9		22		7	
Total Sample	25		24		11	

Question 15:

If this system could be installed in a home with no additional cost, would you be inclined to choose it?

Water-Reuse if it Costs More	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	3	30%	17	74%	6	86%
No	7	70%	6	26%	0	0%
Respondents	10		23		7	
Total Sample	25		24		11	

Question 16:

A "Living Machine" system can be reused for irrigating community farms, gardens, parks, street trees, and other open spaces. Would you choose to purchase a home you liked if it is in a community where this system is installed?

"Living Machine" System	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	8	100%	18	78%	5	83%
No	0	0%	5	22%	1	17%
Respondents	8		23		6	
Total Sample	25		24		11	

Question 17:

A "Living Machine" system can be reused for irrigating community farms, gardens, parks, street trees, and other open spaces. Would you be inclined to support a pilot project in Winnipeg that experiments with this alternative sewage management system?

"Living Machine" Pilot Project	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	8	100%	20	87%	7	100%
No	0	0%	3	13%	0	0%
Respondents	8		23		7	
Total Sample	25		24		11	

Question 18:

Co-Generation: *In Co-generation and District Heating system, the "exhaust" heat from generating the electricity is used to heat water. Hot water is distributed throughout a district network of underground-insulated pipes. This system uses 33% less fossil fuel than conventional methods of home heating.* Assume your monthly share of the cost of renewable energy sources pilot program in your community is $20 per month, would you agree to such an arrangement?

Renewable Energy Pilot Project	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	9	90%	19	83%	7	100%
No	1	10%	3	13%	0	0%
Respondents	10		23		7	
Total Sample	25		24		11	

Question 19:

District Heating: *District heating is overall 35% less costly than conventional home-furnace-heating. It also provides better control of room to room heating.* Would you favour a District Heating System for your home?

District Heating System	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	11	92%	19	83%	6	86%
No	1	8%	2	9%	1	14%
Respondents	12		23		7	
Total Sample	25		24		11	

Question 20:

Community Farms: Would the idea of lands set aside for Community Farm located in the community be a positive factor in deciding your home and community choice?

Opportunity for Farming	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	8	62%	12	57%	4	57%
No	5	38%	8	38%	3	43%
Respondents	13		21		7	
Total Sample	25		24		11	

Question 21:

Vehicular Network: *You wish to make a choice between buying a house in a typical neighbourhood and one in a neighbourhood with reduced street width, "calmed" streets, and reduced front yard. The price of homes in neighbourhoods with these features would cost you between $3000 and $8000 less.* Would you be inclined to choose a "Calm Street" design for your home if the width of the road is narrower than conventional residential street designs, and it meant no additional costs to your initial purchase price?

"Calm Street" with no Additional Cost	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	8	73%	18	78%	7	100%
No	3	27%	4	17%	0	0%
Respondents	11		23		7	
Total Sample	25		24		11	

Question 22:

Would you be inclined to choose a "Calm Street" design for your home if the width of the road is narrower than conventional residential street designs, and it meant an additional cost of between $500 - $800 to your initial purchase price?

"Calm Street" with Additional Cost	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	7	78%	10	45%	6	86%
No	2	22%	12	55%	1	14%
Respondents	9		22		7	
Total Sample	25		24		11	

Question 23:

Would you be inclined to choose a home with a smaller front yard, if the property purchase price is approximately $4000 less?

Smaller Front Yard and Less Cost	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	7	78%	14	64%	4	57%
No	2	22%	8	36%	3	43%
Respondents	9		22		7	
Total Sample	25		24		11	

Question 24:

Would you be inclined to choose a home with a smaller front yard, if the equivalent area of land allocated to a front yard is incorporated into your backyard?

Smaller Front yard and Bigger Backyard	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	9	100%	17	77%	6	86%
No	0	0%	4	18%	0	0%
Respondents	9		22		7	
Total Sample	25		24		11	

Question 25:

Vehicular Network: *You wish to make a choice between buying a house in a typical neighbourhood and one in a neighbourhood with reduced street width, "calmed" streets, and reduced front yard. The price of homes in neighbourhoods with these features would cost you between $3000 and $8000 less.* Would you be inclined to choose a home in this community?

Community with Compact Street	**Web Subjects**		**In-house Subjects**		**Expert Subjects**	
	#	%	#	%	#	%
Yes	7	70%	14	64%	5	71%
No	3	30%	8	36%	2	29%
Respondents	10		22		7	
Total Sample	25		24		11	

The three subject-groups were given the following list of 18 sustainable community design features and were asked to check the features they would like to have in the community in which they live. The outcome of this experiment is presented in Table 6.2.2.

- Energy-efficient units
- Co-generation-District-Heating
- Rainwater Recycling
- Recycling
- Composting
- Compact Community
- Reduced street width
- Second Units
- Attached Homes
- Open-ended Street System
- Dead-ended Street System
- Pedestrian and Bicycle Pathway
- Neighbourhood or Community Core
- Employment Opportunities
- Diverse Household
- Diverse Housing
- Diverse People
- Community Gardens

Table 6.2.2: **Features Preferred by Subject-Group**

Feature	InHouse	%InHous	WebSubj	%Web	Experts	%Expert
EnEffUnits	21	100%	16	100%	7	100%
CoGenDHtg	13	62%	14	88%	5	71%
RainRecyc	19	90%	15	94%	6	86%
RecycLg	18	86%	13	81%	7	100%
Compost	12	57%	9	56%	5	71%
CompComm	14	67%	11	69%	6	86%
RedStrtWidth	13	62%	14	88%	6	86%
SecUnits	18	86%	15	94%	7	100%
AttHomes	13	62%	10	63%	6	86%
OpEndStrt	15	71%	10	63%	6	86%
DeadEndStrt	11	52%	14	88%	4	57%
PedBikWay	20	95%	16	100%	7	100%
CommCore	21	100%	16	100%	7	100%
EmpOpport	15	71%	12	75%	6	86%
DiversHhold	16	76%	11	69%	6	86%
DiversHsg	15	71%	13	81%	7	100%
DiversPeop	16	76%	11	69%	6	86%
CommGardn	16	76%	14	88%	5	71%
MEAN	15.89		13.00		6.06	
STDEV	3.05		2.25		0.87	
n = sample	**21**		**16**		7	

where:

n denotes the number of respondents who completed this section of our questionnaire

InHouse denotes data obtained from in-house/laboratory-based subjects

%InHous denotes percentages obtained from data of in-house/laboratory-based subjects

WebSubj denotes data obtained from Web-based subjects

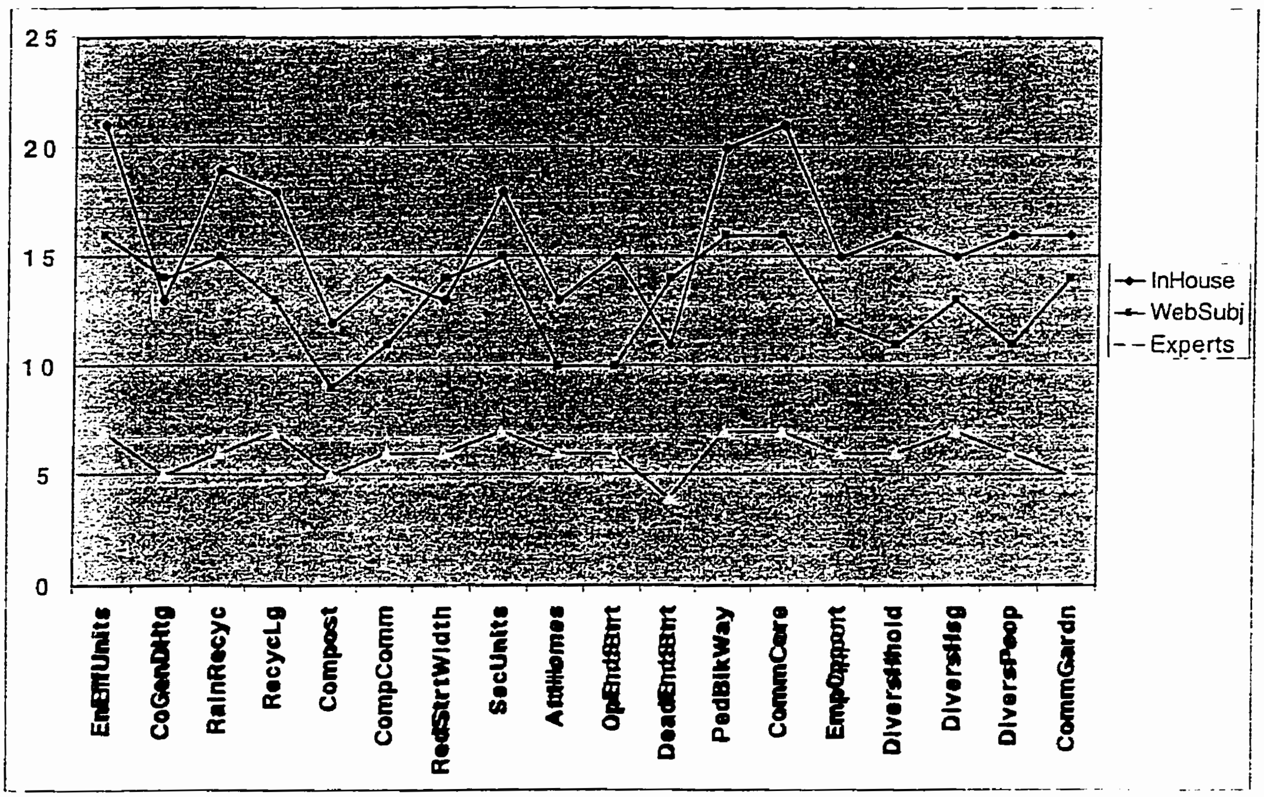
%Web denotes percentages obtained from data of Web-based subjects

Experts denotes data obtained from 'expert' subjects

%Expert denotes percentages obtained from data of 'expert' subjects

STDEV denotes the dispersion of data about the Mean (average) for the subject-group.

Figure 6.2.1: **Chart of Preferred Features by 3 Subject-Groups**



The Trend Analysis Chart shown in Fig. 6.2.1 displays a similarity in the trend of responses obtained from all the subject-groups surveyed. A deduction that can be made from the trend is that the pattern of preference did not change for all the subject-groups. It could thus be safely concluded that prior knowledge of sustainable community design issues and socioeconomic classification had little effect on subjects' preference with respect to the sustainable community design features presented.

6.2.3. Result of the ANOVA Test on Data from 3 Subject-Groups for 18 Features

Further tests of deviations in the sample means for the three subject-groups were performed using single factor analysis of variance. The result of the ANOVA statistical test performed on the data obtained is presented below.

Table 6.2.3: **Result of ANOVA Test for the Three Subject Groups**

Source of Variation	**Sum of Squares**	**d.f.**	**Mean Squares**	**F**
Between	919.6	2	459.8	91.34
Error	256.7	51	5.034	
Total	1176.3	53		

Group A: Number of features = 18

11.0 12.0 13.0 13.0 13.0 14.0 15.0 15.0 15.0 16.0 16.0 16.0 18.0 18.0 19.0 20.0 21.0 21.0

Mean = **15.9**

95% confidence interval for Mean: **14.83** through **16.95**

Standard Deviation = **3.05**

High = **21.0** Low = **11.0**

Median = **15.5**

Average Absolute Deviation from Median = **2.44**

Group B: Number of features = 18

9.00 10.0 10.0 11.0 11.0 11.0 12.0 13.0 13.0 14.0 14.0 14.0 14.0 15.0 15.0 16.0 16.0 16.0

Mean = **13.0**

95% confidence interval for Mean: **11.94** through **14.06**

Standard Deviation = **2.25**

High = **16.0** Low = **9.00**

Median = **13.5**

Average Absolute Deviation from Median = **1.89**

Group C: Number of features = 18

4.00 5.00 5.00 5.00 6.00 6.00 6.00 6.00 6.00 6.00 6.00 6.00 7.00 7.00 7.00 7.00 7.00 7.00
Mean = **6.06**
95% confidence interval for Mean: **4.994** through **7.117**
Standard Deviation = **0.873**
High = **7.00** Low = **4.00**
Median = **6.00**
Average Absolute Deviation from Median = **0.611**

The following notations apply:

- MSG denotes mean squares for "between" groups, and MSE denotes mean square error;
- v_1 = degrees of freedom for preference; and
- v_2 = degrees of freedom for the variation between groups.
- d.f. denotes degree of freedom, and
- F denotes (found variation divided by expected variation).

From the result of the ANOVA test in Table 6.2.3., the NULL hypothesis H_0 for the test statistic can be evaluated. H_0 for the test statistic is then given as:

$H_0 : \mu_1 = \mu_2 = \mu_3$, and

$F = {}^{MSG}\!/_{MSE}$

where: $\nu_1 = 2, \nu_2 = 51$ degrees of freedom.

and: F = the found variation of group averages divided by the expected variation of group averages.

Reject H_0 if $F > F_{.05}$.

Since: $F = 91.34$ (from Table 6.2.3a), and $F_{.05} = 3.19$ (from F distribution table).

This shows that $F > F_{.05}$.

Therefore: **Reject** NULL hypothesis.

We thus conclude that there is sufficient evidence to indicate a difference in means for the three subject-groups at $\alpha = .05$ level of significance.

6.2.4. Interpretation of Results

The sustainable community features presented to the three subject-groups showed a high degree of preference for all the 18 features by all the groups. Sixteen of twenty-one "in-house" or laboratory-based subjects (which accounts for 76% of sample) preferred to have all the features provided in the community in which they live. Thirteen of sixteen Web-based subjects who completed this section of the questionnaire would like to have all features in the community in which they live. This accounts for 81 percent of the Web-based survey sample. Six of seven of our expert subjects (that is, 86% of survey sample) would like to have all the features in the community in which they live (see Table 6.2.2). All listed features had higher than a 50 percent preference rating by the three subject-groups.

This outcome led to the conclusion that, regardless of professional or demographic grouping, there was a high degree of receptivity to the listed sustainable community design features by the sample. Further tests would need to be carried out in order to generalize this outcome as a pattern of response by all householders in the city.

The result obtained from an ANOVA statistical test performed on the data reveals sufficient evidence to indicate a difference in means for the three subject-groups at $\alpha = .05$ level of significance. The result implies that, at 95% confidence level, the three subject-groups surveyed showed a high level of agreement regarding the features they will want to have in the community in which they live, despite the disparity in professional, age, and economic status.

6.2.5. Conclusion

Almost all of the 25 questions presented to participants received higher than a 70% favourable response from the three subject-groups. With the exception of a few questions, notably, the installation of a water-reuse system (if it costs more) and willingness of participants to live in attached housing, the rest of the questions received affirmative ratings by more than 80% of the subject groups.

This shows that consumers are willing to pay for these sustainable design features if implemented in the design of the community in which they live, even when it involves an additional cost to the initial purchase of a new property. Furthermore, Figure 6.2.1 shows that there was no significant difference in the trend of answer by all the subject-groups.

Two further deductions can be made from this result: (1) there is no need to assume that expert response will be different from those of non-experts on issues of sustainable housing, provided the questions and illustrations are clear enough to allow laypersons to understand the issues under investigation; and (2) all the subject-groups used in the survey were sophisticated enough to understand and respond to the issues raised in the questionnaires.

6.3 FGDM Analysis of Preferences for 3 Design Representation Techniques.

The Fuzzy Group Decision-Making (FGDM) technique was used to model the pattern of preference values for three design representation techniques by 21 subjects in the laboratory-based survey. A hierarchy of criteria and decision alternatives was established using FGDM, and evaluation was carried out to determine weights (eigenvectors) for each decision alternative.

Saaty's eigenvector procedure was used to determine the priority rating of participants' preferences based on alternative illustrative design scenarios. Saaty's scale was modified as a 5-point scale of preference (see Table 3.2.1). The modified version was used because it increased the clarity of discrimination between points. The use of a 4- or 5-point scale has been validated in the literature (see Arreola 2000, Frary, 2000, Galloway 1997). This procedure is discussed in detail in Chapter 3.

6.3.1. Establishment of Group Preferences

Individual preferences, based on the rating scale presented in Table 3.2.1, were used by participants to rate design scenarios displayed on a large screen using three design techniques. The data on preferences are presented in Appendix G1. Equations 1 through 3b in Chapter 3 were applied to the data obtained to determine group preferences, and the results are presented in Table 6.3.1.

Table 6.3.1: **Summary of Fuzzy Analysis for Representation Technique Data**

The following notations apply to the following Tables:

S(D1) denotes summary of minimum preference matrices for D1;

S(D1) denotes summary of minimum preference matrices for D2;

S(D1) denotes summary of minimum preference matrices for D3;

MIN(S(Di)) denotes the minimum value of the matrix analysis for all design techniques.

1. Condensed Lot (Interpretation of Data Analysis)

96% of sample claimed they had better understanding of design intent when displayed using Animation/QTVR;
76% of sample claimed they had better understanding of design intent when displayed using 3D rendering;
14% of sample claimed they had better understanding of design intent when displayed using 2D drawing.

Table 6.3.1a: **FGDM Output for Condensed Lot Data**

CONDENSED LOT	
S(D1)	0.86
S(D2)	0.24
S(D3)	0.04
MIN(S(Di))	0.04

2. Residential Intensification (Interpretation of Data Analysis)

91% of sample claimed they had better understanding of design intent when displayed using Animation/QTVR;
76% of sample claimed they had better understanding of design intent when displayed using 3D rendering;
18% of sample claimed they had better understanding of design intent when displayed using 2D drawing .

Table 6.3.1b: **FGDM Output for Residential Intensification Data**

RESIDENTIAL INTENSIFICATION	
S(D1)	0.82
S(D2)	0.24
S(D3)	0.09
MIN(S(Di))	0.09

3. **Mix of Housing Types and Sizes (Interpretation of Data Analysis)**

86% of sample claimed they had better understanding of design intent when displayed using Animation/QTVR;
62% of sample claimed they had better understanding of design intent when displayed using 3D rendering;
40% of sample claimed they had better understanding of design intent when displayed using 2D drawing.

Table 6.3.1c: **FGDM Output for Mix of Housing Types and Sizes Data**

RESIDENTIAL MIX	
S(D1)	0.60
S(D2)	0.38
S(D3)	0.14
MIN(S(Di))	0.14

4. **Community Core (Interpretation of Data Analysis)**

95% of sample claimed they had better understanding of design intent when displayed using Animation/QTVR;
64% of sample claimed they had better understanding of design intent when displayed using 3D rendering;
36% of sample claimed they had better understanding of design intent when displayed using 2D drawing.

Table 6.3.1d: **FGDM Output for Community Core Data**

COMMUNITY CORE	
S(D1)	0.64
S(D2)	0.36
S(D3)	0.05
MIN(S(Di))	0.05

5. Common Buildings (Interpretation of Data Analysis)

86% of sample claimed they had better understanding of design intent when displayed using Animation/QTVR;
76% of sample claimed they had better understanding of design intent when displayed using 3D rendering;
18% of sample claimed they had better understanding of design intent when displayed using 2D drawing.

Table 6.3.1e: **FGDM Output for Common Buildings Data**

COMMON BUILDINGS	
S(D1)	0.82
S(D2)	0.24
S(D3)	0.14
MIN(S(Di))	0.14

6. Mixed Use at the Core (Interpretation of Data Analysis)

82% of sample claimed they had better understanding of design intent when displayed using Animation/QTVR;
67% of sample claimed they had better understanding of design intent when displayed using 3D rendering;
26% of sample claimed they had better understanding of design intent when displayed using 2D drawing.

Table 6.3.1f: **FGDM Output for Mixed Use at the Core Data**

MIXED USE AT THE CORE	
S(D1)	0.74
S(D2)	0.33
S(D3)	0.18
MIN(S(Di))	0.18

7. **Social and Recreational Spaces (Interpretation of Data Analysis)**

85% of sample claimed they had better understanding of design intent when displayed using Animation/QTVR;
54% of sample claimed they had better understanding of design intent when displayed using 3D rendering;
45% of sample claimed they had better understanding of design intent when displayed using 2D drawing.

Table 6.3.1g: **FGDM Output for Social and Recreational Spaces Data**

SOCIAL AND RECREATIONAL	SPACES
S(D1)	0.55
S(D2)	0.46
S(D3)	0.15
MIN(S(Di))	0.15

8. **Universal Accessibility (Interpretation of Data Analysis)**

54% of sample claimed they had better understanding of design intent when displayed using *Animation/QTVR;*
77% of sample claimed they had better understanding of design intent when displayed using *Photomontage;*
26% of sample claimed they had better understanding of design intent when displayed using *3D drawing*.

Table 6.3.1h: **FGDM Output for Universal Accessibility Data**

UNIVERSAL ACCESS	
S(D1)	0.74
S(D2)	0.23
S(D3)	0.46
MIN(S(Di))	0.23

6.4 Observations and Conclusion

The hypermedia visualization interface that was developed to work on both the Internet and local domains provided the flexibility needed to achieve a better degree of success with participants' responses in the surveys. This flexibility helped to eliminate the need to conduct supplementary surveys, since alternative platforms were provided for participants. Secondly, using virtual reality technology to present design issues required the use of a domain that enabled participants to personally explore the potentials of the medium at an individual level. It made the use of photo-realistic graphic imagery necessary in order to obtain a consistent and reliable outcome. The challenge of presenting photorealistic images necessitated that more attention be paid to design and rendering details for the alternative design scenarios. It also helped to eliminate the use of mailed-out questionnaires, since the images on hard copies would not provide the dynamic and interactive experience required for this type of survey.

Finally, the exercise revealed that inviting participants to a controlled environment for the purpose of a survey requires persistent contact with subjects. It was noted in the survey that, even with cash prize inducements, the chances of having more than 60% attendance depended on several other factors, such as the would-be participants' interest in survey issues and their personal knowledge of those conducting the survey.

CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 The Design

This research sought to answer two basic questions:

1. If a suburban community were designed to incorporate goals, ecological-planning criteria, and technological features associated with achieving sustainable development, would people want to live there?
2. Does a design representation technique affect consumers' understanding of design intent, and hence the choice of design alternative that they make?

The research result showed that sustainable community design could be disagreggated into component performance features. The broad categorizations used in this research include community, ecological, and street design features. These parameters were disaggregated to component performance features such as lot configuration, community core, mixed uses at the core, mixed types and sizes of housing, residential intensification, availability of social and recreational spaces, waste management infrastructures, water and wastewater management infrastructures, energy conservation, and street design strategies.

A community design proposal was produced for Whyte Ridge based on a sustainable design concept. The challenge of the research was to produce photo-realistic 3D renderings of the design that were comparable to the output obtainable from photomontages of existing scenarios of views from a built site. These scenarios should be those which best explain the particular sustainable community design features, so that it could serve as a basis for objective comparative assessment. Alternative concept design proposals were presented to internal design jury using FormZ. Three-dimensional computer models of design scenarios that best explained each of the sustainable community design features were presented during the exercise. The final design scenario representations were then paired with 2-dimensional sketches, 3-dimensional renderings, and photomontages of a conventionally designed community, for assessment by three subject-groups on two platforms -- Web based and laboratory platforms.

7.2. **The Hypermedia Visualization Interface** (HVI)

To obtain the data used in this research, a hypermedia visualization interface was developed to present a split-screen pairwise display of design scenarios for each design feature. Prior to the development of the interface, alternative design scenarios for the Whyte Ridge Community in Winnipeg were developed and embedded in graphic frames with explanatory text links. The design abstractions for each of the 22 features considered in the surveys were presented in 2D and 3D formats. Photographic representations of the features were also presented to increase subjects' understanding of the issues being explored. Animations and QuicktimeVR images were provided to allow participants to explore some of the features in virtual space. Links were provided to text frames that contained a list of assessment questions for determining the degree of users' preference for any one of the pairwise-presented design scenarios in the community in which they live. Detailed discussions of this procedure are presented in Chapters 3, 5 and 6.

7.2.1. Advantages of the Hypermedia Visualization Interface

One of the advantages of the hypermedia interface is the flexibility of running repeated tests, both over the Web and in laboratory conditions, with uniform display quality on every platform. This flexibility makes it unnecessary to run supplementary tests with live subjects using a different medium. The flexibility of the medium contributes to the potential of the tool to accommodate repeated testing scenarios, which are carried out over extended periods of time, and in various settings, while maintaining the integrity of the data.

However, one of the greatest problems with direct laboratory-based electronic presentation media is the lack of opportunity for participants to move at their own pace through the presented materials. Subjects are constrained to move at the pace of the presenter, whose main objective is to get through the presentation in the least amount of time to sustain participants' interest in the subject. The presentation-pacing problem described above could hinder participants' in-depth understanding of survey participants. In the survey used for this research, the presentation of a web-based HVI allowed participants to personally investigate and manipulate design data, sometimes in the comfort of their homes, at their own pace. This enhanced their understanding of the subject, and contributed to the quality of responses.

7.2.2. Limitations of the Hypermedia Visualization Interface

A computer-based hypermedia visualization presentation may not be fully effective if it is run as a stand-alone research and information tool (Perks and Clark, 1996). The reason for this is that computer screens are limited in dimension and may not present the immersiveness required for a reliable assessment of the graphic data presented. Secondly, the resolution of images rendered on the computer screen may sometimes not be clear enough for an objective assessment. However, in the tests carried out in this research, subjects claimed to have a better grasp of the issues after a live presentation in which computer-enhanced images of data used in the interface were projected on a large screen. This may be due to the immersive power of projected images (Bertol and Foel 1997).

The internalizing process, in which a subject has adequate time to process the information displayed on the computer screen or on a display board, contributes to subjects' understanding of design issues and the reliability of preference rating. This is not achievable with computer-based or slide projection onto a large screen in a controlled environment alone. Combining slide projection with Web-based data presentation made the internalization process better. Subjects were able to exhaustively examine design alternatives with attached explanatory texts, and were able to critique it before answering the questions.

7.3 **The Fuzzy Group Decision Making Technique and Statistical Analysis**

One of the objectives of this research was to present the use of the Fuzzy decision analysis as a viable technique for evaluating qualitative design data. It has been established in literature that consumers' preferences for the inclusion of certain design features in a community in which they intend to live is a decision-making problem (Perks and Clark 1996, Goldschmidt 1992, Klir and Yuan 1995). Because of the nature of judgments that are often made in the assessment of visual data and in the formulation of sustainable community design criteria, a technique that could capture the imprecision is required. Only a technique such as FGDM, that is capable of modelling data obtained from qualitative assessment of decision alternatives, has the capacity to deal with a decision problem that exemplify vagueness and non-specificity in the formulation of preferences, constraints, and goals. Statistical tools are inadequate for this type of analysis.

FGDM is used in this research to answer the two research questions raised in section 7.1. The findings are discussed in chapter 6. FGDM eliminated the use of statistical procedures such as ANOVA or Principal Components Analysis (PCA) to determine data variability or dispersion about the mean. What is obtained in the former technique was a realistic evaluation of qualitative data, while the latter technique can only produce a crisp value of data variability, Crisp analytic techniques can not capture the linguistic imprecision inherent in the qualitative data that was assessed in this research.

In this research, the results from FGDM analysis is compared to results obtained from other multivariate techniques for analyzing statistical data such as the Descriptive-Analytical method and Multivariate ANOVA. It was found to produce a more reliable outcome from the same sets of data. It is a more robust approach that captures the imprecision in the ordering decision alternatives and statement of goals. While the descriptive method provides only a measure of understanding the distribution of data, FGDM produced a set of satisficing solution upon which the choice of a preferred solution can be based.

7.4 Suggestions for Further Research

One of the problems encountered in this research was the limited technological capability to handle a multi-media presentation. The development of affordable technology to make this happen would increase the quality and versatility of design data that could be presented on the Web. It would also reduce the time required to perform the numerous rendering routines that was required for a photo-realistic presentation.

This research demonstrates the use of the Fuzzy Group Decision-Making technique (FGDM) for determining consumers' receptivity to design features using values from imprecise data. FGDM was used to determine the relative importance of each feature to consumers. This procedure made possible the objective comparison of consumers' preferences within and across parametric lines. It provided the decision-maker with weighted priority ratings for each design criterion. The prioritization of design parameters could be used to advice decision-makers (DM) with regard to areas of design program that DMs ought to accord higher priority. Greater design energy could thus be devoted to those issues that each community believes to be important in the pursuit of a sustainable and livable design.

It would be interesting to have a study of similar community design scenarios using other statistical methods to analyze the data. This would provide an objective basis for comparing the outcomes from both experiments and to further evaluate the strengths and weaknesses of the techniques used in this research.

The Gform protocol used in this research to retrieve survey data has some limitations. The data retrieved are useful only when the profiles of the respondents could be matched with the questions they answer. At present, this is only possible when responses to all the questions by individual respondents are completed and posted sequentially. Where there is more than one respondent submitting response data through the system at the same time, the task of categorizing responses according to respondents becomes difficult. An improvement of the Gform protocol to allow user-recognition for multi-person postings is required. This will make the task of data sorting easier and more reliable than it is at present. One of the ways by which this limitation was overcome in this research was that respondents were allotted sequential time-blocks to complete the questionnaires, and posted data was sorted immediately the questionnaire was completed.

Finally, the interest of end-users in design data evaluation exercises would increase if the medium were improved to allow participants to manipulate design data without affecting the original design template. Interactive cyber design jury would enhance the quality of comments and suggestions received by the designer and contribute to the quality of design solution. This capability would expand the design "jury" to include those who would not otherwise have had the opportunity engage the designer during the design process, thus enriching the process. It would also increase society's 'ownership' of final design solutions, and thus reduce the task of designers and decision makers to win the support of stakeholders during public hearings on publicly funded design projects.

7.5 Conclusion

The Fuzzy Group Decision Model, developed in this research, is an objective method for analyzing subjective data. Design data falls within the category of data that have been difficult to evaluate using discrete statistical techniques that are applied to problems in the sciences and social sciences. FGDM, by representing assessment data based on the degree of membership rather than membership or non-membership, removes the problem of magnifying data-driven errors that may occur during the iterative evaluation process.

Thirdly, FGDM by providing a framework through which a decision-maker can obtain a satisficing solution out of a series of non-dominated solution, reduces the burden of having to conduct further research before a final decision is be made. It also presents decision options to the decision-maker in a form that logical choice is made possible.

Furthermore, the hypermedia visualization interface (HVI) adopted for the surveys made the presence of subjects at the location of the VR data presentation unnecessary. The feedback obtained from the subjects validates the assumption that data obtained from Web-based surveys show little variation from those obtained when the data is presented in a laboratory environment. The additional advantage of the Web-based survey is that it provided subjects with the flexibility of thoroughly examining the choices provided for assessment before making a final choice.

Hypermedia visualization tools have strong potentials for the kind of market research that seeks to test innovative ideas, design schemes and ranges of choice in housing or community services, pricing and costing, consumer-industry trade-off decisions, and for conducting the user-participant planning-and-design process. These direction-finding processes in community planning, municipal planning, urban development could regularly deploy the procedure and technology used in this research for conducting participatory planning, and for educational purposes. The tool is especially useful for focus group-type research, and for comprehensive statistical research.

Finally, an enduring work of design can only be achieved through the participatory process. The final choice depends on the definition of the designed entity and the communication of design intent to the client. The participatory attributes of design approval is used in this research to present ways by which knowledge could be constructed, enhanced and tapped during the design process.

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APPENDICES

APPENDIX A:
SUSTAINABLE COMMUNITY DESIGN PARAMETERS

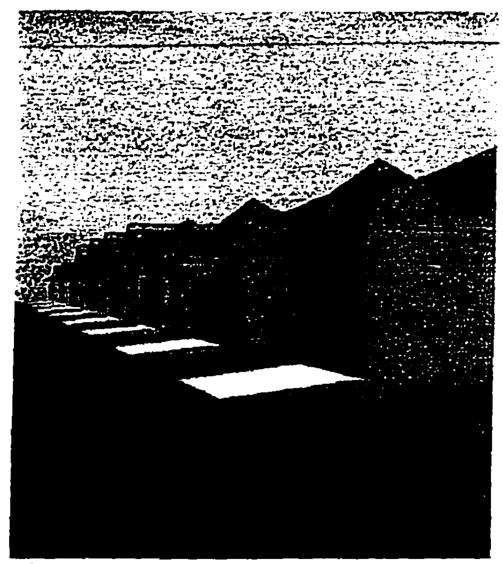
Presented below is a discussion of the original parameters proposed for the design of a sustainable community. The presentation of the proposal and some of the issues raised in its critique provides an argument to support the assumptions made in this study. Some of the assumptions were used to develop the major categories of design features, which was reflected in the final proposal and in determining the direction of our investigation for the consumers' receptivity survey.

1. **Compactness of Built Form**

A major parameter for sustainable community design is compactness. This involves increasing residential density through clustering of higher density dwellings in a number of small groups around the core, and providing lower density detached dwellings towards the periphery of the site. Residences should be located not more than 10 minutes walking distance (or 1000 metres -- about 1100 yards) to open spaces or activity centres.

In the Whyte Ridge proposal, all neighbourhoods and their centres, civic places, skating ponds, eco stations for recycling, and recreational facilities are connected with each other by a continuous parkway corridor with nature walks, tree nurseries, and other landscape features to identify entrances to residential areas, educational, and civic sites.


A Mix of Residential Types at the Centre

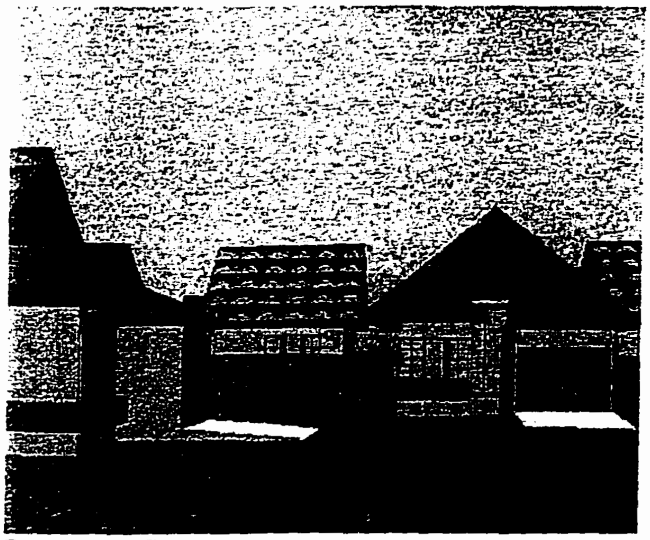

Linear Layout with Limited Setback from Local Street

- *Community Spatial Form* (Perks et al. 1996, Gurstein 1995).

This includes an assessment of community spatial structure, such as:

1. The pattern of aggregation of the elemental units that make up the community, whether the aggregation of buildings is linear, clustered, or amorphous aggregation;
2. The individuality and uniqueness of residential clusters;
3. The exterior spatial harmony and visual continuity of community streetscapes as seen in its geometrical, material, and scale consistency; the types and linkage of its buildings; and
4. The diversity of spatial experiences that can be enjoyed while navigating the site.

Where there is a diversity of building types and a consistent material usage and scale pattern, the "deja vu" sameness that pervade our urban communities is minimized. Lennard (1995) recommends that while the site planning for a community should be designed by an architect or a team of architects working together with a common objective, individual units should be designed by various architects who can bring their diversity of methods into the design to establish a uniqueness needed in the community. The different types should adhere to an architectural code established for the whole community (Duany and Plater-Zyberk 1991). All units are unified/linked by the adoption of consistent scale, material usage, and geometrical patterns.



Residential Clusters

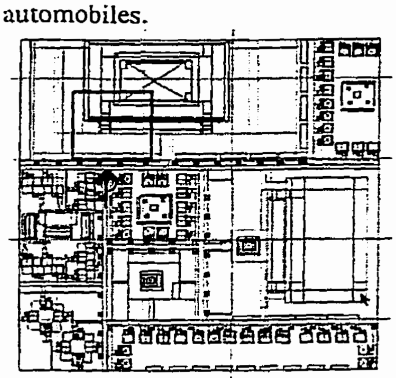
- *Permeability* (Lynch 1981, Alexander 1977, Jacobs 1960):

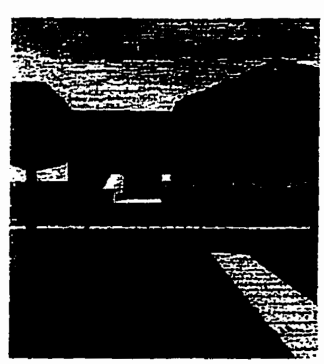
Permeability includes:

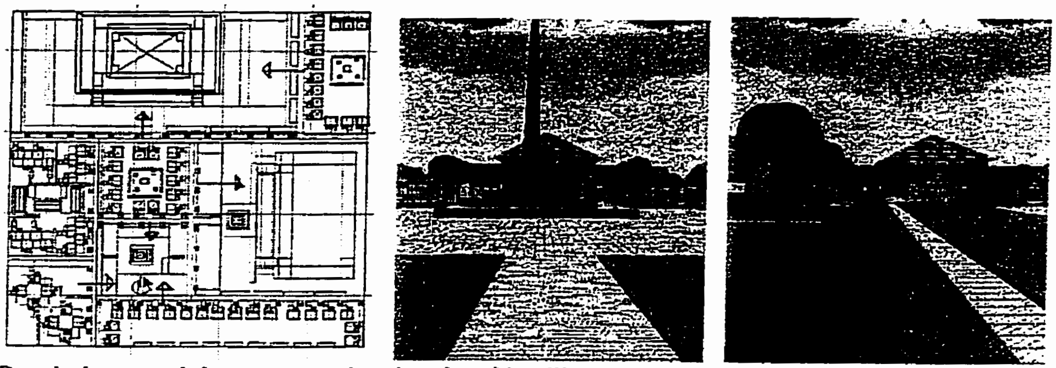
1. The proximity and connection of residences to activity centres such as schools, community centres, parks, and entertainment centres;
2. The pedestrian-friendliness of community streets perceived from the separation of its pedestrian and vehicular networks, the width of sidewalks and bike paths, the design of the street for traffic calming, and the road configuration and alignment design to slow down or exclude vehicular traffic;
3. The length of blocks; and
4. The location of activity centres to reduce automobile dependency.

A major problem of the typical suburban community is the absence of activity areas (Lennard 1995, Perks et al. 1996). Where residences are located close to activity centres, residents are encouraged to walk rather than drive. Because of constant and sustained pedestrian traffic on community streets, security is improved, and vitality and life returns to the street.

Typical suburban communities are almost exclusively designed for the automobile. Walkways are virtually non-existent. A pedestrian-friendly street is a street that is designed with the safe movement of pedestrians as its main objective. Such streets have wide and convenient sidewalks sheltered from the elements. The roads, in a pedestrian-friendly community, are designed to slow down vehicular traffic so that families and children can play and organize street activities secure from intrusion by automobiles.







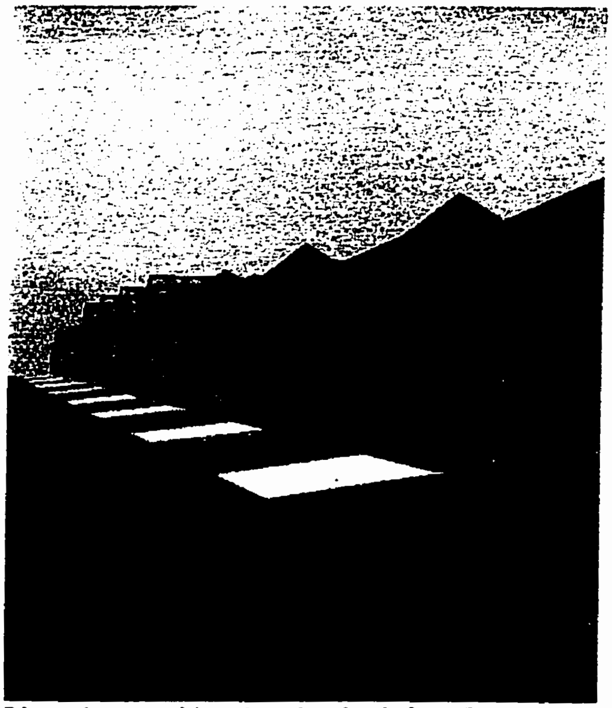
Proximity to activity centre and pedestrian-friendliness

- *Openness* (Ashihara 1979):

Openness includes:

1. The assessment of building setbacks from transportation routes and other buildings;
2. The height-to-width ratio (Ashihara recommends a 1:1 or 1:2 ratio for adequate compactness);
3. The enclosure factor (i.e., an assessment of the continuous width and height of containing walls of buildings along the street in relation to street depth, as a measure of containment); and
4. The building and/or residential density.

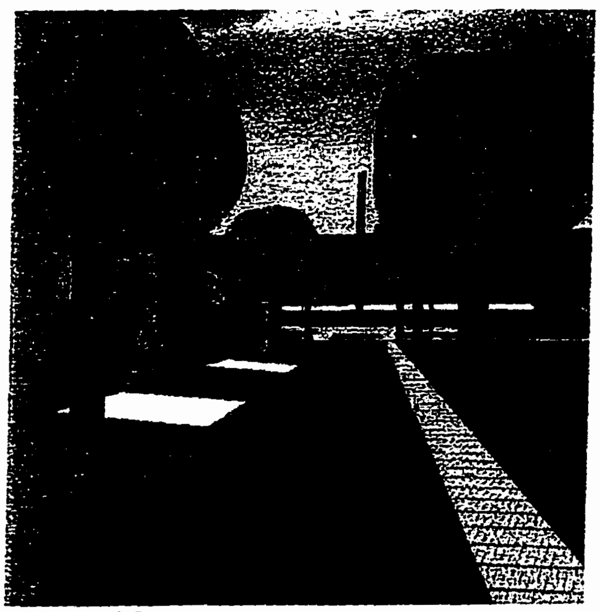
The setback of buildings and the lot coverage influences the penetration of sunlight into the building enclosure. The design and orientation of buildings to facilitate access to natural lighting helps to reduce dependency on supplementary artificial lighting in the daytime and cuts down on power usage. However, the spacing between buildings ought to be planned with the objective of maximizing compactness and minimizing the consumption of land for buildings alone. Where building spacing is too wide in relation to height, space becomes nebulous and difficult to comprehend or articulate. The sense of containment and compactness is lost, and more urban land is wasted and consumed unnecessarily to provide housing for fewer people.



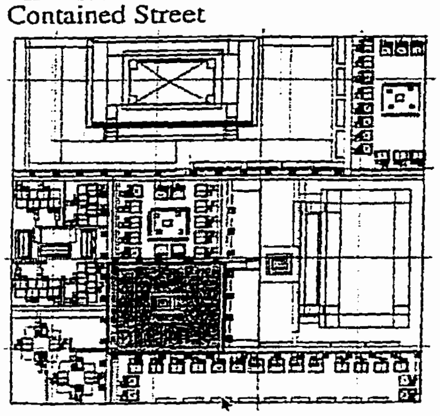
Linear layout with reduced setback from Local Street

Containment of streets by city walls reduces the exposure of residents to avoidable forces of nature. such as gusting wind and downdraft. It influences the feeling of security by pedestrians and encourages the use of community streets. Containment is determined in part by the ratio of the height of containing buildings to street width. The smaller the ratio, the more compact is the community, and vice versa. The enclosure factor, combined with the height-to-width ratio, influences the feeling of containment and security by users of public open spaces. The enclosure factor is determined by the assessment of the continuous width and height of containing walls of buildings along the street in relation to street depth. In typical gridiron planning, adjacent streets, which surround a public open space, create a psychological feeling of perforation to users of such public spaces. This reduces the needed feeling of containment that makes the enjoyment of squares or plazas complete.

Where community blocks are longer and farther away from activity centres, there is a tendency to use the automobile for simple tasks such as going to purchase a bottle of mineral water or taking a child to the community plaza. Where activity centres are concentrated along one end of a long community block, the distribution of pedestrian activity is impacted, and movement is concentrated on that end of the community block. Distributing activity areas on both ends of a community block, and making them accessible to residents at short walking distance encourages pedestrian activity and enhances vitality.

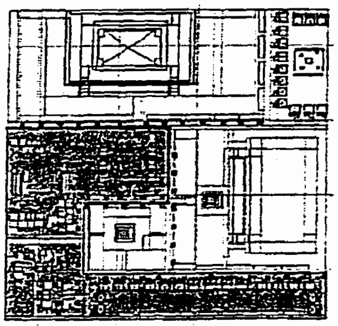


Contained Street



Contained Open Space which evokes a feeling of enclosure

The number of building/residential units per acre of land is a major determinant of compactness. The more the units of building per acre (up to an acceptable limit), the higher the density and the less land and infrastructures is wasted for providing services to community buildings.



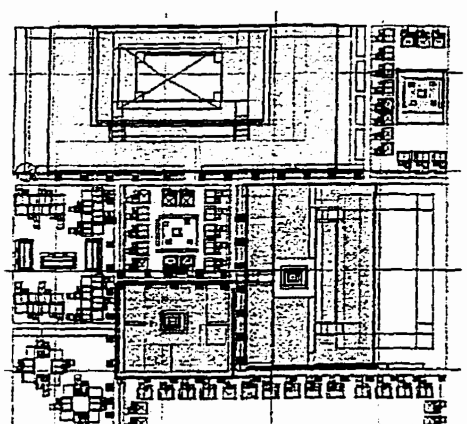
Varying Mix of Residential Densities

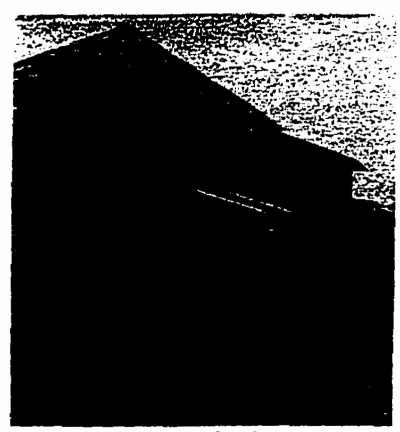
Medium Density Residential Units

- *Transparency* (Lynch, 1981):

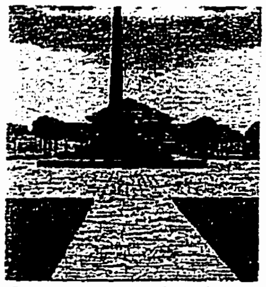
Transparency refers to structures that facilitate activities and events that convey a sense of life, and the pattern of life in the community. It includes physical structures that enhance intensity of use such as residential density. It involves such public or social spaces that generate the action of movement of persons such as parks, restaurants, community and entertainment centres. It also involves significant evidence of maintenance of the activity areas that helps to sustain life in the community. Such structures include the provision of garbage collection units, availability of drainage channels for draining flash floods, provision of shades and plantings, and availability of street furniture.

Public social space is the single most important element for enhancing community livability. Lennard (1995) observes that "a centrally located public space can function as the 'heart' of the community, generating positive energy and a sense of membership." Spontaneous social contacts in community public spaces, through exchange of greetings and engaging in conversations while going shopping or to work, are the seeds from which a sense of community develops.





Communities with designed social spaces declares an intent for intense social contact



Open Spaces for Social Interaction

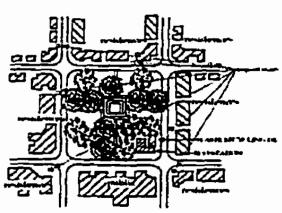
The perception of order and neatness of a community enhances our perception of livability and good government. It also helps us to draw conclusions about the character and quality of its residents. And the perception of orderliness of the communities in specific locations is a factor for measuring the value placed on living in certain locations within a city.

2. **Ecological Design Considerations**

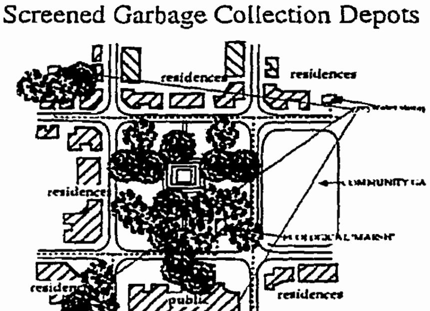
- *Eco-balance Enhancement Potential of Design*

One of the goals of sustainable community design is the creation of a friendly, healthy environment with energy- and water-conserving home designs and site planning, less wastes, and recycling of unusables. A community with wastes, storm water, and sewage management at the local or community level. For a community to be ecologically sustainable, structures should be provided for storm water management and water recovery. There should be provision of natureways, civic places, walking and bike networks, "greening", and streets designed for walking in safety and comfort. It should also provide spaces for gardens and greenhouses for food production within the community.

In typical suburban community setting, recycling bins are usually located at points very distant from residences. This makes it very difficult for residents to recycle on a regular basis. In order to enhance good recycling habit, recycling 'drop-off stations' should be located within a two-minute walk from every home.



Screened Garbage Collection Depots



Unit and Community Sewage Recycling

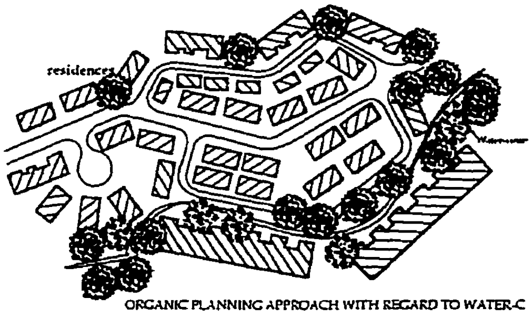
Composting 'eco- stations' should be centrally located in a space large enough for sorting all discards and processing useful ones for resale (Perks et al).

The prevailing practice of draining storm water through sewers to a centralized point makes the re-use of effluents as fertilizers impossible. It also prevents the channeling of excess water through ponds and canals for irrigation. The use of smaller-sized biological 'greywater' systems in which wastewater is passed through a fully closed ecologically-engineered "marsh" makes possible an effective, acceptable wastewater treatment in communities. These systems are placed in varying locations near a garden or green house, so that the effluents can be efficiently re-used as fertilizers, and the excess water channeled for irrigation of open spaces.

- *Respect for Site Landscape*

Two important goals of sustainable community design are the protection of environmentally sensitive areas, and the creation of open landscapes. Residential areas become islands of human intervention in the midst of natural environments when the topography, vegetation patterns, wildlife habitats, watercourses, and landscape screenings are knitted-in with housing (Perks et al. 1997).

When watercourses are blended with community design, there is a natural flow and connection between built space and the natural environment. Built space become "islands" of human intervention in the midst of the natural environment.



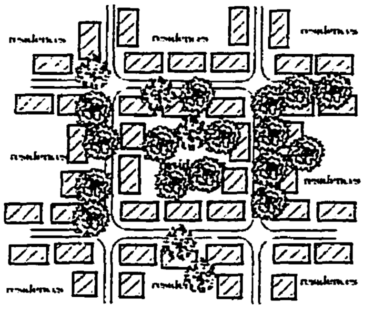
Layout of Site to take best advantage of Natural Phenomena

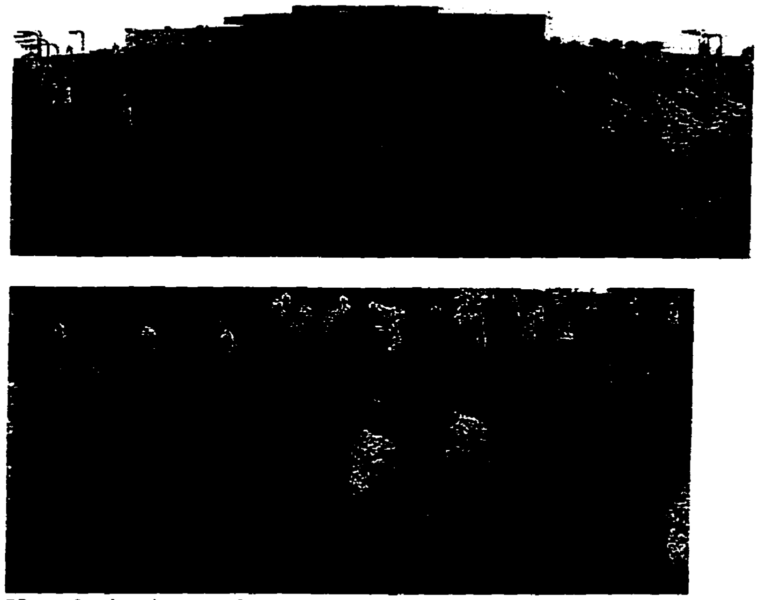
When niches of vegetation which are dependent on creeks, ground-water, and soil stability are preserved; and when houses are built with due regard to the topography of the site, soil, water, and other land-nutrients, disturbances to the ecological balance is mitigated.

In small residential districts where housing type are the same, the use of landscape screenings will help to give perception of variety and stimulate visual interest. This will help to increase the sense of orientation by first-time visitors to such communities, and make referencing of location referencing easy.

- *Reduced Embodied Energy Potential*

Affordability of housing for all economic groups is determined in part by the cost of providing housing units for the market. When the community form is compact, and the ratio of attached or stacked units-to-free-standing single units are high, the cost of providing services are minimized. Therefore compact communities tend to cost less to build, and could be sold for less than houses in communities that are not compactly built.





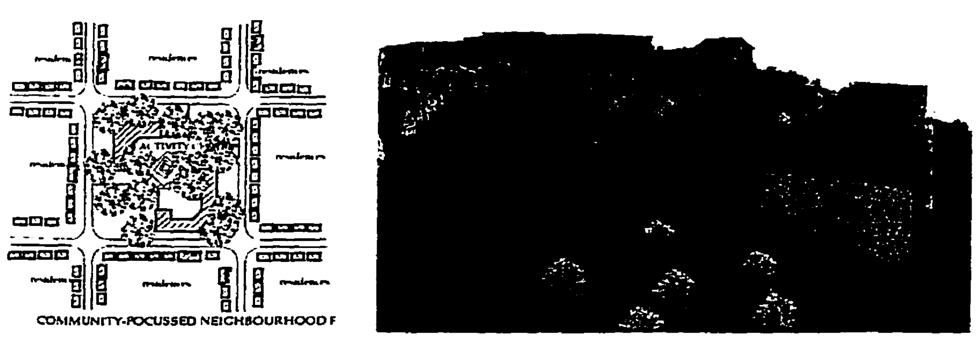
Use of selective landscape screening to enhance view

The ratio of attached or stacked dwelling units to free-standing single family dwelling units influence the size and cost of extending power lines, road paving and maintenance, sewer connections, and water supply. This in turn affects the affordability of housing units to a broader base of the population, and the sustainability of a community.

The design of a community's neighbourhood can strengthen or weaken social contacts within the community. When neighbourhoods are designed without a core or cores of social activity, contact is minimized and the forging of community identity is difficult. However, in communities with activity centres and meaningful open spaces, the intensity of contact is higher and relationships tend to grow from continuous contact.

3. **Promotion of Community Identity and Sense of Place**

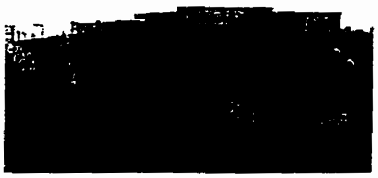
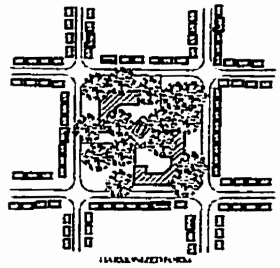
An important factor of sustainable community design is the realization of a community that promotes a sense of place and develops unique community character. The development of strong community identity depends in part on the unique architectural character of buildings and designed spaces in the community. Use of materials and architectural standards should be sensitive to the culture and environmental realities of the community.



A mix of attached and multi-family dwellings results in a compact and vibrant core

- *Uniqueness of Design Typologies for All Neighbourhoods in the Community*

When architectural forms and elements such as windows, doors, facade definition, and open space planning are unique and differentiated from one neighborhood to another, the sense of orientation and location is enhanced. The familiarity and cultural relevance of these elements helps to strengthen the sense of identity and community pride. Legibility of space is improved when forms are harmonized to attain spatial balance. Neighbourhoods with a multiplicity of uncoordinated forms are visually unpleasant.

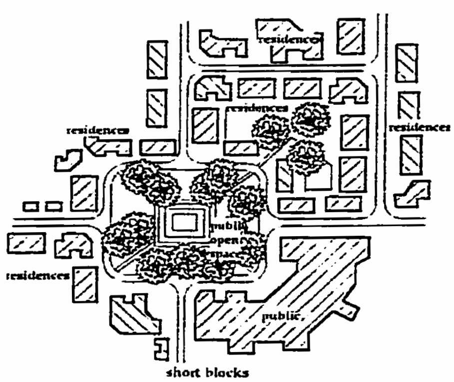




Accessible Multi-purpose Centre encourages intense use

- *Residence-Open Space Access*

A major problem of the typical suburban community is the absence of a core of activity areas (Lennard 1995, Perks et al. 1997). Where residences are located close to the core, residents are encouraged to walk rather than drive. Because of constant and sustained pedestrian traffic on community streets, security is improved, and vitality and life returns to the street. The more diverse the activity spaces at the core the more the intensity of use of the core, and the more the social interaction of residents at such activity centres. Open spaces with diverse activity areas tend to attract different social classes and age groups of users more than mono-functional open spaces.

When an open space is located close to residential areas, there is an increased tendency to walk rather than drive to such open space. Less use of the automobile means less urban pollution through gas emissions, and a cleaner more environmentally sustainable community.



Accessible open space is a social catalyst

APPENDIX B: SAMPLE DATA PRESENTATION METHODOLOGY

(a) DESIGN FEATURES
5. Explanatory Text
6. Typical Evaluation Questions for Testing Consumer Receptivity

(b) CONVENTIONAL SUBURB AND SUSTAINABLE SUBURB SCENARIOS
7. 2D schematic drawings (Explanatory): *Plan/ Section*
8. 3D view of scenes which will explain the feature under consideration
9. Animation/VRML of the portion of design proposal that shows the elements of the feature being considered (not included in this mock-up).

- *COMMUNITY DESIGN FEATURES*

The homogeneous structure of conventional suburban communities has resulted in a number of problems, such as: the dominance of single family detached housing and high urban land consumption, limited variety of housing types, the high cost of housing, feelings of isolation by suburbanites, intense commuting and auto-dependency, and sprawl. The design of a sustainable community strives to maintain a balance of physical and ecological considerations with the purpose of developing an inclusive and vibrant, yet ecologically sensitive community. Discussed below are community design features that could be enhanced to improve a community's sustainability.

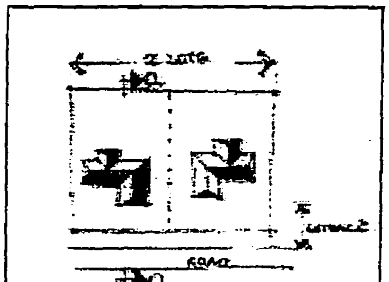
1.1 Land use and Housing

In most conventional suburban communities the planning and design of the landuse is not properly adapted to local macro and microclimate. Buildings are not sheltered from aggressive climatic influences. Landuse planning and housing design in sustainable community is adapted to local macro- and microclimate. Buildings are sheltered from aggressive climatic influences and there is enough intensity at the centre to sustain viable commercial and social life and to promote sustained use of public space.

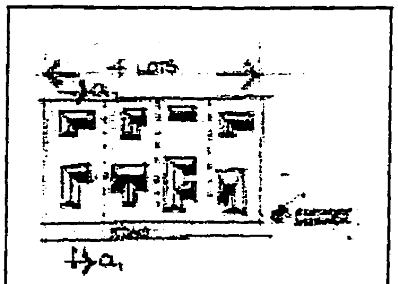
- *THE LOT:*

  Condensed lot configurations have increased in order to use land more efficiently, to reduce the costs of infrastructure, and to promote a stronger sense of community. Condensed lots typically increase single family detached housing lots from 4 dwelling units / acre to 8 dwelling units per acre while retaining privacy and livability issues common to detached housing. Methods for achieving this include reduced frontyards and setbacks, incorporating two storeys, rather than one storey, dwellings that reduce the building 'footprint', and careful residential landscaping. In turn, buildable land can be used for nature reserves, community gardens and or open space and parks.

GRAPHICAL ILLUSTRATION



Conventional



Sustainable

Illustrative Photomontage

❑ <u>Evaluation Questions</u>

– Front Yards

Reducing front yards to 10 feet can save buyers up to $4,000 and make streets more intimate to building scale.

- *Would you consider this savings appropriate enough to consider living in a community with reduced front yard?*

  Yes   *No*   *Other (state reason)* ______________________

- *Would you trade a deep front yard for a more intimate dwelling-street relationship and a bigger private backyard?*
  Yes *No* *Other (state reason)* ______________________

– Attached Homes

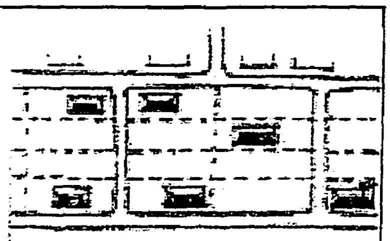
Attached homes makes an effective use of reduced lot sizes and helps to reduce the cost of services to each dwelling *unit. By living in attached home, a homeowner could have the same living space in most high-class suburban developments for less than 66% of the cost of detached buildings. In addition, buildings are more closely connected to each other without a loss of privacy.*

- *Would you consider saving appropriate enough to consider living in a community with a mix of attached and detached units?*
  Yes *No* *Other (state reason)* ______________________

- *RESIDENTIAL INTENSIFICATION*

Residential intensification supports the creation of new living accommodations by 'infilling' within existing neighbourhoods and communities. It has the potential to revitalize and to introduce diversity into 'mono-functional' urban and suburban contexts and to accommodate a diverse population including the young, the elderly and the disabled. The intent is to make suitable use of under utilized and vacant buildings and sites: to achieve more efficient use of land and infrastructure; to create a sense of community, to reduce energy demands; to reduce real estate / housing costs, and to reduce development demands on new lands.

GRAPHIC ILLUSTRATION



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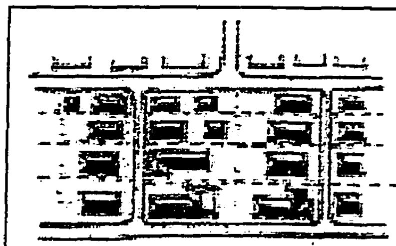


Sustainable

Photomontage

❑ <u>Evaluation Questions</u>

– Second home units

Residential second units are customarily located in the upper level of a garage, in the attic, or at the basement level. They have to be self-contained for bathroom and cooking facilities. By renting out a second unit, a family could purchase a home that would otherwise be unaffordable. The "second unit" could be used as a self-contained guest suite or for home offices for people working out of their homes.

5. *Would you be willing to live in an area where Residential Second Units are allowed?*
   Yes *No* *Other (state reason)* ______________________

   ____

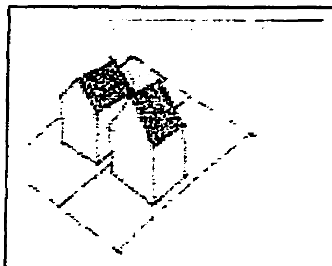
10. *Would you wish to own a home in which you could have a residential second home?*
   Yes *No* *Other (state reason)* ______________________

   ____

- *TYPES AND SIZES OF HOUSING:*

Integration as opposed to segregation is an objective of sustainable communities - accommodating individual and community needs and aspirations. Housing types such as: single family, detached, cluster, row houses, low rise apartments, secondary suites, shared housing, collective living, work/studio, and care/service housing, which are common to urban settlement, are merged in the overall community design. Their arrangement within the community is typically oriented toward including higher density housing types toward the centre and lower density housing types toward the periphery. Mixed housing encourages community diversity and provides an opportunity for closer social contact among a wide range of community residents.

GRAPHIC ILLUSTRATION



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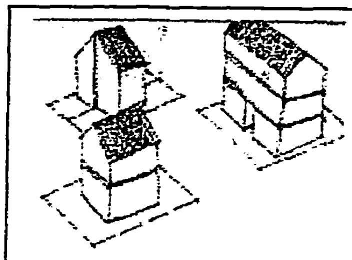

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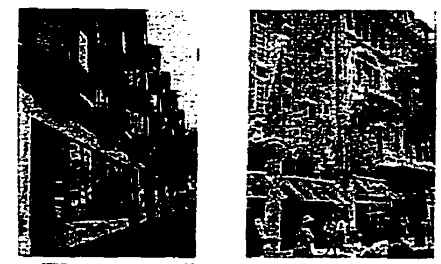


Illustrative Photomontage

❑ <u>Evaluation Questions</u>

- *If living in a community with a mix of detached dwelling units and attached units such as. apartments and townhouses will cost about 30% less than in a typical suburban development with single family dwelling only, would you consider it a better option?*
  Yes *No* *Other (state reason)* ______

– Attached Homes
Attached homes like townhouses, duplexes, and multi-family apartment units can co-exist with high-value single family residences without impacting on property values. The guiding principles are to ensure that it keeps within the architectural character of the neighbourhood, the height is limited to the general height of buildings in the neighbourhood, the street environment is appealing, and attractive open spaces are close to multi-unit housing projects.

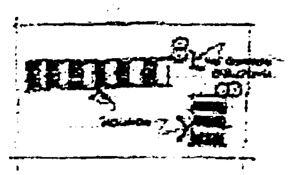
- Considering that an attached unit can cost 20%-35% less than a detached unit of comparable size and stature, *which housing option would you most likely choose for your household?*
  Yes *No* *Other (state reason)* ______

– Diversity of Household, Housing and People in the Community

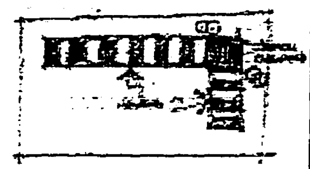
- Would you be inclined to choose a home in a community made up of a diversity of households, families and people of differing age, income status, and cultural lifestyle if:
- *Your home was located in an area of some 2 or 3 residential street blocks where all of the homes are designed for people of similar household status and "market bracket" as yours?*
  Yes *No* *Other (state reason)* ______
- *Your home was located in an area where the household status and "market bracket" of people are varied but the street presentation of each home is similar in architectural character and appearance?*
  Yes *No* *Other (state reason)* ______

- *COMMON BUILDINGS:*
  The sustainable community promotes interaction among residents through the use of shared facilities and common buildings. These can include: neighbourhood recycling centres, seniors and youth centres, daycare facilities, workshops and hobby spaces, and shared cooking/dining facilities, among many others. Community arrangements that support shared facilities and common buildings vary from condominium associations to housing cooperatives to co-housing concepts. Community owned and operated amenity help to reduce individual reliance on consumer products and help to reduce the cost of living while providing a higher quality of life.

GRAPHIC ILLUSTRATION



Conventional



Sustainable

Illustrative Photomontage

- ☐ Evaluation Questions
- *Would you prefer to live in a community with neighbourhood recycling centres as opposed to a community without recycling facilities?*

  Yes *No* *Other (state reason)* ______________________________

- *Would you prefer to live in a community with a core of community-related activity centres such as, senior and youth facilities, daycare facilities, workshops and hobby centres?*

  Yes *No* *Other (state reason)* ______________________________

- ***The Core***

The core of a community is the heart of its activities. It is the centre toward which all residents gravitate for social, economic, and sometimes, spiritual fulfillment. The sustainable suburban structure is based on the need tc have a vibrant centre that will be a social magnet in the community.

☐ Evaluation Questions

To support a community core with work, shopping, recreation and entertainment uses integrated with residential suburban developments, the overall density of the community would have to be higher than it is in conventional community.

- *Would you favour a community with a Community Core?*

  Yes *No* *Other (state reason)* ______________________________

- *Assume your home is located within 15 minutes walking distance from the community core. On a scale on 1 to 5 (where 1 means least preferred and 5 means most preferred), indicate your preference in the two displayed scenarios.*

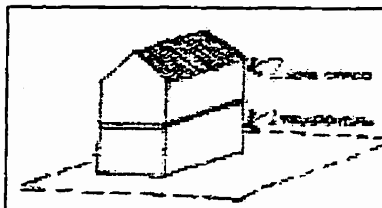
  1 2 3 4 5

- *MIXED USES*

  Diversity is key to sustainable land use. A sustainable community endeavours to promote poly-functional rather than mono-functional settlement patterns, by providing compact urban centres, with broad range of services and amenities, in close proximity to. These include commercial and retail shops, schools and daycare, health care and live/work housing units among other uses. Compact centres reduce the tendency towards `deserted' urban settings after business hours by providing sources for continuous activity on streets. Increased street activity enhances real and perceived safety needs. Providing for the needs of a community at the neighbourhood level reduces the need for vehicular and public transport, thereby decreasing demands on infrastructure and energy resources while promoting pedestrian accessibility and community.

GRAPHIC ILLUSTRATION


Conventional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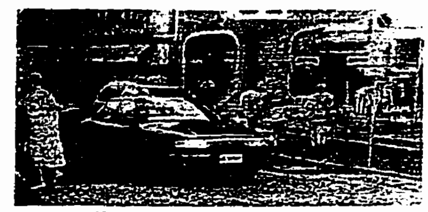
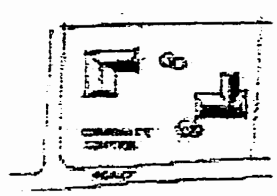
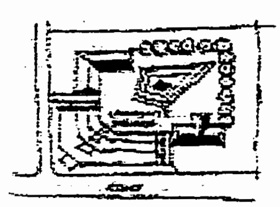

Photomontage

- Evaluation Questions
- *Would you like to have commercial and retail shops close to or integrated into residential homes in the community you live?*
  Yes *No* *Other (state reason)* ______________________
- *Would you prefer a community with schools, healthcare and daycare centres easily accessible from homes to a community without any of these amenities?*
  Yes *No* *Other (state reason)* ______________________

- *SOCIAL SPACES AND SENSE OF PLACE:*
  A community's sense of identity should stem from an understanding of context - of its natural surroundings and the related processes of settlement. The careful planning and design of community places is dedicated to the consideration of local aspects as well as global issues influencing a particular region and expressing these in its collective built form.

GRAPHIC ILLUSTRATION


Conventional


Sustainable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- Evaluation Questions

A community's main street serves as a social magnet for the community.

- *Would you like to live in a community with a centre of social and community activities such as, meeting halls, restaurants, and cinema/shopping facilities as opposed to a community with only residential units?*
  Yes *No* *Other (state reason)* ______________________

Cultural icons promote a sense of association, and contribute to the intensity of use.

- *Would you like to live in a community that has culturally significant built icons?*
  Yes *No* *Other (state reason)* ______________________

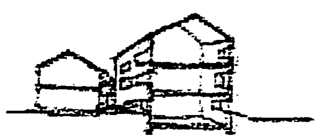
Neighbourhood Centre

- A neighbourhood centre would offer some retail and business services. It would comprise largely of 2 or 3 storey attached building forms. *Would you favour having such a development within 5-minutes walking distances from your home?*
  Yes *No* *Other (state reason)* ______________________

- *CORE STREETSCAPES*
  Streetscapes that support pedestrian travel in addition to vehicular movement should be encouraged. Pedestrian oriented streets provide protection from the 'elements', safety and amenity, and encourage outdoor interaction among residents. Separation between pedestrian and vehicular traffic should be provided with planting and other buffers. Streets should accommodate pedestrians and cyclists with

reduced road widths for vehicular traffic wherever possible (narrower road widths help to reduce speeding).

GRAPHIC ILLUSTRATION



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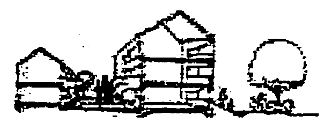

Sustainable

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❑ Evaluation Questions

11. Streetscapes that encourage pedestrian movement over vehicular movement tend to increase pedestrian-related activities

Yes *No* *Other (state reason)* ____________________

- *Would you prefer to live in a community where the sidewalks are wider and the roads are narrower and safer for walking and cycling?*

Yes *No* *Other (state reason)* ____________________

- *Would you like to stay in a community which has numerous levels of informal outdoor social spaces between building clusters?*

Yes *No* *Other (state reason)* ____________________

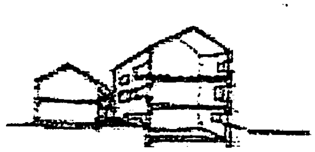
- **In-between Spaces**

The spaces that connect buildings are as important in design consideration as the buildings themselves. These spaces are like threads that weave the fabric of the community together in a unique and identifiable form. In sustainable suburban communities, in-between spaces are woven into the semi-public and private zones of adjoining buildings for a continuous flow of interaction at the home and neighbourhood levels.

- *COMMUNITY STREETSCAPES:*

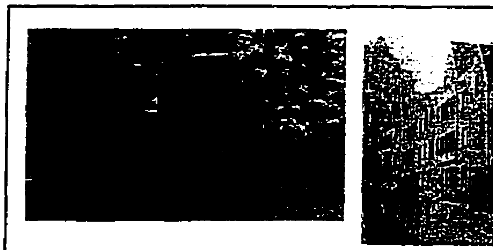
Streetscapes that support pedestrian travel in addition to vehicular movement should be encouraged. Pedestrian oriented streets provide protection from the 'elements', safety and amenity, and encourage outdoor interaction among residents. Separation between pedestrian and vehicular traffic should be provided with planting and other buffers. Streets should accommodate pedestrians and cyclists with reduced road widths for vehicular traffic wherever possible (narrower road widths help to reduce speeding).

GRAPHIC ILLUSTRATION



Conventional

Sustainable



Photomontage

❑ Evaluation Questions

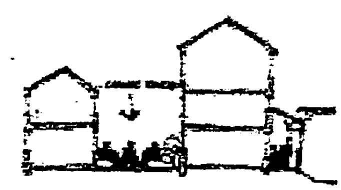
Streetscapes that encourage pedestrian movement over vehicular movement tend to increase pedestrian-related activities

- *Would you prefer to live in a community where the sidewalks are wider and the roads are narrower and safer for walking and cycling?*
  Yes *No* *Other (state reason)* ____________________
- *Would you like to stay in a community which has numerous levels of informal outdoor social spaces between building clusters?*
  Yes *No* *Other (state reason)* ____________________

- *SOCIAL AND RECREATIONAL SPACES:*
  Social spaces encourage contacts between individuals and groups in both indoor and outdoor settings. Social spaces are seen to be important to the advancement of individual and societal well being. Essentially, these spaces are those that are associated with the public or semi public realms of urban settlement. Social spaces should be planned and designed to promote community interaction and to facilitate the programming of neighbourhood events and functions. These include common rooms and shared facilities as well as local gathering places such as community recreational facilities. Social spaces should be open to the public wherever possible to foster civic values in the community and beyond.

GRAPHIC ILLUSTRATION

Conventional



Sustainable

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- ☐ Evaluation Questions
- *On a scale of 1 to 5, where 1 denotes least preferred and 5 denotes most preferred, how would you rate your preference for shared facilities such as, local gathering places (community hall), and recreational facilities for both young and old in the community you live?*
  1 2 3 4 5

Landscaping
- Consider that the initial cost of a home is about 1% higher but there are attractive maintenance savings of about 75% and 60-70% less labour time. *Would you favour a residential landscaping option with hardy drought-resistant plants species over conventional non-resistant species?*
  Yes *No* *Other (state reason)* ____________________
- Using permeable pavement surfaces for driveways and patios maintains subsoil water balance, makes the yard cooler in summer, and looks better than asphalt. It may add up to $300 in initial cost. *Would you be in favour of using this type of surfacing?*
  Yes *No* *Other (state reason)* ____________________

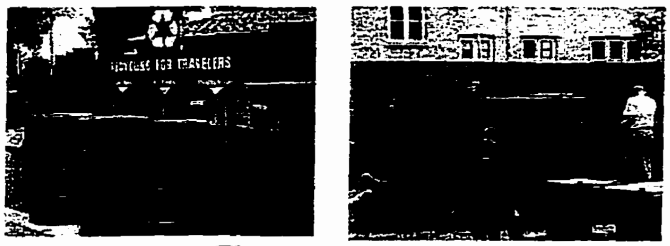
6. ECOLOGIC DESIGN

Ecologic design is a design paradigm that emphasizes practices that minimize the impact of intervention on the ecology of the site.

2.1 **Waste Management**

At the heart of a community's sustainability is its effectiveness to manage wastes. Canada rates higher than the U.S. in per capita waste generation. The major reason is that wastes are not recycled. Landfills are getting expanded continually and reusable materials are getting incinerated and wasted. Practices such as this will eventually put a stress on the natural resources that are used to produce these materials.

- *LOCATION OF RECYCLING CENTRES*
  The location of recycling centres has a major effect on residents' attitude toward recycling. Most conventional suburbs do not have recycling centres within their borders. The result is that residents dump recyclable materials in the garbage rather than take them to remote locations outside of the community. Sustainable suburbs have recycling centres within their borders. Drop-off depots are within 2 to 3 minutes walking distance from residences so that residents will be encouraged to recycle. even in inclement weather. The result is that residents are encouraged to recycle more rather than dump them in the garbage for incineration or landfill.



Illustrative Photomontage

❑ Evaluation Question

- *Would you be inclined to regularly recycle your household discards if a collecting point was located within 2 to 3 minutes walking distance from your home?*
  Yes *No* *Other (state reason)* ______________________________

- *CONSPICUITY OF RECYCLING CENTRES*
  Recycling depots should be easily identifiable so that dumping of garbage/non-recyclables is minimized. This is one of the goals of sustainable community design.

Illustrative Photomontage

❑ Evaluation Questions

- *Do you favour a more local opportunity and community-organized facilities like "neighbourhood collection points" and "eco-station" for recycling waste in the community you choose to live?*
  Yes *No* *Other (state reason)* ______________________________

Composting

- A home equipped for convenient recycling and composting does not cost more. It conserves resources and saves on garbage collection and landfill costs.
  Would you be inclined to choose a home that was designed and equipped for easy sorting and composting given that such a home would cost about $300 more in initial cost than conventional building?
  Yes *No* *Other (state reason)* ______________________________

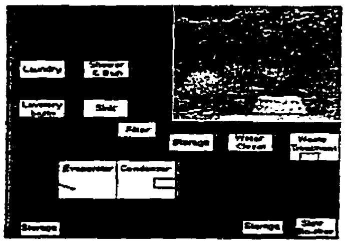
- Suppose that the home you choose is equipped for convenient sorting and composting, *would you recycle and compost more or less reusable wastes and discards?*
  Yes *No* *Other (state reason)* ______________________________

- **Water and Waster water Management**

The Calgary research (Perks et al) has shown that more than 30% of the water we use can be recycled and reused for household cleaning and irrigation. A sustainable practice aims at minimizing the use of water by recycling and reusing greywater and stormwater, and by re-channeling rainwater for domestic use.

- *GREYWATER REUSE*

  Sustainable suburban communities are designed to 'harvest' and recycle greywater from toilets, bathrooms and kitchens for the purpose of reusing them for irrigation.



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❑ Evaluation Questions

- Re-using water for toilet flushing or garden irrigation costs between $0 to $1200 more than conventional system, but conserves 50% or more of water piped into the home. The additional system cost would be recouped in 5 years through savings on your water bill. *Would you be inclined to choose the "water re-use" system over the conventional system?*

  Yes *No* *Other (state reason)* ______________________________
- *If this system could be installed in a home with no additional cost, would you be inclined to choose it?*

  Yes *No* *Other (state reason)* ______________________________
- "Living Machine" system can be reused for irrigating community farms, gardens, parks, street trees, and other open spaces.

- *Would you choose to purchase a home you liked if it is in a community where this system is installed?*

  Yes *No* *Other (state reason)* ______________________________
- *Would you be inclined to support a pilot project in Winnipeg that experiments with this alternative sewage management system?*

  Yes *No* *Other (state reason)* ______________________________

- *STORMWATER RECYCLE*

Storm water retention ponds are utilized primarily as a way of easing the pressure on the street sewer drain system during a heavy rainfall. The ponds typically hold water throughout the year, collecting water during a storm and releasing it slowly after the peak flow has subsided. This slow release reduces the need for storm sewers to be sized for maximum potential peak flow, which reduces infrastructure costs. This water can be used for irrigation, but also serves to provide urban habitat for migrating waterfowl. Moisture levels in the community can be increased marginally through evaporation, and many sites can be developed into aesthetically pleasing active or passive recreation areas that complement housing development.

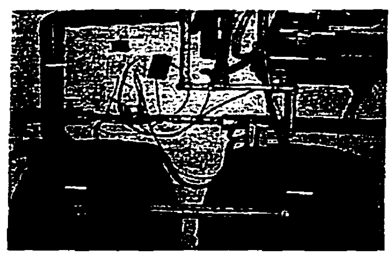
Photomontage

- ☐ Evaluation Question
- *Would you be inclined to support a pilot project in Winnipeg that experiments with stormwater management system?*

  Yes *No* *Other (state reason)* ____________________

- *RAINWATER RECYCLE*

  Rainwater collection and use help to lower demand for water from the mains. Houses in communities that are designed for self-sustenance are designed to collect and re-channel rainwater for use within individual buildings.



Illustrative Photomontage

- ☐ Evaluation Question
- Installing "rainwater recycling" system would save you $10.00 per month on your water utility bill during the month that you water your lawn. Consider that the system could mean an additional $300 in initial purchase price of your home. Afterwards you have net savings. *Would you be inclined to choose a home that has rainwater collection-storage system?*

  Yes *No* *Other (state reason)* ____________________

- **Energy**

About 33% of housing budget are expended on power and heat consumption. An energy-efficient building will cut its maintenance budget by 33%. A goal of sustainable suburban community design is to reduce the cost of power generation and the dependence on the use of fossil fuel.

- *CO-GENERATION*

  Co-generation is an alternative decentralized power generation system that allows energy to be efficiently generated and distributed right at the site. This system uses up to 33% less fossil fuel than conventional methods of power generation. Sustainable suburbs are designed for reduced power consumption.

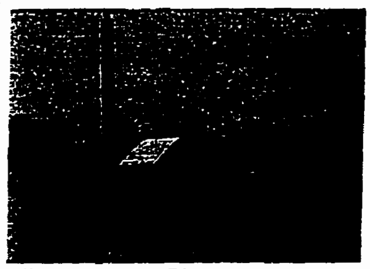
Illustrative Photomontage

- ☐ Evaluation Questions
- In Co-generation and District Heating system, the "exhaust" heat from generating the electricity is used to heat water. Hot water is distributed throughout a district network of underground-insulated pipes. This system uses 33% less fossil fuel than conventional methods of home heating. *How likely would you be to choose a neighbourhood with this feature over another with conventional heat generating system?*

  Likely *Not likely* *Other (state reason)* ____________________

- *Assume your monthly share of the cost of renewable energy sources pilot program in your community is $20 per month, would you agree to such an arrangement?*
  Yes *No* *Other (state reason)* ______________________________

- *DISTRICT HEATING*
  District heating is a decentralized heating system that allows heat to be efficiently generated and distributed at the site. Conventional communities are not designed to 'harvest' exhaust heat from generating plants for heating water and distributing it through a network of insulated underground pipes to service buildings. However, efficient generation and distribution of heat is at the heart of sustainable community design.



Illustrative Photomontage

❑ Evaluation Question

- District heating is overall 35% less costly than conventional home-furnace-heating. It also provides better control of room to room heating.
  Would you favour a District Heating System for your home?
  Yes *No* *Other (state reason)* ______________________________

- **Local Food Production**

The capacity of a community to locally produce its food impacts the amount of money it spends on food items that could be produced locally and the energy wasted on commuting to regional malls.

- *COMMUNITY FARMS*
  Parcels of community land dedicated to the production of food are important for energy/ nutrient cycling, decreasing food import costs (supporting the local economy), and opportunities for local employment. Community farms include both pastoral and arable farming of livestock and grains, vegetables and fruits as a way of increasing cycling of energy and nutrients. Excess produce is often used as animal feed and animal waste utilized as organic fertilizers.

Illustrative Photomontage

❑ Evaluation Question

- Would the idea of lands set aside for Community Farm located in the community be a positive factor in deciding your home and community choice?
  Yes No Other (state reason)

- *DISTRICT GARDENS*

Areas of land set aside for food production for the local neighbourhood. These allotments contribute to resident nutrition, aid in reducing household costs, and engage the residents in productive activity, in education, and community support.

Illustrative Photomontage

❑ Evaluation Question

- *Would the idea of District Garden be a positive factor in deciding on your home and community choice?*

  Yes *No* *Other (state reason)* ______________________

7. STREET DESIGN

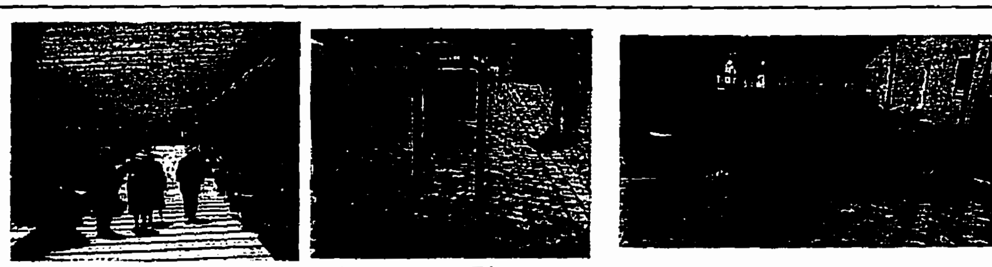
Streets should be designed as a place of interaction rather than a mere link between two locations in the community. Traffic networks should be designed to be narrow, pedestrian-friendly and connected. More, rather than fewer intersections should be encouraged, within a denser urban fabric. Maximum distances for essential destinations should be established, to encourage walking or cycling. In most situations a 5-minute walk, approximately 450 metres, is the most desirable walking distance that would discourage the use of vehicles for such trips.

3.1 **Circulation Networks**

The approach to traffic planning and design within a community should be holistic not disaggregated. In a sustainable suburban community, traffic planning is approached as a system of circulation networks with good connectivity and smooth transition from one network to the other.

- *PEDESTRIAN*

  Interaction is most intense at the pedestrian traffic level. A sustainable suburb should be designed to maximize contact at the pedestrian level.



Illustrative Photomontage

❑ Evaluation Questions

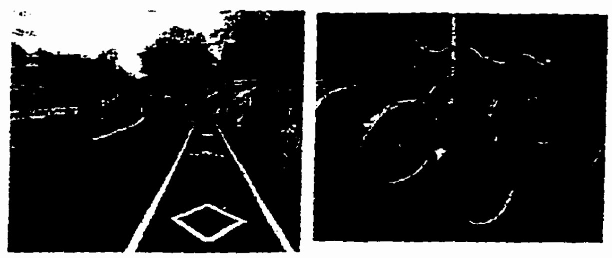
In a community with well-designed pathway system for walking and biking, there are possibilities for some savings on your gasoline consumption and a healthier lifestyle for you and others in your home. On a scale of 1 to 5 (where 1 means least preferred and 5 means most preferred) provide a score of your preference regarding having pedestrian and bicycle network assuming:

- *Your property taxes had to be 5% higher in order to support these pathway arrangements?*

  1 2 3 4 5

- *Your property tax had to be 10% higher in order to support these pathway arrangements?*
  1 2 3 4 5

- *BICYCLE*
  One of the greatest contributors to a healthy community is the potential of the community to reduce greenhouse gas emissions from automobile exhausts and stimulate physical exercise. Both of these can be achieved by the use of bicycle rather than automobiles for transportation. A sustainable designed community should emphasize this environmentally safe mode of transportation by providing a network of bicycle traffic system.



Illustrative Photomontage

❑ <u>Evaluation Questions</u>

In a community with well-designed pathway system for walking and biking, there are possibilities for some savings on your gasoline consumption and a healthier lifestyle for you and others in your home. On a scale of 1 to 5 (where 1 means least preferred and 5 means most preferred) provide a score of your preference regarding having pedestrian and bicycle network assuming:

- *Your property taxes had to be 5% higher in order to support these pathway arrangements?*
  1 2 3 4 5
- *Your property tax had to be 10% higher in order to support these pathway arrangements?*
  1 2 3 4 5
- *VEHICULAR*

Public transportation is a very important component of a sustainable community. It helps to reduce congestion and improve traffic flow, reduce air and land pollution, reduce infrastructure expenditures in terms of energy, construction and maintenance, and reduce our dependence on non-renewable resources. Public transportation, rather than private automobiles, should be encouraged through the development of efficient, frequent, safe and accessible public transportation services. Public transportation systems should help to guide or to determine the structure of a sustainable community.

Illustrative Photomontage

❑ <u>Evaluation Questions</u>

Below are three alternative street designs with a description of the qualities and costs involved in each.

Type 1: Typical 4-lane divided highway (2 traffic lanes with 2 parking lanes and 1 sidewalk). Road width is 9.50m (31 ft). Cost is $1150 per average home property;

Type 2: 3-lane highway (2 traffic lanes with 1 parking lane and 1 sidewalk). Road width is 6.60m (22 ft). Cost is $750 per average home property;

Type 3: 3-lane highway (2 traffic lanes with 1 parking lane and 2 sidewalks). Road width is 6.60m (22 ft). Cost is $1050 per average home property.

- *Which of these street designs would you most prefer?* *Type 1* *Type 2* *Type 3*
- *Which of these street designs would you least prefer?* *Type 1* *Type 2* *Type 3*
- *Would you be inclined to choose a "Calm Street" design for your home if the width of the road is narrower than conventional residential street designs, and it meant no additional costs to your initial purchase price?*
  Yes *No* *Other (state reason)* ______________________
- *Would you be inclined to choose a "Calm Street" design for your home if the width of the road is narrower than conventional residential street designs, and it meant an additional cost of between $500 - $800 to your initial purchase price?*
  Yes *No* *Other (state reason)* ______________________
- *Would you be inclined to choose a home with a smaller front yard, if the property purchase price is approximately $4000 less?*
  Yes *No* *Other (state reason)* ______________________
- *Would you be inclined to choose a home with a smaller front yard, if the equivalent area of land allocated to a front yard is incorporated into your backyard?*
  Yes *No* *Other (state reason)* ______________________

– You wish to make a choice between buying a house in a typical neighbourhood and one in a neighbourhood with reduced street width, "calmed" streets, and reduced front yard. The price of homes in neighbourhoods with these features would cost you between $3000 and $8000 less.

- *Would you be inclined to choose a home in this community?*
  Yes *No* *Other (state reason)* ______________________

- **Rights-of-Way/Street Width**

The size of the urban block and the system-wide approach to the planning and design of its street networks in relation to the intensity of land use typically determine the width of interconnecting roads. Conventional suburban community streets are too wide. The size of the right-of-way does not encourage the type of closeness that makes streets the arteries of community life.

- *ARTERIAL*

  Arterials are designed to channel traffic through conventional communities rather than funnel it in a web of interconnected layers of traffic networks. Most arterials have a right-of-way of between 40 feet and 60 feet. This is too wide for closeness at the human level, and for meaningful interaction within a community.

Illustrative Photomontage

❑ Evaluation Questions

- *Would you be inclined to choose a home in a community where 40 to 60 feet wide arterials run through the community?*
  Yes *No* *Other (state reason)* ______________________

- *Would you be inclined to choose a home in a community where there is no wide arterial running through the community?*
  Yes *No* *Other (state reason)* ______________________

- *COLLECTORS AND LOCAL STREETS*

Instead of arterials, the street hierarchy in a sustainable community should comprise of only collectors and local streets. Arterials in conventional communities are designed to channel traffic through conventional communities rather than funnel it in a web of interconnected layers of circulation networks. Most suburban collectors have a right-of-way of between 35 feet and 60 feet. This is too wide for meaningful interaction within a community. Reducing the right-of-way for local streets to between 19 feet and 22 feet in a community will save almost $400 in transportation-based tax to adjacent homeowners. It will also reduce asphalt-paved surfaces by 10%-25%.

Illustrative Photomontage

❑ Evaluation Questions

Cul-de-sacs (dead-ended street system – Type A) do not allow through traffic but may lead to congestion on the feeder streets. Grid system (open-ended street system – Type B) with short distances between intersections provides an easier and more evenly distributed traffic flow on each of the streets, as well as easier and more convenient pedestrian access to other locations in the community. Consider the characteristics of two types of street: open-ended and dead-ended.

- *Which street would you most likely favour for your home?*
- Consider the characteristics of cul-de-sac versus grid system. *Which street system would you most likely favour for your community?*

  Type A *Type B* *Other (state reason)* ______________________

- **Universal Access**

Universal access is intended to be inclusive rather than exclusive. The idea is that everyone should have access to everything all of the time including public spaces, buildings, products and services. Integrating universal access in all forms of transportation is a goal of sustainable community design.

- *THE STREET*

The speed of traffic a sustainable community should encourage ambulatory or handicap traffic.

Illustrative Photomontage

❑ Evaluation Question

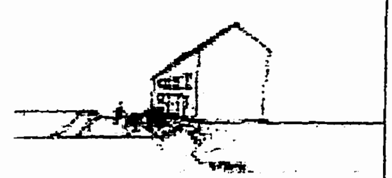
- *Would you be inclined to choose a home in a community where all the streets are accessible to everyone –handicapped or not?*

  Yes *No* *Other (state reason)* ______________________

- *PUBLIC AREAS*

  All buildings and public open spaces should be easily accessible to all members of the community. More specifically, attention should be directed to the planning and design of: external areas, parking and pedestrian ways, stairs, ramps, lifts, signage, emergency exit routes, interior spaces and furnishings. Disabilities vary including mobility and dexterity to hearing and seeing, among others. A commitment to "barrier free" design demonstrates an inclusive attitude, acknowledges interdependency of people within the community, and fosters the spirit and strength of an integrated community.

GRAPHIC ILLUSTRATION



Conventional

Sustainable

Photomontage

- <u>Evaluation Questions</u>
- *Would you like to live in a fully integrated community with access to public areas by all its residents, irrespective of their physical or mental capabilities?*

  Yes No Other (state reason) ____________________

- *Would you prefer a 'barrier-free' community with due design consideration for people with disability to one in which no such consideration is made in their design and implementation?*

  Yes No Other (state reason) ____________________

APPENDIX C

WEB-BASED QUESTIONNAIRE AND ANALYSIS OF RETRIEVED DATA

QuestNo	Question
2a	**Lot Configuration:** *Reducing front yards to 10 feet can save buyers up to $4,000 and make streets more intimate to building scale.* Would you regard this saving appropriate enough to consider living in a community with reduced front yard?
2a1	Would you trade a deep front yard for a more intimate dwelling-street relationship and a bigger private backyard?
2a2	**Residential Intensification:** *Residential second units are customarily located in the upper level of a garage, in the attic, or at the basement level. They have to be self-contained for bathroom and cooking facilities. By renting out a second unit, a family could purchase a home that would otherwise be unaffordable. The "second unit" could be used as a self-contained guest suite or for home offices for people working out of their homes.* Would you be willing to live in an area where Residential Second Units are allowed?
2a3	Would you wish to own a home in a community in where you could have a residential second home?
2a4	**Mix of Housing Types:** *Living in a community with a mix of detached dwelling units and attached units such as, apartments and townhouses will cost about 30% less than in a typical suburban development with single family dwelling only.* Would you consider living in a community with a mix of different types of housing units?
2a5	*Attached homes like townhouses, duplexes, and multi-family apartment units can co-exist with high-value single family residences without impacting on property values. The guiding principles are to ensure that it keeps within the architectural character of the neighbourhood, the height is limited to the general height of buildings in the neighbourhood, the street environment is appealing, and attractive open spaces are close to multi-unit housing projects.* Considering that an attached unit can cost 20%-35% less than a detached unit of comparable size and stature, would you be inclined to choose this type of building for your household?
2a6	**Mix of Household and People:** Would you be inclined to choose a home in a community made up of a diversity of households, families and people of differing age, income status, and cultural lifestyle if your home was located in an area of some 2 or 3 residential street blocks, if all of the homes are designed for people of similar household status and "market bracket" as yours?
2a7	Would you be inclined to choose a home in a community made up of a diversity of households, families and people of differing age, income status, and cultural lifestyle if your home was located in an area if the household status and "market bracket" of people are varied, but the street presentation of each home is similar in architectural character and appearance?
2a8	**Common Buildings/Rooms:** Would you prefer to live in a community with neighbourhood recycling centres as opposed to a community without recycling facilities?
2a9	Would you prefer to live in a community with a core of community-related activities centres such as, senior and youth facilities, daycare facilities, workshops and hobby centres?

2a10 **The Community Core:** *To support a community core with work, shopping, recreation and entertainment uses, integrated with residential suburban developments, the overall density of the community would have to be higher than it is in conventional community.* Would you favour a community with a Community Core?

2a11 *To support a community core with work, shopping, recreation and entertainment uses, integrated with residential suburban developments, the overall density of the community would have to be higher than it is in conventional community.* Assume your home is located within 15 minutes walking distance from the community core. On a scale on 1 to 5 (where 1 means least preferred and 5 means most preferred), indicate your preference in the two displayed scenarios.

2a12 *A community's main street serves as a social magnet for the community.* Would you like to live in a community with a centre of social and community activities such as, meeting halls, restaurants, and cinema/shopping facilities as opposed to a community with only residential units?

2a13 *Cultural icons promote a sense of association, and contribute to the intensity of use.* Would you like to live in a community that has culturally significant built icons?

2a14 *NEIGHBOURHOOD CENTRE: A neighbourhood centre would offer some retail and business services. It would comprise largely of 2 or 3 storey attached building forms.* Would you favour having such a development within a 5-minute walking distance from your home?

2a15 *CORE STREETSCAPES: Streetscapes that encourage pedestrian movement over vehicular movement tend to increase pedestrian-related activities.* Would you prefer to live in a community where the sidewalks are wider and the roads are narrower and safer for walking and cycling?

2a16 Streetscapes that encourage pedestrian movement over vehicular movement tend to increase pedestrian-related activities. Would you prefer to live in a community where the sidewalks are wider and the roads are narrower and safer for walking and cycling?

2a17 **Mixed Uses at the Core:** Would you like to have commercial and retail shops close to or integrated into residential homes in the community you live?

2a18 Would you prefer a community with schools, healthcare and daycare centres easily accessible from homes to a community without any of these amenities?

2b **Social and Recreational Space:** On a scale of 1 to 5, where 1 denotes least preferred and 5 denotes most preferred, how would you rate your preference for shared facilities such as, local gathering places, and community hall for both young and old in the community you live?

2b1 On a scale of 1 to 5, where 1 denotes least preferred and 5 denotes most preferred, how would you rate your preference for recreational facilities for both young and old in the community you live?

2a19 *LANDSCAPING: Consider that the initial cost of a home is about 1% higher but there are attractive maintenance savings of about 75% and 60-70% less labour time.* Would you favour a residential landscaping option with hardy drought-resistant plants species over conventional non-resistant species?

2a20 *Using permeable pavement surfaces for driveways and patios maintains subsoil water balance, makes the yard cooler in summer, and looks better than asphalt. It may add up* *to $300 in initial cost.* Would you be in favour of using this type of surfacing in the community you live?

2a21 **Recycle Centres:** Do you favour a more local opportunity and community-organized facilities like "neighbourhood collection points" and "eco-station" for recycling waste in the community you choose to live?

2a22 Would you be inclined to regularly recycle your household discards if a collecting point was located within 2 to 3 minutes walking distance from your home?

2a23 **Composting Centres:** *A home equipped for convenient recycling and composting does not cost more. It conserves resources and saves on garbage collection and landfill costs.* Would you be inclined to choose a home that was designed and equipped for easy sorting and composting given that such a home would cost about $300 more in initial cost than conventional building?

2a24 Suppose that the home you choose is equipped for convenient sorting and composting, would you recycle and compost more or less reusable wastes and discards?

2a25 **Greywater Reuse:** *Re-using water for toilet flushing or garden irrigation costs between $0 to $1200 more than conventional system, but conserves 50% or more of water piped into the home. The additional system cost would be recouped in 5 years through savings on your water bill.* Would you be inclined to choose the "water re-use" system over the conventional system?

2a26 If this system could be installed in a home with no additional cost, would you be inclined to choose it?

2a27 *"Living Machine" system can be reused for irrigating community farms, gardens, parks, street trees, and other open spaces.* Would you choose to purchase a home you liked if it is in a community where this system is installed?

2a28 Would you be inclined to support a pilot project in Winnipeg that experiments with this alternative sewage management system?

2a29 **Stormwater Recycle:** Would you be inclined to support a pilot project in Winnipeg that experiments with stormwater management system?

2a30 **Rainwater Recycle:** *Installing "rainwater recycling" system would save you $10.00 per month on your water utility bill during the month that you water your lawn. Consider that the system could mean an additional $300 in initial purchase price of your home. Afterwards you have net savings.* Would you be inclined to choose a home that has rainwater collection-storage system?

2b2 **Co-Generation:** *In Co-generation and District Heating system, the "exhaust" heat from generating the electricity is used to heat water. Hot water is distributed throughout a district network of underground-insulated pipes. This system uses 33% less fossil fuel than conventional methods of home heating.* On a scale of 1 to 5 (where 1 means least preferred, and 5 means most preferred) state your preference for having this system in the community you live.

2a31 Assume your monthly share of the cost of renewable energy sources pilot program in your community is $20 per month, would you agree to such an arrangement?

2a32 **District Heating:** *District heating is overall 35% less costly than conventional home-furnace-heating. It also provides better control of room to room heating.* Would you favour a District Heating System for your home?

2a33 **Community Farms:** Would the idea of lands set aside for Community Farm located in the community be a positive factor in deciding your home and community choice?

2a34 **District Gardens:** Would the idea of District Garden be a positive factor in deciding on your home and community choice?

2b3 **Pedestrian Network:** *In a community with well-designed pathway system for walking and biking, there are possibilities for some savings on your gasoline consumption and a healthier lifestyle for you and others in your home.* On a scale of 1 to 5 (where 1 means least preferred and 5 means most preferred) provide a score of your preference regarding having pedestrian and bicycle network, assuming that your property taxes had to be 5% higher in order to support these pathway arrangements?

2b4 On a scale of 1 to 5 (where 1 means least preferred and 5 means most preferred) provide a score of your preference regarding having pedestrian and bicycle network, assuming that your property taxes had to be 10% higher in order to support these pathway arrangements?

2b5 On a scale of 1 to 5 (where 1 means least preferred and 5 means most preferred) provide a score of your preference regarding having pedestrian and bicycle network, assuming that your property taxes had to be 5% higher in order to support these pathway arrangements?

2b6 On a scale of 1 to 5 (where 1 means least preferred and 5 means most preferred) provide a score of your preference regarding having pedestrian and bicycle network, assuming that your property tax had to be 10% higher in order to support these pathway arrangements?

2d **Vehicular Network:** *Below are three alternative street designs with a description of the qualities and costs involved in each. Type 1: Typical 4-lane divided highway (2 traffic lanes with 2 parking lanes and 1 sidewalk). Road width is 9.50m (31 ft). Cost is $1150 per average home property; Type 2: 3-lane highway (2 traffic lanes with 1 parking lane and 1 sidewalk). Road width is 6.60m (22 ft). Cost is $750 per average home property; Type 3: 3-lane highway (2 traffic lanes with 1 parking lane and 2 sidewalks). Road width is 6.60m (22 ft). Cost is $1050 per average home property.* Which of these street designs would you most prefer?

2d1 Which of these street designs would you least prefer for your community?

2a35 *You wish to make a choice between buying a house in a typical neighbourhood and one in a neighbourhood with reduced street width, "calmed" streets, and reduced front yard. The price of homes in neighbourhoods with these features would cost you between $3000 and $8000 less.* Would you be inclined to choose a "Calm Street" design for your home if the width of the road is narrower than conventional residential street designs, and it meant no additional costs to your initial purchase price?

2a36 Would you be inclined to choose a "Calm Street" design for your home if the width of the road is narrower than conventional residential street designs, and it meant an additional cost of between $500 - $800 to your initial purchase price?

2a37 Would you be inclined to choose a home with a smaller front yard, if the property purchase price is approximately $4000 less?

2a38 Would you be inclined to choose a home with a smaller front yard, if the equivalent area of land allocated to a front yard is incorporated into your backyard?

2a39 Would you be inclined to choose a home in this community?

2e **Street Design** - *Collectors Cul-de-sacs (dead-ended street system - Type A) do not allow through traffic but may lead to congestion on the feeder streets. Grid system (open-ended street system - Type B) with short distances between intersections provides an easier and more evenly distributed traffic flow on each of the streets, as well as easier and more convenient pedestrian access to other locations in the community.* Consider the characteristics of two types of street: open-ended and dead-ended. Which street type would you favour in your community?

2e1 *Consider the characteristics of cul-de-sac versus grid system.* Which street type would you most likely favour for your community?

2a40 **Local Streets:** *You wish to make a choice between buying a house in a typical neighbourhood and one in a neighbourhood with reduced street width, "calmed" streets, and reduced front yard. The price of homes in neighbourhoods with these features would cost you between $3000 and $8000 less.* Would you be inclined to choose a home in this community?

2a41 **Universal Access on Streets:** Would you be inclined to choose a home in a community where all the streets are accessible to everyone - handicapped or not?

2a42 **Universal Access to Public Buildings:** Would you like to live in a fully integrated community with access to public areas by all its residents, irrespective of their physical or mental capabilities?

2a43 Would you prefer a 'barrier-free' community with due design consideration for people with disability to one in which no such consideration is made in their design and implementation?

SUMMARY OF DATA OBTAINED FROM WEB-BASED SURVEY

File#	Yes	No	Total	%Yes	%No
2a	15	3	18	83.33%	16.67%
2a1	12	1	13	92.31%	7.69%
2a2	12	3	15	80.00%	20.00%
2a3	11		11	100.00%	0.00%
2a4	15	1	16	93.75%	6.25%
2a5	5	5	10	50.00%	50.00%
2a6	9	1	10	90.00%	10.00%
2a7	8	3	11	72.73%	27.27%
2a8	12	4	16	75.00%	25.00%
2a9	10		10	100.00%	0.00%
2a10	15	2	17	88.24%	11.76%
2a11	4	1	5	80.00%	20.00%
2a12	8	1	9	88.89%	11.11%
2a13	7	1	8	87.50%	12.50%
2a14	11		11	100.00%	0.00%

File#	Yes	No	Total	%Yes	%No
2a15	12	1	13	92.31%	7.69%
2a16	11		11	100.00%	0.00%
2a17	9	3	12	75.00%	25.00%
2a18	8	1	9	88.89%	11.11%
2b					
2b1					
2a19	9		9	100.00%	0.00%
2a20	11	2	13	84.62%	15.38%
2a21	9	1	10	90.00%	10.00%
2a22	6		6	100.00%	0.00%
2a23	8		8	100.00%	0.00%
2a24	8		8	100.00%	0.00%
2a25	6	3	9	66.67%	33.33%
2a26	3	7	10	30.00%	70.00%
2a27	8		8	100.00%	0.00%
2a28	8		8	100.00%	0.00%
2a29	12		12	100.00%	0.00%
2a30	11		11	100.00%	0.00%
2a31	9	1	10	90.00%	10.00%
2a32	11	1	12	91.67%	8.33%
2a33	6	5	11	54.55%	45.45%
2a34	8	5	13	61.54%	38.46%
2b3					
2b4					
2b5					
2b6					
2d					
2d1					
2a35	8	3	11	72.73%	27.27%
2a36	7	2	9	77.78%	22.22%
2a37	7	2	9	77.78%	22.22%
2a38	9		9	100.00%	0.00%
2a39	7	3	10	70.00%	30.00%
2e					
2e 1					
2a40	8	3	11	72.73%	27.27%
2a41	11		11	100.00%	0.00%
2a42	11		11	100.00%	0.00%
2a43	10	1	11	90.91%	9.09%

APPENDIX D: **GFORM SAMPLE FOR PERSONAL DATA FORM**

```
<!--This is where the gform codes begin-->
<!--gform "<pre>\n=========================================\n"-->
<!--gform "The date is: $(date) and the time is: $(time)\n"-->
<!--gform "Selected option is: $(copy)\n"-->
<!--gform "Selected option is: $(domicile)\n"-->
<!--gform "Selected option is: $(knowcity)\n"-->
<!--gform "Selected option is: $(location)\n"-->
<!--gform "Selected option is: $(duration)\n"-->
<!--gform "Selected option is: $(tenancytype)\n"-->
<!--gform "Selected option is: $(gender)\n"-->
<!--gform "Selected option is: $(read)\n"-->
<!--gform "Selected option is: $(age)\n"-->
<!--gform "Selected option is: $(occupation)\n"-->
<!--gform "Selected option is: $(compuse)\n"-->
<!--gform "Textfield1:\n"-->
<!--gform "$(textfield1)\n"-->
<!--gform "Selected option is: $(interspeed)\n"-->
<!--A comment: See my use of environment variables below-->
<!--gform "He/She is using: $(HTTP_USER_AGENT)\n"-->
<!--gform "and the host is: $(REMOTE_HOST)\n"-->
<!--gform "Home page address given as: $(addID)\n"-->
<!--gform "E-mail address given as: $(addID2)\n"-->
<!--gform "</pre>"-->
<!--gform deliver=file "/www/data/faculties/architecture/eco-
whyteridge/data1/databank1.htm"-->
<!--gform deliver=mail "umafolay@cc.umanitoba.ca" subject="Sustainable
Community Receptivity Survey - Pre-test Questionnaire"-->
<!--gform reply="/faculties/architecture/eco-whyteridge/messages/thanksla.htm"-
->
<p>
</form>
</body>
</html>
```

APPENDIX E: GENERAL ATTIDUDE SURVEY QUESTIONS

I. <u>General Attitude Study</u>

Below are *statements expressing our attitudes to the form of the community* in which we live. What we want is your response, even if you know little about particular urban issues. Please respond to each statement, using the following scale. Circle the response that, in your judgment, most satisfy your understanding of the issue being discussed.

Attitudes	Ratings
Strongly Disagree	1
Disagree	2
Not sure	3
Agree	4
Strongly Agree	5

1. Communities that are compactly built are more sustainable than communities in which the buildings are widely spaced out.
   1 2 3 4 5
2. The presence of open social spaces in a community contributes to the livability of the community.
   1 2 3 4 5
3. Communities with compactly built residences that are connected by common dividing walls tend to enhance community interaction than communities with single family houses on separate lots.
   1 2 3 4 5
4. Communities with more "green" areas (such as trees, lawns, shrubs etc.) tend to be more livable than communities with more paved areas and fewer green spaces.
   1 2 3 4 5
5. Where energy generation unit is centrally provided and shared, the overall energy consumption in the community is reduced.
   1 2 3 4 5
6. Communities with a mixture of housing types tend to be more sustainable than communities with fewer types housing units.
   1 2 3 4 5
7. Communities that have shopping, meeting, and work areas at a distance of less than ten minutes walk from residences tend to be more livable than communities that do not.
   1 2 3 4 5
8. Communities with different categories of residential units tend to attract more diverse types of tenants.
   1 2 3 4 5
9. A community that is designed to respect the ecology of the area in which it is sited tends to be more livable than a community that is not.
   1 2 3 4 5
10. Where public areas are universally accessible, the character and quality of the community is enhanced.
    1 2 3 4 5
11. The relationship between the height of buildings and the width of the street affects our understanding of the quality of a community street.
    1 2 3 4 5
12. A community that has the potential to expand and rearrange itself is more sustainable than a community that no room for growth and expansion.
    1 2 3 4 5
13. Universal access to public areas in a community encourages people of diverse physical ability to use such public areas.
    1 2 3 4 5

14. The streets in communities with safe sidewalks tend to be more intensely used by pedestrians than communities where there are no sidewalks

1 2 3 4 5

15. The more universally accessible a community is, the more intense is the use of its public areas

1 2 3 4 5

16. Where building interiors have direct access to sunlight, energy use is minimized.

1 2 3 4 5

17. A community where there is opportunity for recycling wastes tends to be more ecologically friendly.

1 2 3 4 5

18. The quality of material used for construction in a community determines the life and durability of its buildings and infrastructures.

1 2 3 4 5

19. People tend to have a better feeling of enclosure where public places are surrounded by continuous walls of buildings that are not penetrated by roads on every side.

1 2 3 4 5

20. A community with recycling depots and drop-off areas that are easily accessible to residents tends to recycle better.

1 2 3 4 5

21. A community that has opportunity to for reusing wastes tends to have reduced garbage per resident.

1 2 3 4 5

APPENDIX E1: RESULTS OBTAINED FROM SURVEY

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
1	1	2	24	8.33%			
	2	3	24	12.50%		20.83%	
	3	1	24	4.17%			4.17%
	4	9	24	37.50%			
	5	9	24	37.50%	75.00%		
2	1	0	24	0.00%			
	2	4	24	16.67%		16.67%	
	3	0	24	0.00%			0.00%
	4	7	24	29.17%			
	5	13	24	54.17%	83.33%		
3	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	1	24	4.17%			4.17%
	4	9	24	37.50%			
	5	13	24	54.17%	91.67%		
4	1	2	24	8.33%			
	2	2	24	8.33%		16.67%	
	3	0	24	0.00%			0.00%
	4	10	24	41.67%			
	5	10	24	41.67%	83.33%		
5	1	2	24	8.33%			
	2	4	24	16.67%		25.00%	
	3	6	24	25.00%			25.00%
	4	5	24	20.83%			
	5	7	24	29.17%	50.00%		
6	1	1	24	4.17%			
	2	1	24	4.17%		8.33%	
	3	6	24	25.00%			25.00%
	4	10	24	41.67%			
	5	6	24	25.00%	66.67%		
7	1	1	24	4.17%			
	2	0	24	0.00%		4.17%	
	3	1	24	4.17%			4.17%
	4	6	24	25.00%			
	5	16	24	66.67%	91.67%		
8	1	0	24	0.00%			
	2	2	24	8.33%		8.33%	
	3	0	24	0.00%			0.00%
	4	6	24	25.00%			
	5	16	24	66.67%	91.67%		

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
9	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	2	24	8.33%			8.33%
	4	10	24	41.67%			
	5	11	24	45.83%	87.50%		
10	1	0	24	0.00%			
	2	2	24	8.33%		8.33%	
	3	1	24	4.17%			4.17%
	4	4	24	16.67%			
	5	17	24	70.83%	87.50%		
11	1	0	24	0.00%			
	2	3	24	12.50%		12.50%	
	3	6	24	25.00%			25.00%
	4	9	24	37.50%			
	5	6	24	25.00%	62.50%		
12	1	0	24	0.00%			
	2	4	24	16.67%		16.67%	
	3	1	24	4.17%			4.17%
	4	8	24	33.33%			
	5	11	24	45.83%	79.17%		
13	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	2	24	8.33%			8.33%
	4	6	24	25.00%			
	5	15	24	62.50%	87.50%		
14	1	0	24	0.00%			
	2	3	24	12.50%		12.50%	
	3	1	24	4.17%			4.17%
	4	4	24	16.67%			
	5	16	24	66.67%	83.33%		
15	1	0	24	0.00%			
	2	2	24	8.33%		8.33%	
	3	2	24	8.33%			8.33%
	4	3	24	12.50%			
	5	17	24	70.83%	83.33%		
16	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	0	24	0.00%			0.00%
	4	6	24	25.00%			
	5	17	24	70.83%	95.83%		

QstN	Ratg	RatgSum	TotSamp	%ofTotal	%Agree	%Disagree	%Neutral
17	1	1	24	4.17%			
	2	0	24	0.00%		4.17%	
	3	0	24	0.00%			0.00%
	4	7	24	29.17%			
	5	16	24	66.67%	95.83%		
18	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	0	24	0.00%			0.00%
	4	4	24	16.67%			
	5	19	24	79.17%	95.83%		
19	1	0	24	0.00%			
	2	2	24	8.33%		8.33%	
	3	6	24	25.00%			25.00%
	4	10	24	41.67%			
	5	6	24	25.00%	66.67%		
20	1	0	24	0.00%			
	2	1	24	4.17%		4.17%	
	3	0	24	0.00%			0.00%
	4	9	24	37.50%			
	5	14	24	58.33%	95.83%		
21	1	1	24	4.17%			
	2	2	24	8.33%		12.50%	
	3	3	24	12.50%			12.50%
	4	9	24	37.50%			
	5	9	24	37.50%	75.00%		

LEGEND OF TABLE TITLE

QstN denotes Question Number in the survey questionnaire
Ratg denotes the rating scale (1-5)
RatgSum denotes the summary of participants' rating of the question
TotSamp denotes Total survey sample
%Total denotes the percentage of total sample that falls within each rating category
%Agree denotes the percentage of sample that agrees with the hypothetical statement
%Disagree denotes the percentage of sample that agrees with the hypothetical statement
%Neutral denotes the percentage of sample that is not sure whether they agree or disagree with the hypothetical statement

II. General Sustainable Community Design Receptivity Evaluation

A. COMMUNITY DESIGN

Land Use and Housing

By investing 5% more in the home construction OR by selecting a home that is 5% smaller in size, lower heating costs and conservation of earth's resources results. You are given an opportunity to choose between,

- Type A -- a home with conventional building envelope,
- Type B -- a home with energy-efficient features of the same size, and
- Type C -- a home with energy-efficient feature that is about 5% smaller than the conventional home.

1. *Which of the building envelope and level of energy efficiency would you be most inclined to choose?*

   Type A   Type B   Type C

Housing Diversity:

2. Compact community helps to achieve more effective use of natural resources and ecological conservation. It helps to achieve a more cost-effective and convenient public transportation service for residents. It also helps to achieve really effective choice and affordability because of the range of home prices, home types, and property situations.
3. *From the 2 alternative community-form strategies displayed, score your preference on a scale of 1 to 5 (where 1 means least preferred and 5 means most preferred) in regard to:*

- Alternative A: Diversity of housing types

  1   2   3   4   5

- Alternative B: Community Compactness

  1   2   3   4   5

4. *In a short phrase or two state your reason for responding as you did in Question 18*

- Low preference for both alternatives: ____________________
- Preference for A over B: ____________________
- Preference for B over A: ____________________

Second Units

Residential second units are customarily located in the upper level of a garage, in the attic, or at the basement level. They have to be self-contained for bathroom and cooking facilities. By renting out a second unit, a family could purchase a home that would otherwise be unaffordable. The "second unit" could be used as a self-contained guest suite or for home offices for people working out of their homes.

5. *Would you be willing to live in an area where Residential Second Units are allowed?*

   Yes   No   Other (state reason) ____________________

6. *Would you wish to own a home in which you could have a residential second home?*

   Yes   No   Other (state reason) ____________________

Attached Homes

Attached homes like townhouses, duplexes, and multi-family apartment units can co-exist with high-value single family residences without impacting on property values. The guiding principles are to ensure that it keeps within the architectural character of the neighbourhood, the height is limited to the general height of buildings in the neighbourhood, the street environment is appealing, and attractive open spaces are close to multi-unit housing projects.

7. Considering that an attached unit can cost 20%-35% less than a detached unit of comparable size and stature, *which housing option would you most likely choose for your household?*

   Yes   No   Other (state reason) ____________________

Employment Opportunities within the Community

8. Assume you are looking for a home. *Would you be inclined to choose a community in which selected areas provide for substantial number of places and types of employment and business enterprises?*

   Yes   No   Other (state reason) ____________________

Diversity of Household, Housing and People in the Community

9. Would you be inclined to choose a home in a community made up of a diversity of households, families and people of differing age, income status, and cultural lifestyle if:

10. *Your home was located in an area of some 2 or 3 residential street blocks where all of the homes are designed for people of similar household status and "market bracket" as yours?*
Yes *No* *Other (state reason)* ________________

11. *Your home was located in an area where the household status and "market bracket" of people are varied but the street presentation of each home is similar in architectural character and appearance?*
Yes *No* *Other (state reason)* ________________

The Core

Neighbourhood Centre

12. A neighbourhood centre would offer some retail and business services. It would comprise largely of 2 or 3 storey attached building forms. *Would you favour having such a development within 5-minutes walking distances from your home?*
Yes *No* *Other (state reason)* ________________

Community Core

To support a community core with work, shopping, recreation and entertainment uses, integrated with residential suburban developments, the overall density of the community would have to be similar to the one in the alternative proposal shown – it has to be compact.

13. *Would you favour a community with a Community Core?*
Yes *No* *Other (state reason)* ________________

14. *Assume your home is located within 15 minutes walking distance from the community core. On a scale on 1 to 5 (where 1 means least preferred and 5 means most preferred), indicate your preference in the two displayed scenarios.*
1 2 3 4 5

In-between Spaces

Community Gardens and Community Farm enterprise

15. *Would the idea of lands set aside for Community Garden located in the community be a positive factor in deciding your home and community choice?*
Yes No Other (state reason) ________________

16. *Would the idea of "Community Tree Nurseries" be a positive factor in deciding on your home and community choice?*
Yes *No* *Other (state reason)* ________________

Landscaping

17. Consider that the initial cost of a home is about 1% higher but there are attractive maintenance savings of about 75% and 60-70% less labour time. *Would you favour a residential landscaping option with hardy drought-resistant plants species over conventional non-resistant species?*
Yes *No* *Other (state reason)* ________________

18. Using permeable pavement surfaces for driveways and patios maintains subsoil water balance, makes the yard cooler in summer, and looks better than asphalt. It may add up to $300 in initial cost. *Would you be in favour of using this type of surfacing?*
Yes *No* *Other (state reason)* ________________

B. ECOLOGIC DESIGN

Waste Management

Recycling in the Community

19. *Do you favour a more local opportunity and community-organized facilities like "neighbourhood collection points" and "eco-station" for recycling waste in the community you choose to live?*
Yes *No* *Other (state reason)* ________________

20. *Would you be inclined to regularly recycle your household discards if a collecting point was located within 2 to 3 minutes walking distance from your home?*
Yes *No* *Other (state reason)* ________________

21. A home equipped for convenient recycling and composting does not cost more. It conserves resources and saves on garbage collection and landfill costs.

Would you be inclined to choose a home that was designed and equipped for easy sorting and composting given that such a home would cost about $300 more in initial cost than conventional building?

Yes *No* *Other (state reason)* ______

22. Suppose that the home you choose is equipped for convenient sorting and composting, *would you recycle and compost more or less reusable wastes and discards?*
    Yes *No* *Other (state reason)* ______

Water and Wastewater Management

23. Low volume lavatories, showerheads and toilets, and high efficiency water heating results in lower monthly utility bill with negligible extra cost. *Would you be inclined to choose a home with water-conserving fixtures and equipment given that they would cost no more than conventional alternatives?*
    Yes *No* *Other (state reason)* ______
24. Re-using water for toilet flushing or garden irrigation costs between $0 to $1200 more than conventional system, but conserves 50% or more of water piped into the home. The additional system cost would be recouped in 5 years through savings on your water bill. *Would you be inclined to choose the "water re-use" system over the conventional system?*
    Yes *No* *Other (state reason)* ______
25. *If this system could be installed in a home with no additional cost, would you be inclined to choose it?*
    Yes *No* *Other (state reason)* ______
26. Installing "rainwater recycling" system would save you $10.00 per month on your water utility bill during the month that you water your lawn. Consider that the system could mean an additional $300 in initial purchase price of your home. Afterwards you have net savings. *Would you be inclined to choose a home that has rainwater collection-storage system?*
    Yes *No* *Other (state reason)* ______
27. "Living Machine" system can be reused for irrigating community farms, gardens, parks, street trees, and other open spaces.

- *Would you choose to purchase a home you liked if it is in a community where this system is installed?*
  Yes *No* *Other (state reason)* ______
- *Would you be inclined to support a pilot project in Winnipeg that experiments with this alternative sewage management system?*
  Yes No Other (state reason) ______

Energy

Home Heating and Co-Generation

28. In Co-generation and District Heating system, the "exhaust" heat from generating the electricity is used to heat water. Hot water is distributed throughout a district network of underground-insulated pipes. This system uses 33% less fossil fuel than conventional methods of home heating. *How likely would you be to choose a neighbourhood with this feature over another with conventional heat generating system?*
    Likely *Not likely* *Other (state reason)* ______
29. District heating is overall 35% less costly than conventional home-furnace-heating. It also provides better control of room to room heating.
    Would you favour a District Heating System for your home?
    Yes *No* *Other (state reason)* ______

Alternative Energy System implementation

30. *Assume your monthly share of the cost of renewable energy sources pilot program in your community is $20 per month, would you agree to such an arrangement?*
    Yes *No* *Other (state reason)* ______
31. *Would you see it as attractive and advantageous to your lifestyle to have all the feature listed above "packaged" together in the community that you live in?*
    Yes *No* *Other (state reason)* ______

C. STREET DESIGN

Traffic Network

Vehicular

Below are three alternative street designs with a description of the qualities and costs involved in each.

Type 1: Typical 4-lane divided highway (2 traffic lanes with 2 parking lanes and 1 sidewalk). Road width is 9.50m (31 ft). Cost is $1150 per average home property;

Type 2: 3-lane highway (2 traffic lanes with 1 parking lane and 1 sidewalk). Road width is 6.60m (22 ft). Cost is $750 per average home property;

Type 3: 3-lane highway (2 traffic lanes with 1 parking lane and 2 sidewalks). Road width is 6.60m (22 ft). Cost is $1050 per average home property.

32. *Which of these street designs would you most prefer?* *Type 1* *Type 2* *Type 3*
33. *Which of these street designs would you least prefer?* *Type 1* *Type 2* *Type 3*
34. *Would you be inclined to choose a "Calm Street" design for your home if the width of the road is narrower than conventional residential street designs, and it meant no additional costs to your initial purchase price?*
    Yes *No* *Other (state reason)* ____________
35. *Would you be inclined to choose a "Calm Street" design for your home if the width of the road is narrower than conventional residential street designs, and it meant an additional cost of between $500 - $800 to your initial purchase price?*
    Yes *No* *Other (state reason)* ____________
36. *Would you be inclined to choose a home with a smaller front yard, if the property purchase price is approximately $4000 less?*
    Yes *No* *Other (state reason)* ____________
37. *Would you be inclined to choose a home with a smaller front yard, if the equivalent area of land allocated to a front yard is incorporated into your backyard?*
    Yes *No* *Other (state reason)* ____________

38. You wish to make a choice between buying a house in a typical neighbourhood and one in a neighbourhood with reduced street width, "calmed" streets, and reduced front yard. The price of homes in neighbourhoods with these features would cost you between $3000 and $8000 less.

- *Would you be inclined to choose a home in this community?*
  Yes *No* *Other (state reason)* ____________

Street System

Cul-de-sacs (dead-ended street system – Type A) do not allow through traffic but may lead to congestion on the feeder streets. Grid system (open-ended street system – Type B) with short distances between intersections provides an easier and more evenly distributed traffic flow on each of the streets, as well as easier and more convenient pedestrian access to other locations in the community. Consider the characteristics of two types of street: open-ended and dead-ended.

39. *Which street would you most likely favour for your home?*
    Type A *Type B* *Other (state reason)* ____________
40. Consider the characteristics of cul-de-sac versus grid system. *Which street system would you most likely favour for your community?*
    Type A *Type B* *Other (state reason)* ____________

Pedestrian and Bicycle Pathway

In a community with well-designed pathway system for walking and biking, there are possibilities for some savings on your gasoline consumption and a healthier lifestyle for you and others in your home. On a scale of 1 to 5 (where 1 means least preferred and 5 means most preferred) provide a score of your preference regarding having pedestrian and bicycle network assuming:

41. *Your property taxes had to be 5% higher in order to support these pathway arrangements?*
    1 2 3 4 5
42. *Your property tax had to be 10% higher in order to support these pathway arrangements?*
    1 2 3 4 5

Compact Community Form and Transportation

In order to have better service-frequency and shorter trip times, bus stops within 5-minutes walking distance from home, and conveniences by bus stops, one would have to live in a more compact community.

43. *In the light of this reason, would you favour a more compact arrangement for your community?*

Yes *No* *Other (state reason)* ____________________

44. *Considering the features one-at-a-time, tick off ALL the features you would wish to see incorporated into your community.*

Energy-efficient units	______
Co-generation-District-Heating	______
Rainwater Recycling	______
Recycling	______
Composting	______
Compact Community	______
Reduced street width	______
Second Units	______
Attached Homes	______
Open-ended Streets System	______
Dead-ended Streets System	______
Pedestrian and Bicycle Pathway	______
Neighbourhood Centre/ Community Core	______
Employment Opportunities	______
Diverse Household	______
Diverse Housing	______
Diverse People	______
Community Gardens	______

APPENDIX F1: TABULATED RESULT OF GENERAL RECEPTIVITY SURVEY QUESTIONNAIRE

QstN	Ratg	StatRatg	RatgSum	TotSamp	%ofTotal	%Yes	%No	%Other
1	Type A		0	23	0.00%			
	Type B		22	23	95.65%			
	Type C		1	23	4.35%			
2	1		3	23	13.04%			
	2		6	23	26.09%		39.13%	
	3		4	23	17.39%			17.39%
	4		4	23	17.39%			
	5		6	23	26.09%	43.48%		
3	1		3	23	13.04%			
	2		3	23	13.04%		26.09%	
	3		4	23	17.39%			17.39%
	4		4	23	17.39%			
	5		7	23	30.43%	47.83%		
4	Yes		19	23	82.61%	82.61%		
	No		4	23	17.39%		17.39%	
	Other		0	23	0.00%			0.00%
5	Yes		19	23	82.61%	82.61%		
	No		4	23	17.39%		17.39%	
	Other		0	23	0.00%			0.00%
6	Attached		9	23	39.13%	39.31%		
	Detached		13	23	56.52%		56.52%	
	Other		1	23	4.35%			4.35%
7	Yes		16	23	69.57%	69.57%		
	No		6	23	26.09%		26.09%	
	Other		1	23	4.35%			4.35%
8	Yes		12	23	52.17%	52.17%		
	No		8	23	34.78%		34.78%	
	Other		1	23	4.35%			4.35%
9	Yes		16	23	69.57%	69.57%		
	No		6	23	26.09%		26.09%	
	Other		1	23	4.35%			4.35%
10	Yes		15	23	65.22%	65.22%		
	No		4	23	17.39%		17.39%	
	Other		1	23	4.35%			4.35%
11	Yes		22	23	95.65%	95.65%		
	No		0	23	0.00%		0.00%	
	Other		1	23	4.35%			4.35%
12	Yes		11	23	47.83%	47.83%		
	No		10	23	43.48%		43.48%	
	Other		1	23	4.35%			4.35%
13	Yes		9	23	39.13%	39.13%		
	No		14	23	60.87%		60.87%	
	Other		0	23	0.00%			0.00%

QstN	Ratg	StatRatg	RatgSum	TotSamp	%ofTotal	%Yes	%No	%Other
14	Yes		18	23	78.26%	78.26%		
	No		5	23	21.74%		21.74%	
	Other		0	23	0.00%			0.00%
15	Yes		20	23	86.96%	86.96%		
	No		3	23	13.04%		13.04%	
	Other		0	23	0.00%			0.00%
16	Yes		21	23	91.30%	91.30%		
	No		2	23	8.70%		8.70%	
	Other		0	23	0.00%			0.00%
17	Yes		21	23	91.30%	91.30%		
	No		2	23	8.70%		8.70%	
	Other		0	23	0.00%			0.00%
18	Yes		20	23	86.96%	86.96%		
	No		2	23	8.70%		8.70%	
	Other		0	23	0.00%			0.00%
19	Yes		21	23	91.30%	91.30%		
	No		1	23	4.35%		4.35%	
	Other		0	23	0.00%			0.00%
20	Yes		23	23	100.00%	100.00%		
	No		0	23	0.00%		0.00%	
	Other		0	23	0.00%			0.00%
21	Yes		17	23	73.91%	73.91%		
	No		6	23	26.09%		26.09%	
	Other		0	23	0.00%			0.00%
22	Yes		18	23	78.26%	78.26%		
	No		5	23	21.74%		21.74%	
	Other		0	23	0.00%			0.00%
23	Yes		21	23	91.30%	91.30%		
	No		2	23	8.70%		8.70%	
	Other		0	23	0.00%			
24	Yes		20	23	86.96%	86.96%		
	No		3	23	13.04%		13.04%	
	Other		0	23	0.00%			0.00%
25	Yes		19	23	82.61%	82.61%		
	No		3	23	13.04%		13.04%	
	Other		1	23	4.35%			4.35%
26	Likely		19	23	82.61%	82.61%		
	Not Likely		2	23	8.70%		8.70%	
	Other		2	23	8.70%			8.70%

QstN	Ratg	StatRatg	RatgSum	TotSamp	%ofTotal	%Yes	%No	%Other
27	Yes		19	23	82.61%	82.61%		
	No		2	23	8.70%		8.70%	
	Other		2	23	8.70%			8.70%
28	Yes		12	23	52.17%	52.17%		
	No		8	23	34.78%		34.78%	
	Other		1	23	4.35%			4.35%
29	Yes		21	23	91.30%	91.30%		
	No		1	23	4.35%		4.35%	
	Other		0	23	0.00%			0.00%
30	Type1		3	23	13.04%			
	Type2		9	23	39.13%			
	Type3		9	23	39.13%			
31	Type1		13	23	56.52%			
	Type2		4	23	17.39%			
	Type3		4	23	17.39%			
32	Yes		18	23	78.26%	78.26%		
	No		4	23	17.39%		17.39%	
	Other		1	23	4.35%			4.35%
33	Yes		10	23	43.48%	43.48%		
	No		12	23	52.17%		52.17%	
	Other		0	23	0.00%			0.00%
34	Yes		14	23	60.87%	60.87%		
	No		8	23	34.78%		34.78%	
	Other		0	23	0.00%			0.00%
35	Yes		17	23	73.91%	73.91%		
	No		4	23	17.39%		17.39%	
	Other		1	23	4.35%			4.35%
36	Yes		14	23	60.87%	60.87%		
	No		8	23	34.78%		34.78%	
	Other		0	23	0.00%			0.00%
37	TypeA		9	23	39.13%			
	TypeB		13	23	56.52%			
	Other		0	23	0.00%			
38	TypeA		7	23	30.43%			
	TypeB		13	23	56.52%			
	Other		2	23	8.70%			

QstN	Ratg	StatRatg	RatgSum	TotSamp	%ofTotal	%Yes	%No	%Other
39	1		3	23	13.04%			
	2		1	23	4.35%		17.39%	
	3		5	23	21.74%			21.74%
	4		8	23	34.78%			
	5		5	23	21.74%	56.52%		
40	1		6	23	26.09%			
	2		3	23	13.04%		39.13%	
	3		6	23	26.09%			26.09%
	4		5	23	21.74%			
	5		2	23	8.70%	30.43%		
41	Yes		18	23	78.26%	78.26%		
	No		4	23	17.39%		17.39%	
	Other		0	23	0.00%			0.00%
42	EnEffUnits	1	21	21	100.00%			
	CoGenDHtg	2	13	21	61.90%			
	RainRecyc	3	19	21	90.48%			
	RecycLg	4	18	21	85.71%			
	Compost	5	12	21	57.14%			
	CompComm	6	14	21	66.67%			
	RedStrtWidth	7	13	21	61.90%			
	SecUnits	8	18	21	85.71%			
	AttHomes	9	13	21	61.90%			
	OpEndStrt	10	15	21	71.43%			
	DeadEndStrt	11	11	21	52.38%			
	PedBikWay	12	20	21	95.24%			
	CommCore	13	21	21	100.00%			
	EmpOpport	14	15	21	71.43%			
	DiversHhold	15	16	21	76.19%			
	DiversHsg	16	15	21	71.43%			
	DiversPeop	17	16	21	76.19%			
	CommGardn	18	16	21	76.19%			

LEGEND OF TABLE TITLE
QstN denotes Question Number in the survey questionnaire
StatRatg denotes the statistical rating attached to the feature (a-priori)
Ratg denotes the rating scale (Mixed)
RatgSum denotes the summary of participants' rating of the question
TotSamp denotes Total survey sample
%ofTotal denotes the percentage of total sample that falls within each rating category
%Yes denotes the percentage of sample that agrees with the hypothetical statement
%No denotes the percentage of sample that agrees with the hypothetical statement
%Other denotes the percentage of sample that is not sure whether they agree or disagree with the hypothetical statement

APPENDIX G: EVALUATION OF THE EFFECTIVENESS OF REPRESENTATION TECHNIQUES

Provide an assessment of the degree of your agreement with the clarity of then following representation techniques to communicate the required design intent. Please try to compare and score the pairs of design scenarios as accurately as possible. Base your scores on a scale of 1 to 5, as explained below:

---

1 – strongly disagree that the first scenario communicates design intent better than the second
2 - disagree that the first scenario communicates design intent better than the second
3 – not sure if the first scenario communicates design intent better than in the second
3 - agree that the first scenario communicates design intent better than in the second
5 - strongly agree that the first scenario communicates design intent better than in the second

---

A. Assessment of 2D/3D Design Representation Techniques

1. **Condensed Lots**
First Scenario vs. Second Scenario
1 2 3 4 5
2. **Residential Intensification**
First Scenario vs. Second Scenario
1 2 3 4 5
3. **Residential Mix**
First Scenario vs. Second Scenario
1 2 3 4 5
4. **Community Core**
First Scenario vs. Second Scenario
1 2 3 4 5
5. **Common Buildings**
First Scenario vs. Second Scenario
1 2 3 4 5
6. **Mixed Use at the Core**
First Scenario vs. Second Scenario
1 2 3 4 5
7. **Social and Recreational Space**
First Scenario vs. Second Scenario
1 2 3 4 5
8. **Universal Accessibility**
First Scenario vs. Second Scenario
1 2 3 4 5

B. Assessment of 2D/Animation or QTVR Design Representation Techniques

1. **Condensed Lots**
First Scenario vs. Second Scenario
1 2 3 4 5
2. **Residential Intensification**
First Scenario vs. Second Scenario
1 2 3 4 5
3. **Residential Mix**
First Scenario vs. Second Scenario
1 2 3 4 5
4. **Community Core**
First Scenario vs. Second Scenario
1 2 3 4 5

5. **Common Buildings**
First Scenario vs. Second Scenario
1 2 3 4 5

6. **Mixed Use at the Core**
First Scenario vs. Second Scenario
1 2 3 4 5

7. **Social and Recreational Space**
First Scenario vs. Second Scenario
1 2 3 4 5

8. **Universal Accessibility**
First Scenario vs. Second Scenario
1 2 3 4 5

C. <u>Assessment of 3D/Animation or QTVR Design Representation Techniques</u>

1. **Condensed Lots**
First Scenario vs. Second Scenario
1 2 3 4 5

2. **Residential Intensification**
First Scenario vs. Second Scenario
1 2 3 4 5

3. **Residential Mix**
First Scenario vs. Second Scenario
1 2 3 4 5

4. **Community Core**
First Scenario vs. Second Scenario
1 2 3 4 5

5. **Common Buildings**
First Scenario vs. Second Scenario
1 2 3 4 5

6. **Mixed Use at the Core**
First Scenario vs. Second Scenario
1 2 3 4 5

7. **Social and Recreational Space**
First Scenario vs. Second Scenario
1 2 3 4 5

8. **Universal Accessibility**
First Scenario vs. Second Scenario
1 2 3 4 5

APPENDIX G1: SUMMARY OF RESULTS

Section A - 2D vs. 3D **SUMMARY OF RATINGS**

QstN	*Ratg*	*RatgSum*	*TotSamp*	*%ofTotal*	1	2	3	4	5
1	1	13	21	61.90%	61.90%				
	2	4	21	19.05%		19.05%			
	3	1	21	4.76%			4.76%		
	4	0	21	0.00%				0.00%	
	5	3	21	14.29%					14.29%
2	1	12	21	57.14%	57.14%				
	2	4	21	19.05%		19.05%			
	3	2	21	9.52%			9.52%		
	4	1	21	4.76%				4.76%	
	5	2	21	9.52%					9.52%
3	1	7	21	33.33%	33.33%				
	2	5	21	23.81%		23.81%			
	3	1	21	4.76%			4.76%		
	4	3	21	14.29%				14.29%	
	5	6	21	28.57%					28.57%
4	1	12	21	57.14%	57.14%				
	2	1	21	4.76%		4.76%			
	3	0	21	0.00%			0.00%		
	4	3	21	14.29%				14.29%	
	5	3	21	14.29%					14.29%
5	1	11	21	52.38%	52.38%				
	2	5	21	23.81%		23.81%			
	3	0	21	0.00%			0.00%		
	4	2	21	9.52%				9.52%	
	5	2	21	9.52%					9.52%
6	1	7	21	33.33%	33.33%				
	2	3	21	14.29%		14.29%			
	3	2	21	9.52%			9.52%		
	4	5	21	23.81%				23.81%	
	5	4	21	19.05%					19.05%
7	1	9	21	42.86%	42.86%				
	2	3	21	14.29%		14.29%			
	3	0	21	0.00%			0.00%		
	4	2	21	9.52%				9.52%	
	5	5	21	23.81%					23.81%
8	1	13	21	61.90%	61.90%				
	2	3	21	14.29%		14.29%			
	3	2	21	9.52%			9.52%		
	4	1	21	4.76%				4.76%	
	5	0	21	0.00%					0.00%

Section B - 2D vs. Animation/QTVR SUMMARY OF RATINGS

QstN	*Ratg*	*RatgSum*	*TotSamp*	*%ofTotal*	1	2	3	4	5
1	*1*	19	21	90.48%	90.48%				
	2	2	21	9.52%		9.52%			
	3	0	21	0.00%			0.00%		
	4	0	21	0.00%				0.00%	
	5	1	21	4.76%					4.76%
2	1	18	21	85.71%	85.71%				
	2	2	21	9.52%		9.52%			
	3	0	21	0.00%			0.00%		
	4	1	21	4.76%				4.76%	
	5	0	21	0.00%					0.00%
3	1	13	21	61.90%	61.90%				
	2	6	21	28.57%		28.57%			
	3	0	21	0.00%			0.00%		
	4	1	21	4.76%				4.76%	
	5	1	21	4.76%					4.76%
4	1	15	21	71.43%	71.43%				
	2	4	21	19.05%		19.05%			
	3	0	21	0.00%			0.00%		
	4	0	21	0.00%				0.00%	
	5	2	21	9.52%					9.52%
5	1	15	21	71.43%	71.43%				
	2	4	21	19.05%		19.05%			
	3	1	21	4.76%			4.76%		
	4	1	21	4.76%				4.76%	
	5	0	21	0.00%					0.00%
6	1	14	21	66.67%	66.67%				
	2	4	21	19.05%		19.05%			
	3	0	21	0.00%			0.00%		
	4	2	21	9.52%				9.52%	
	5	1	21	4.76%					4.76%
7	1	8	21	38.10%	38.10%				
	2	6	21	28.57%		28.57%			
	3	1	21	4.76%			4.76%		
	4	1	21	4.76%				4.76%	
	5	5	21	23.81%					23.81%
8	1	8	21	38.10%	38.10%				
	2	3	21	14.29%		14.29%			
	3	4	21	19.05%			19.05%		
	4	2	21	9.52%				9.52%	
	5	3	21	14.29%					14.29%

Section C -3D vs. Animation/QTVR **SUMMARY OF RATINGS**

QstN	Ratg	RatgSum	TotSamp	%ofTotal					
1	1	13	21	61.90%	61.90%				
	2	4	21	19.05%		19.05%			
	3	1	21	4.76%			4.76%		
	4	2	21	9.52%				9.52%	
	5	1	21	4.76%					4.76%
2	1	11	21	52.38%	52.38%				
	2	3	21	14.29%		14.29%			
	3	2	21	9.52%			9.52%		
	4	3	21	14.29%				14.29%	
	5	2	21	9.52%					9.52%
3	1	13	21	61.90%	61.90%				
	2	3	21	14.29%		14.29%			
	3	2	21	9.52%			9.52%		
	4	2	21	9.52%				9.52%	
	5	2	21	9.52%					9.52%
4	1	10	21	47.62%	47.62%				
	2	5	21	23.81%		23.81%			
	3	1	21	4.76%			4.76%		
	4	3	21	14.29%				14.29%	
	5	2	21	9.52%					9.52%
5	1	9	21	42.86%	42.86%				
	2	3	21	14.29%		14.29%			
	3	2	21	9.52%			9.52%		
	4	5	21	23.81%				23.81%	
	5	1	21	4.76%					4.76%
6	1	9	21	42.86%	42.86%				
	2	3	21	14.29%		14.29%			
	3	2	21	9.52%			9.52%		
	4	3	21	14.29%				14.29%	
	5	3	21	14.29%					14.29%
7	1	10	21	47.62%	47.62%				
	2	5	21	23.81%		23.81%			
	3	3	21	14.29%			14.29%		
	4	1	21	4.76%				4.76%	
	5	1	21	4.76%					4.76%
8	1	4	21	19.05%	19.05%				
	2	2	21	9.52%		9.52%			
	3	5	21	23.81%			23.81%		
	4	3	21	14.29%				14.29%	
	5	6	21	28.57%					28.57%

APPENDIX H: FGDM ANALYSIS OF RESULTS FROM SURVEY

SUBJECT#1 **3x3 MATRICES OF REPRESENTATION TECHNIQUES**

D1=*2D DRAWINGS - PLAN/ELEVATION*

D2=*3D DESIGN - AXONOMETRICS/PERSPECTIVES*

D3=*DYNAMIC REPRESENTATION - ANIMATION/QTVR*

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.11	1.00	0.04
			MIN(P(Di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

COMMUNTY CORE

	D1	D2	D3
D1	1.00	3.00	0.20
D2	0.33	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.11	1.00	0.11
D2	1.00	1.00	1.00	1.00
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

MIXED USES

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	1.00	0.20
D2	1.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	1.00	1.00	1.00	1.00
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

SUBJECT#2

CONDENSED LOT

	D1	D2	D3	
D1	1.00	1.00	0.20	
D2	1.00	1.00	0.20	
D3	5.00	5.00	1.00	
	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	1.00	
D3	5.00	1.00	1.00	
	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3	
D1	1.00	5.00	0.33	
D2	0.20	1.00	0.20	
D3	3.00	5.00	1.00	
	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.11	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNTY CORE

	D1	D2	D3	
D1	1.00	5.00	0.20	
D2	0.20	1.00	0.20	
D3	5.00	5.00	1.00	
	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

MIXED USES

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	5.00	5.00
D2	0.20	1.00	0.20
D3	0.20	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	0.04	0.04
D2	1.00	1.00	1.00	1.00
D3	1.00	0.04	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	1.00
D2	5.00	1.00	5.00
D3	1.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

SUBJECT#3

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	3.00
D3	5.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.11	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	1.00	3.00
D2	1.00	1.00	3.00
D3	0.33	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	0.11	0.11
D2	1.00	1.00	0.11	0.11
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.11

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	3.00	0.33
D2	0.33	1.00	0.20
D3	3.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.11	1.00	0.11
D2	1.00	1.00	1.00	1.00
D3	0.11	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	3.00
D3	5.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.11	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3	
D1	1.00	3.00	3.00	
D2	0.33	1.00	3.00	
D3	0.33	0.33	1.00	

	D1	D2	D3	P(Di)
D1	1.00	0.11	0.11	0.11
D2	1.00	1.00	0.11	0.11
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.11

MIXED USE AT THE CORE

	D1	D2	D3	
D1	1.00	3.00	3.00	
D2	0.33	1.00	3.00	
D3	0.33	0.33	1.00	

	D1	D2	D3	P(Di)
D1	1.00	0.11	0.11	0.11
D2	1.00	1.00	0.11	0.11
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.11

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3	
D1	1.00	3.00	3.00	
D2	0.33	1.00	0.20	
D3	0.33	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	0.11	0.11	0.11
D2	1.00	1.00	1.00	1.00
D3	1.00	0.04	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3	
D1	1.00	1.00	3.00	
D2	1.00	1.00	1.00	
D3	0.33	1.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	0.11	0.11
D2	1.00	1.00	1.00	1.00
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.11

SUBJECT#4

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

SUBJECT#5

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	0.20	5.00
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	1.00	0.04	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

SUBJECT#6

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	1.00	0.20
D2	1.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	1.00	0.33
D2	1.00	1.00	0.20
D3	3.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	1.00	1.00	1.00	1.00
D3	0.11	0.04	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	1.00
D2	5.00	1.00	5.00
D3	1.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

SUBJECT#7

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	3.00
D3	5.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	0.11	0.11
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	5.00	0.33
D2	0.20	1.00	3.00
D3	3.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	0.11	0.11
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.33
D2	5.00	1.00	3.00
D3	3.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.11	0.04
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	0.33	1.00
D2	3.00	1.00	3.00
D3	1.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	0.11	0.11
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.11

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	0.33	0.33
D2	3.00	1.00	3.00
D3	3.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	0.11	0.11
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.11

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	0.33	1.00
D2	3.00	1.00	0.33
D3	1.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	1.00	0.11	1.00	0.11
			MIN(P(di))	0.11

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.33	3.00
D2	3.00	1.00	0.33
D3	0.33	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	0.11	0.11
D2	0.11	1.00	1.00	0.11
D3	1.00	0.11	1.00	0.11
			MIN(P(di))	0.11

SUBJECT#8

CONDENSED LOT

	D1	D2	D3	
D1	1.00	5.00	0.20	
D2	0.20	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3	
D1	1.00	1.00	0.20	
D2	1.00	1.00	0.33	
D3	5.00	3.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	1.00	1.00	1.00	1.00
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3	
D1	1.00	0.33	0.20	
D2	3.00	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3	
D1	1.00	5.00	0.20	
D2	0.20	1.00	0.33	
D3	5.00	3.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3	
D1	1.00	0.20	0.33	
D2	5.00	1.00	1.00	
D3	3.00	1.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	5.00	0.33
D2	0.20	1.00	0.33
D3	3.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.11	0.11	1.00	0.11
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	3.00	0.20
D2	0.33	1.00	1.00
D3	5.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.11	1.00	0.11
D2	1.00	1.00	1.00	1.00
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

SUBJECT#9

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.33
D2	5.00	1.00	1.00
D3	3.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	0.33	0.33
D2	3.00	1.00	0.20
D3	3.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.11	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	3.00	5.00
D2	0.33	1.00	0.33
D3	0.20	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.11	0.04	0.04
D2	1.00	1.00	1.00	1.00
D3	1.00	0.11	1.00	0.11
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3	
D1	1.00	3.00	0.33	
D2	0.33	1.00	0.33	
D3	3.00	3.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	0.11	1.00	0.11
D2	1.00	1.00	1.00	1.00
D3	0.11	0.11	1.00	0.11
			MIN(P(di))	0.11

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	3.00	3.00
D2	0.33	1.00	3.00
D3	0.33	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.11	0.11	0.11
D2	1.00	1.00	0.11	0.11
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.11

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	5.00	5.00
D2	0.20	1.00	1.00
D3	0.20	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	0.04	0.04
D2	1.00	1.00	1.00	1.00
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	5.00
D2	5.00	1.00	5.00
D3	0.20	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	0.04	0.04
D2	0.04	1.00	0.04	0.04
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

SUBJECT#10

CONDENSED LOT

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.33	
D3	5.00	3.00	1.00	
	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3	
D1	1.00	3.00	0.20	
D2	0.33	1.00	1.00	
D3	5.00	1.00	1.00	
	D1	D2	D3	P(Di)
D1	1.00	0.11	1.00	0.11
D2	1.00	1.00	1.00	1.00
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3	
D1	1.00	0.33	3.00	
D2	3.00	1.00	1.00	
D3	0.33	1.00	1.00	
	D1	D2	D3	P(Di)
D1	1.00	1.00	0.11	0.11
D2	0.11	1.00	1.00	0.11
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.11

COMMUNITY CORE

	D1	D2	D3	
D1	1.00	0.20	0.33	
D2	5.00	1.00	0.33	
D3	3.00	3.00	1.00	
	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.11	0.11	1.00	0.11
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	3.00	0.20
D2	0.33	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.11	1.00	0.11
D2	1.00	1.00	1.00	1.00
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	5.00	0.33
D2	0.20	1.00	0.33
D3	3.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.11	0.11	1.00	0.11
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	1.00
D2	5.00	1.00	3.00
D3	1.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.11	0.04
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

SUBJECT#11

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	3.00
D3	5.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.11	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	3.00
D3	5.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.11	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	3.00
D3	5.00	0.33	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.11	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

SUBJECT#12

CONDENSED LOT

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	1.00
D3	5.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	1.00
D3	5.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	0.20	5.00
D2	5.00	1.00	1.00
D3	0.20	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	0.04	0.04
D2	0.04	1.00	1.00	0.04
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	5.00
D2	5.00	1.00	1.00
D3	0.20	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	0.04	0.04
D2	0.04	1.00	1.00	0.04
D3	1.00	1.00	1.00	1.00
			S(di)	0.04

SUBJECT#13

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	3.00	0.20
D2	0.33	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.11	1.00	0.11
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3	
D1	1.00	0.33	0.20	
D2	3.00	1.00	3.00	
D3	5.00	0.33	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	0.11	0.11
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3	
D1	1.00	3.00	0.20	
D2	0.33	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	0.11	1.00	0.11
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3	
D1	1.00	0.33	0.20	
D2	3.00	1.00	3.00	
D3	5.00	0.33	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	0.11	0.11
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3	
D1	1.00	0.33	5.00	
D2	3.00	1.00	3.00	
D3	0.20	0.33	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	0.04	0.04
D2	0.11	1.00	0.11	0.11
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

SUBJECT#14

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	1.00
D3	5.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	3.00	
D3	5.00	0.33	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.11	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.33	
D3	5.00	3.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3	
D1	1.00	5.00	0.33	
D2	0.20	1.00	1.00	
D3	3.00	1.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3	
D1	1.00	0.20	1.00	
D2	5.00	1.00	3.00	
D3	1.00	0.33	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.11	0.04
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

SUBJECT#15

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

SUBJECT#16

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3	
D1	1.00	0.20	0.20	
D2	5.00	1.00	0.20	
D3	5.00	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	1.00
D3	5.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

SUBJECT#17

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	5.00	5.00
D2	0.20	1.00	5.00
D3	0.20	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	0.04	0.04
D2	1.00	1.00	0.04	0.04
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	5.00	5.00
D2	0.20	1.00	5.00
D3	0.20	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	0.04	0.04
D2	1.00	1.00	0.04	0.04
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	5.00	5.00
D2	0.20	1.00	0.20
D3	0.20	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	0.04	0.04
D2	1.00	1.00	1.00	1.00
D3	1.00	0.04	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

SUBJECT#18

CONDENSED LOT

	D1	D2	D3	
D1	1.00	5.00	5.00	
D2	0.20	1.00	0.20	
D3	0.20	5.00	1.00	

	D1	D2	D3	P(Di)
D1	1.00	0.04	0.04	0.04
D2	1.00	1.00	1.00	1.00
D3	1.00	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	5.00
D2	5.00	1.00	0.20
D3	0.20	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	0.04	0.04
D2	0.04	1.00	1.00	0.04
D3	1.00	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	0.20	5.00
D2	5.00	1.00	0.20
D3	0.20	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	0.04	0.04
D2	0.04	1.00	1.00	0.04
D3	1.00	0.04	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	1.00
D2	5.00	1.00	5.00
D3	1.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	1.00	1.00	1.00	1.00
			MIN(P(di))	0.04

SUBJECT#19

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	5.00
D3	5.00	0.20	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	0.04	0.04
D3	0.04	1.00	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	1.00	0.20
D2	1.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	0.33	0.33
D2	3.00	1.00	0.33
D3	3.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.11	0.11	1.00	0.11
			MIN(P(di))	0.11

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.33	0.33
D2	3.00	1.00	1.00
D3	3.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.11

SUBJECT#20

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.33
D3	5.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.11	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.20	0.33
D2	5.00	1.00	0.33
D3	3.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.11	0.11	1.00	0.11
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	0.20	0.33
D2	5.00	1.00	0.33
D3	3.00	3.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.11	0.11	1.00	0.11
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	5.00	0.33
D2	0.20	1.00	1.00
D3	3.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	1.00	0.33
D2	1.00	1.00	1.00
D3	3.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	1.00	1.00	1.00	1.00
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.11

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	1.00	0.33
D2	1.00	1.00	1.00
D3	3.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	1.00	1.00	1.00	1.00
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.11

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	1.00	0.33
D2	1.00	1.00	1.00
D3	3.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	1.00	1.00	1.00	1.00
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.11

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	1.00	0.33
D2	1.00	1.00	1.00
D3	3.00	1.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	1.00	1.00	1.00	1.00
D3	0.11	1.00	1.00	0.11
			MIN(P(di))	0.11

SUBJECT#21

CONDENSED LOT

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL INTENSIFICATION

	D1	D2	D3
D1	1.00	0.33	0.20
D2	3.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.11	1.00	1.00	0.11
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

RESIDENTIAL MIX

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMUNITY CORE

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

COMMON BUILDINGS

	D1	D2	D3
D1	1.00	5.00	0.20
D2	0.20	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	0.04	1.00	0.04
D2	1.00	1.00	1.00	1.00
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

MIXED USE AT THE CORE

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

SOCIAL AND RECREATIONAL SPACES

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

UNIVERSAL ACCESS

	D1	D2	D3
D1	1.00	0.20	0.20
D2	5.00	1.00	0.20
D3	5.00	5.00	1.00

	D1	D2	D3	P(Di)
D1	1.00	1.00	1.00	1.00
D2	0.04	1.00	1.00	0.04
D3	0.04	0.04	1.00	0.04
			MIN(P(di))	0.04

APPENDIX J: CORRELATED OUTCOMES OF SURVEY

Quest	WebSubj					InSubj				
	Yes	No	TotSub	%Yes	%No	Yes	No	TotSub	%Yes	%No
1	12	3	15	80%	20%	19	4	23	83%	17%
2	11	0	11	100%	0%	19	4	23	83%	17%
3	5	5	10	50%	50%	9	13	23	39%	57%
4	9	1	10	90%	10%	12	8	21	57%	38%
5	8	3	11	73%	27%	16	6	23	70%	26%
6	15	2	17	88%	12%	15	4	20	75%	20%
7	11	0	11	100%	0%	22	0	23	96%	0%
8	9	0	9	100%	0%	11	10	22	50%	45%
9	11	2	13	85%	15%	18	5	23	78%	22%
10	9	1	10	90%	10%	20	3	23	87%	13%
11	6	0	6	100%	0%	21	2	23	91%	9%
12	8	0	8	100%	0%	21	2	23	91%	9%
13	8	0	8	100%	0%	20	2	22	91%	9%
14	6	3	9	67%	33%	21	1	22	95%	5%
15	3	7	10	30%	70%	17	6	23	74%	26%
16	8	0	8	100%	0%	18	5	23	78%	22%
17	8	0	8	100%	0%	20	3	23	87%	13%
18	9	1	10	90%	10%	19	3	23	83%	13%
19	11	1	12	92%	8%	19	2	23	83%	9%
20	8	5	13	62%	38%	12	8	21	57%	38%
21	8	3	11	73%	27%	18	4	23	78%	17%
22	7	2	9	78%	22%	10	12	22	45%	55%
23	7	2	9	78%	22%	14	8	22	64%	36%
24	9	0	9	100%	0%	17	4	22	77%	18%
25	7	3	10	70%	30%	14	8	22	64%	36%
MEAN	8.52	1.76	10.28	84%	16%	16.9	5.08	22.44	75%	23%
STDEV	2.45	1.9	2.372	18%	18%	3.77	3.35	0.821	16%	15%

APPENDIX J: CORRELATED OUTCOMES OF SURVEY (contd.)

Quest	ExpSubj				
	Yes	No	TotSub	%Yes	%No
1	5	1	6	83%	17%
2	6	1	7	86%	14%
3	3	2	5	60%	40%
4	6	1	7	86%	14%
5	5	2	7	71%	29%
6	7	0	7	100%	0%
7	7	0	7	100%	0%
8	4	1	5	80%	20%
9	6	0	6	100%	0%
10	4	2	6	67%	33%
11	5	1	7	71%	14%
12	6	1	7	86%	14%
13	6	1	7	86%	14%
14	5	1	7	71%	14%
15	6	0	7	86%	0%
16	5	1	6	83%	17%
17	7	0	7	100%	0%
18	7	0	7	100%	0%
19	6	1	7	86%	14%
20	4	3	7	57%	43%
21	7	0	7	100%	0%
22	6	1	7	86%	14%
23	4	3	7	57%	43%
24	6	0	7	86%	0%
25	5	2	7	71%	29%
MEAN	5.52	1	6.68	82%	15%
STDEV	1.12	0.91	0.627	14%	14%