Reducing Conflict between Rural Residential Developments and Hog Operations:

A Decision Support Tool for the Selkirk and District Planning Area, Manitoba

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Abstract

In certain rural areas of Manitoba, the character of the rural residential population has changed. People have built or bought houses around land that had been previously used exclusively for agriculture. These rural residents have invested in their property and are very sensitive to any activity that may interfere with their “rural lifestyle” or affect the value of their property. In the past, livestock production, in particular hog production was generally one component of mixed farming operation. Livestock production in Manitoba has undergone significant changes in recent years, both in size of operation and production method. It has now become a specialized industry where operations have become much larger and more capital intensive than farms of thirty years ago. These factors have resulted in situations where land use conflicts have and continue to occur.

Typically, regulatory zoning, in conjunction with manual review of land cover overlay and topographic maps have been used to select sites for livestock operations. This approach can be time consuming and expensive. An alternative approach is the development of a geographic information system (GIS) to define optimal locations for livestock operations and non-farm rural residents. The use of such a model has the capability to reduce the number of rural land use conflicts.

This study starts by documenting the significant changes in recent years of rural residential development and the size as well as the production method of hog operations in Manitoba. It then draws on a series of interviews to gain insight into the complex land use conflicts within the study area and to inform the creation of a geographic information system (GIS) model. This practicum explores “smart” land use analysis using a combination of GIS and Land Use Conflict Identification Strategy (LUCIS) modeling to represent the spatial consequences of land use decisions.

This research has resulted in the development of a GIS model to be used as a decision support tool in developing policy surrounding future development and land use; including appropriate locations of any new or expanding livestock operations and rural non-farm residents within the Rural Municipality (RM) of St. Andrews, MB.

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1.0 Introduction

The past few years have seen dramatic changes in agriculture, which have created challenges for traditional family farms. However, recently the agricultural industry has embraced new opportunities to diversify the rural farm economy through value added organic production and transformation into livestock production. Diversification and changing farm economics have introduced concerns about the growth and location of livestock operations (see Glossary of Terms) and potential impacts that larger scale livestock operations may have upon the quality of life enjoyed by communities, as well as their impacts upon the natural environment. In the past, livestock production was primarily part of a mixed farming operation. It has now become a specialized industry where operations have become much larger and more capital intensive than farms of thirty years ago. These factors led to situations where land use conflicts have occurred and continue to occur.

In areas of rural Manitoba, the character of the residential population has also changed. Non-farm rural residential dwellings have been built in and around land that had been previously used strictly for agriculture. New rural non-farm residents have invested in their property and are very sensitive to any activity that may interfere with their "rural lifestyle" or affect the value of their property.

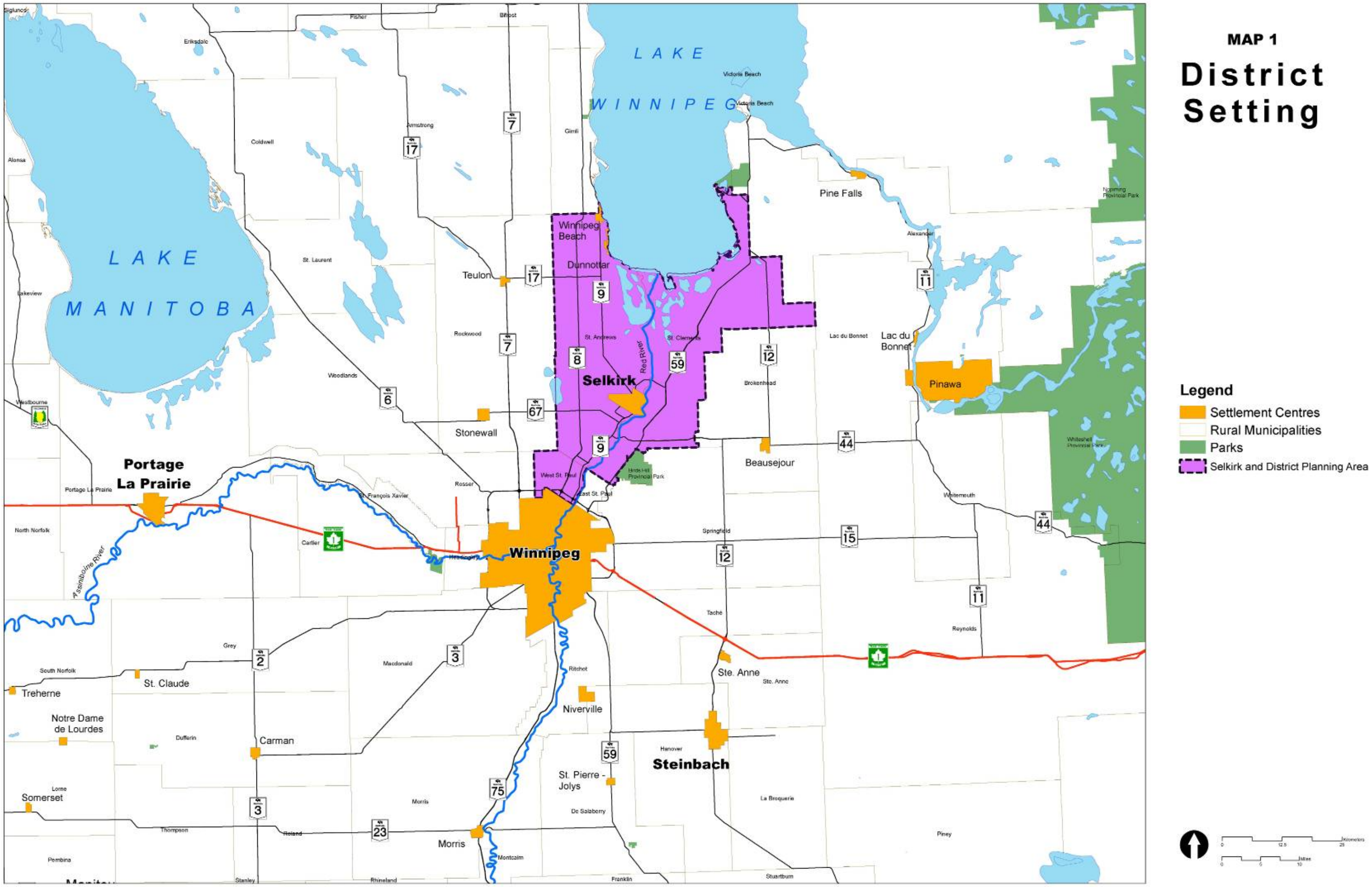
Intensification of rural Manitoba's livestock operations has created a need for information to understand the nature and location of the livestock operations in each municipality and to better define the roles of local and provincial governments in managing growth and expansion of livestock operations.

The intensification in the hog industry sector, and its concentration in certain locations within the province, has increased public concerns regarding the environment, in particular air and water quality. Although several politicians welcomed and encouraged the dramatic growth of Manitoba's hog industry in the late 1990's and early 2000's, some citizens and non-governmental groups became increasingly resistant to hog development within their localities (Vandean, 2003). Municipalities and planning districts are now examining hog barn development and/or expansion proposals with increased scrutiny while ensuring that more public input and consultation take place. It is very difficult to find a single industry in Manitoba that has sparked more public resistance and opposition than the intensification of the Manitoba hog industry in the late 1990's and early 2000's.

Conventionally, regulatory zoning criteria, in conjunction with review of manual land cover overlay and topographic maps, have been used to select sites for livestock operations. This approach can be time-consuming and expensive. An alternative approach is the development of an interactive spatial decision model to help delineate optimal locations for livestock operations and non-farm rural residents. A geographic information system (GIS) can be used as a tool for decision support and to develop policy for future development and land use; including appropriate location of any future or expanding livestock operations and siting of non-farm rural residential developments within a rural municipality.

The Selkirk and District Planning Area consists of approximately 1,580 km^2 and covers an area from the northern boundary of Winnipeg to the southern basin of Lake Winnipeg (see **Map 1**). The population is in excess of 32,000 and is comprised of the City of Selkirk and the Rural Municipalities of St. Andrews, St. Clements and West St. Paul (Selkirk and District Planning Area Board, 2005).

The use of a GIS, will help to determine the most suitable and more efficient evaluation of potential locations for new and expanding livestock operations, as well as identify those areas in which rural non-farm forms of development, such as rural residential may be considered. This practicum will explore smart land use analysis by using Land Use Conflict Identification Strategy (LUCIS) modeling to represent highly probable spatial consequences of rural land use conflicts (see **Section 4.2.1: Land Use Conflict Identification Strategy – LUCIS**).



Map 1 – Selkirk & District Planning Area (Source: Manitoba Land Initiative, 2003)

1.1 Livestock Issues in the Selkirk and District Planning Area

Public concern is often expressed toward livestock operations and in particular towards hog farm operations. Although hog farms do not constitute anywhere near the majority of farms types or even livestock farm types in the District, special consideration should be made when planning around these operations. The location and size of manure spreadfields (see Glossary of Terms) have to be taken in to consideration when reviewing an application for a new or expanding livestock operation with more that 300 animal units (>300 AU, see Glossary of Terms). It is evident that St. Andrews has some hog operations according to the 2006 livestock inventory that was conducted by the Selkirk and District Planning Area Board. A majority of these hog farms are grower/finisher pig farms (see Glossary of Terms). It is important to note that the *size* of an operation, rather than a particular *type* holds greater merit when developing land use policy.

Livestock production is not limited to prime agricultural lands and much of the livestock operation expansion in the Selkirk and District Planning Area is taking place on lower class agricultural lands. In the Selkirk and District Planning Area, there are many acres of parkland that are well-suited and becoming increasingly valuable for livestock production. Additionally, lower class agricultural lands are suitable for expanding forage production and may provide for maximum agricultural diversification opportunities.

From a planning perspective, the most relied upon approach to control odour nuisances from livestock operations is proper land use planning and the use of the mutual separation distances (see **Figure 1**) shown in the Provincial Land Use Policies (2005) – (see Glossary of Terms). In Manitoba, local governments are responsible for creating, administering and enforcing land use planning. Rural municipalities must create their own by-laws regarding minimum separation distances for new or expanding livestock operation facilities from designated residential land uses. Local municipalities and/or planning districts may enforce by-laws that exceed the mutual separation distances shown in the Provincial Land Use Policies (2005) but they may not use separation distances that are below these minimums. The following table outlines the minimum setback distances for livestock operations mandated by the provincial government.

Size of Livestock Operation in Animal Units[1]	**Separation Distance in Metres (feet) from Single Residence**	**Separation Distance in Metres (feet) from Designated Residence**
	To Earthen Manure Storage Facility	*To Earthen Manure Storage Facility*
10-100	200 (656)	800 (2,625)
101-200	300 (984)	1200 (3,937)
201-300	400 (1,312)	1600 (5,249)
301-400	450 (1,476)	1800 (5,906)
401-800	500 (1,640)	2000 (6,561)
801-1,600	600 (1,968)	2400 (7,874)
1,601-3,200	700 (2,297)	2800 (9,186)
3,201-6,400	800 (2,625)	3200 (10,499)
6,401-12,800	900 (2,953)	3600 (11,811)
>12,800	1000 (3,281)	4000 (13,123)

Figure 1 - Recommended Siting Criteria for Livestock Operations (Provincial Land Use Policies, 2005)

Livestock operations which operate in accordance with the farm practices guidelines should be encouraged and supported as primary land uses in designated agricultural areas. More developed areas, including residences and more densely settled areas must be buffered from potential nuisance factors such as odours and noise from new or expanding livestock operations. Consideration should be given to separation distances between livestock operations and designated residential land uses as well as the maximum size of livestock operations permitted in areas where the potential for land use conflict is greatest.

1.2 Livestock Trends

There has been a trend in recent years toward fewer farms that are larger in size. In addition many farmstead sites may have been rendered surplus to farm operators and sold for rural non-farm residential purposes. The farming community has been very active in the subdivision process (i.e. subdivisions for retirement income and for individuals actively involved in the operation[2]) and a number of these lots are eventually converted

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[1] See Appendix B: Data Collection for the Animal Unit Summary Table

[2] Section 52 of the Provincial Land Use Policies 193/2005 states the following:

14. Subdivision of land for agricultural purposes should reflect the general type of agriculture, overall land use and average parcel size in the area.

15(1) Except in an urban centre or unless otherwise permitted in a development plan, prime agricultural land and viable lower class land should be subdivided only where:

(a) agricultural operations require small parcels, such as apiaries, nurseries and livestock or poultry operations (in which case the operator shall make suitable arrangements for proper waste disposal);
(b) a retiring farmer wishes to retire on his or her farm;

to use by non-farm residents. This changes the farm/non-farm composition of rural communities, raises the probability of conflicts with agriculture and may contribute to the potential for nuisance complaints and restrictive policy curtailing farming practices. As well, the general trend towards larger farms and larger farm equipment in turn makes smaller land parcels more and more difficult and inefficient to farm.

Another major change in the agricultural industry is the advancement of the livestock industry from the relatively small diverse individual farms into the large-scale modern highly specialized livestock production operations. Non-farm development in agricultural areas represents a significant concern for livestock operations. The shadow effect of these trends is amplified if the development of non-farm rural residential land uses is scattered rather than confined to a designated area. Also, land use conflicts increase as the number and density of non-farm rural residential developments increase near livestock operations. The development of non-agricultural uses, especially residential, in an agricultural area may inflate surrounding land values and have an indirect effect on the viability of surrounding agricultural lands. Higher farmland prices make it difficult to sustain intergenerational transfer of farms and for young farmers to expand their land holdings. Higher land values influence the land assessment value on adjacent farm properties causing higher property taxes and an increase in the operating costs of the farm. Additionally, higher farmland prices make the subdivision of valuable farmland much more lucrative than farming and, therefore, create an incentive for more subdivision to take place. Non-agricultural uses may also create undue expenses for municipalities, including road improvements, drainage or other infrastructure services that are not generally related to local agricultural needs; services local farmers may have to help pay for through taxation. This trend is occurring in the RM of West St. Paul and is also taking place to a lesser extent in the RM of St. Clements and RM St. Andrews.

In the United States large scale livestock operations tend to be referred to as CAFOs (Confined Animal Feeding Operations) and in Canada they are known by a variety of names including Intensive Livestock Operations (ILOs) or Confined Feeding Operations (CFOs). The conflict associated with the establishment of these facilities has led to an

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(c) an existing farmstead is no longer required as part of a farm; or
(d) a home is required by an individual participating in the operation of the farm and deriving a significant income from it.

equal amount of debate concerning the nature of government response. Grey (2000) notes that the concerns associated with livestock production are not exclusive to Manitoba and have resulted in numerous conflicts in rural communities across all of North America. Real and perceived environmental, social, and economic issues related to the intensification of livestock production have led governments at the municipal, provincial/state and federal level to respond as discussed below (Edelman et al., 1998; Henderson, 1998; Caldwell and Toombs, 1999).

1.3 Planning Legislation and Implications for Livestock Operations

Caldwell (2002) notes that "right to farm" legislation exists throughout Canadian provinces and selected United States as official acts to protect farmers from nuisance and odour complaints provided the farmer complies with practices of the provincial/state laws or guidelines. In 1992, the Province of Manitoba passed the *Farm Practices Protection Act*, creating a platform whereby any farm operator who complies with normal farm practices is protected by the *Nuisance Act* and any subsequent lawsuits.

Development plan and zoning by-laws are tools used by rural municipalities to direct development of livestock operation, for the betterment of the community as a whole. Manitoba's food and agricultural industry has intensively grown in the past decade, making agriculture one of the prime economic sectors in the Province. With this economic growth has come a corresponding growth in the size and structure of the agricultural industry itself. Agriculture is important to the Selkirk and District Planning Area's economy. Farm practices have changed over the years in reaction to economic conditions and market demands. Since 1950, the total number of farms within the area has declined as has its ratio to the non-farm population. The move towards industrial agriculture may have repercussions for the long-term stewardship of the land, while increasing farm amalgamations has resulted in declining numbers of rural families and communities; and reduced agricultural diversity. Non-farm residents in rural municipalities that contain livestock operations are often concerned the issues associated with hog manure odour associated with intensive hog operations.

While the population densities of this District will likely not reach the point where they will take away from the rural character, it is possible that its population could reach the point where there would be greater conflict between new residents and existing farmers. Complaints from non-farm neighbours about the noise, dirt, and/or smells produced by livestock operations could rise as the population increases in capital region municipalities that surround Winnipeg. In some instances increased non-farm residential development in rural municipalities of the Manitoba capital region has resulted in an increase in property taxes. Farm owners could begin facing increased economic hardship because of a decrease in net revenue when required to pay higher property taxes, resulting from the higher property assessments triggered by a negative cost-benefit of increased rural residential development in the area (Jopling, 1998).

A large percentage of the land in the District is used for agricultural purposes. The Census Subdivisions of St. Clements and St. Andrews have the highest total number of farms (see **Table 1**) and also consume the largest number of acres of land for agricultural production. The subdivision of agricultural land reduces the overall amount of land available for agricultural production. Technological improvements has allowed a reduced labour force to work more acres. Between 1996 and 2001, the total number of farms has gone down in all three municipalities; from 32 to 30 in the R.M. of West St. Paul; from 311 to 243 in the R.M. of St. Andrews and from 268 to 257 in the R.M. of St. Clements.

Table 1 - Number of Farms and Farm Acreage
Source: Statistics Canada: Census of Agriculture, 2001

	RM of West St. Paul		RM of St. Andrews		RM of St. Clements	
Date	# of Farms	Total Farm Area (acres)	# of Farms	Total Farm Area (acres)	# of Farms	Total Farm Area (acres)
1996	32	N/A	311	142,275	268	118,668
2001	30	19,034	243	129,404	247	115,923

While the number of farms has declined over the years, the average farm size has significantly increased in the District (see **Table 2**). There are large numbers of farms in the three municipalities that have a total farm capital (see Glossary of Terms) of greater than $100,000 (see **Table 3**). The total amount of farm business operating expenses for the District is $47,569,329, a significant amount of money. Therefore, consideration should be given to protect the land resource required for agricultural production, including livestock from non-compatible land uses.

Table 2 - Average Farm Size (acres) for the Selkirk and District Planning Area
Source: Statistics Canada: Census of Agriculture, 2001

Date	RM of West St. Paul Avg. Farm Size (acres)	RM of St. Andrews Avg. Farm Size (acres)	RM of St. Clements Avg. Farm Size (acres)
1996	N/A	745	689
2001	1,232	763	793

Table 3 - Farms Classified by Total Farm Capital
Source: Statistics Canada: Census of Agriculture, 2001

Farm Capital	RM of West St. Paul	RM of St. Andrews	RM of St. Clements
Under $50,000	0	5	5
50,000 to 99,999	2	18	20
100,000 to 199,999	4	52	69
200,000 to 349,999	9	60	51
350,000 to 499,999	2	27	31
500,000 to 999,999	7	44	40
1,000,000 to 1,499,999	2	11	15
1,500,000 to 1,999,999	0	12	12
2,000,000 and greater	4	14	4

Governments at both municipal and provincial levels in Manitoba have sought to regulate the intensification of the agricultural industry by establishing size thresholds based on number of animal units (AU) permitted per site, separation distances and comprehensive manure management plans. Caldwell (2002) notes that this “patchwork” approach to agricultural planning became a source of land use conflicts between livestock farmers, non-agricultural rural residences and the local government in Michigan.

Local governments have been faced with the difficulty of having to pass new legislation that would continue to encompass all of their constituents’ needs and demands. It has been challenging to adequately address public concern while recognizing the role of animal production in the agricultural sector. This has led the Provincial government to intervene. The new *Planning Act* (2005) sets the direction for development of agricultural land. Local governments are responsible for creating, administering and enforcing the land use plans. Section 42(2) of the *Act* states that all development plans must include a livestock operation policy that guides zoning by-laws dealing with livestock operations. Section 42(2)a i-iii states that the livestock policy must identify areas in the municipality where expansion or development of livestock operations may be allowed; may be allowed up to a maximum size; or will not be allowed. The livestock operation policy must also set out the general standards for separation distances between livestock operations (earthen manure storage – see Glossary of Terms) and residential land uses as dictated by the respective municipal zoning by-law and development plan. It is strongly recommended that separation distances utilize the *Provincial Land Use Policies: Recommended Siting Criteria for Livestock Operations* (2005), which were developed in an attempt to address the issue of "reasonable" and "consistent" standards for the livestock industry (Manitoba Agriculture, 2006).

The issue of regulating an industry that is in flux is a challenge for all municipalities across North America. The Province of Manitoba has addressed changes in the livestock sector through environmental regulations, best management practices and with a strong regard for the social impacts generated by the livestock industry. The Province of Manitoba still faces challenges in its approach; it has taken decisive action to protect the environment while creating a framework for agricultural growth and expansion.

The intensification of agriculture has led to conflict within the rural community. Recent developments in the livestock sector have been a catalyst for debate and action within many rural communities. As livestock facilities have grown larger, become more geographically concentrated, and more reliant upon technology many people living in proximity to these facilities have expressed concerns related to odour and water quality. Some of these concerns are valid, while others are based on perceived speculations. Whether these concerns are real or perceived, there has been no community-based, systematic and objective study of environmental, economic and social implications following the establishment of new, modern livestock facilities. In response to this conflict provincial and municipal governments are thrust into the midst of the issue and are often pressured to develop approaches to assist with the establishment of new facilities and to regulate existing situations. The resulting approaches include a mix of legislation, policy, local by-laws and recommendations concerning management.

It is clear that both rural communities and the livestock industry will continue to evolve and change. Current and anticipated future trends suggest that the rural community, as it becomes less farm oriented, more urbanized and more environmentally conscious will increasingly come into conflict with a livestock industry that seems to be committed to an ever increasing scale of production (Caldwell, 1999). The research proposed herein will aim to provide an objective analysis of this complex issue facing rural municipalities and the livestock industry.

1.4 Problem Statement

Endeavouring to minimize land use conflicts with regard to intensive hog operations is a difficult task. The major environmental impacts of livestock operations are the unpleasant odour emissions, the disposal of waste and potential of nearby water contamination. This project will examine how environmental and social impacts can be reduced for the Manitoba hog industry and how local land use conflicts between livestock operations and non-farm rural residential developments can be minimized in the Selkirk District Planning Area through the use of a geographic information system (GIS).

As residential development continues to encroach upon existing livestock operations, clear policies need to be adopted by the Selkirk and District Planning Area Board that address future development and deal with competing land use interests. It is important that land use policies recognize the significant role of agricultural production within the District. **Table 4** shows the assessed value of each industry. From these assessed values, the tax assessments are calculated and collected. It is quite clear that residential land is the highest assessed value for all three municipalities. Agriculture is in a distant second for the RM's of St. Clements and St. Andrews, while it is the smallest amount for the RM of West St. Paul. To many people, rural land is no longer seen as a resource for food production, rather it is seen as a commodity that can attract a fair price in the residential market place. To others, agricultural land is a non-renewable resource that should be protected and preserved. This is certainly a dilemma for agricultural operations located within the vicinity of urban areas.

Table 4 - Full Assessed Value in $ for the Selkirk and District Planning Area Source: Manitoba Assessment (2006)			
Type	**R.M. of St. Andrews**	**R.M. of St. Clements**	**R.M. of West St. Paul**
Residential	593,510,888 (78%)	526,197,777 (83%)	249,136,355 (80%)
Commercial	42,844,753 (6%)	27,106,384 (4%)	27,115,476 (6%)
Industrial	15,580,769 (2%)	8,780,984 (1%)	19,197,169 (5%)
Agricultural	107,543,538 (14%)	75,237,115 (12%)	16,816,807 (3%)
Total	716,635,195	637,322,260	312,265,807

1.5 Research Approach

Through the use of various research methods, including GIS modeling and key informant interviews, the primary intent of this practicum is to develop a practical GIS model for the Selkirk and District Planning Area Board. The application of this modeling will be focused exclusively on the RM of St. Andrews – a mixed urban and primarily rural municipality, which has experienced intensification pressures and land use conflicts in recent years. GIS modeling will be used to identify land use resolution strategies, while interviews with local key stakeholders, such as planners and test the applicability of the GIS model to professionals working in the Selkirk District Planning Area.

1.5.1 Significance of Proposed Research

It is anticipated that this practicum will result in a number of important contributions to both the planning profession and the Selkirk and District Planning Area Board. This research has the basic objective to identify alternative approaches to land use planning that are of significant importance to planners, municipal officials, farmers and community members as policies established in the local zoning by-law and development plan shape the future of hog production in the planning district. Firstly, this study will contribute to the growing body of literature focusing on land use planning for livestock operations. Secondly, this practicum will serve as a valuable source of information for rural Municipal Councils and planning boards throughout the Province of Manitoba, regarding the development of GIS modeling as a means to reduce land use conflicts between livestock operations and rural residential development. This project will help the Selkirk and District Planning Area Board determine the areas best suited for livestock operations, as well as those areas in which rural non-farm forms of development, such as rural residential development may be considered. Once developed, this information will be used in conjunction with the GIS to:

- Document rural land use trends and issues in the RM of St. Andrews, MB.
- Identify from local officials and planners in the planning district, practices, policies and legislation that contribute positively and/or negatively to the relationship between livestock operations and neighbouring residential land uses.
- Develop an interactive model to identify issues of land use compatibility and to better understand the relationship between livestock operation and rural residents.
- Identify new and best practices for the planning district and local municipalities to effectively respond to public concern with livestock operations, in particular with establishment of new or expanding large-scale livestock operations.

1.5.2 Purpose and Objectives

Through the use of various research methods – interviews with key informants and the creation of a GIS model – the primary intent of this practicum was to develop a highly analytical land use conflict analysis tool for the RM of St. Andrews, MB. The decision to undertake key informant interviews was used to gain insight and develop an understanding of how land use conflicts are perceived within the study area. The results generated from the key informants were used to aid in the development of the GIS model for land use conflicts. A set of focus group interviews were undertaken in order to demonstrate the capabilities of the GIS model in a practical setting, applicable to the RM of St. Andrews, MB. The result is a land use conflict identification model to be used as an analytical tool for the creation and designation of policy areas.

1.5.3 Key Informant Interviews

The second part of this practicum made use of semi-structured key informant interviews. Semi-structured interviews allowed for the exploration of contextual information and provided greater flexibility in responses than other research methods such as questionnaires. The flexibility of the semi-structured interview allowed for follow-up questions and a greater degree of interaction among participants. Interviews were conducted with the planners from the Selkirk and District Planning Area Board. The preliminary information obtained from these interviews helped guide the “calibration” of the GIS model by collectively assigning weighting factors to the criteria shown in **Appendix B: Data Collection** and **Appendix C: Detailed Case Study GIS Model Development**. The information gathered helped gain a greater appreciation of how land-use conflicts are currently addressed, including the current challenges and solutions.

Each participant spoke as an official and their identity was not revealed. An oral introduction of the practicum was provided prior to the interview in order to familiarize participants with the purpose and scope of the project. The participant had the option to discontinue his/her participation in the study or halt the interview at any stage.

1.5.3 Focus Group Interviews

The final part of this practicum used focus group interviews with key informants in the RM of St. Andrews, which included planners from the Selkirk and District Planning Area Board and land use planners from Manitoba Agriculture Food and Rural Initiatives (MAFRI). This includes planners who process development applications in the area and land use specialists who have commented on subdivision and livestock development applications in the Selkirk District Planning Area. Similar to that of the key informant interviews, each participant in the focus group will also be speaking as an official and their identity will be revealed. Qualitative methods better uncover the tacit knowledge and rich contextual information necessary to more completely understand land use conflicts at the local level.

Focus group interviews can be used in a variety of settings. The focus group for this research involved an organized discussion with a selected group of key informants. This methodology was suitable for obtaining multiple perspectives on the research topic. The information gathered from the interviews helped gain a greater appreciation of how the issue of land use conflicts with livestock operations are perceived locally. The second component of the focus group process was used as a demonstration process of the GIS model with key informants. This component tested the usefulness, relevance and practicality of the GIS model with key informants.

Focus group interviews were favourable for this study as they combine a structured agenda with the flexibility to ask follow up questions. This research method was chosen in order to obtain as much information in greater detail while bringing out qualitative results. Morgan (1993) notes that focus group interviews draw upon respondents' attitudes, experience and reactions in a manner that is not possible with other research methods such as a questionnaire or survey.

1.5.4 Outline

This practicum consists of five chapters. The introductory chapter to this practicum provides a contextual summary of some of the key livestock issues and trends within the study area. This chapter also discusses the research methods, purpose and objectives, and limitations. The second chapter provides a review of the literature and explores issues related to the intensification of the livestock industry in Manitoba and the impacts related to population increase of rural bedroom commuter areas. This review is from both a provincial and local study area perspective. The third chapter discusses the basis for developing the GIS LUCIS model from the preliminary key informant interviews. The fourth chapter presents the findings from the application of the GIS LUCIS model and the focus group. The fifth chapter provides recommendations to the planning district and RM of St. Andrews, MB in making use of the model.

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2.0 Literature Review

This chapter of the practicum focuses on the history, evolution and rationale of the land use conflicts, including trends in livestock, and the application of a GIS for assessing land use conflicts. It begins by describing contemporary land use conflicts, followed by a review of the basis of land use conflicts. The next section focuses on the history of land use conflicts indicative of the Selkirk and District Planning Area. The next section explores livestock trends in the Manitoba and the Selkirk and District Planning Area with a focus on the application of a GIS and planning implications for livestock operations and associated regulations.

2.1 Setting the Stage for Land Use Problems and Conflicts – Sprawl

The subject of land use is both broad and complex. There are several actual and perceived controversies that affect land use decisions. Urban sprawl, right-to-farm laws, urban decay, traffic gridlock, automobile pollution, and trophy homes are all topics associated directly or indirectly with land use conflicts (Bergstrom et al., 2005). One of the main land use controversies in Manitoba and other parts of North America has been the conversion of agricultural land to single-family residential subdivision homes in and around existing large confined livestock operations. According to Bergstrom et al. (2005) this has created concern over issues related to food security and urban sprawl. With increased residential development around livestock operations, tensions rise from both sides over issues of subdivision of agricultural land for non-agricultural purposes. Caldwell (2003) notes that one person's land use decision typically has impacts on the well-being of nearby individuals. Residential encroachment in and around farm operations on the rural-urban fringe are adversely impacted and have resulted in numerous land use conflicts in rural areas in Canada (Caldwell, 2003).

Bergstrom et al. (2005) notes that the "causes, consequences and control of land use change" have quickly become key challenging issues for planners. The Selkirk and District Planning Area lies within Manitoba's Capital Region (see **Map 2**). According to Bergstrom et al. (2005) at the roots of land use conflicts are effects of urban sprawl and the need for better planning and “smart growth” development. As shown in the figure below, the City of Winnipeg central metropolitan area has had the slowest growth of all large urban centres in Canada over the 15 years (see **Table 5**). While the percentage of the total population living in Winnipeg has been steadily declining over the last 20 years, the majority of the capital region municipalities have experienced double-digit population growth (see **Table 6**).

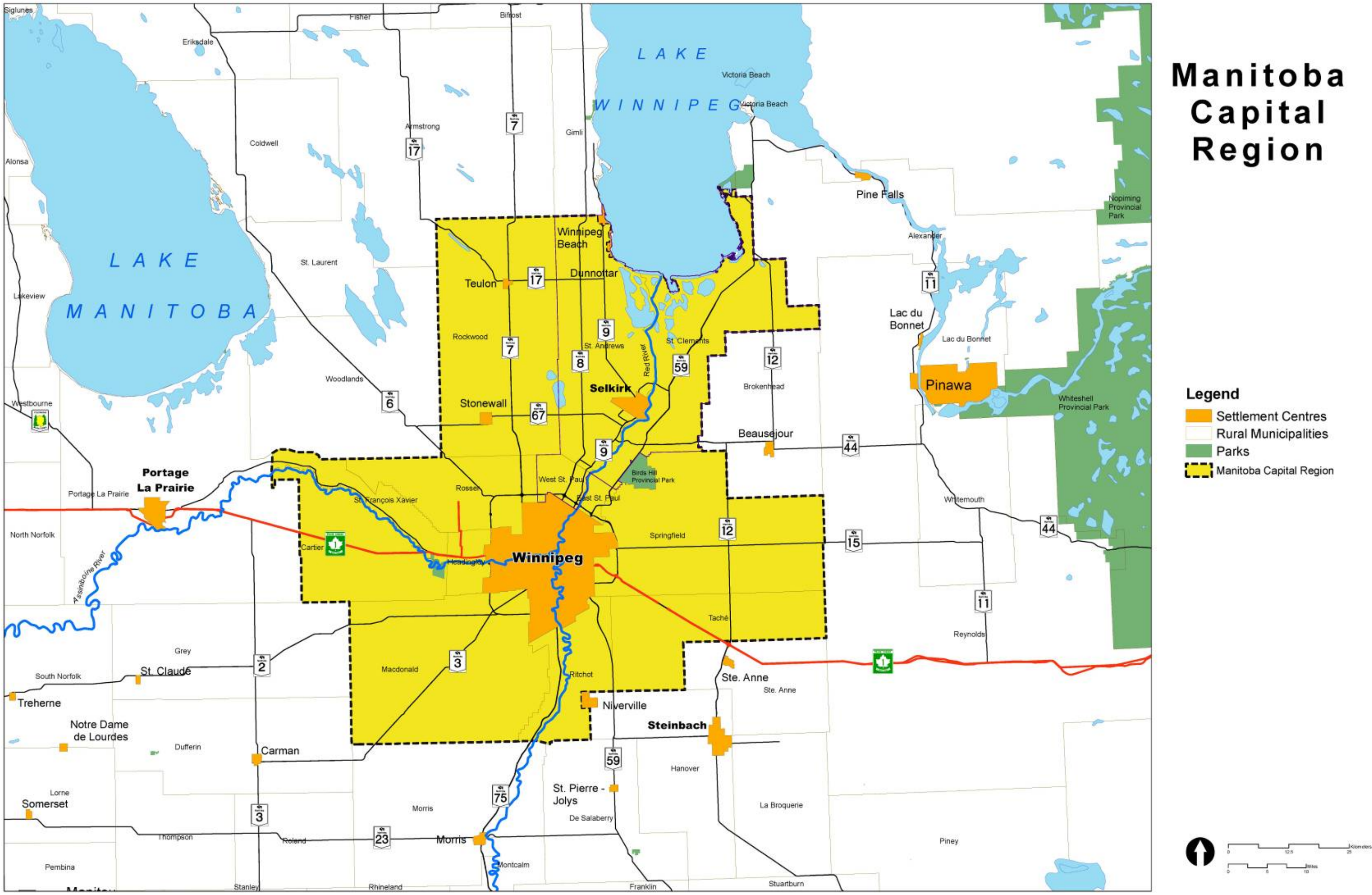
Table 5 - Growth Rate of Large Urban Centres in Canada
Source: Statistics Canada: Census of Populations, 2006

	Population (000's)				Percentage Growth (%) between Census Years		
CMA[1]	1991	1996	2001	2006	1991-1996	1996-2001	2001-2006
Calgary	754	822	951	1,079	8.3	13.6	11.9
Edmonton	841	863	938	1,035	2.6	8.0	9.4
Toronto	3,899	4,264	4,682	5,113	8.6	8.9	8.4
Vancouver	1,603	1,832	1,987	2,117	12.5	7.8	6.1
Ottawa	942	1,010	1,064	1,130	6.7	5.1	5.8
Montreal	3,209	3,326	3,426	3,636	3.5	2.9	5.8
Hamilton	600	624	662	693	3.9	5.7	4.5
Quebec	646	672	683	715	3.9	0.6	4.5
Winnipeg	660	667	671	694	1.5	0.6	3.3

Table 6 - Growth Rate of Municipalities in the Manitoba Capital Region
Source: Statistics Canada: Census of Populations, 2006

	Population (000's)				Percentage Growth (%) between Census Years		
Municipality	1991	1996	2001	2006	1991-1996	1996-2001	2001-2006
Headingley	1575	1587	1907	2726	0.8	20.2	30.0
East St. Paul	5820	6437	7677	8733	10.6	19.3	12.1
Stonewall	2997	3689	4012	4376	23.1	8.8	8.3
West St. Paul	3658	3720	4085	4357	1.7	9.8	6.2
St. Clements	7823	8516	9115	9706	8.9	7.0	6.1
Macdonald	3999	4900	5320	5653	22.5	8.6	5.9
St. Andrews	9471	10144	10695	11359	7.1	5.4	5.8
St. Francois Xavier	898	992	1024	1087	10.5	3.2	5.8
Tache	7576	8273	8578	9083	9.2	3.7	5.6
Springfield	11102	12162	12602	12990	9.6	3.6	3.0
Winnipeg	612215	618477	619544	633451	0.5	0.2	2.2
Ritchot	5146	5364	4958	5051	4.2	-7.6	1.8
Cartier	3115	3009	3120	3162	-3.4	3.7	1.3
Rockwood	6990	7504	7654	7692	7.4	2.0	0.5
Selkirk	9815	9881	9752	9515	0.7	-1.3	-2.5
Rosser	1364	1349	1412	1364	1.1	4.7	-3.5

[1] CMA stands for the Census Metropolitan Area as defined by Statistics Canada. The CMA for Winnipeg has different boundaries than the Provincial Government's definition of the Manitoba Capital Region.



Map 2 – Manitoba Capital Region (Source: Manitoba Land Initiative, 2003)

In addition, household size has been steadily declining in Winnipeg (see **Figure 2**) leading to a relatively constant yet more dispersed population, putting even greater strain on infrastructure and land consumption. Winnipeggers have traditionally chosen single-family dwellings over more infrastructure-efficient compact multi-family dwellings. During the period from 1986 – 2002, 73% of new homes built were single-family dwellings (City of Winnipeg, 2004).

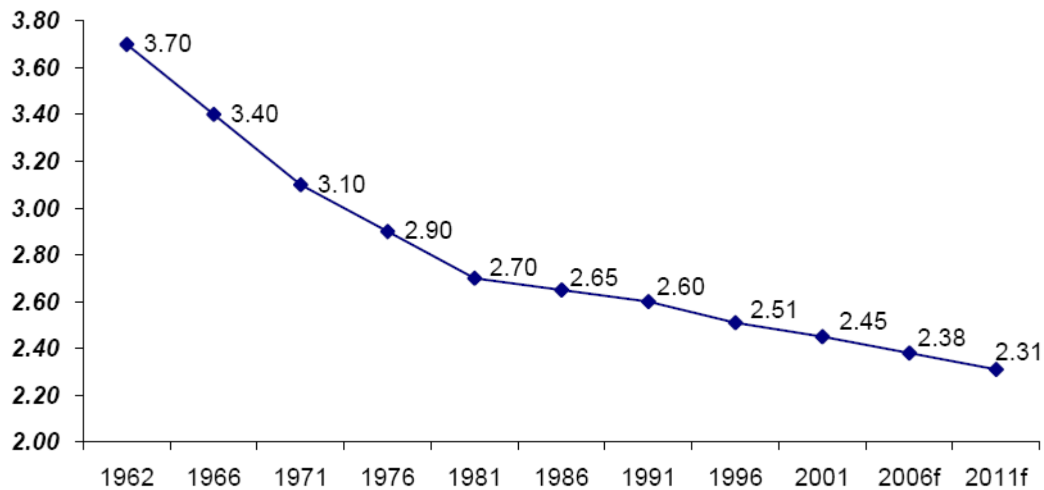


Figure 2 - Declining household size for Winnipeg from 1962-2011 (City of Winnipeg, 2004)

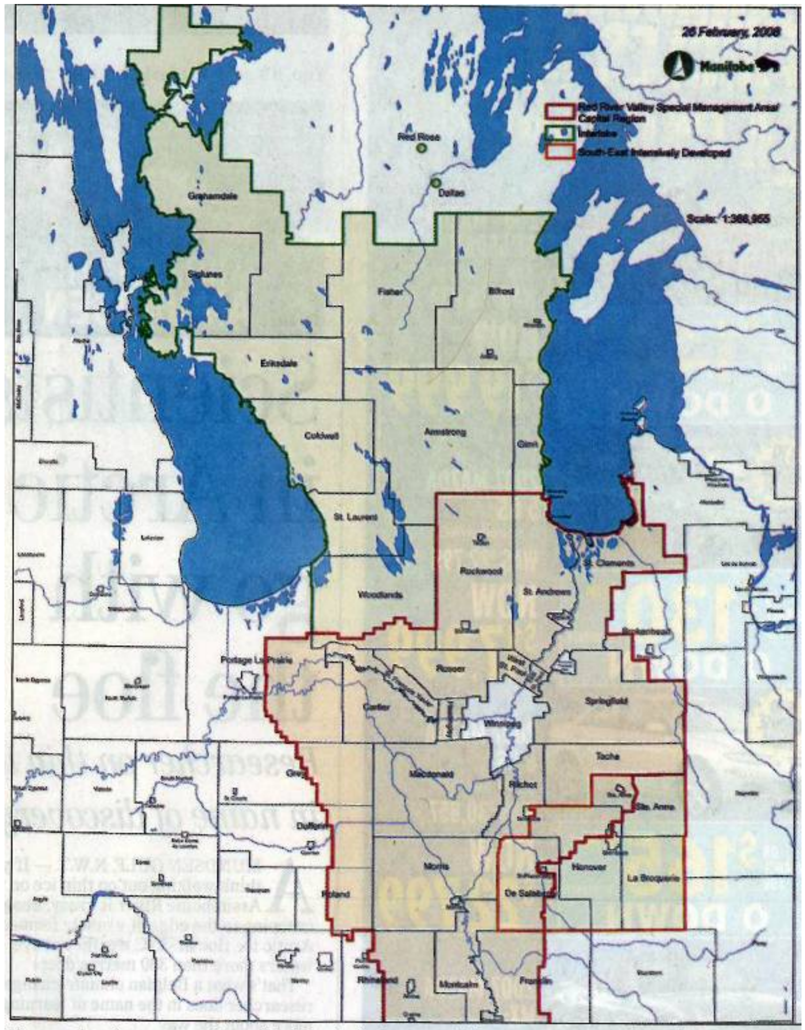
Land use both reflects and determines where economic activity takes place (Bergstrom, 2005). According to Bergstrom et al. (2005) land use not only affects the built environment and where individuals live and work, but also the quality of the natural environment, more specifically air and water quality. They add that land use has become an important policy issue for rural planners as it involves balance among community stakeholders that represent different factions that have significant impacts on economic and social well being of communities.

Sprawl may be viewed from two points of view. According to Bergstrom et al. (2005), sprawl is seen as wasteful and environmentally harmful by some while others (namely smaller municipalities) view sprawl as a local economic development opportunity. An increasing sense of urgency surrounds current and future land use decisions because of the large amount of capital investment that goes into rural non-farm developments that are in close proximity to livestock operations. Both the magnitude and the pattern of current land uses are at issue. Bergstrom et al. (2005) note that among all of the causes or determinants of modern day land use conflicts in America, the single most important reason is the "American Dream" or outright desire for large single-residential unit lots.

A quarter section of agricultural farmland (160 acre parcel), if redesignated and re-zoned for residential purposes could potentially be subdivided into 160 housing units of one acre each, not counting space for roads and sidewalks and other eases. Alternatively, with proper planning, farmers looking to sell off portions of their land may subdivide a smaller area (20-30acres) and still be able to build 160 housing units. By clustering 160 homes and establishing natural buffers in a 20-30 acres parcel, this will result in less likelihood of land use conflicts than if the land were to be fully developed over the entire 160 acres. Bergstrom et al. (2005) note, that the magnitude of development is the same in terms of the number of housing units created, but the pattern of development differs markedly, with the later being potentially more "environmentally, locally and traffic-friendly."

In the United States, and certainly in Manitoba, single-residential units have been the fastest growing residential category during the last decade, for reasons that likely have both social and economic origins (Bergstrom et. al, 2005). Bergstrom et al. (2005) note that advances in computer technology, changes in the social structure of workplaces have allowed more people to work from home and able to purchase residential units that are located in rural areas.

On March 4th, 2008 the Manitoba Government imposed an out-right ban on all new and expanding hog operations in the Interlake and Red River Valley. This area as shown in **Figure 3** covers almost all of central Manitoba. The moratorium has lowered values of the operations in the affected region and made it more difficult to transfer farms to next generation. Many livestock farmers in Manitoba are struggling to turn a profit. The profitability of farming in Manitoba has a direct impact on the rate at which farmland is converted into non-agricultural housing developments. Farmers are faced with a tough decision when residential users encroach on their operations and their land becomes more valuable than its use. In addition, aging farmers sometimes must choose between keeping their land in agriculture and cashing out their equity to retire (Bergstrom et. al, 2005). One lesson that can be learned from this outcome, is that proper planning and site tool analysis for land use conflicts and environmental impacts may have curbed the current situation.



No new hog farms are allowed in the shaded area, which covers most of central Manitoba

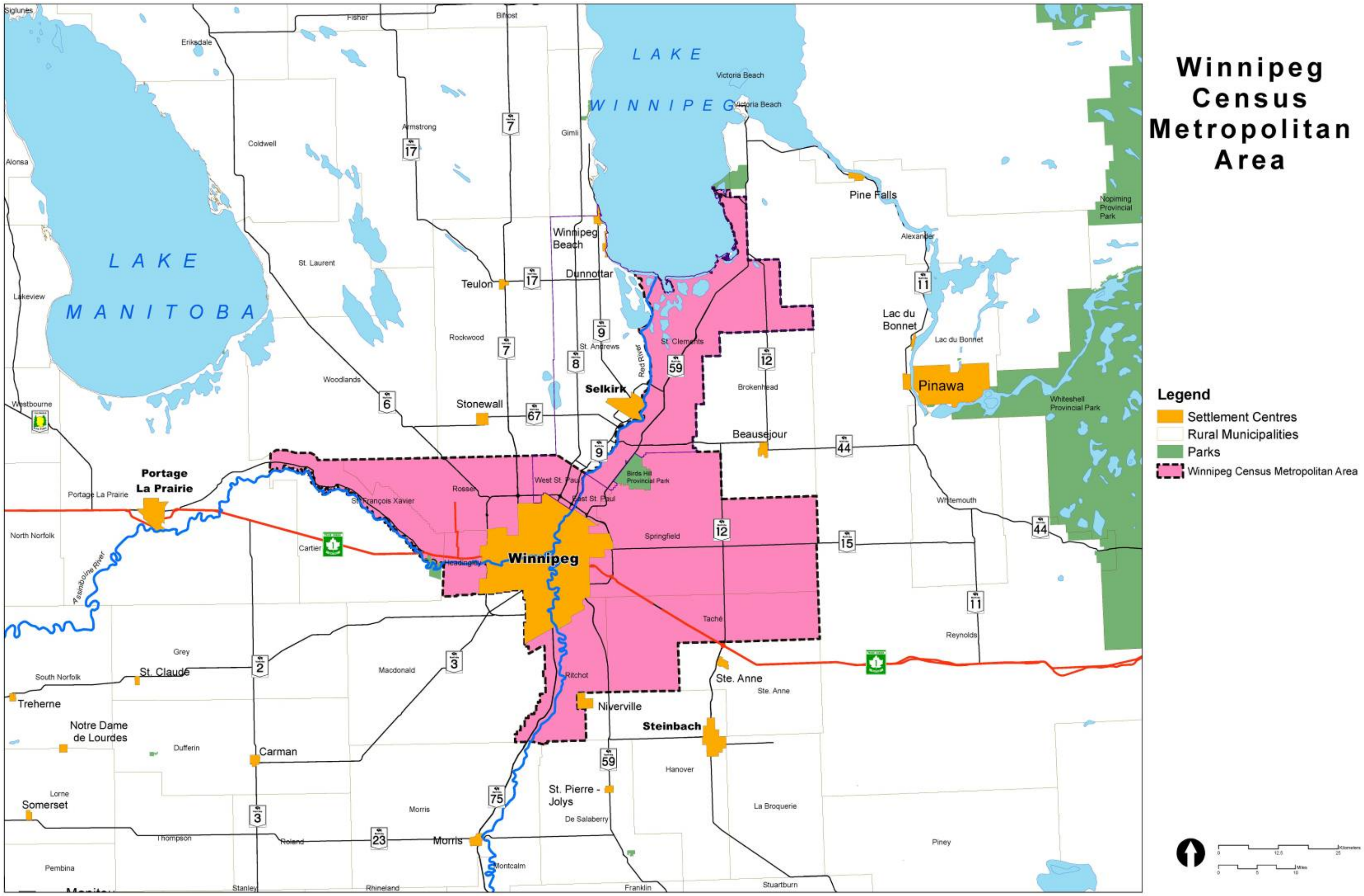
Figure 3 – No new or expanding hog farms allowed in shaded area, (Winnipeg Free Press, 2008)

Recent United States Department of Agriculture (USDA) reports show that an increasing number of people are living in rural “bedroom community” areas. There is a rising trend in the conversion of prime agricultural land (see Glossary of Terms) to urbanized non-agricultural purposes (Bergstrom et. al, 2005). Between 1992 and 1997, more than 11 million acres of agricultural land were converted to urbanized non-agricultural purposes in the US, 3 million of which were defined by the USDA as prime agricultural land - Class 2 and 3 soils (Bergstrom, 2005). In 2006, the total population for the city of Winnipeg was 633,451 and the total population for the surrounding municipalities that make up the census metropolitan area (CMA) had a total population of 59,037. The surrounding population figure represents roughly 8.5% of the total CMA population. Winnipeg and the surrounding municipalities that encompass the CMA are shown in **Map 3**. In Manitoba, a large percentage of people are living in rural municipalities outside of the city of Winnipeg. The increase in some of these municipalities, as previously shown in **Table 6** has been substantial compared with Manitoba's and Winnipeg's overall growth rates.

All provinces have programs to tax farmland on a lower mill rate and assessed value than other designated land uses. According to Bergstrom et al. (2005) these methods are used as incentives to protect the agricultural industry and keep farmers afloat. However, in realty these incentives guide rather than control growth. Development impact fees and exactions are increasingly popular ways to fund infrastructure. This "user pays" approach to providing public services is increasingly attractive among local officials, planners, and economics as the fairest approach to distributing the cost of development.

2.2 Rural Land Use Issues

Bergstrom et al. (2005) argue that unplanned low-density residential development has had the greatest impact on the rural-urban interface. In rural-urban fringe areas of Manitoba, large single-family homes have been built with lot sizes that vary from suburban-style subdivisions that are less than 1 acre in size to large rural lots of 5-10 acres. The growing population in the municipalities surrounding Winnipeg increases the demand for services that residents are accustomed to being available in the rural villages nearby. "Sprawl is the law of the land" (Richmond, 2000). As is typical with most metropolitan cities, the decline of the urban centre has resulted in the growth of sprawl in suburban and rural fringe areas (Bergstrom et al., 2005). Municipal governments, especially in the case of Winnipeg; depend primarily on property tax for their operating budget. In Winnipeg, property taxes represented 56.2% of the entire 2006 operating budget (City of Winnipeg, 2006). As populations continue to grow in the surrounding Capital Region Municipalities, the City of Winnipeg is faced with a major challenge of finding additional sources of revenue without significantly impacting the local economy. Services and the temptation to accommodate development is too great, even in the face of evidence that much of that development costs more to serve than it generates in local property taxes.



Map 3 – Winnipeg Census Metropolitan Area (Source: Manitoba Land Initiative, 2003)

> *The American Farmland Trust (1997), a national non-profit group encouraging farmland protection and stewardship, has sponsored dozens of local "cost of community services" studies throughout the US and concludes that on average, residential development requires $1.02 to $1.67 in service cost for every dollar in property tax revenue they generate, while commercial and industrial development cost $0.03 to $0.83 for a dollar in taxes* (Bergstrom et al., 2005:15)

Bergstrom et al. (2005) note that very seldom do small villages, towns and rural municipalities have full-time planners employed to work exclusively for that area. In most parts of rural Manitoba, planners are responsible for large planning districts that cover multiple municipalities, towns and villages. Thoughtful planning that incorporates a community's needs is essential in guiding effective policy. Planning gets people together to determine the vision of a community and to participate in community workshops that focus on deriving the needs of the community that will shape the planning strategies and policies (Hodge, 2001).

Price (1999) states that rural municipalities and district planning boards in Manitoba are often faced with pressure to develop "greenfield" sites. "Greenfield" sites are often undeveloped, have little or no infrastructure in place and are located at the periphery or outside of the city boundary. The National Roundtable on Environmental and Economy (1998) says "brownfield" sites are abandoned or under-used properties where past actions have caused real or suspected environmental contamination. They can include abandoned industrial sites, railways yards, decommissioned refineries or abandoned gas stations to name a few. In Winnipeg, many of these sites are located in urban areas, where existing municipal services are available, or along transportation corridors. "Brownfield" site developments have significant economic, social and environmental benefits, regardless of the project or the type of use. "Brownfield" site development fosters urban revitalization, improves aesthetic quality of the urban fabric, increases downtown population and housing opportunities and eliminates significant environmental hazards. Price (1999) notes that Winnipeg and the surrounding capital regional municipalities ought to explore the idea of implementing economic incentives that will direct development toward "brownfield" sites in order to slow pressure toward "greenfield" site development will slow.

2.2.1 Population Growth and Settlement

In the United States, population growth in metropolitan cities has steadily declined, while in the rural-urban fringe areas of large metropolitan cities it has increased from 7.1% during 1982-1987 to over 10% during 1992-1997 (Bergstrom, 2005). Bergstrom et al. (2005) note that during the 1990s, more than 80% of newly constructed homes were built in the suburbs. The spatial growth of cities has negative impacts on land and water quantity. Hellerstein et al. (2002) note that the pattern of low density single-residential housing development at the edge or in the surrounding capital region municipalities of large metropolitan cities raises concern over the costs of "urban sprawl" and create "car dependent" neighbourhoods. Sprawl that results in the conversion of prime agricultural cropland to non-agricultural urban-related uses raises issues of concern with respect to land use conflicts, the reduced quality and quantity of local food production, and the loss of "rural amenities". Rural amenities include open space, wildlife habitat areas and rural scenery. (Hellerstein et al., 2002). Bergstrom et al. (2005) note that in 2005, approximately 60% of Americans lived in suburban areas. In the same year, in the 25 largest metropolitan cities of the United States, 75% of Americans lived in suburban neighbourhoods.

The highest population growth rates in most metropolitan cities, including Winnipeg are at the rural-urban edges. Agricultural, social and economic change has now altered the way agriculture is viewed in the rural-urban fringe areas. The driving forces behind sprawl and spatial growth are numerous. In some large rapidly growing cities, such as Los Angeles, sprawl has taken place as a result of simple population growth. However in some cites, such as Winnipeg, average annual per capita land consumption has increased far greater than the average yearly growth rate (Lorch, 2002). Lorch notes that people are choosing to move to the suburbs or the case of Winnipeg, the surrounding capital region municipalities because of personal desires and the municipal governments' choice to facilitate this choice by welcoming single-family residential development. In Manitoba, the surrounding capital region municipalities have seen significant growth in the past decade.

Other cities in North America have taken measures to address their sprawling populations and promote "smart growth" development. In 1998, Tennessee passed legislation that requires counties to adopt and adhere to growth plans, including urban growth boundaries for each municipality (English et al., 1999). The *Smart Growth Law* in Wisconsin was passed in 1999 and gives funding priority to municipal governments that identify planned growth areas for development or redevelopment (English et al., 1999)

Population growth is not the sole determinant of urban land consumption. An equally important force is that of declining household size. Bergstrom et al. (2005) note that one of the main forces behind sprawl is the dynamic changes in household formation. Because the number of persons living in each housing unit has declined, more houses are now needed to house the same number of people. Family structure has significantly changed in Canada over the past 30 years. Family sizes have decreased, divorce rates have increased and fewer families live together communally. In 2006, about 48.5% of the adult population in Canada was married as opposed to single, separated, divorced or widowed. Statistics Canada: Marriage Database, 2006). This is the first time in Canadian history that the percentage was under 50%. The number of common-law relationships has increased 19.6% from 2001-2006 and now represents roughly 10% of the population in Canada. All of these factors help contribute to an increase in housing demand.

The average household size has dropped from 3.7 persons in 1950 to 2.5 in 2006 as shown in **Figure 4** (Statistics Canada: Census of Population, 2006). According to Bergstrom et al. (2005), the change in family size is also occurring in the United States and has created approximately 1 million new households each year. The family structure change in the United States has resulted in the same number of people now requiring 30% more housing than in 1950.

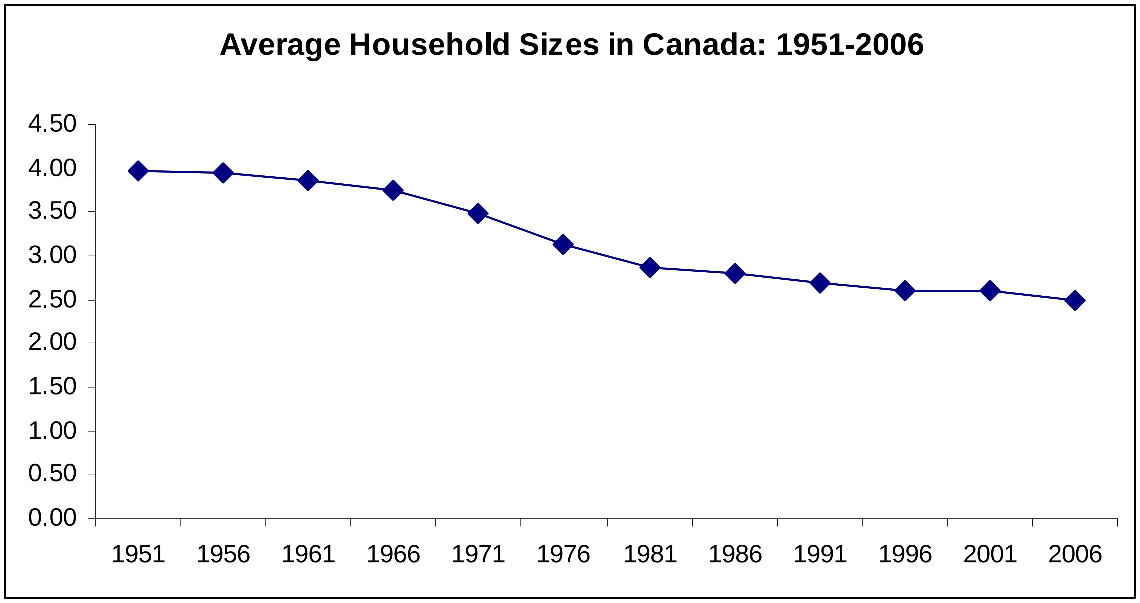


Figure 4 - Declining household size for Canada from 1951-2006 (Statistics Canada: Census of Population, 2006)

2.2.2 Trends in Population Location: The Rise of the Suburbs

Large-lot development around the urban-rural fringe areas of large metropolitan cities is not a new phenomenon (Anderson, 2002). This form of development has arisen primarily since automobile ownership became widespread post-World War II. However, Bergstrom et al. (2005) note that over the past 30 years in the United States, there has been a dramatic increase in the portion of land area that is used for single-family housing in rural fringe areas where residents seek the largest lot sizes that are available. Anderson (2002) notes that this isolated large-lot housing development (> 1 acre) beyond the urban fringe and gradually shades out into more and more fragmented developments posing consequences for agriculture and the environment.

The traditional perception of a city is that of a central core of economic activity surrounded by “bedroom” suburbs from which residents commute daily. However, in today’s North American cities, businesses and other economic ventures are detached from the central business district of the downtown and spread across the entire metropolitan area. Bergstrom et al. (2005) note that some United States cities have seen larger growth in the percentage of employment located in suburban and urban fringe areas than in the central city. Lorch (2002) notes that in Winnipeg, large business centres have recently been built in suburban and surrounding capital region municipality locations. One recent exception is the new Manitoba Hydro building, which is the first addition to downtown office space in Winnipeg in several years.

The suburbanization of businesses in the United began in the 1950's coincided with the advancements in automobile transportation over the past century which provided for an increased the range of location choices for residential, commercial and industrial functions (Knight et al., 1972). Bergstrom et al. (2005) note that housing preferences have also changed as have business locations to more suburban locations. People's choices to locate in suburban or surrounding rural-urban fringe areas have been influenced by hath the automobile revolution and advancement in communication and computer technology which has enabled more people to work from their homes. People and jobs often move together. In the United States, 60% of the total national office space is located in the suburbs, which reflects a 25% increase in suburban office space since 1970. Bergstrom et al. (2005) note that new businesses locating in the suburbs have partly been a result of population growth in suburban locations movement of jobs to suburban locations.

New businesses in Winnipeg have been geared towards the car-dependency of the city's population by locating in suburban locations where they can provide ample, free parking. The rent for downtown office space can be equal to that or even less than newly constructed office space that is located in the suburbs (Lorch, 2002). Bergstrom et al. (2005) state that businesses that are located in the central business district of a large metropolitan city offer greater access to public transportation and are typically able to be located within close proximity to other related businesses. In addition, the "friction" costs, which refers to the costs of moving goods, services and employees, increases as the distance from the central business district increases (Bergstrom, 2005).

2.3 Land Use Conflicts

2.3.1 Advancements in Technology

Advancements in computer and information technology have allowed for an increasing number of people to work from their homes. Bergstrom et al. (2005) note that people are no longer tied to the central business district of major metropolitan cities for conducting business. Bergstrom et al. (2005) note that the regular commute to the central business district for work purposes is no longer required. Telecommunication, the internet and e-mail have, for some, removed the necessity of daily travel to places of employment located in the central business district of large metropolitan cities. The result of this is a greater choice in location for individual homes and businesses.

Recent innovations in technology have reduced the costs of communication and transportation needs to and from the central the business district. However, Bergstrom et al. (2005) note that in large metropolitan cities, these innovations have resulted in residential and commercial developments in areas great distances from the central business district. In turn, more land per unit of workforce population is being consumed in the suburbs and the rural-urban fringe than in the central business district of large metropolitan cities.

2.3.2 Encroachment of Rural Residential Development

Over the past 30 years, non-agricultural land uses have encroached upon agricultural land uses. Caldwell (2003) notes that the increase in population for rural-urban fringe areas in Ontario has led to conflicting land uses and an increase in property taxes for some rural communities due to the costs of infrastructure and services. The subdivision of agricultural land produces fragmented lands, which in turn reduces the viability of agricultural production. Some municipalities have done little to support the protection of farmland. Caldwell (2003) notes that the loss of one acre of agricultural land for non-agricultural, rural residential purposes is significant, but it pales in comparison to the restrictions associated with that lot. Each residential lot has the potential to restrict more than 300 acres from a livestock operation. This is based on the type of livestock, manure system and size of barn as determined using the minimum setback requirements for livestock operation (Provincial Land Use Policies, 2005).

Tensions between modern agricultural uses and residential uses in rural areas are a common problem throughout North America and are becoming more and more apparent in Manitoba. The expansion of residential development in rural-urban fringe area of the capital region municipalities for Manitoba which are predominantly agriculturally-based municipalities has added to the population base and the potential for conflicts (Royal

LePage, 2004). People migrating to rural areas in the Manitoba capital region typically have urban ideologies with different values and expectations of the rural lifestyle. The likelihood of land use conflicts and complaints over issues of noise and odour between a livestock operation and a neighbouring rural residential dwelling unit has increased at locations where either the operation or residential development or both have intensified (Royal LePage, 2004). This is particularly evident in parts of rural Manitoba. There are a number of hog farms in close proximity to non-farm rural residential developments. A great deal of planning is required for the site selection process for new residential developments.

Although no scientific evidence has been produced, Perry (2003) notes that some residents who live near intensive livestock operations have reported incidents of headaches, nausea and respiratory problems. The Farm Practices Guidelines for Hog Farmers (2006) recommends injecting manure into fields rather than spraying and using straw to cover manure storage facilities (see Glossary of Terms). This practice greatly reduces odour and decreases the likelihood of nutrient runoff. The human response to odour is very subjective. What is offensive to one person may be tolerable to another. The rapid increase in hog production in Manitoba combined with the increase in people living in rural-urban fringe areas that are close to hog operations over the past 10 years has increased the levels of public concern. There is very little scientific information available as to the level and variability of the odour emissions from hog operations in Manitoba. However, Elite Swine Inc. conducted a measurement of odour emissions in 2001 (Plohman, 2001). It was found that odour emissions were approximately equal for small-scale and large-scale hog farms. The lowest emissions were found to be on lagoons that were covered with straw and in nearby fields that were injected with manure rather than sprayed (Plohman, 2001).

The *Farm Practices Protection Act* (1992) deals with situations when agricultural practices conflict with surrounding residential development. It is designed to protect farmers within reason, based upon the fact that “they were there first”. However, an ever- increasing rural population is producing a strong voice and opposition to odourous hog operations that are close to their homes. As Caldwell (1999) notes, the intensification of agriculture often leads to conflict within surrounding rural development and local communities. As livestock facilities have become larger and more geographically concentrated, some people living in proximity to these facilities have expressed concern related to odour and water quality. Caldwell (2003) notes that some provincial and municipal jurisdictions are forced to deal with pressure from developers seeking to add residential development near existing livestock operations that would add a great deal of revenue to the property tax base. At the same time, municipal and government officials are also faced with pressure from livestock operations looking to expand or develop near land that could potentially be developed for residential development. Who has priority? As a result of these conflicts, provincial and municipal officials have been forced to develop regulations, acts, zoning and development plan policies to try and mitigate these situations.

It is very difficult to find a single industry in Manitoba that has sparked more public resistance and opposition than the intensification of the Manitoba hog industry. Vandean (2003) notes that although several politicians in the past 10 years welcomed and encouraged the dramatic growth of Manitoba's hog industry as a means of employment and tax revenue, the increased negative publicity voiced from local rural residents, activist groups and government departments increased the skepticism of hog development within rural-urban fringe areas of the capital region municipalities in Manitoba. Recently the falling hog prices, increasing feed prices, strong Canadian dollar and moratorium on expansion in Manitoba have caused the industry to slump (Rance, 2008). Rance notes that sustainable agriculture in Manitoba needs livestock production, including hogs. The expansion of the hog industry is uneconomic now and for the near future. In 2008, the hog industry took the blame for poor water quality in Manitoba Lakes and Rance (2008) asks, "has the Government of Manitoba abandoned the hog industry altogether?" There are over 1,200 hog producers in Manitoba that contribute over $1 billion to the Manitoba economy.

Trying to minimize land use conflicts with regards to intensive livestock operations is a difficult task. Jain (1995) states that some municipal and provincial governments have placed an increased emphasis on environmental quality which in turn demands more from livestock producers to ensure they follow the appropriate practices, guidelines and regulations that have been put in place to establish environmental standards. Several citizens are urging their local and provincial governments to increase the level of regulations and control the location of new livestock operations.

2.4 Livestock Production in Manitoba

2.4.1 Hog Production

Like any agricultural industry in Manitoba, it feels the impacts of market fluctuations. Currently, the rising Canadian dollar, poor hog market prices and the hog moratorium that has been imposed by the provincial government have put a strain on hog producers in Manitoba. In Manitoba, the total number of hogs dropped by 8.9% from 2005-2006 and by 11.7% over that same period nationally, which also represents the largest annual drop in 30 years (Statistics Canada: Census of Agriculture, 2006). With many hog producers facing the reality that euthanasia is a cheaper solution, the federal government has agreed to compensate Manitoba hog farmers with $50 million for 150,000 sows (Kusch, 2008). This works out to roughly $325 per sow and according to Dickson (2008) this is not enough. The federal government added one stipulation; hog producers that agree to compensation and euthanize their stock are unable to restock their farm for three years. Those operations deemed to be legal non-conforming will not be allowed to re-establish unless provided for in the zoning by-law. The hog industry in Manitoba has come full circle. For a once rapidly expanding industry that caused so much controversy that the provincial *Planning Act* (2005) added a new policy that all development plans must include a livestock policy with clear direction on where operations are permitted, not permitted and where permitted up to a certain size. It would seem that the hog industry in Manitoba is disappearing. However, farmers adapt as the market changes. 2008 grain prices in Canada are high (approximately $9/bushel) but this is liable to fluctuate along with the price of pork. On April 23rd, 2008, the Provincial government announced that they would provide $500,000 in funding to hog producers. Hogs that were scheduled for euthanasia were in turn used to feed Manitoba’s less fortunate (Northcott, 2008). These funds helped process 5,000 surplus sows which produced 150,000 kg of pork for food banks in Manitoba. Wiebe (2008) notes that this represents only about 20% of the hogs that will be euthanized which means the remaining 80% will not be processed for food banks unless the Province and Winnipeg Harvest can find additional funding sources.

Between 1991 and 2001, the number of hog farms in Manitoba declined by more than 50 percent from 3,150 to 1,280, while the average number of hogs per farm has more than tripled (see **Figure** 5) with the average number of head per farm has increased from 388 to 1290 (Statistics Canada: Census of Agriculture, 2001). The number of hogs produced has gone from 3.2 million to 8.8 million over the same period. (Pork in Manitoba: Manitoba Agriculture, 2006). Manitoba has more than 5 million hectares of land suitable for agricultural production and has seen significant change over this period.

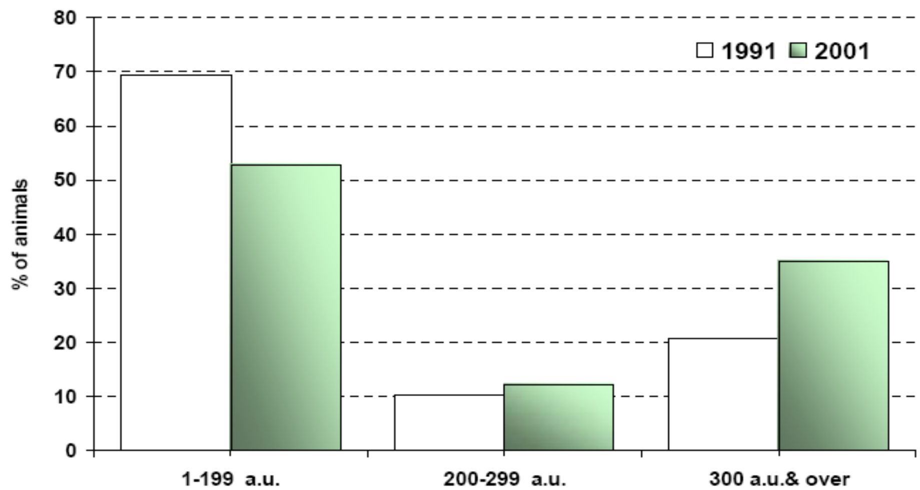


Figure 5 – Percentage of livestock (>300 Animal Units) on farms in Canada, (Statistics Canada: Census of Agriculture, 2001)

Cattle production has decreased while hog production increased more than sevenfold from 870,000 in 1975 to 6.7 million in 2006 (Pork in Manitoba: Manitoba Agriculture, 2006). The concentration of animals on large livestock operations (greater than 300 animal units) increased significantly from 1991 to 2001 in Canada. Manitoba almost doubled in the percentage of large livestock operations (greater than 300 animal units) from 1991 to 2001 as shown in **Figure 6** below.

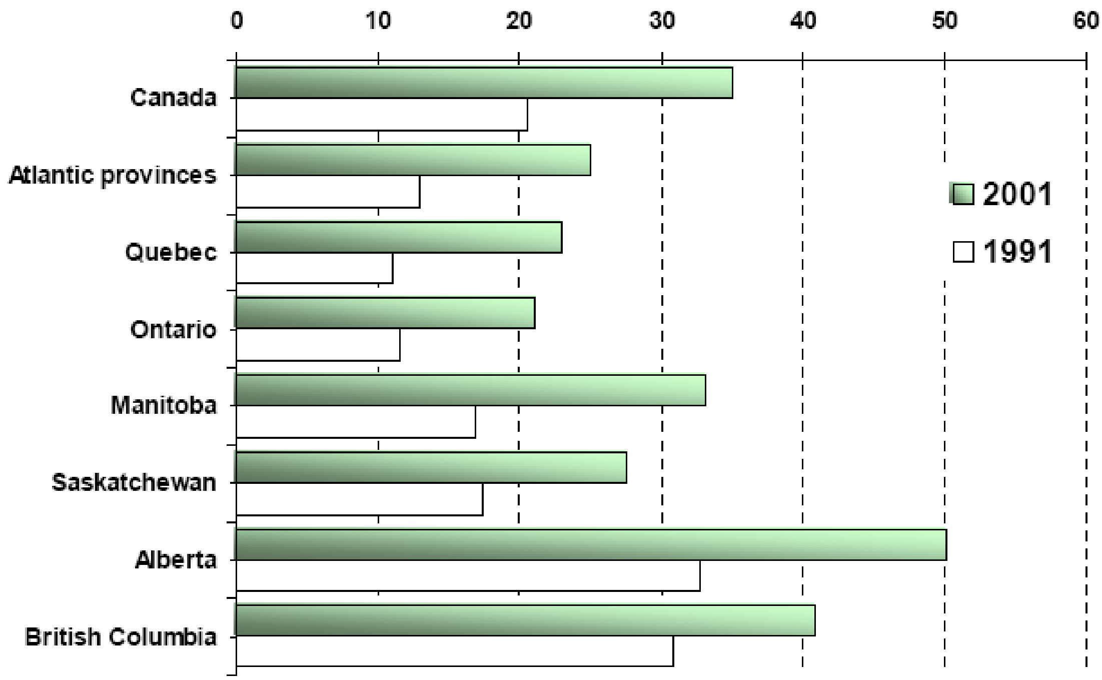


Figure 6 – Percentage of livestock on farm by province in Canada, (Statistics Canada: Census of Agriculture, 2001)

From 1991-2001, the most significant change in rural Manitoba in the type of farm operations has been a trend toward increased intensification of the livestock industry. The average number of hogs on farms has nearly doubled over this ten-year period, but the number of facilities to support this growth has only risen slightly. This can cause severe environmental hazards, and stress existing lagoons including lagoon leakage (Sustainable Livestock Development: Manitoba Agriculture, 2006) due to this more concentrated hog industry. Total hog production in Manitoba rapidly increased from 3.2 million hogs in 1996 to 4.8 million in 1999. In 1999, Manitoba exported over 2.2 million live hogs to the United States (Pork in Manitoba: Manitoba Agriculture, 2006). Manitoba is the largest hog exporting province, next to Quebec (Manitoba Livestock Industry Profiles: Manitoba Agriculture, 2006). Manitobans consume only about 11 percent of the pork produced in the province, while the remaining 88 million kilograms is exported mainly to the United States and Japan at an estimated value of $240 million (Manitoba Livestock Industry Profiles: Manitoba Agriculture, 2006). The hog industry in Manitoba has been able to contribute $1 billion to the economy. Novek (2003) notes that livestock operations have been transitioning into more commercial/industrial sized operations.

Mcdougall (2000) noted that some of the factors that influenced the growth of the hog industry from 1991-2001 included: lower grain prices, the loss of the Crow Benefit on export grain resulting in farmers facing the full cost of freight and lower feed grain prices and an increased in demand for meat around the world. As previously mentioned, this has completely changed, with grain prices rising and hog prices plummeting. It should be noted that over a 10 year period beginning in the mid-late 1990's the hog industry rapidly expanded giving rise to large hog production facilities that created an industrialization of pork production in Manitoba (Guilford et al., 1999).

2.4.2 Social Impacts

Opposition to large livestock barns often is associated with "NIMBYISM" (not in my back yard) attitude and in some cases has lead to intense emotional debate and conflict. The debate can pit one part of the community against another, raise fundamental questions about how we want our communities to evolve and can lead to questions concerning the role of agriculture in the local community. This emotion can complicate the best intentions of involving the community in policy development, implementation and ongoing monitoring

Large-scale livestock operations are wide-ranging and important for the local economy (Commissioners' Report, 1999). Local residents cannot control the business practices of livestock operations. However, they must deal with the social consequences of the industry's presence. To some, the agri-industrial meat production system that has developed in North America has been described as threatening the long-term sustainability of rural and small town communities (Commissioners' Report, 1999). Traditional livestock farms, which are owner-operated and involve little hired help, are quite different from the large-scale operations. The large-scale operations are usually corporate-owned, operated by a manager with some hired help, and are often part of an integrated meat production and processing organization (Commissioners' Report, 1999). The large-scale operations are more technologically advanced and require less hired help than small scale operations, which has resulted in some displaced jobs in some rural areas throughout North America (Commissioners' Report, 1999).

In Manitoba, large-scale livestock operations that exceed 300 AU tend to be both family and corporately owned, while in Missouri, Iowa, and other parts of North America, corporate livestock operations have tended to eliminate family farm operations (Commissioners' Report, 1999). These family-run operations have a hard time competing with a vertically-integrated industry that artificially depresses livestock prices. Harrowsmith Magazine (February, 2000), for example, advises "anyone who lives the rural life…to …Scream bloody murder if some agri-business proposes to build a 200 sow finishing barn within 10 miles of your place." These types of attitudes reflect legitimate interests in air and water quality, but also reflect subjective paranoia about livestock farming that is not always justified.

In rural communities, planners are often faced with local opposition over proposed development and/or expansion of livestock operation. Caldwell (2002) notes that for planners, this can be a very difficult situation. Planners can be caught in middle between livestock producers' economic needs and desire to expand their operations and extreme community opposition as a result of municipal by-laws and regulations that reflect a more urban perspective.

The growing trend has raised concerns about social impacts like air quality (odours) and long-term protection of environmental resources - surface water, groundwater and soil quality. Decisions made today concerning these issues must seek to balance job creation and rural economic diversification with the longer term needs of communities to safe guard quality of life, the environment. It is generally understood all these factors contribute achieving sustainable development within the Selkirk and District Planning Area.

2.4.3 Environmental Impacts

Odourous gases are generated by the microbial breakdown of plant and animal proteins. The three main sources of manure odours include the following: livestock barns, manure storage areas and manure spreadfields (Livestock Odours: Sources, Concerns and Solutions: Manitoba Agriculture, 2006). The level of odour emissions varies from one operation to another and may be affected by the size of the operation, the design of the operation and the type of manure storage/handling system. Fong (1973) notes that the level of odours emitted from the actual operation themselves are generally of low intensity. Modern day operations are equipped with carbon filters and intensive air filtration systems that attempt to minimize odours in these facilities to make it comfortable for the workers and the animals. The nearby manure storage facilities and the spreadfields produce the most potent odours.

Perry (2003) states that manure odour can have serious health impacts. Manure contains over 150 gaseous compounds, including hydrogen sulfide, ammonia, carbon dioxide, and methane. Harmful gases can collect and bond to dust particles in livestock operations, which can be very deadly when inhaled. If a manure-holding pit located beneath the floor of a livestock operation barn is significantly disturbed, large amounts of hydrogen sulfide can be released into the barn. The Manitoba Government Department of Agriculture has produced guidelines that attempt to ensure that manure pits have fans in them with a substantial ventilation system (Livestock Odours: Sources, Concerns and Solutions: Manitoba Agriculture, 2006). Dust particles are still a major concern in large-scale modern hog barns. As minute as these particles may be, the ventilation system may eliminate most odour particles. Some dust particles may have small fragments of manure attached to them. The Manitoba government has produced regulations related to when manure is to be applied to fields and has helped to establish a safe working environment in the Farm Practices Guidelines for Livestock Producers.

Water contamination is a major concern with the growth of the Manitoba Hog industry. Novek (2002) notes that the E. coli tragedy in Walkerton, Ontario has increased fears of water contamination in other parts of rural Canada that have large concentrations of livestock operations. Grassroots activism has grown rapidly over the rapid expansion of the Manitoba hog industry. A group called "Oly-Opp" formed in the fall of 2006 in an attempt to prevent the construction of a hog processing plant in St. Boniface called Oly West. Public concern over hog facilities typically centres around the issues of public health. There is public concern that high nitrate levels can develop in local wells, ponds and local water bodies from surrounding hog farms (Manitoba Agriculture, 2005). Nitrates can leach from the soil into underground aquifers, contaminating well water. The extent of nitrate contamination depends both on soil type and on depth of the water source (Manitoba Agriculture, 2006). The Manitoba government has set forth regulations for manure use in Manitoba (Funke, 2003). Funke notes under classification from Manitoba Conservation, a majority of the agricultural soils in Manitoba tend to be alkaline and therefore are able to bind tightly to phosphorus. Therefore, the phosphorus content of manure that is applied on fields poses less of a threat to Manitoba lakes and streams then other provinces in Canada. Funke adds that nitrates are soluble in water. And the recent moratorium on hog operations certainly implies that the poor water quality of Lake Winnipeg is attributed to the hog industry. If manure is injected into the soil it poses less of a risk to water contamination, provides the crop with more nutrients and gives off fewer odours. Manure application is cheaper than chemical fertilizers and supply is readily available.

In general, Manitoba and particularly the surrounding capital region municipalities are comprised of clay based soils. Unlike sandy soils, clay based soils make nitrate leaching more difficult. Macleod (2003) notes that although leaching can be accelerated or decelerated based on soil type, heavy rains and/or surface flooding also impact the amount of nitrate that reaches both ground and surface water. Baumel (2002) explains that there is some public concern that the amount of nutrients, specifically nitrogen and phosphorus that are added to soil from hog manure, exceed crop requirements and the retention capacity of soil. In Manitoba, this has been a contentious. The moratorium placed on hog operations in Manitoba by the Provincial Government in Manitoba (April, 2008) was attributed to high nitrogen and phosphorus levels in Lake Winnipeg. Manitoba Conservation has advised that surplus nutrients in Manitoba waters, including surface and groundwater systems pose a risk to human and ecosystem health. Guilford (1999) notes that there is both public and private concern that manure from waste lagoons and fields can potentially seep deep enough in the ground and contaminate groundwater which is used for drinking wells which that rural communities use as their source of drinking water. Large-scale hog barns use anywhere from 700 to 1025 litres of water per hog to process coming from a variety of sources depending on the proximity of the hog barn to municipal services. Green (1996) conducted a study to determine the effects of hog manure application on snow cover to water quality during spring runoff in the Manitoba Interlake Region. It was found that nutrient concentrations significantly increased in drainage ditches at sample sites downstream. A random set of fields was selected along with nearby surface water samples. Green (1996) explains that some areas saw a significant increase in phosphorus and ammonia nitrogen.

Runoff from a confined livestock area could harm water quality if it is allowed to enter a surface watercourse. Guilford (1999) explains that excessive amounts of nutrients, including nitrogen and phosphorus can increase aquatic plant growth. If these nutrients enter a surface watercourse, the ammonia forms and levels can be potentially deadly. Runoff may also contain pathogenic organisms, including E. coli and salmonella, which if present in sufficient numbers, create a health hazard. Nitrate leaching is a major environmental concern. Leaching of nitrate-nitrogen occurs if excess nitrates are not utilized by the crop and are moved down the soil profile by infiltrating water (Land Application of Manure: Manitoba Agriculture, 2006). This usually occurs if too much manure is applied to a field by a method other than injection. If nitrates move out of the root zone, the nitrates eventually end up in the groundwater, where they may cause adverse health effects in drinking water (Land Application of Manure: Manitoba Agriculture, 2006). It is imperative that farmers follow The Farm Practices Guidelines for Hog Farmers and apply the manure in the spring using injection procedures. In addition, the *Sustainable Development Act* (1997) abolished all steel lagoons and enforced the use of concrete structures or clay lined lagoons. As a result there have been fewer instances where there have been lagoon leaks that caused serious problems in water quality.[1]

Larger hog operation proposals (i.e. more than 400 Animal Units - soon to go down to 300 Animal Units) must now demonstrate that they have sufficient land (owned or made available to them) to ensure that manure does not exceed crop requirements. Manitoba Conservation annually audits a sample of these larger operations for compliance with maximum levels of nitrogen in nitrate form in the first 60 cm of soil. The Acts and Regulations of the Manitoba government are quite comprehensive and

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[1] The *Sustainable Development Act* abolished all steel lagoons and enforced the use of concrete structures or lagoons. As a result there have been fewer instances where there have been lagoon leaks that caused serious problems in water quality. An engineer must approve the design of a new operation and inspect it every year. As well, a random number of farms are completely audited every year for total inspection. The Manitoba Government introduced legislation further safeguarding the quality of drinking water in Manitoba. Government initiatives saw the establishment of the Office of Drinking Water, the re-introduction of subsidized water testing for private well owners and the certification of drinking water operators (Manitoba Pork Council, 2006). All of these measures have helped to reinforce existing regulations to provide a safe, clean water supply.

specify that manure can only be applied as a fertilizer on the land; this being done at agronomic rates to ensure that the manure's nutrients are balanced with nutrient requirements of the crop to be grown. Conceptually, this is no different than what should also be happening with chemical fertilizers, except that manure fertilizer is regulated and chemical or synthetic fertilizers are not (Land Application of Manure: Manitoba Agriculture, 2006). The amount of manure to be applied must be calculated based on soil testing and manure nutrient testing. For all livestock operations of 300 Animal Units (AU) or over, this must be included along with type of manure, quantity and location and method of spreading in an annual manure management plan to be registered with Manitoba Conservation (Land Application of Manure: Manitoba Agriculture, 2006). According to Manitoba Conservation, there is no general requirement for owning a specified piece of land surrounding the hog barn to which manure must be applied. More often than not, neighbouring crop producers are delighted to receive the free fertilizer and when the competition grows, neighbouring producers have to pay for the manure (the cost is usually much lower than for commercial fertilizer equivalents).

Environmental impacts both perceived and real are the main impediment to hog industry expansion. Phosphorous and nitrogen levels are continually monitored from local water bodies around hog farm operations. Routine samples are taken from water bodies around the province and tested. On a regular basis, Manitoba Conservation monitors water quality around the province, in particular around Lake Winnipeg and ensures that there are sustainable environments.

2.5 Land Transformation Trends

The transformation of rural land uses is the result of three realities, all of which are linked to the *fundamental regional land-use equation*. The first reality is an increasing population in the bedroom communities of cities. The second land-use reality is a trend toward lower gross urban density largely driven by lower residential densities. A 2002 survey by National Association of Realtors (NAR) and the National Association of Home Builders (NAHB) reveals the preferences of recent homebuyers (NAR, 2002). Single-family detached homes were the choice of 76% of them. When asked how they would rank 16 criteria for choosing their next home, after price, the feature receiving the greatest percentage of very important/important responses, 62%, was “houses spread out”. “Bigger houses” received 47% and “bigger lots” received 45%. “Away from the city” received 39%. Given the combination of homeowner preference and lower land prices beyond the urban fringe, it is no wonder that residential densities appear to be declining. The third land-use realty is related to the issue of density. The average household size is decreasing. This is attributed to a range of social changes within the United States and Canada, including an increasing number of single person households. The result is that more housing units are required to accommodate the same population.

Because of current trends in gross urban density and household size, it is clear that more land is required by fewer individuals than ever before. Add to this population growth, and the fundamental land-use equation has demonstrated that the acres of land required for human settlement is an increasing number. This has contributed to *sprawl*, the rapid and inefficient expansion of urban/suburban land use. The NAR survey previously cited, asked the same home buyers who they thought was responsible for sprawl. 49% of the respondents placed the blame on builders/developers, 48% with elected planning officials, 43% with consumers who want larger homes and 37% with the local government.

2.6 Geographical Information Systems (GIS)

A geographic information system (GIS), also known as a geographical information system, is any system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to Earth. In the strictest sense, it is any information system capable of integrating, storing, editing, analyzing, sharing, and displaying geographically referenced information. In a more generic sense, GIS is a tool that allows users to create interactive queries (user created searches), analyze the spatial information, edit data, maps, and present the results of all these operations.

GIS manages information describing the territory and offers spatial analysis operators:

> GIS is an integrated system of computer hardware and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced (Lysenko, 2004).

A well-designed GIS should be able to provide quick and easy access to large volumes of data, both spatial and non-spatial. A GIS can analyze and manipulate spatial data by selecting details by area or theme, lining one dataset with another, analyzing spatial characteristics of data and the ability to update data efficiently. Using GIS as a tool for displaying, integrating and interpretation of information has immediate value for rural municipalities in planning for livestock operations. According to Aspinall (1993), a GIS can be used to simply monitor land use changes, but a more sophisticated system can be used to predict future land use changes and evaluate the potential impact of land use decisions. GIS offers an ability to store information in a highly accurate, multi-function manner that not only assists in planning decisions, but also provides the ability to display data spatially which aid in the creation of highly detailed maps.

Rural municipal investment into a GIS is becoming more common in Manitoba. The raw spatial data required to properly use these systems to their potential is also becoming increasingly available at an acceptable cost. Individuals working in a planning office often have access to spatial data that includes both thematic and infrastructure layers along with aerial photos. However, this information is often used solely for inventory purposes and the potential for using GIS as a land use planning tool is overlooked. According to Craw (1999), if increasingly complex land use planning problems are to be thoroughly examined and properly addressed by a GIS model. The implementation of a land use system model can provide for effective land use planning.

With the collection of agricultural and residential data, demographic and resource information can be incorporated into a GIS and analyzed to create map products that spatially illustrate different management options to assist in the management of agriculture. Information developed will allow local decision makers to analyze current livestock regulations and operations and assess future livestock expansion proposals. A GIS model for land use planning is capable of spatially illustrating options, issues, and information relevant to decisions for livestock development within the provincial and municipal regulatory frameworks. This application does not replace the need for site-specific assessment of each operation; however, it can assist in general land use planning for the Planning District.

As with all computer-based analysis, a GIS is only as good as the data that it uses. Aspinall (1993) notes that GIS can be used in a variety of ways for land use planning, including inventory and assessment. It can be also be used for predicting impacts of policies and/or the effects of change in land use (Aspinall, 1993). GIS can be used as a tool for proper planning and siting of livestock operations which minimize associated environmental problems and conflicts (Jain, 1995). Jain notes that the potentially adverse environmental and social impacts of livestock operations can be minimized if planners and other land use decision makers are able to use an effective spatial decision support system (see Glossary of Terms), such as a GIS.

Conventionally a GIS has been used by local municipalities and planning districts to assist in identifying areas where future livestock operations and residential development should take place. Clear policies and planning are needed to establish accurate buffers to try minimize land use conflicts. Effective land use policy and administration depend on accurate information. Investment in digital mapping and land use information will pay off now and into the future. Integrated GIS provides models with spatial analytical capabilities. The GIS component can provide a more detailed and analytical approach to examining land use conflicts. The implementation of a GIS model developed as a tool for rural land use planning has yet to be explored in planning districts throughout the province. This multiple objective approach to land use planning requires sufficient data and software that will allow planners to explore alternative approaches to land use planning.

3.0 Developing a GIS Model

Current and anticipated trends suggest that as the rural community becomes increasingly urbanized, there will be an escalation of conflict between non-farm rural residents and livestock operations. Agriculture remains a main stable contributor to the labour force in the RM of St. Andrews. While the total number of people employed by agriculture has declined in the last thirty years, the number of animal units per farm has increased. Some modern large-scale livestock operations are technologically advanced and require fewer employees. The Manitoba capital region municipalities have experienced significant growth over the last two census periods and are projected to continue at a higher growth rate than the city of Winnipeg. The literature review for this study presented an overview of the current trends and major issues pertaining to hog farming in the Selkirk and District Planning Area and the Province of Manitoba. GIS LUCIS modeling was presented as alternative strategy or tool at the disposal of local municipalities and/or planning districts in order to carefully analyze future growth areas and methodology to reduce land use conflicts. The primary intent of this section is to build on the literature review and lay the foundation for the development of the LUCIS GIS model for the RM of St. Andrews. This section will attempt to answer the following questions:

1) Is the current provincial legislation and methodology for siting livestock operations effective in reducing or preventing land use conflicts in the RM of St. Andrews?
2) How do the views of local government officials in the RM of St. Andrews and the Selkirk and District Planning Area on land use issues for livestock operations compare with the literature?
3) How can a GIS modeling be used to minimize land use conflicts in the RM of St. Andrews?

3.1 Rationale for Research

The intensification of the hog industry in the late 1990's and early 2000's in Manitoba has contributed to land use conflicts within rural communities. Intensive developments in the livestock sector in the late 1990's to early 2000's have been a particular catalyst for debate and action within many rural communities. As livestock facilities have grown larger, become more geographically concentrated, and more reliant upon technology (for example liquid manure injection systems) some people living in proximity to these facilities have expressed concerns related to odour and water quality. In response to this conflict provincial and municipal governments are thrust into the midst of the issue and are pressured to develop policies that are able to protect the agricultural industry as well as promote non-farm rural residential developments. Albeit this is conflicting in and of itself, the resulting approaches include a mix of legislation, policy, local by-laws and recommendations concerning management.

3.2 Introduction to Research Objectives

An understanding of the range of issues related to conflicts between non-farm rural residents and livestock operations reveals many areas in the province could be used as study cases. The research question to be addressed in the practicum dictated the type of research untaken. This chapter identifies the problems faced by the livestock industry - caveats to research that ensure a manageable subject area that led to the research question, which was the basis for inquiry in this practicum.

3.3 Problems

As demonstrated by numerous newspaper headlines and the Government of Manitoba's Task Force Inquiry on Livestock Production, there is a close correlation between increasing land use conflicts with proximity and mixing of livestock operations and non-farm residential uses. Mixing non-farm residential uses within developed livestock production areas, adds uncomfortable levels of anxiety and the financial uncertainty about the future of the livestock industry.

The growth in the Province's livestock industry from the late 1990's to early 2000's represented a challenge to both the Provincial Government and local municipalities to take action to ensure that growth of this industry was achieved in a sustainable manner. Planning District's and municipalities are the approving authorities when the local Development Plan contains provisions for livestock developments and therefore are very important to the future of the livestock industry. A study of the relation between local planners and land use specialists, the livestock industry is valuable in determining how planning for livestock will take place in the future. The view of local government officials working in the Selkirk and District Planning Area regarding planning for livestock operations, and ascertain how that view compares with the literature. Sub-problems linked to this involve the three aspects of sustainability. These aspects are:

- Environmental - how livestock operations have impacts on the land water, and air;
- Social - how livestock operations have impacts on neighbours; and
- Economic - how livestock operations have impacts on local and regional economic development.

3.4 Caveats

Although the two elements of the livestock industry, namely production and processing, are inextricably linked, the issues they raise are sufficiently different to warrant individual study. In addition, the land use issues surrounding livestock production are arguably more compelling and far-reaching for the land use planner than those issues pertaining to processing.

Also, this practicum will not focus on the entire province. Instead the Rural Municipality of St. Andrews and the Selkirk and District Planning Area Board from a regional context will be considered as representative of the livestock industry for reasons previously discussed. This also simplifies the conduct of a study and compilation/analysis of collected data from interviews. It is not the objective of this practicum to attempt to change what has already happened, but to assess the industry and utilize GIS tools that will enable effective long term land use planning.

Finally, the intended interviews are proposed for both local planners and land use specialists. It is the local level of government that will ultimately decide whether livestock farming is sustainable or not by approving or rejecting applications for development. While the provincial officials obviously have a stake in this matter, they are included in the interview since land use decisions are also made at provincial level.

3.5 Rationale for Developing a GIS Model for the RM of St. Andrews

A thorough knowledge of the considered and rational thought provided by environmentalists, social scientists, and economists is very important in comprehending issues related to the livestock industry. More specifically, decisions and subsequent action in the Selkirk and District Planning Area of Manitoba undertaken by rural councils as a result of applications for livestock farm development and/or non-farm rural residential developments. In determining the status of land use conflicts in the RM of St. Andrews Manitoba, it is necessary to relate academic thought to the will of elected officials on rural councils in the Planning District.

The dynamics of the land use conflicts in the Selkirk and District Planning Area requires the issue are examined a local geographic context. The study area’s current land use has been examined to determine the local and regional forces that influence land use conflicts. The data that has been used for this study are described in further detail in **Appendix B: Data Collection**. GIS mapping data has been used to examine two variables:

1. Spatial Capacity

Through on-site field verification and GIS analysis, the spatial capacity of the area has been quantified. Land use features, number of residential units and total number (and type) of livestock operations (including number of animal units) has been recorded and used to assess the spatial capacity and land use demands placed upon the study area.

2. Ecological Capacity

Ecological capacity was assessed based. GIS land resource analysis and observations derived from interviews. Soil erosion, land use/vegetation types, drainage levels and percentage of slope were all used in assessing the ecological capacity of the study area.

3.6 Preliminary Key Informant Interviews: Building a Model

The following section discusses the findings from the key informant interviews with current and former planners from the Selkirk and District Planning Area Board. Each participant brought a different perspective to the study. The primary objective of the interviews was to gain a greater appreciation of how conflicts between rural non-farm residents and livestock operations are perceived in the RM of St. Andrews, MB and secondly, to aid in the development of a GIS decision support tool model for the purpose of accurately analyzing land use conflicts on a spatial level.

In December of 2008 and January of 2009, two preliminary interviews were conducted with key informants. The interviews, which ranged from approximately 30 minutes to 45 minutes in duration, made use of a set of standardized questions that were developed prior to the interview process (see **Appendix E: Key Informant Questions**). Semi-structured questions were used for the interviews, which allowed for greater flexibility during the interview process. Participants were able to elaborate and be more candid with their responses. Prior to conducting the key informant interviews, a trial run with the standardized questions was administered to a colleague of the researcher, who provided feedback on structure and delivery method of conducting the interviews.

While the research initially used the same standardized questions to generate discussion with each stakeholder, additional probing questions that flowed from the discussion were asked. This triggered questions from the interviewee regarding how a GIS decision support tool model may be used by the Selkirk and District Planning Area Board and the RM of St. Andrews. Both participants cited a current land use conflict between a specific livestock operation and certain surrounding non-farm rural residents. This current land use conflict is ongoing and as such there were no follow up questions regarding whether this conflict had been resolved in a timely and efficient manner. Below is a discussion of the key issues identified by informants.

3.6.1 Planners from Selkirk and District Planning Area Board

As the literature review discussed, Statistics Canada: Census of Population (2006) showed a significant increase in population in the rural-urban fringe areas of Winnipeg's capital region from 1991-2006. Bergstrom et al. (2005) note that a common trend has emerged across Canada - in-migration from urban centres resulting in a population increase of rural-urban fringe areas. Figures from Statistics Canada: Census of Agriculture (2006) would suggest that the farming population across Canada fell to a historic low in 2006. In 1931, one in three Canadians lived on a farm; that number has dropped to one in forty-six in 2006. Statistics Canada: Census of Agriculture trends have shown that farmers have moved from growing food and raising livestock for themselves to producing food for cities and export. Large-scale livestock corporate farms have pushed production volumes up steadily, thus forcing producers to continually increase the size of their operation to cover their costs. Planners from the Selkirk and District Planning Area Board must balance the demand for non-agricultural residential development with large-scale modern highly specialized livestock production operations. This task is extremely challenging and as the planners both discussed this ongoing issue that has led to several land use conflicts between non-farm rural residents and livestock operations.

A select sample of planners that are currently or were previously employed within the past 5 years for the Selkirk and District Planning Area Board were asked to participate in the study. In total, two planners (one former and one current) from the Selkirk and District Planning Area Board were interviewed for this study. These planners are typically responsible for reviewing subdivision applications, and development proposals for the entire planning district. They are also responsible for reviewing, amending and updating the district development plan and respective municipal zoning by-laws and secondary plans. They both have many years of experience in rural land use planning and planning for livestock.

Both planners agreed that as mandated by the *Planning Act* (2005), the RM of St. Andrews must identify areas where livestock operations are permitted, permitted up to a certain size and not permitted. They must also identify the separation distances in the zoning by-law for livestock operations (earthen manure storage) based on the Provincial Land Use Policies (2005). The municipality may exceed this separation distance but cannot go below the required distance. The separation distances for livestock operations (earthen manure storage) are based on the number of animal units, which are calculated using the Animal Unit Summary Table from the Provincial Land Use Policies (2005). Each type of animal is assigned a different animal unit. The total number of animal units per operation determines the separation distance for each livestock operation based on the Provincial Land Use Policies (2005). The development plan identifies designations into which livestock operations may be located and the maximum number of animal units allowed. The zoning by-law provides further details regarding how many animal units are allowed in each designated zone. Both planners agreed that this is an accurate summary of how the Provincial Government determines the criteria for separation distance for livestock operations and added that the RM of St. Andrews follows this methodology fairly closely and they are generally appropriate for creating separation distances between existing non-farm rural residences and livestock operations. One planner noted that these distance guidelines serve as a minimum distance for all livestock operations. Minimums setback distances are required when municipalities and planning offices do not have the resources and expertise to determine a science based separation distance calculated on more than one factor - amount of animal waste. The animal unit summary table takes into account the amount of waste each type of animal produces. Furthermore, animals that produce more waste are given a higher multiplier and thus must be farther away from non-farm rural residential land uses than animals that produce a small amount of waste. The guidelines assume that waste and odour are the only nuisances of livestock operations. However, there may be other factors such as noise, environmental impacts and traffic associated with livestock operations that for which the separation distances are not factored.

The development plan and zoning by-laws (for each respective municipality with the planning district) are evaluated by both the Selkirk and District Planning Area Board and Provincial Planning Services and take in to account all provincial legislation and regulations to ensure consistency. One planner added that this methodology tends to minimize land use conflicts. However, this also places significant limitations on where livestock operations can expand where/how new operations establish. It was noted that some livestock operations are grandfathered from these regulations. It was noted that a methodological standard for separation distances between rural residential dwellings and livestock operation uses a “one size fits all” approach. More context sensitive solutions could be used that takes into account such phenomenon as prevailing winds and topographical features.

According to one of the planners, the most important criteria in determining separation distances from livestock operations are the nearest residential dwelling and public health related issues. It was noted that nuisance factors such as noise and odours need to be taken into consideration when determining appropriate separation distances and health factors are by far the most important. Livestock production methods are constantly changing with technological improvements that minimize odour and environmental concerns. It may be fair to reduce the minimum separation distances for livestock operations that incorporate modern odour minimizing technology. However, it was noted by one of the planners that the biggest challenge in reducing the minimum separation distances for livestock operations that incorporate modern odour minimizing technology would be appropriate monitoring of these management practices. One of the planners noted that the use of anaerobic digesters (see Glossary of Terms) for manure storage could potentially reduce the minimum separation distances from provincial highways and the number of non-farm rural residents within the specified municipal separation distances. Livestock operations were noted as important criteria in determining appropriate separation distances from livestock operations and non-farm rural residents. Prevailing winds should also be taken as to consideration in terms of whether a livestock operation is upwind or downwind from non-farm rural residents and/or designated settlement centres. One planner noted that drainage patterns are an important separation distance factor because livestock operations located on gradient surface may produce nutrient runoff in to nearby water bodies and drainage networks.

One planner made reference to a large-scale hog farm operation in the RM of St. Andrews that is located in close proximity to several non-farm rural residents. Planners from the Selkirk and District Planning Area Board have received several complaints from non-farm rural residents that are in close proximity to livestock operations regarding odour and environmental issues. One planner noted that at present there is little that the RM of St. Andrews and/or the Selkirk and District Planning Area Board can do to address this specific land use conflict. The Selkirk and District Planning Area Board has explored the possibility of persuading the operator to relocate to a more suitable location; however, this does not seem to be a viable or financially feasible option for the operator. It was noted that non-farm rural residential subdivisions surrounding this livestock operation should not have been permitted and it is likely that building permits were granted prior to the formation of the Selkirk and District Planning Area Board.

One of the planners agreed that current hog moratorium on new or expanding hog operations in the Red River valley region that was imposed by the Provincial Government in April, 2008 should help in minimizing land use conflicts in the RM of St. Andrews. Another planner agreed that the moratorium will eliminate land use conflicts with hog operations in the RM of St. Andrews for the present time. However, this planner added that if the moratorium is lifted in the future, land use conflicts between hog operations and non-farm rural residents are likely to arise. It was noted that the hog moratorium has eliminated potential new conflicts between new or expanding hog operations and non-farm rural residents. However there are larger implications associated with this decision. Both planners agreed that the hog moratorium has placed a significant impact on the agricultural industry because there is no opportunity for new or expanding hog operations within the RM of St. Andrews. One planner added that non-farm rural residential growth is strong in the RM of St. Andrews and may continue to expand closer to livestock operations. There is a constant demand for residential development in the municipality. Traffic and congestion is a concern when increased non-farm residential subdivisions develop on or near roads that were originally built for low traffic agricultural purposes and not intended to handle large traffic volumes or to be serviced on a regular basis. One planner felt that the hog moratorium has a negative implication for the RM of St. Andrews. This planner felt that a science based analysis on a case–by-case basis should be used to determine the carrying capacity of any additional or expanding livestock operation within a specific location of a municipality. Furthermore, a restriction on any new or expanding hog operations may cause hardship for farmers in the hog industry and could potentially decrease the value of their land and entity based upon increased restrictions of permitted uses for their land.

Both planners stressed that the existing land use conflicts in the RM of St. Andrews could have potentially been avoided with prior land use analysis. They both stressed that using GIS models provides a great opportunity for the Board to make optimal land use decisions, such as designating policy areas in the Development Plan and Zoning By-Law and could potentially reduce future land use conflicts between non-farm rural residences and livestock operations. Both planners noted several environmental factors and criteria if taken in to consideration by the RM of St. Andrews, would aid in the ability of determining optimal siting of livestock operations:

- Prevailing winds
- Drainage patterns
- Hazard areas (flooding)
- Number of dwellings within specified distances
- Type of waste storage, treatment, disposal
- Type of animals
- Distance from major road networks
- Distance from ecologically sensitive areas (heritage marshes)
- Distance from waterways
- Soil capability and distance to aquifer
- Land values within the area
- Areas designated for residential development
- Areas designated for recreation and park
- RM St. Andrews residents' tolerance for agricultural nuisances

Ensuring orderly development of land, one planner felt that ecologically sensitive areas, land values within the study area, areas designated for recreation and open space and the RM of St. Andrews residents' tolerance for agricultural nuisances are the most important criteria. However, from a nuisance perspective, this planner felt that prevailing winds, number of dwellings within specified minimum separation distances, type of waste storage, type of animals, distance from ecologically sensitive areas, distance from waterways and soil capability and distance to aquifers are also equally important criteria.

One planner noted that using a sustainable development framework that spatially models social, economic, and environmental criteria of locating a livestock operation is valuable as a multitude of criteria that should be taken in to consideration. The planners added that both RM of St. Andrews and Selkirk and District Planning Area Board would be aided in having the capability to conduct detailed environmental land analysis for any new or expanding livestock operations. However, the technical learning curve for performing this analysis may be steep. They both noted that if the skills to perform in depth GIS modeling can be acquired, this method of land use planning and site analysis has the potential to positively contribute to minimizing future land use conflicts between non-farm rural residents and livestock operations in the following ways:

- Greater empowerment of the Selkirk and District Planning Area Board to perform detailed long term land use analysis;
- More efficient analysis in creating and designating policy areas in the Development Plan;
- Allows for optimal siting locations of both non-farm rural residences and livestock operations;

3.6.1 Summary

The key informants interviewed for this study both come from similar academic backgrounds and had general concurrence regarding the key issues associated with land use conflicts between non-farm rural residents and livestock operations in the RM of St. Andrews. Both informants agreed that rural land use conflicts in the Manitoba, and more specifically in the RM of St. Andrews, are a difficult ongoing issue that local municipalities and planning districts confront on a regular basis. In all cases, improper land use planning was cited as the main reason for land use conflicts in the study area. Discussion with planners from the Selkirk and District Planning Area Board revealed two common themes related to the development of GIS model: highly detailed analysis for long term land use planning, optimal site analysis and the ability to potentially minimize land use conflicts between livestock operations and non-farm rural residences.

One planner made several references to a specific land use conflict in the RM of St. Andrews and stated that odours was the most commonly mentioned complaint from adjacent non-farm rural residents. In addition, informants noted land use conflicts are difficult to resolve at the present time without resulting to the relocation of a livestock operation. Issues related to health and odour was stressed by the planners as the two most important factors in determining minimum separation distances from livestock operations. It was argued that the ease of use and effective detailed analysis of a GIS model that is able to perform multiple tasks will be more likely to be accepted amongst planners and municipal officials in both the RM of St. Andrews and Selkirk and District Planning Area Board.

Minimizing land use conflicts through alternative approaches to siting of livestock operations and long term land use planning was perceived as having considerable value to the planners. Informants noted that the current moratorium on new and expanding hog operations within the Red River Valley in part arose because of several land use conflicts between non-farm rural residences and livestock operations. The planners noted that this legislation has put a significant strain on the industry. Informants agreed that one of the most important lessons a planner can learn when addressing land use conflicts is to respect both parties equally. The use of a GIS model for planners was positively viewed as a helpful tool that could potentially reduce the number of land use conflicts between rural residences and livestock operations with the RM of St. Andrews and the entire Selkirk and District Planning Area Board. Informants noted that land use conflicts between rural residences and livestock operations are not a recent phenomenon, but have certainly increase in recent years with the increase of non-agricultural residences to the study area.

3.7 Using a GIS to Identify Land Use Conflicts

There are various types of research questions. These include exploratory, descriptive, explanatory and predictive. GIS can be used to help answer all types of research questions. For exploratory questions, a GIS can help determine if a spatial pattern exists. For descriptive questions, a GIS can be used to see if the pattern has changed over time. To adequately represent current livestock operations relative to land capacity and social constraints, the Rural Municipality of St. Andrews needed to develop capabilities that allowed for the acquisition and utilization of information for use in decision-making. With the collection of agricultural and residential data by Selkirk and District Planning Area Board staff, councilors and local residents; demographic and resource data were loaded into a GIS and analyzed to create map products that spatially illustrate different management options to assist in the sustainable management of agriculture in St. Andrews. Information produced by the GIS allows local decision makers to analyze current livestock regulations and operations and analyze future livestock expansion proposals. This product does not replace the need for site specific assessment of each operation but assists in general land use planning for the RM. Data needed to complete the project was discussed and agreed upon.

A GIS analysis has used to produce a spatial layer that through overlay analysis can show the comparative capability of the study area's land resources to accommodate livestock operations. The mapping attributes describing non-farm rural residential and livestock development potential and constraints when overlaid provide a composite view of how the variables in site characteristics combine to create an understanding of land use suitability to sustain livestock operations. This GIS tool has been used to create a long term planning strategy to mitigate land use conflicts. The LUCIS model has been used to reassign nominal ranking values based on suitability potential for land use conflicts to the base layer and GIS overlay data. This data has been reclassified based on the nominal values. Using the LUCIS model operation, key areas for suitability and land use conflicts were identified. By conducting a comparative analysis of the LUCIS model and the existing RM of St. Andrews Development Plan policy areas, one is able to visually see the similarities and differences as well as the advantages and disadvantages of both methodologies.

It should be noted that the designation of site limitations for a given area does not automatically preclude all development. It acknowledges the existence of one or more constraints that in some circumstances may be resolved subject to precautionary actions.

Simulation of land use changes is important for a variety of planning and management issues. By utilizing a GIS model, it can provide the baseline growth scenario to show the future land development pattern when the current land development process continues into the future. The baseline growth can be used to assess future urban development problems. Such simulation provides useful information about locations, types, scale, amount and density of land conversion that will probably take place. Hathout (1988) notes that simulation of land use changes enables planners to provide the public with the proper tools make effective land use planning decisions that minimize future rural land use conflicts. The simulation of land use changes can help to assess development impacts, prepare land use plans, and seek optimal land use patterns. It can also identify the possibility of severe land use problems, such as the encroachment on important environmental areas, including protected wildlife habitats and other environmentally sensitive areas.

3.7.1 Land Use Conflict Identification Strategy

The Land Use Conflict Identification Strategy (LUCIS) is a goal driven GIS model that produces spatial representation of probable patterns of land use (Carr, 2007). The probable land use patterns can be divided among others, areas of probable future conflict between agricultural land and urban land uses. LUCIS was developed over a period of 10 years in a graduate design studio at the University of Florida Departments of Landscape Architecture and Urban and Regional Planning. The conceptual basis was derived from the work of ecologist Eugene Odum and his 1969 article “The Strategy of Ecosystem Development.” Odum proposed four general land use types in a simplified model. In his compartment model, all areas of land use were classified into four categories: (1) productive areas, (2) protective areas, (3) compromise areas and (4) urban/industrial areas. Odum wrote that “by dividing land uses into these four categories and by increasing or decreasing the size and capacity of each compartment through computer simulation, it would be possible to determine objectively the limits that balances on the exchange of vital energy and materials” (Odum, 1969, 268). This systems analyst procedure was the basis for LUCIS land classification scheme. The LUCIS model uses three land use categories rather than four, which include agriculture areas, conservation areas and urban area. Using three categories rather than four tends to maximize the contrast among the categories and relates better to the patterns and purposes of public and private land ownership (Carr, 2007). There are five steps to the LUCIS model. The first step involves defining goals and objectives that become the criteria for determining suitability. The second step involves identifying resources potentially relevant to each goal and objective. The third step focuses on analyzing data to determine relative suitability for each goal. The fourth goal involves combining the relative suitability of each goal to determine the preference for the three land use categories of LUCIS. The final step involves comparing the three land use preferences to determine the likely areas of future land use conflicts (Carr, 2007).

LUCIS is a GIS model that is able to produce a spatial representation of future land use patterns for areas of probable future conflict between agricultural and urban land uses (Carr, 2007). LUCIS can be applied to any land-use project as the application of its results develops an alternative for land use planning. Carr (2007) notes that LUCIS provides an opportunity for users, especially planners to visualize, analyze and interpret future land use changes on a regional scale. This form of analysis provides an opportunity for planners to spatially represent land use changes over time. The output results of LUCIS modeling reveal the distribution of potential land use conflict areas. As such, upon implementation of this model, planning districts, including the Selkirk and District Planning Area Board are able to explore alternative land use planning strategies and effective polices to reflect this approach.

GIS is a relatively new tool to many municipalities and planning district offices in Manitoba. It has been traditionally used as a tool to store spatial data as a large inventory database. Carr (2007) notes that the potential for GIS is great and can be used to help municipal and planning district offices to resolve complicated land use planning issues. Some Rural Municipalities and/or Planning Districts in Manitoba have faced extraordinary pressure to make decisions on siting and approval of new/expanding livestock operations. Carr notes that these decisions are somewhat contentious as they deal with environmental, social and economic issues. This model allows for an ability to see the connection between land use decisions and the long-term spatial consequences.

McHarg (1969) first introduced the overlay analysis method for evaluating land use issues. He focuses primarily on patterns of land use and the morphology of human settlements. He makes clear and comprehensible recommendations for reversing the destructive process of development. McHarg falls short in his approach by not applying weighting factors to his overlay analysis method (only 3 categories of land class were employed for any given layer on an ordinal scale). As GIS has evolved over time, more training and education is required for users to fully understand the capabilities of the software. Lynch (1960) captured people's mental images of an urban environment and applied a level of importance (on an ordinal scale) to features of an urban environment. He had to take the time to train participants in his 'language' that included introducing the concepts of nodes, edges and landmarks in order for them to fully participate. Today, participants in this study will have to be trained in GIS and LUCIS in order for them to assist in the calibration of the weightings for the model and to provide critical feedback on this approach.

The tension between non-farm rural residents and livestock operations in Manitoba is coming under greater scrutiny than ever before. Carr (2007) notes that there are three stages to conflict: *prevention, resolution and settlement*. This study will focus on the prevention aspect. Rather than traditional mapping which asks "what is most suitable to determine preference, the more analytical approach based on LUCIS modeling is to ask the question; which of the suitability criteria are most important?" This study will use the LUCIS analytical hierarchy process transformation values for common data sets. The data used in this case study can be found in **Appendix B: Data Collection**. The model uses a number of strategies for ranking suitability of criteria. Essentially, this technique will assign weighted values to the data shown in **Appendix B: Data Collection** based on a series of ranking and analytical techniques determined by the user in the LUCIS model. Next, the layers will be combined using the assigned weighted values to create a single suitability layer.

4.0 Application of a GIS Model

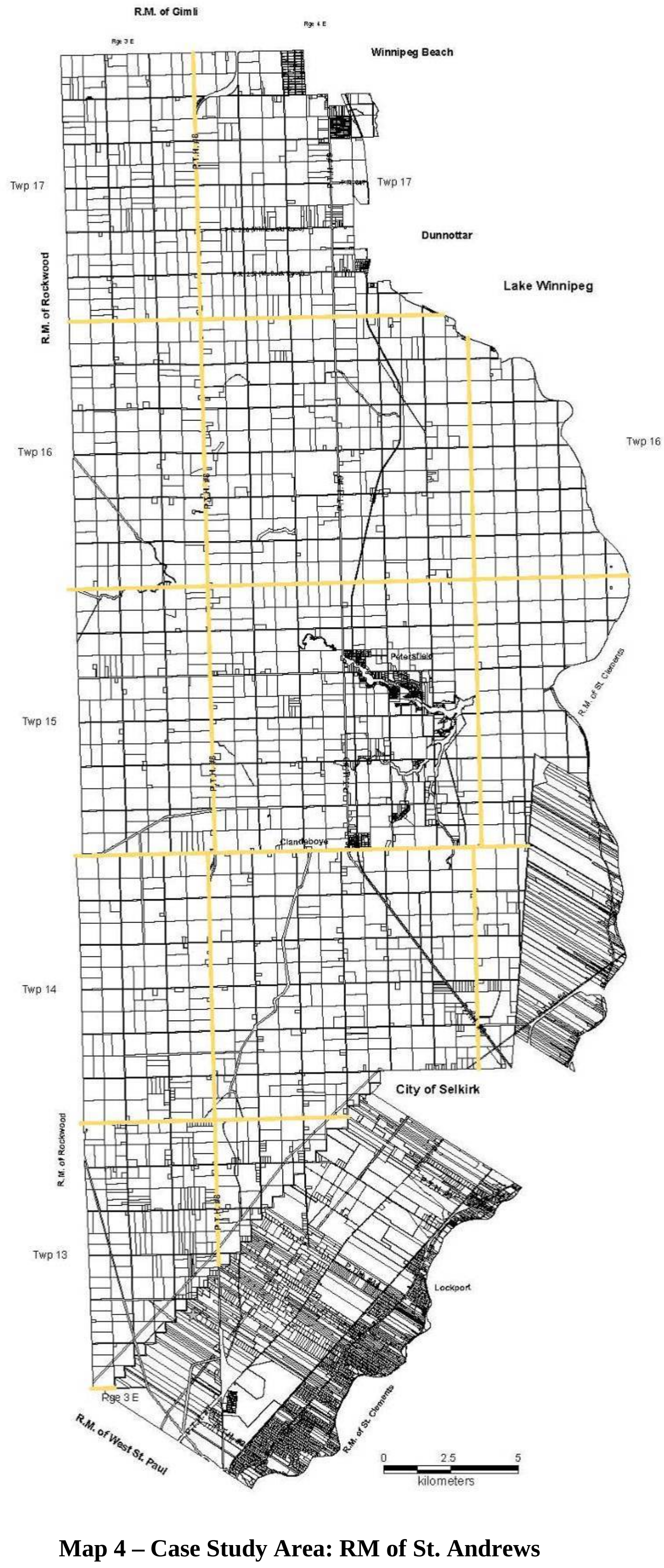
The research undertaken for this project consisted of two primary methods: 1) GIS LUCIS modeling; and 2) focus group interviews. Each of the methods provided important information regarding land use conflicts. ArcGIS 9.2 with the Spatial Analyst Extension was used for the GIS modeling in this case study. The Euclidean Distance, Reclassify and Single Map Algebra Tools were used for creating the sub-models, models and goals. All reclassified values use an ordinal scale with a value range of 1 to 9, with 1 representing the lowest suitability and 9 being the highest suitability. All weighted values that were multiplied using the Single Map Algebra Tool and totaled to a combined value of 1. The RM of St. Andrews was chosen as the case study area for this research. **Map 4** and **Map 5** highlight the case study area.

4.1 Introduction of Suitability Modeling

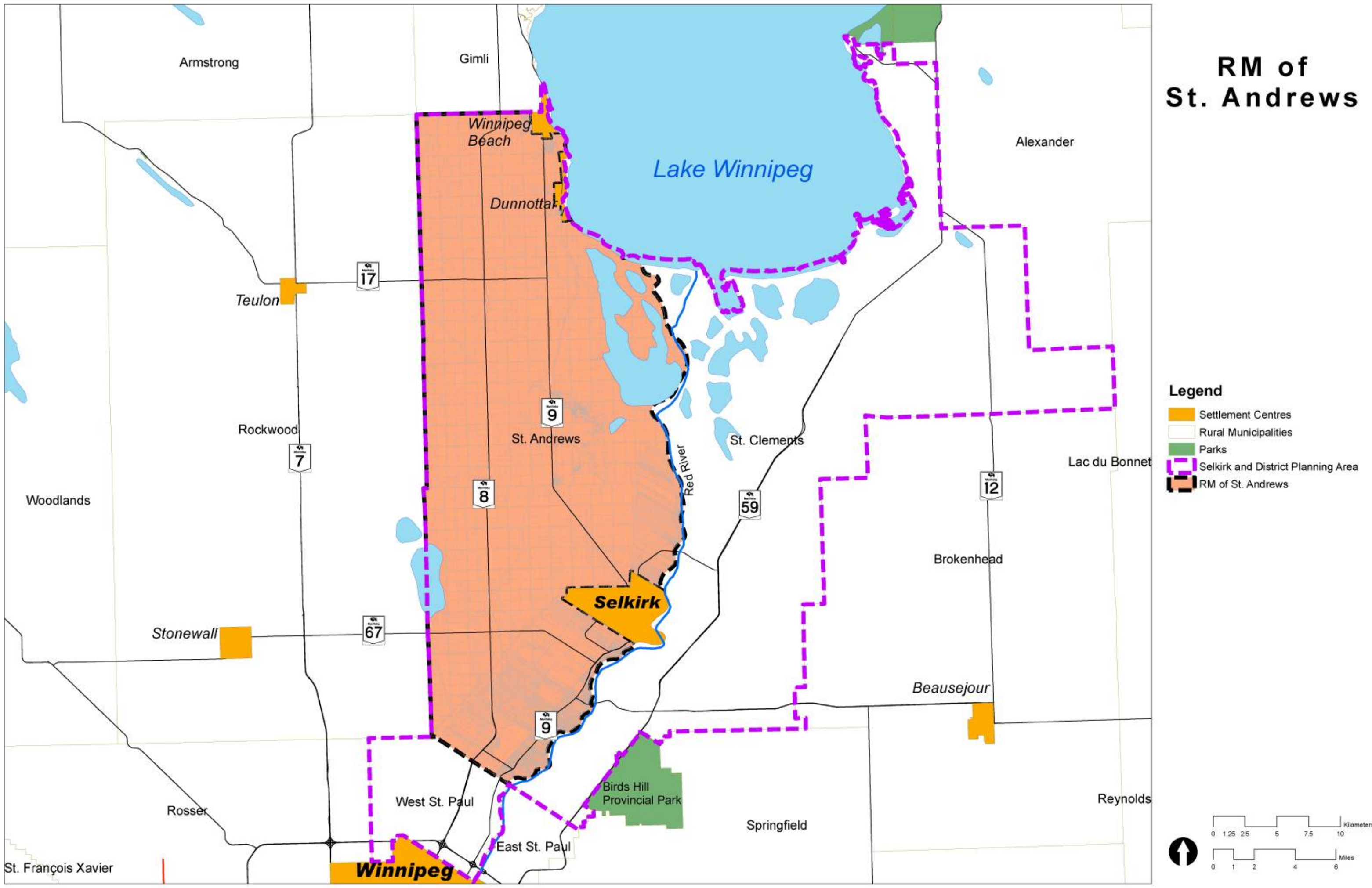
Suitability modeling is not a recent phenomenon. The earliest well documented example can be attributed to Charles Eliot and Warren Manning, who collectively worked together in the Olmsted landscape architecture practice in the late 1800's. They utilized "sunprints", the overlay of transparent maps – each representing different characteristics of a site – on a window in order to view multiple criteria simultaneously (McHarg et al., 1998). By having the ability to visualize different factors and criteria simultaneously, it allowed for designers to more accurately determine suitability of site for development. During the mid-twentieth century English and Scottish planners were known to have used overlay maps and to have combined layers into a representation of suitability mapping. The elimination of areas with constraints and the evaluation of the remaining areas revealed suitability. Ian McHarg described how to use overlay mapping using vector data. Vector data is a coordinate-based data model that represents geographic features as points, lines and polygons (Carr et al., 2007). Individual factors were analyzed to support a variety of land uses and maps were created using a range of light to dark values. Since the time of McHarg's manual overlay techniques for suitability analysis, the evolution of GIS has fueled the development and application of modern suitability analysis (Carr et al., 2007). Many others have explored suitability analysis mapping, including Lewis Hopkins in 1977, John Lyle in 1985 and Nicholas Chrisman in 2002. Today, suitability analysis is typically done using raster data, which is in contrast to McHarg's early vector work. While the analysis of LUCIS is primarily done with raster data, base vector data is used to build raster data sets and determine suitability. Raster datasets are composed of equally-sized cells organized into rows and columns. Each cell is a square. Cell size is determined by the length of one cell and the area of the cell of determined by the squaring the cell size. Combining raster layers to determine suitability may appear to be a simple process because the processing time is fairly quick. However, it is requires a complex understanding of characteristics of combined data sources, rules on combining spatial data and an understanding on how to develop goals and objectives to be used as a guide for suitability analysis (Carr et al., 2007).

4.1.1 Levels of Measurement

There are four basic levels of measurement for data: nominal, ordinal, interval, and ratio. Nominal data provide no quantification, simply a name. Nominal data are categorized by type. For example, land uses (such as residential, commercial, industrial or conservation) would be categorized using nominal data. Ordinal data contain no measurements just ranking or order between categories. For example, residential homeowners may be categorized as wealthy, moderate and poor. Each category can be directly in relation to another. Interval data are quantifiable and ordered intervals between categories that can be measured. For example, temperatures are interval data. Ratio data have all the characteristics of interval data, but have an absolute zero value. For example, population counts and distance are both ratio scales. As Carr (2007) notes, these types of data are important when combining raster data. Using the LUCIS model and GIS suitability analysis, it is most appropriate to use interval or ratio data to ensure appropriate levels of measurement.



Map 4 – Case Study Area: RM of St. Andrews



Map 5 – Case Study Area: RM of St. Andrews

4.1.2 Rules for Combining Spatial Data

Carr (2007) highlights four rules for spatial data combination: enumeration, distance, contributory and interaction. The *enumeration rule* for data combination preserves all attribute values from multiple input layers. Enumeration creates an output layer that combines all attributes from the input layers to produce a clear set of unique attribute combinations from the inputs (Carr et al., 2007). One downside to this method is that it creates data not information. The *dominance rule* selects one single value that is preferred over all other values found at the same spatial location (Carr et al., 2007). This method uses exclusionary screening, also known as "sieve mapping" which uses an "all or nothing" process of selection where features are either selected or not selected at all. This form of screening results in a binary output where 1 = true (included) and 0 = false (excluded). The *contributory rule* can be applied to spatial data with Boolean classification and is used for nominal data. The contributory rule differs from the dominance rule because the value is determined from the internal values of the attribute and not from an external rule. If a true value equals 1 and a false value equals 0, then a summary of all cellular locations can determine the number of true or positive factors that contribute to the result for each cell. The problem with the simple counting of these values is that the reliance on the equity of values among inputs. For example, it assumes that all layers are of equal value when defining suitability. One application of the contributory rule is the weighted voting operation which eliminates the necessity for counting values and ranks the values within each layer. Each input feature of a particular input layer is weighted on a scale of importance (Carr et al., 2007). In other words, each feature is ranked based on values between most important and least important. In the LUCIS model, the weighted voting operation is used with several input layers and ranked on a scale of 1 to 9 (1 being the lowest and least important value and 9 being the highest and most important) and was applied to all raster inputs. The final rule, the *interaction rule* considers the interaction between factors. One application of the interaction rule is weighted overlay analysis in which individual layers are grouped into standardized intervals and then weighted to show the importance of each layer in the model (Carr et al., 2007). Another application of this rule is the single utility assignment, which is accomplished using the Single Output Map Algebra Tool. In the LUCIS model, this tool was used to combine multiple layers and assign percentage weights to each input layer for a total of 1.

The assignment of values for individual features in a single layer of spatial data is called a single utility assignment (SUA) and is the foundation of GIS suitability modeling (Carr et al., 2007). Any range of values can be used for an SUA as long as it is used consistently between all the SUA's of a suitability model. In the LUCIS model for the RM of St. Andrews, a value range of 1 to 9 was used, with 1 representing the lowest suitability and 9 being the highest suitability.

4.2 Establishing Model Goals and Objectives

Establishing goals and objectives is typically the starting point for land use design planning. Goals have been established in the LUCIS model as a hierarchal set of statements and are accomplished through a series of sub-objectives. Goals are used in the LUCIS model to address broad areas or themes and both objectives the sub-objectives were established that are coincide to each goal. Two land use categories – urban and agriculture were used for the LUCIS model and corresponding goals, objectives and sub-objectives were used for these land use categories.

> Statement of Intent: *To identify lands that are preferred for agricultural (livestock), rural non-farms and residential uses in the RM of St. Andrews and to compare the results of both preferred areas to identify areas of potential conflict.*

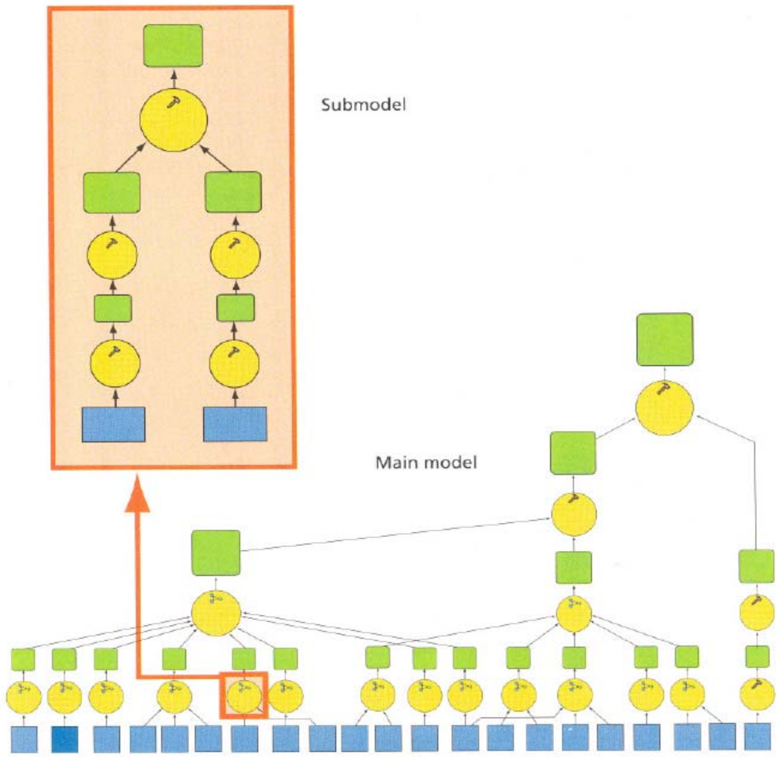


Figure 7 – Main LUCIS Model – Comprised of a Series of Sub-models

4.2.1 Urban Goals and Objectives

The following is a list of the urban goals, objectives and sub-objectives that were used in the LUCIS model for the case study of the RM of St. Andrews. These goals were created as a result of the preliminary key informant interviews, data availability and literature review on the subject to identify the preferred areas for current residential land use.

Goal 1: Identify lands suitable for residential land use

Objective 1.1: Determine lands physically suitable for residential land use

Sub-objective 1.1.1: Identify soils suitable for residential land use
Sub-objective 1.1.2: Identify lands free of flood potential
Sub-objective 1.1.3: Identify quiet areas
Sub-objective 1.1.4: Identify lands free of hazardous waste
Sub-objective 1.1.5: Identify lands with good air quality

Objective 1.2: Determine lands economically suitable for residential land use

Sub-objective 1.2.1: Identify lands proximal to existing residential development
Sub-objective 1.2.2: Identify lands proximal to schools

Sub-objective 1.2.3: Identify lands proximal to health care facilities
Sub-objective 1.2.4: Identify lands proximal to roads
Sub-objective 1.2.5: Identify lands proximal to parks, recreation facilities, community clubs, golf courses, churches and historic sites
Sub-objective 1.2.6: Identify land values with assessed land and building values suitable for residential use

4.2.2 Agricultural Goals and Objectives

The following is a list of the agricultural goals, objectives and sub-objectives that were used in the LUCIS model for the case study of the RM of St. Andrews. These goals were created to identify the preferred areas for current agricultural; livestock land use.

Goal 2: Identify lands suitable for intensively managed livestock operations (≥300 animal units)

Objective 2.1: Identify lands physically suitable for intensively managed livestock operations

Sub-objective 2.1.1: Identify nutrient management areas that are suitable for intensively managed livestock operations
Sub-objective 2.1.2: Identify existing intensively managed livestock operation lands as suitable

Objective 2.2: Determine lands economically suitable for intensively managed livestock operations

Sub-objective 2.2.1: Identify lands proximate to meat processing facilities
Sub-objective 2.2.2: Determine lands proximity to potential conflict adjacent land uses based on setbacks outlined in the Provincial Land Use Policies (2005)
Sub-objective 2.2.3: Identify lands with values suitable for intensively managed livestock operations

Goal 3: Identify lands suitable for low-intensity livestock operations (<300 animal units)

Objective 3.1: Identify lands physically suitable for intensively managed livestock operations

Sub-objective 3.1.1: Identify nutrient management areas that are s suitable for low-intensity livestock operations
Sub-objective 3.1.2: Identify existing low-intensity livestock operation lands as suitable

Objective 3.2: Determine lands economically suitable for low-intensity livestock operations
Sub-objective 3.2.1: Identify lands proximate to meat processing facilities
Sub-objective 3.2.2: Identify lands with values suitable for intensively managed livestock operations

4.3 Data Collection

Critical to developing the LUCIS model was collecting a wide variety of data. In considering which datasets to include in the model, the creating of this model used McHarg's (1969) methodology for grouping datasets for land use analysis decision-making in to five broad categories. These categories include:

- Geophysical - these datasets include natural environmental characteristics of the municipality. These include soil types, natural land use characteristics, nutrient management areas and flood risk areas;
- Economic – these datasets include parcel ownership mapping and assessed land values per acre.
- Political - these datasets include political boundaries, politically defined designated lands uses in the zoning by-law and development plan and the municipal boundary;
- Cultural – these datasets were selected to capture the distribution and character of cultural features, including historic sites, parks and recreation facilities, hospitals, schools and other municipal points of interest;
- Infrastructure – these datasets represent the physical infrastructure of the municipality. These include provincial and local municipal roads, railways, dwellings, livestock operations, lagoons, meat-processing plants in the city of Winnipeg and waste disposal sites.

4.3.1 Data Sources and Preparation

A great deal of GIS data that was used in creating the LUCIS model was taken from the Manitoba Land Initiative (2003). Parcel data, dwelling location, livestock operation inventory, flood risk areas and orthographic (satellite imagery) photography were provided by the Selkirk and District Planning Area Board.

The LUCIS model was developed using projected data. Map projections are used as a way to represent spatial data on a flat surface while taking into account the curvature of the earth. For this model, all data was projected using Universal Transverse Mercator (UTM) NAD 1983 Zone 14. All vector-based data that were converted into raster data using a 50 metre cell size based on technical considerations and disk storage space

4.4 Determining Residential Land Use Suitability

4.4.1 Lands Physically Suitable for Residential Land Use

Land use suitability modeling is an analytical process that determines the optimal use for a given area of land (Carr et al., 2007). The urban and agricultural objectives and sub-objectives of the LUCIS model are used as the foundation for the evaluation criteria of the model. The LUCIS suitability model that was developed for the RM of St. Andrews works from the bottom of the criteria hierarchy to the top. More specifically, the suitabilities for the defined sub-objectives are completed first, which affect the determination of suitabilities for the objectives and in turn affect the suitabilities for the goals.

Each suitability model appears to be a stand alone model, however as shown in **Figure 7**, each one is a sub-model for a large main model that corresponds with each defined land use category (i.e. urban and agricultural). Each sub-model is stored as a custom processing tool which is added to the main model. When the main model processes, each individual sub-model is run in its entirety. In identifying the lands suitable for residential land use, each objective and sub-objective were calculated using various ArcGIS 9.2 tools and calculations. Two suitability goal models were created for identifying lands most suitable for residential development – lands most suitable for residential land use and lands economically suitable for residential land use. To produce the final suitability model for identifying lands most suitable for residential development, both goal models were combined through a series of calculations. The details of the model and all calculations for each sub-model are shown below.

In identifying lands most suitable for residential land use, a series of environmental characteristics were analyzed to determine suitability. This objective model is comprised of a series of stand alone sub-models. Lastly, the objective models were combined to create the respective goal models. The sub-models for identifying lands most suitable for residential land use include identifying suitable soils, lands free of flood potential, quiet areas, lands free of hazardous waste and lands with good air quality. To produce the final goal for identifying lands most suitable for residential land use, each objective model was combined through a series of calculations. The details of the objective models and all calculations for each sub-model can be found in **Appendix C**: **Detailed Case Study GIS Model Development.**

4.4.2 Lands Physically Suitable for Residential Land Use

In identifying the lands economically suitable for residential land use, each objective and sub-objective were calculated using a series of ArcGIS 9.2 tools. This objective model is comprised of a series of stand alone sub-models. Lastly, the objective models were combined to create the respective goal models These sub-models include identifying lands in close proximity to exiting residential development, lands in close proximity to schools, health care facilities, major roads, parks, other recreational opportunities, protected conservation lands and cultural/historic sites. Also identified are lands economically suitable for residential land use. Each objective model was combined through a series of calculations. The details of the objective models and all calculations for each sub-model can be found in **Appendix C**: **Detailed Case Study GIS Model Development.**

4.5 GOAL 1: Final Model – Identifying Lands Most Suitable for Residential Development

In determining the final model for identifying lands most suitable for residential development, the objective models – 1.1 identifying lands suitable for residential land use and 1.2 identifying lands economically suitable for residential land use – were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(UGModel1*

** 0.5) + (UGModel2 * 0.5).* The two urban goals were both multiplied by equal weights of 0.5 and produced a combined output layer of the two residential objective models.

Next, the lands in close proximity to existing residential developments vector layer for the RM of St. Andrews (that was created by selecting designated residential areas within the development plan and zoning by-law for the RM of St. Andrews) was converted in to a raster layer. All of the cells that were highlighted as existing urban areas were reclassified based on geometric interval using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in the Table 7 below. Non-urban areas were assigned a value of 1 (low suitability) and existing urban area cells were assigned a value of 9 (high suitability). The rationale for this decision is that from a long term planning, servicing and development perspective, developing residential land uses near existing residential developments is cheaper and promotes neighbourhood clustering of non-opposing land uses.

Table 7 – Designated Urban Areas Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
Identified Urban Areas	9
Identified Non-Urban Areas	1

The reclassified identified urban areas were combined with the output layer of the two residential objective models using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *CON(recresidentialareas EQ 9, 9, (UGModel1 * 0.5) + (UGModel2 * 0.5)).* The CON function was used to control the output value for each cell based on whether the cell value evaluates to true or false in a specified conditional statement. In this case, if a cell is found to be in the existing identified urban areas (suitability equals 9), then it was assigned a new value of 9. Otherwise, the value obtained from the map algebra equation was assigned; the lands physically suitable for residential land use value multiplied by 0.5 (50%) plus the lands economically suitable for residential land use multiplied by 0.5. The results of the final residential model are shown in **Map 6** below. **Figure 8** and **Figure 9** show the conceptual steps involved in the GIS model for identifying lands most suitable for residential development. As shown in these figures, suitability modeling works from the bottom criteria hierarchy to the top. In other words, the suitabilites for the sub-objectives were completed first, which affected the determination of suitabilities for the objectives, which in turn affected the determination of the suitabilities for *Goal 1: Identifying Lands Most Suitable for Residential Development*. What is revealed is not surprising – the most suitable lands are those in existing residential areas and those close to existing all-weather residential roads. The least suitable are those with physical constraints, especially those in flood prone areas.

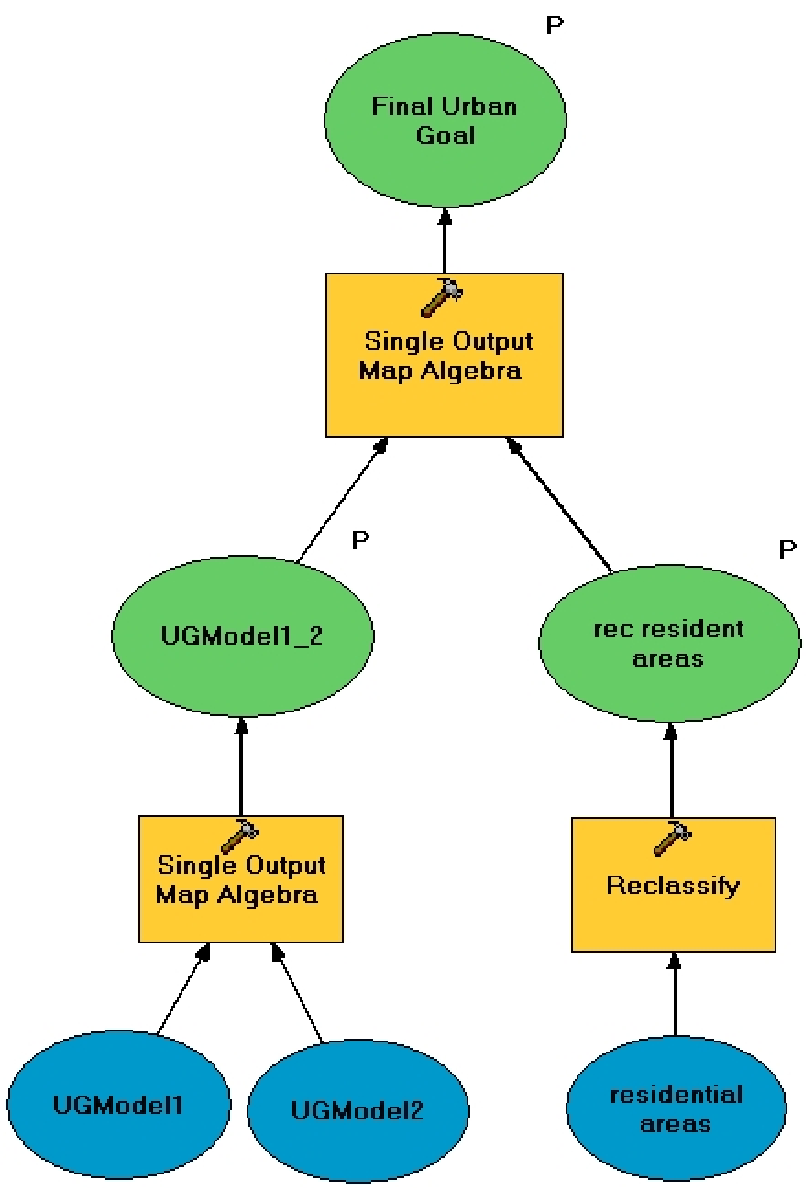


Figure 8 – Final Re8sidential Model

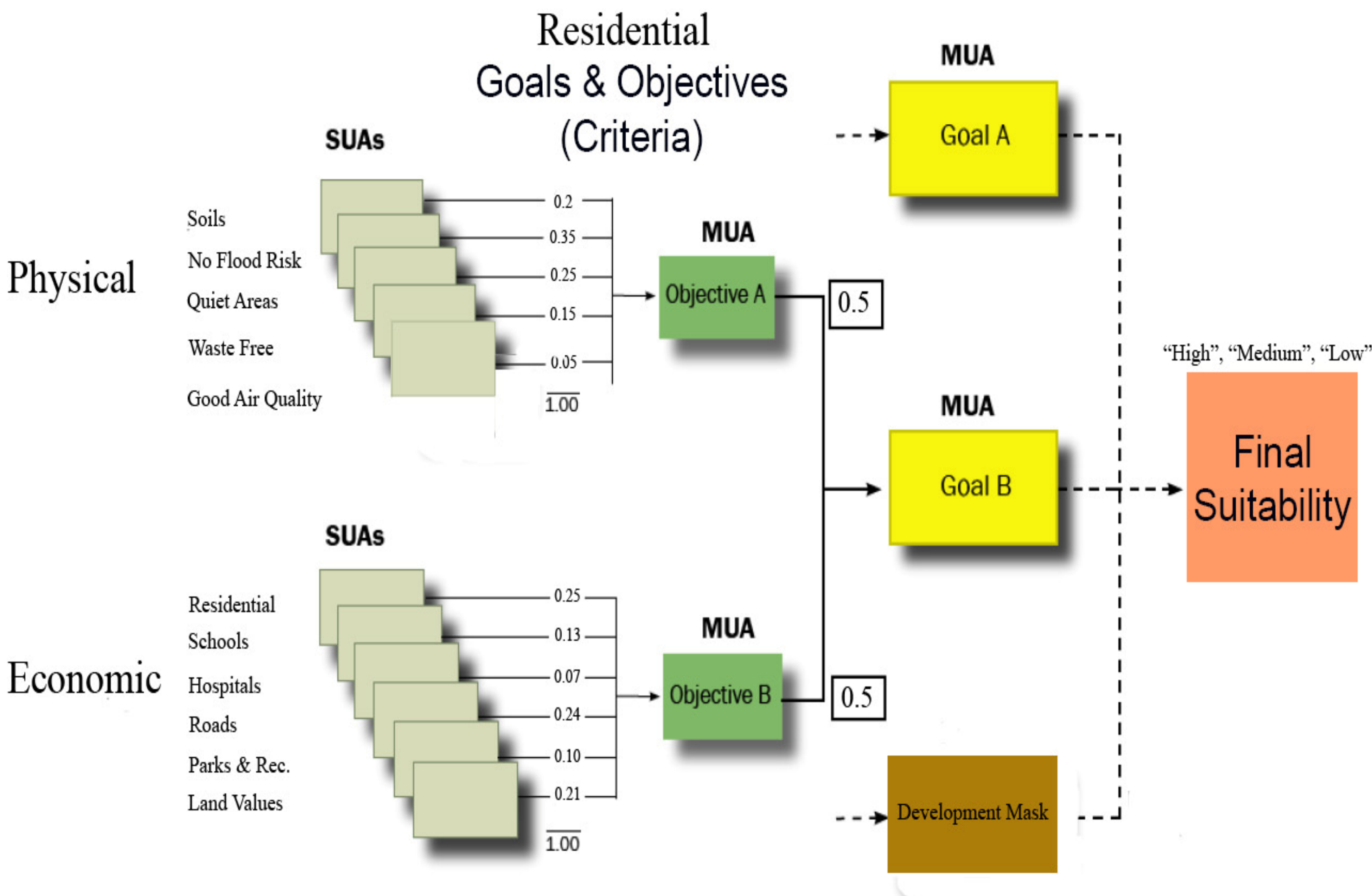
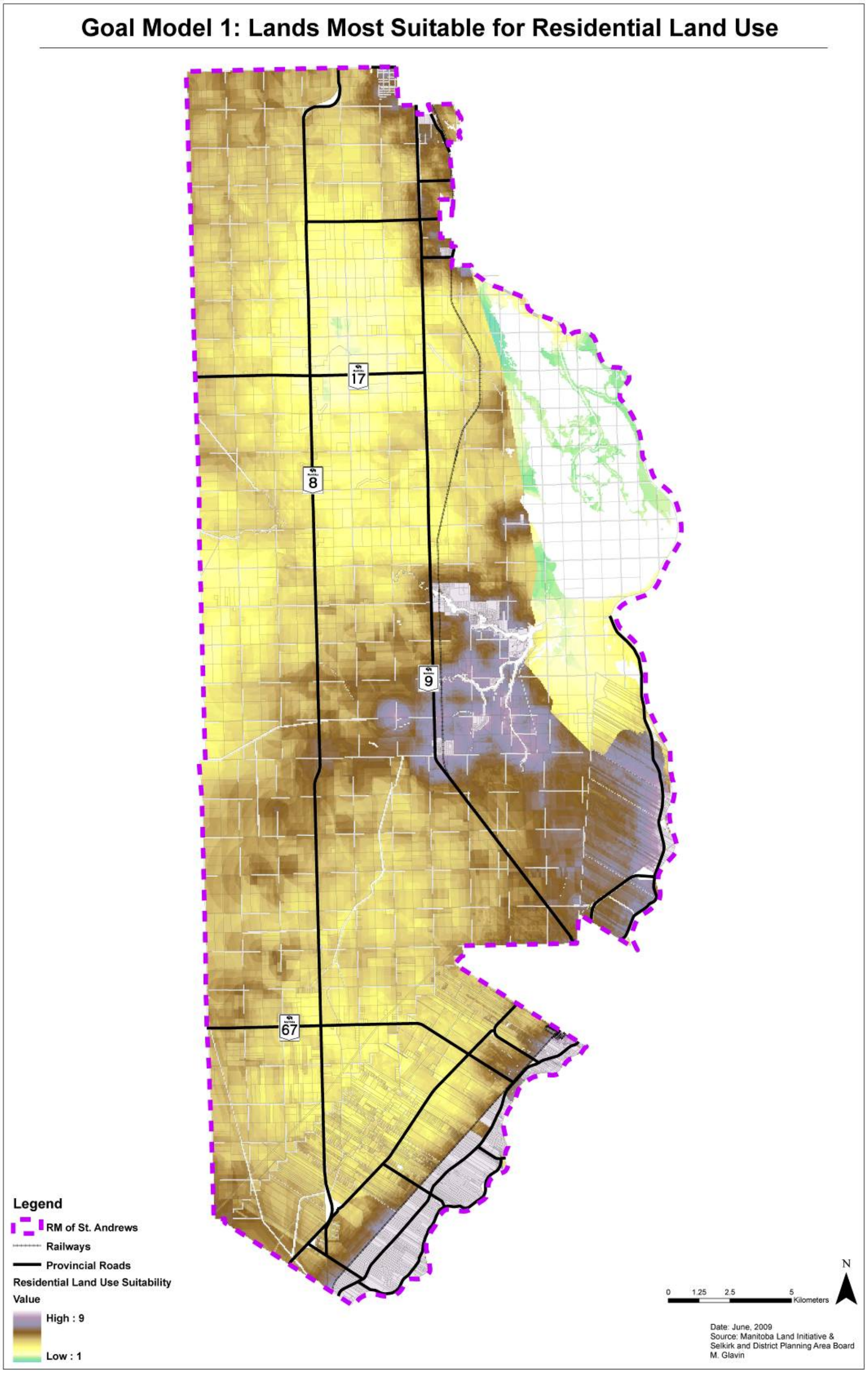


Figure 9 – Residential Goals and Objectives (Criteria) Model



Map 6– Lands Most Suitable for Residential Land Use Final Raster Map

4.6 Determining Intensively Managed Livestock (>300 Animal Units) Land Use Suitability

4.6.1 Lands Physically Suitable for Intensively Managed Livestock (>300 Animal Units)

In identifying lands most physically suitable for intensively managed livestock, a series of environmental characteristics were analyzed to determine suitability. Similar to the model used to identify lands most physically suitable for residential land use, this objective model is comprised of a series of stand alone sub-models. The sub-models for identifying lands most suitable for residential land use include nutrient management areas suitable for intensively managed livestock and existing suitable intensively managed livestock lands. To produce the final objective model for lands most physically suitable for intensively managed livestock, each sub-model was combined through a series of calculations. The details of the objective models and all calculations for each sub-model can be found in **Appendix C**: **Detailed Case Study GIS Model Development.**

4.6.2 Lands Economically Suitable for Intensively Managed Livestock (>300 Animal Units)

In identifying lands most economically suitable for intensively managed livestock, a series of characteristics were analyzed to determine suitability. Similar to the model used to identify areas economically suitable for residential land use, this objective model is comprised of a series of stand alone sub-models. The sub-models for identifying lands most suitable for residential land use include lands in close proximity to meat processing facilities, identifying lands in close proximity to potentially troublesome adjacent land uses and identifying lands with values suitable for intensively managed livestock. To produce the final objective model for lands economically suitable for intensively managed livestock, each sub-model was combined through a series of calculations. The details of the objective models and all calculations for each sub-model can be found in **Appendix C**: **Detailed Case Study GIS Model Development.**

4.7 GOAL 2: Final Model – Identifying Lands Most Suitable for Intensively Managed Livestock (>300 Animal Units)

In determining the final model for identifying lands most suitable for intensively managed livestock, the objective models – 2.1 identifying lands physically suitable for intensively managed livestock and 2.2 identifying lands economically suitable for intensively managed livestock use – were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(AGModel1 * 0.5) + (AGModel2 * 0.5)*. The two intensively managed livestock objectives were both multiplied by equal weights of 0.5 and produced a combined output layer. The Single Map Output Algebra calculation model for identifying lands most suitable for intensively managed livestock can be seen in **Figure 10** below. **Figure 11** shows the conceptual steps involved in the GIS model for identifying lands most suitable for intensively managed livestock. The suitabilites for the sub-objectives were completed first, which affected the determination of suitabilities for the objectives, which in turn affected the determination of the suitabilities for *Goal 2: Identifying Lands Most Suitable for Intensively Managed Livestock (>300 Animal Units)*. The results of the final residential model are shown in **Map 7** below.

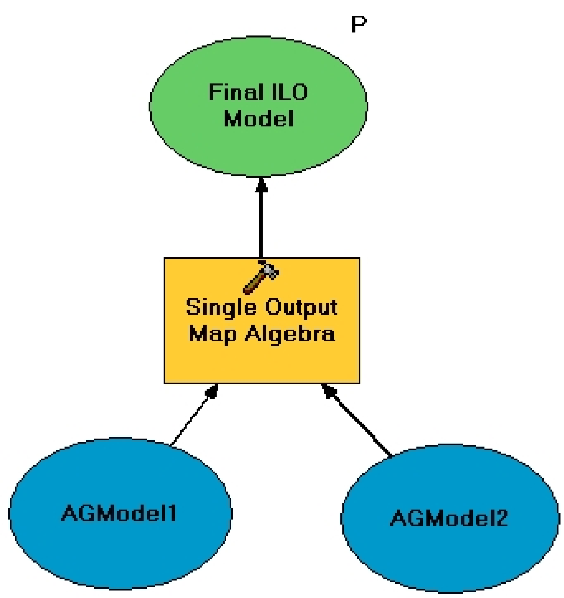


Figure 10 – Final Intensively Managed Livestock Model

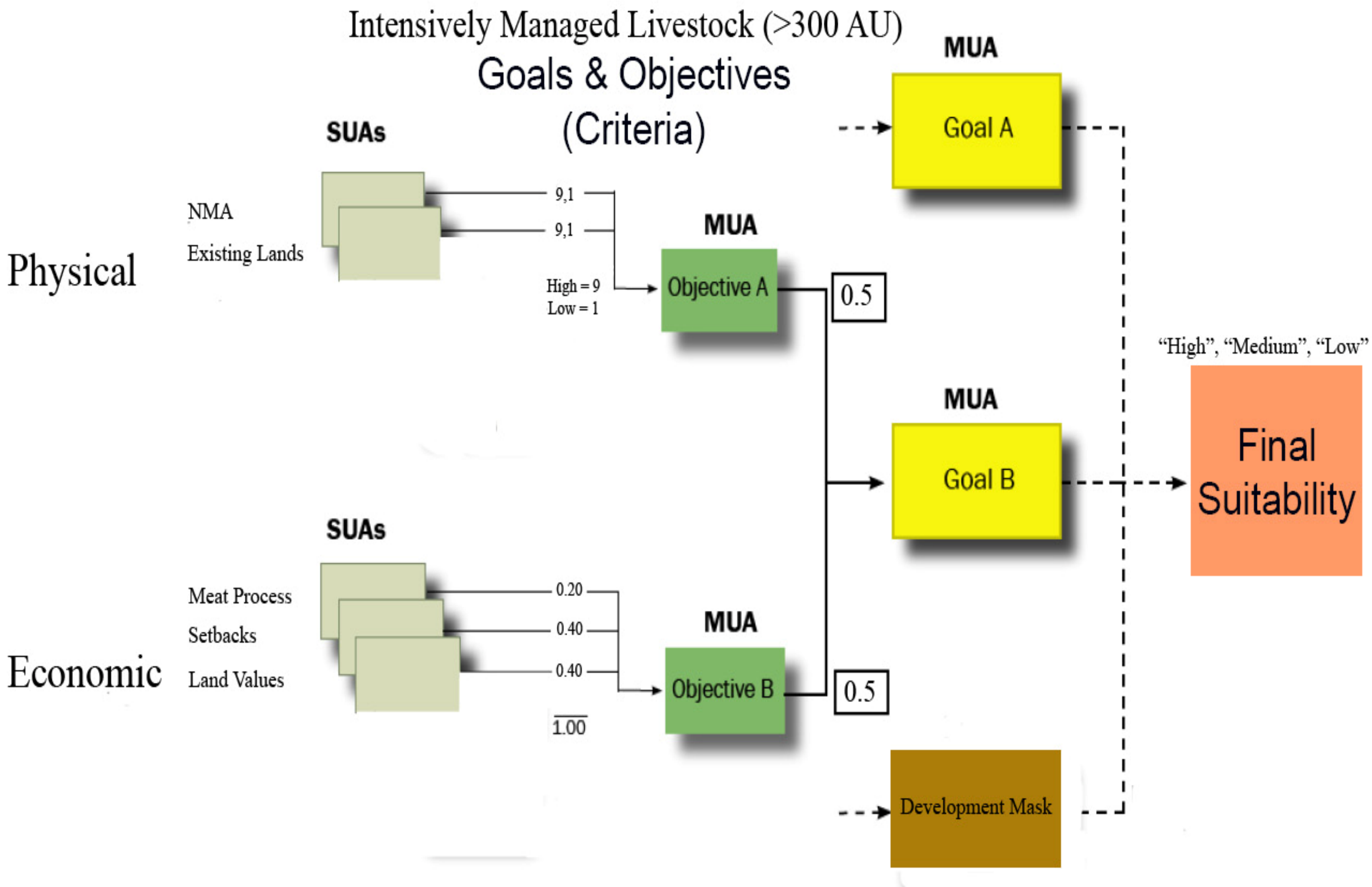
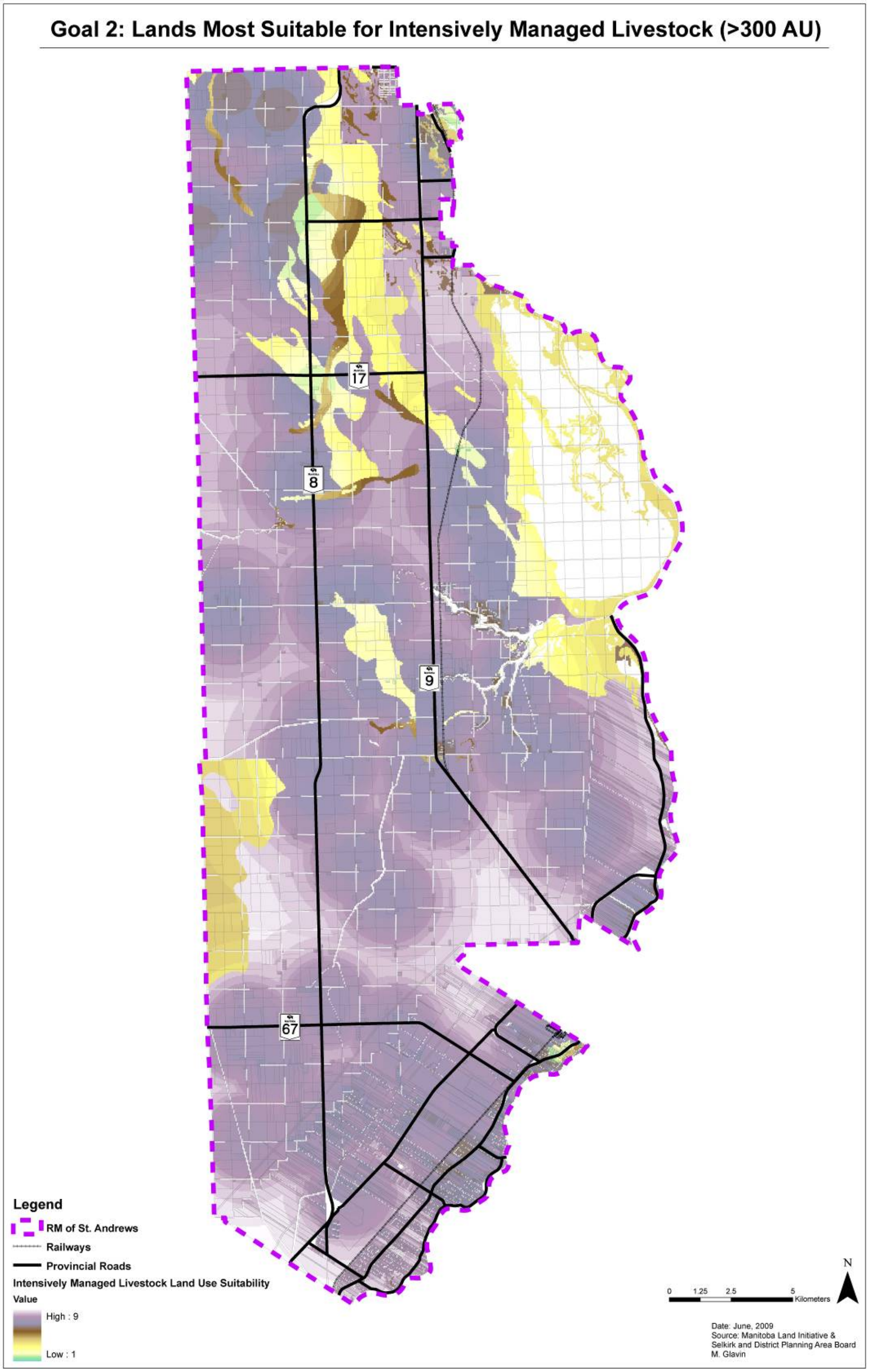


Figure 11 – Intensively Managed Livestock (>300 AU) Goals and Objectives (Criteria) Model



Map 7 –Lands Most Suitable for Intensively Managed Livestock Final Raster Map

4.8 Determining Low-Intensity Livestock (<300 Animal Units) Land Use Suitability

4.8.1 Lands Physically Suitable for Low-Intensity Livestock (<300 Animal Units)

In identifying lands most physically suitable for low-intensity livestock, a series of characteristics were analyzed to determine suitability. Similar to the model used to identify lands physically suitable for intensively managed livestock, this objective model is comprised of a series of stand alone sub-models. The sub-models for identifying lands most suitable for low-intensity livestock include identifying soils most suitable for low-intensity livestock and identifying existing low-intensity livestock that are suitable. To produce the final objective model for identifying lands physically suitable for low-intensity livestock, each sub-model was combined through a series of calculations. The details of the objective models and all calculations for each sub-model can be found in **Appendix C**: **Detailed Case Study GIS Model Development.**

4.8.2 Identifying Soils Economically Suitable for Low-Intensity Livestock (<300 Animal Units)

In identifying lands most economically suitable for low-intensity livestock, a series of characteristics were analyzed to determine suitability. Similar to the model used to identify lands physically suitable for low-intensity livestock, this objective model is comprised of a series of stand alone sub-models. The sub-models for identifying lands most suitable for residential land use include identifying lands in close proximity to meat processing facilities and lands with values suitable for low-intensity livestock. To produce the final objective model for identifying lands economically suitable for low-intensity livestock, the two sub-models – lands in close proximity to meat processing facilities and lands with values suitable for low-intensity livestock was combined through a series of calculations. The details of the objective models and all calculations for each sub-model can be found in **Appendix C**: **Detailed Case Study GIS Model Development.**

4.9 GOAL 3: Final Model – Identifying Lands Most Suitable for Low-Intensity Livestock (>300 Animal Units)

In determining the final model for identifying lands most suitable for low-intensity livestock, the objective models – 3.1 identifying lands physically suitable for low-intensity livestock and 3.2 identifying lands economically suitable for low-intensity livestock use – were combined using the Single Output Map Algebra Tool within the spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(AGLowModel1 * 0.5) + (AGLowModel2 * 0.5).* The two low-intensity livestock objectives were both multiplied by equal weights of 0.5 and produced a combined output layer. The Single Map Output Algebra calculation model for identifying lands most suitable for low-intensity livestock can be seen in **Figure 12** below. **Figure 13** shows the conceptual steps involved in the GIS model for identifying lands most suitable for low-intensity livestock. The suitabilites for the sub-objectives were completed first, which affected the determination of suitabilities for the objectives, which in turn affected the determination of the suitabilities for *Goal 3: Identifying Lands Most Suitable for Low-Intensity Livestock (<300 Animal Units).* The results of the final residential model are shown in **Map 8** below.

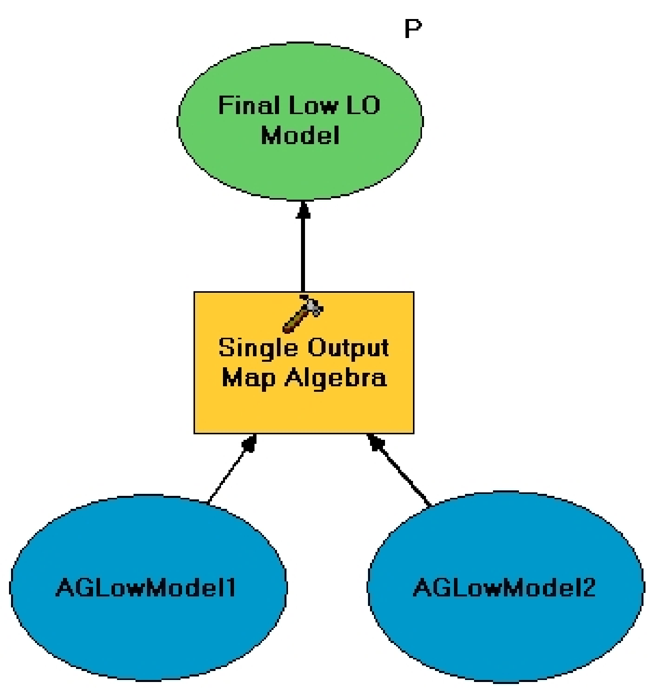


Figure 12 – Final Low-Intensity Livestock Model

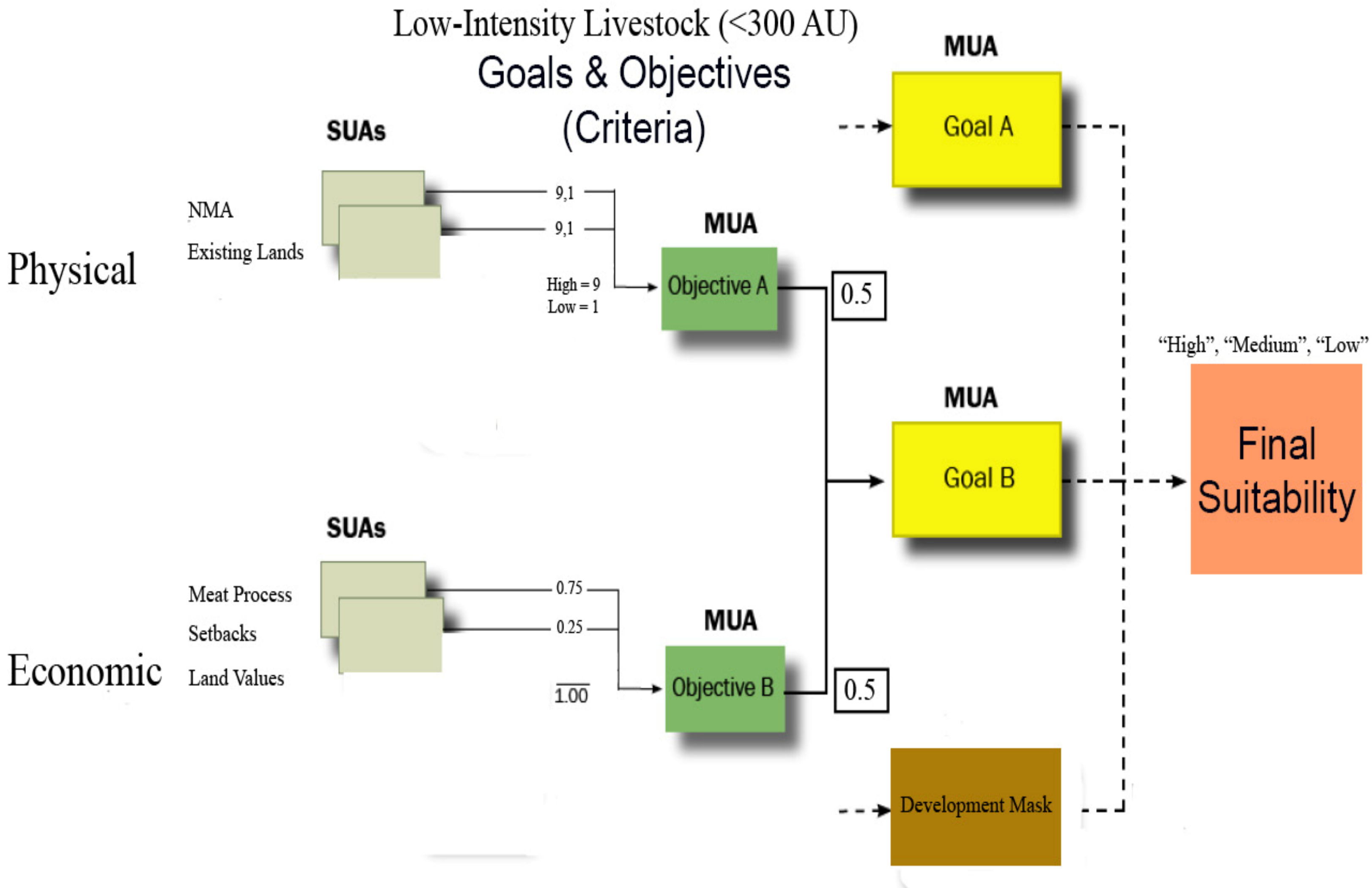
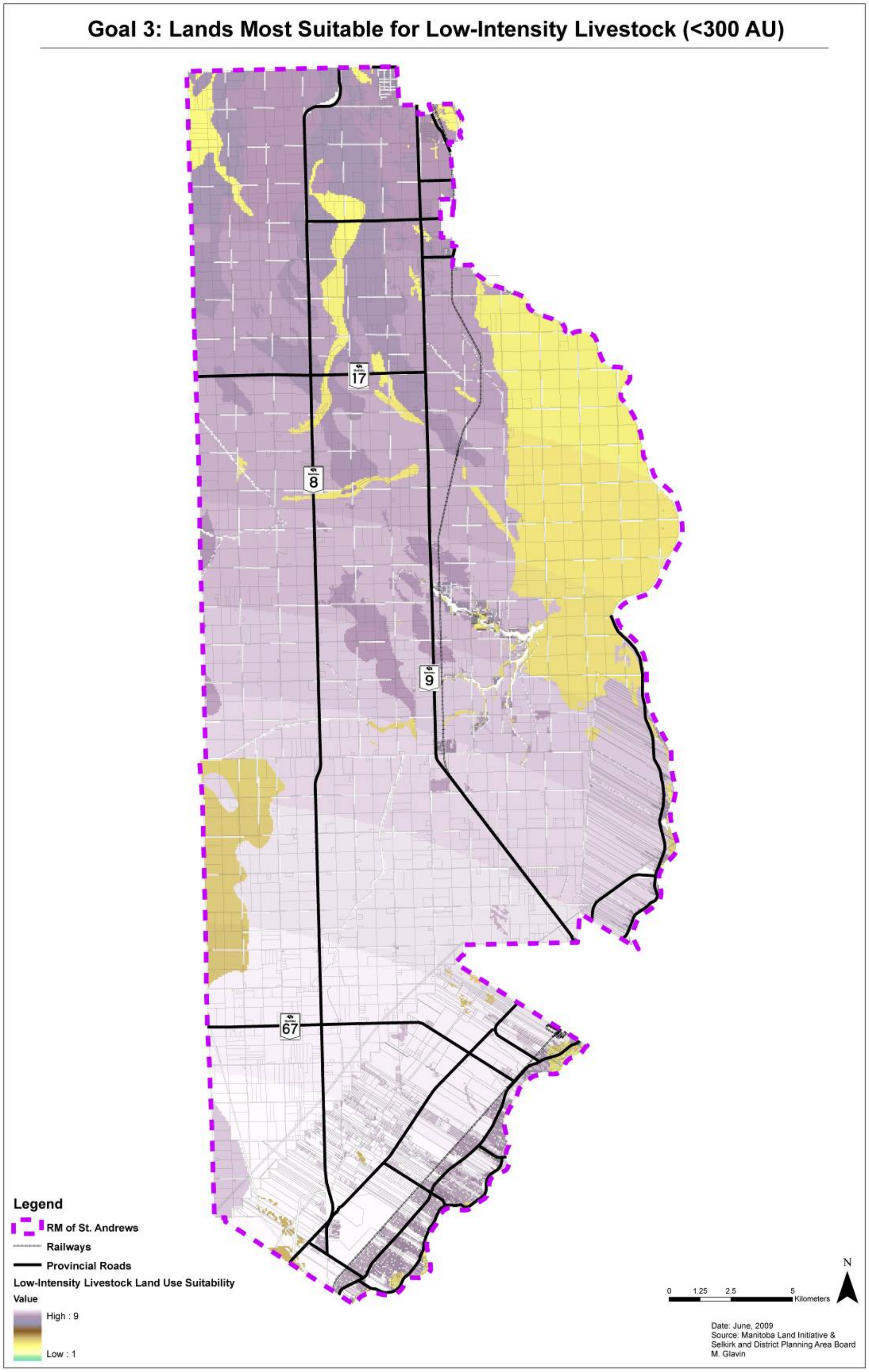


Figure 13 – Low Intensity Livestock (<300 AU) Goals and Objectives (Criteria) Model



Map 8 – Lands Most Suitable for Low-Intensity Livestock (<300 AU) Final Raster Map

4.10 Development Mask – Identifying Available Lands for Development

When calculated by a GIS, land use preferences (urban areas, intensively managed livestock and low-intensity livestock) is an indication of the degree to which any given cell in a raster dataset is preferred for a specific land use category (Carr et al., 2007). However, regardless of the degree of suitability result from the application of the LUCIS model, there are some areas whose current uses are unlikely to change. These include, current urban lands, protected conservation or parklands and open water areas. Conflict will not occur on these lands because they are already permanently designated; so these areas were removed from consideration in order to produce the preferred development areas for the identified land use categories – urban areas, intensively managed livestock areas and low-intensity livestock areas.

In order to address this issue, a raster mask was created for the existing urban lands, existing conservation lands and open water was created. This was achieved by using the Reclassify Tool in ArcGIS 9.2. No data values were assigned to those areas to be excluded from consideration. All remaining cells were assigned the value of 1, thereby making all cells with a value of 1 available for analysis (see **Table 8, Table 9** and **Table 10**). Next, using the Single Output Map Algebra Tool, the three individual mask layers – urban areas, conservations lands and open water were multiplied using the following equation: *(rec_non urbanareas) * (rec_non waterbods) * (rec_non conlands)*. This calculation (see **Figure 14**) created a final mask of areas available for future land use development consideration (see **Map 9**). This development mask was then used to limit preferred future development to those areas where development has the potential to occur.

Table 8 – Urban Areas Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
Identified Urban Areas	No Data
Available Lands	1

Table 9 – Conservation Lands Reclassified Values
Source: Manitoba Land Initiative, 2003

Old Values	New Values
Identified Conservation Lands	No Data
Available Lands	1

Table 10 – Open Water Reclassified Values Source: Manitoba Land Initiative, 2003	
Old Values	**New Values**
Identified Open Water	No Data
Available Lands	1

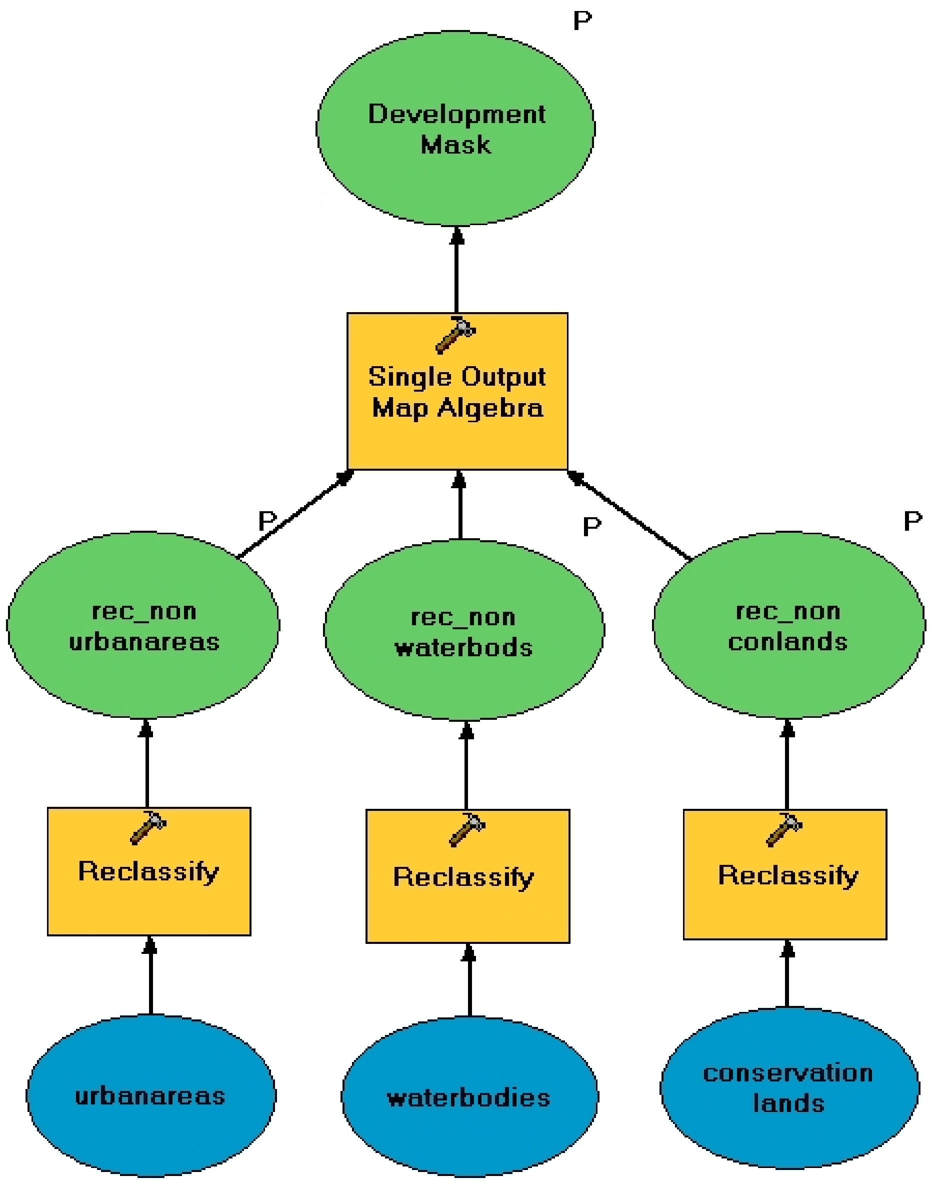
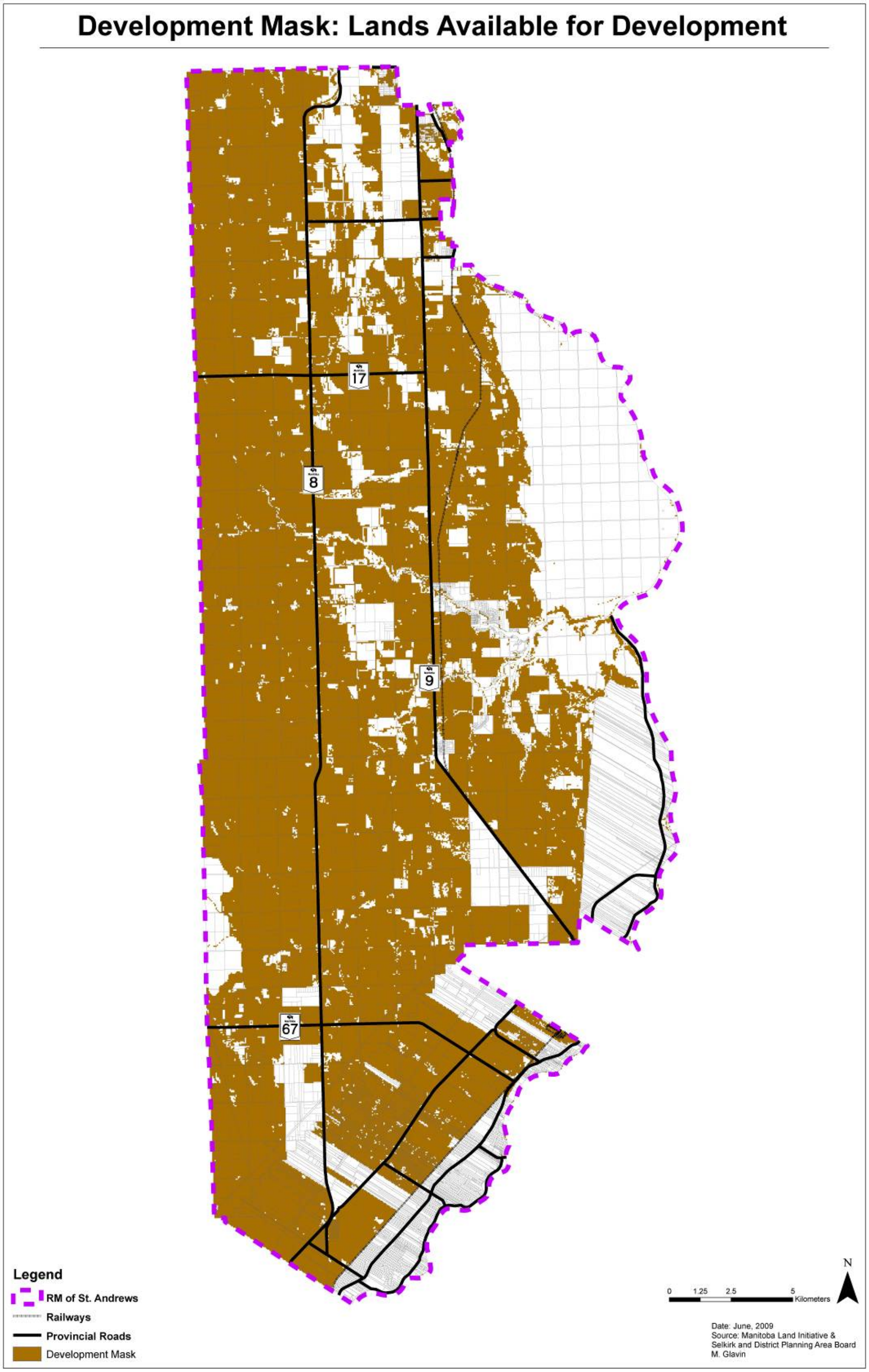


Figure 14 – Development Mask Model



Map 9 – Development Mask – Lands Available for Development

4.11 Preferred Development Areas – Identifying Preferred Development Areas for Residential, Intensively Managed Livestock (>300 AU) and Low-Intensity Livestock (>300 AU) Areas

As previously examined, the combined suitabilities for each goal (urban, intensively managed and low-intensity livestock) were assigned weighted values to produce three final land use preference raster layers. The values used in these raster layers ranged from 1 to 9, but did not necessarily include the value of 9. For a value of 9 to exist, at least one cell in the raster had to be optimally suited for that land use category. Since this is a limited occurrence, Carr (2007) suggests that normalizing the values of each land use category prior to comparing preferential development areas is considered to be the best practice. The development mask was designated as a parameter in the preferred development areas model, so the normalization only occurred in the areas with development potential.

Normalizing values was achieved by using the divide tool within the Math Toolset of the Spatial Analyst Tools in ArcGIS 9.2. This process divided each cell value in each respective final land use preference raster by the highest cell values in that raster. The raster produced from this calculation contained a cell value that ranged from 0 to 1.0. In this study, the final urban goal values were divided by the highest cell values in that model, more specifically a value at or near 9. This process was repeated for both the intensively managed livestock goal and the low-intensity livestock goal.

To simplify comparison among the normalized results, the normalized preferences were collapsed in to three classes – “high”, “medium” and “low” preferences. Collapsed preference mapping allows planners and municipal officials to easily and quickly identify areas most suitable for the three land use categories.

To collapse values, the equal interval reclassification method was used with the Reclassify Tool in ArcGIS 9.2. The equal interval classification method is the easiest to understand. The range values in each of each respective final land use preference raster were divided into three equal intervals through the Reclassify Tool. The first interval does not begin at 0, but at the lowest cell value in the raster. Since, 0.78 was the lowest calculated values amongst the three final land use preference, all normalized values that began with 0.7 were assigned a new value of 1 (“low”), or the lowest preference value.

All normalized values that began with 0.8 were assigned a new value of 2 ("medium"), or a moderate preference value and all normalized values that began with 0.9 or higher were assigned a value of 3 ("high"), or the highest preference value. The reclassified normalized values for each final land use preference model are shown in **Table 11, Table 12** and **Table 13**. The methodology for creating the three preferred development area raster is shown in **Figure 15**. The three preferred development area raster – preferred urban area, preferred intensive livestock areas and preferred low-intensity livestock are shown in **Map 10, Map 11** and **Map 12**. These raster maps provide a visual representation of the analysis and calculation that was performed to produce these outputs.

Table 11 – Normalized Urban Goals Model Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0.777778 - 0.78245	1
0.78245 - 0.786046	1
0.786046 - 0.790718	1
0.790718 - 0.796787	1
0.796787 - 0.804671	2
0.804671 - 0.814913	2
0.814913 - 0.828218	2
0.828218 - 0.845503	2
0.845503 - 0.867958	2
0.867958 - 0.897128	2
0.897128 - 0.935022	2
0.935022 - 0.98425	3

Table 12 – Normalized Intensive Livestock Goals Model Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0.888889 - 0.889099	2
0.889099 - 0.896598	2
0.896598 - 0.904098	2
0.904098 - 0.911598	3
0.911598 - 0.919098	3
0.919098 - 0.926597	3
0.926597 - 0.934097	3
0.934097 - 0.941597	3
0.941597 - 0.949097	3
0.949097 - 0.956597	3
0.956597 - 0.964096	3
0.964096 - 0.977778	3

Table 13 – Normalized Low-Intensity Livestock Goals Model Reclassified Values Source: Selkirk and District Planning Area Board, 2006	
Old Values	**New Values**
0.888889 - 0.898148	2
0.898148 - 0.907407	2
0.907407 - 0.916667	3
0.916667 - 0.925926	3
0.925926 - 0.935185	3
0.935185 - 0.944444	3
0.944444 - 0.953704	3
0.953704 - 0.962963	3
0.962963 - 0.972222	3
0.972222 - 0.981481	3
0.981481 - 0.990741	3
0.990741 - 1	3

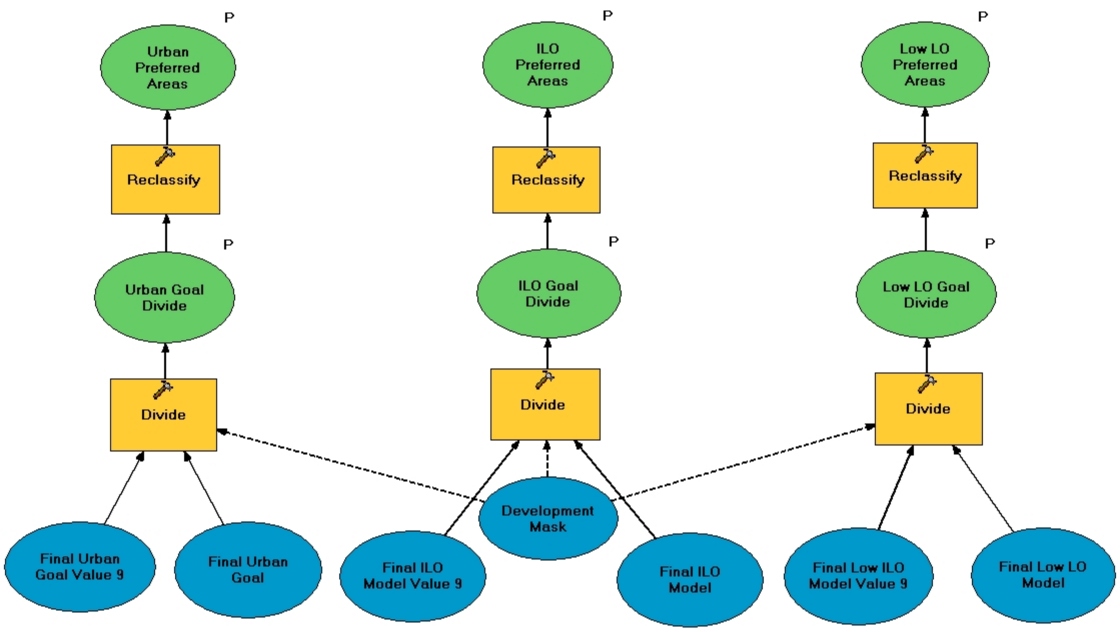
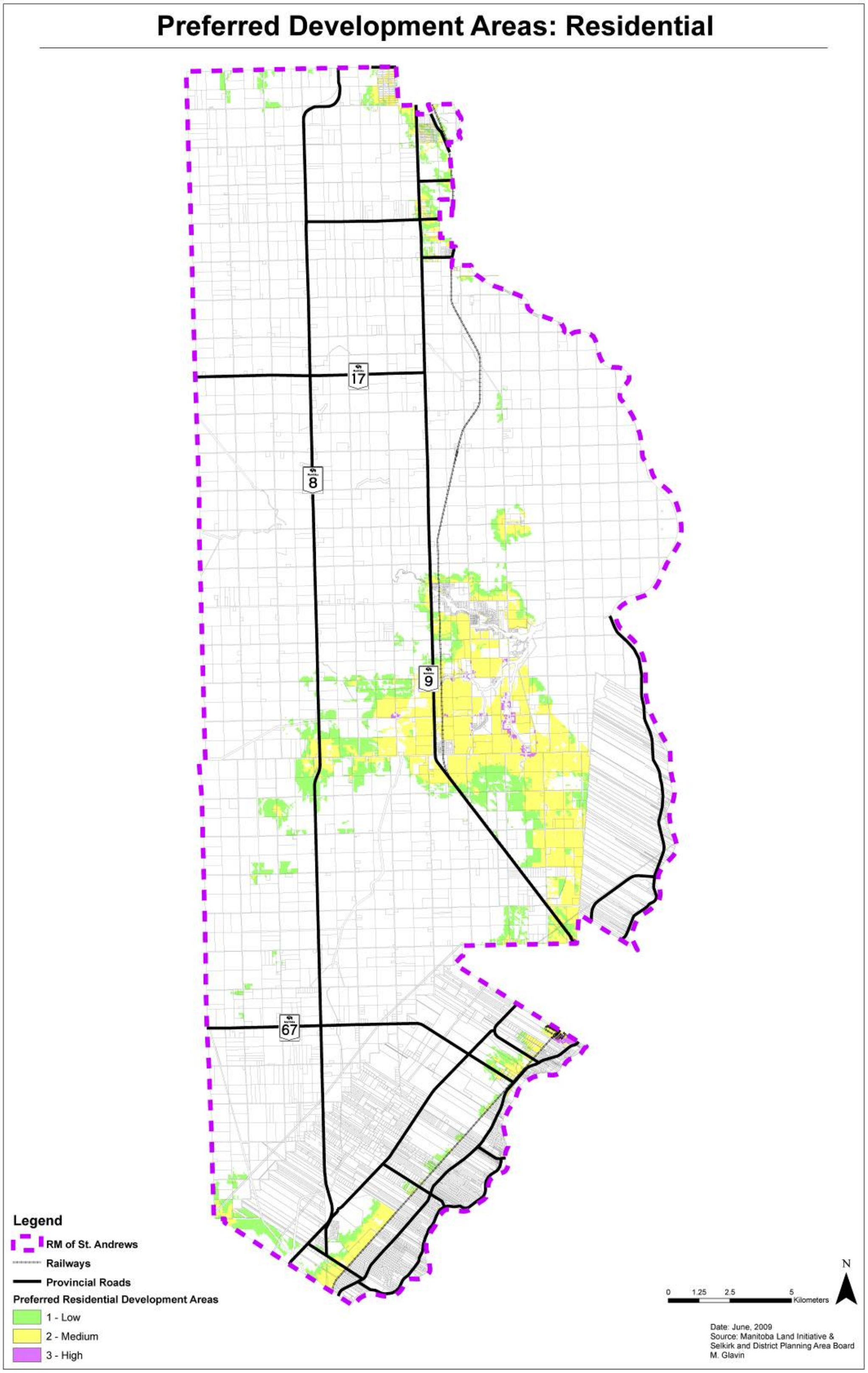
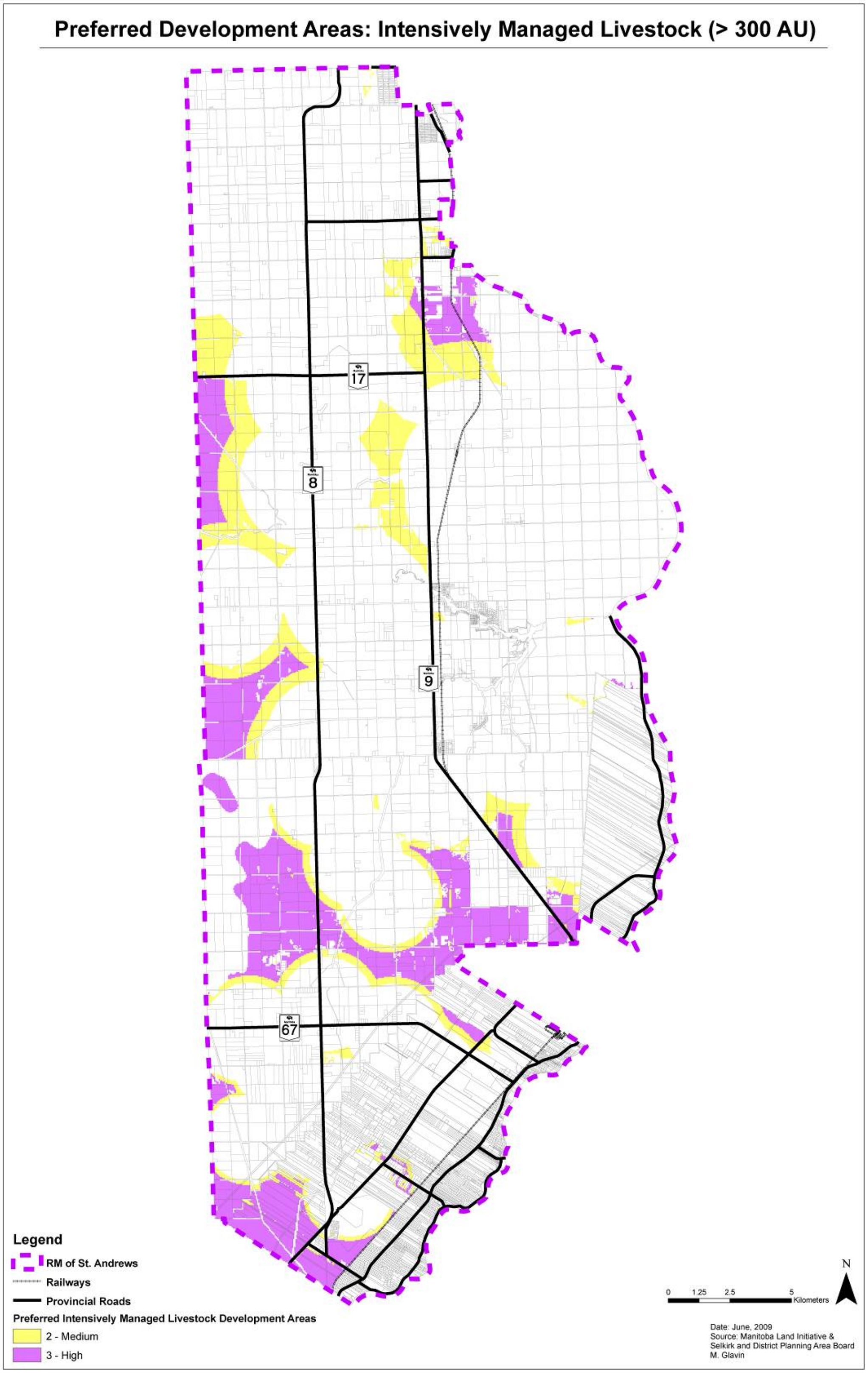


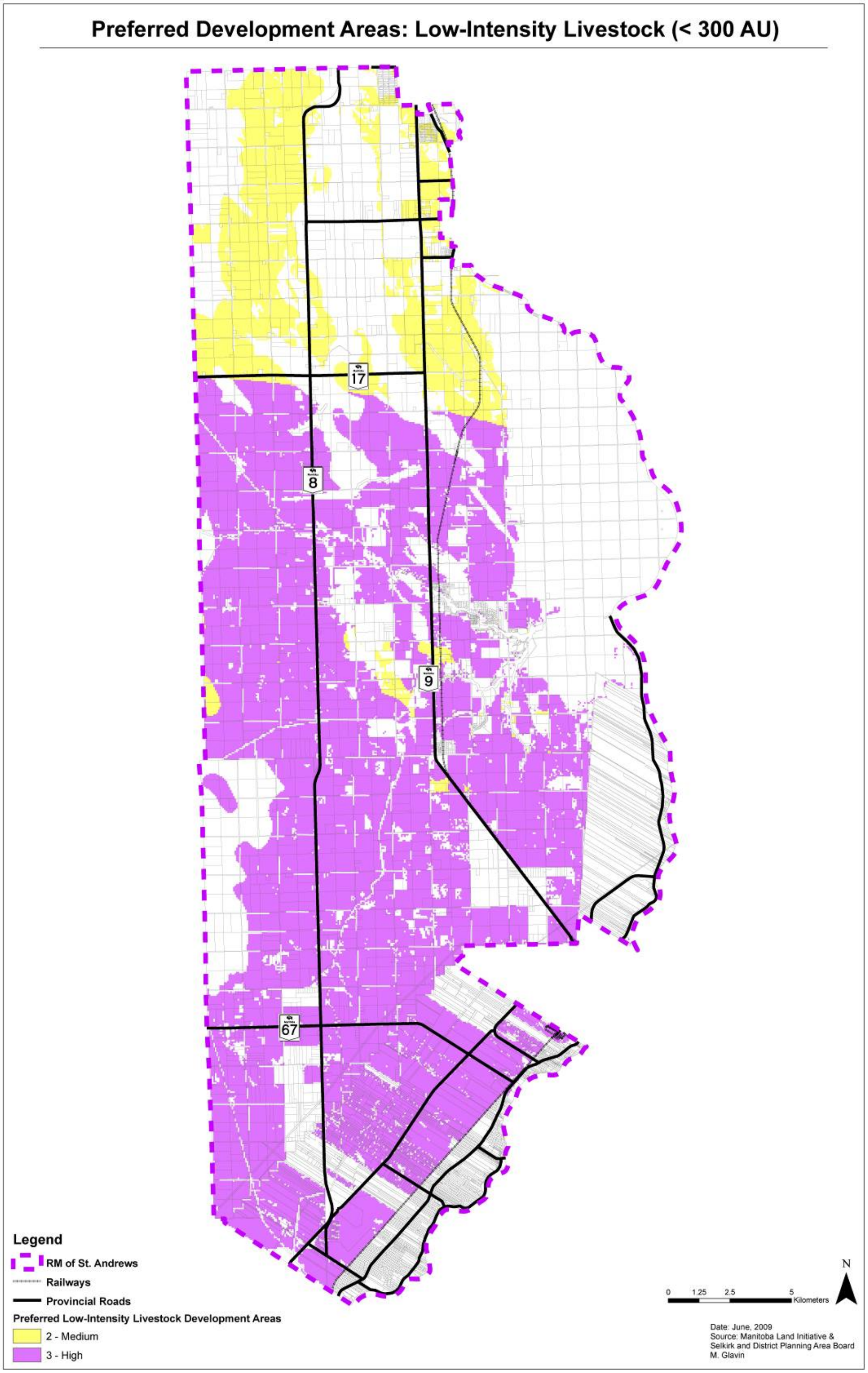
Figure 15 – Preferred Development Areas Model



Map 10 – Preferred Residential Development Areas – "High", "Medium", "Low"



Map 11 – Preferred Intensively Managed Livestock (>300 AU) Development Areas – "High", "Medium", "Low"



Map 12 – Preferred Low-Intensity Livestock (<300 AU) Development Areas – "High", "Medium"

4.12 Discussion

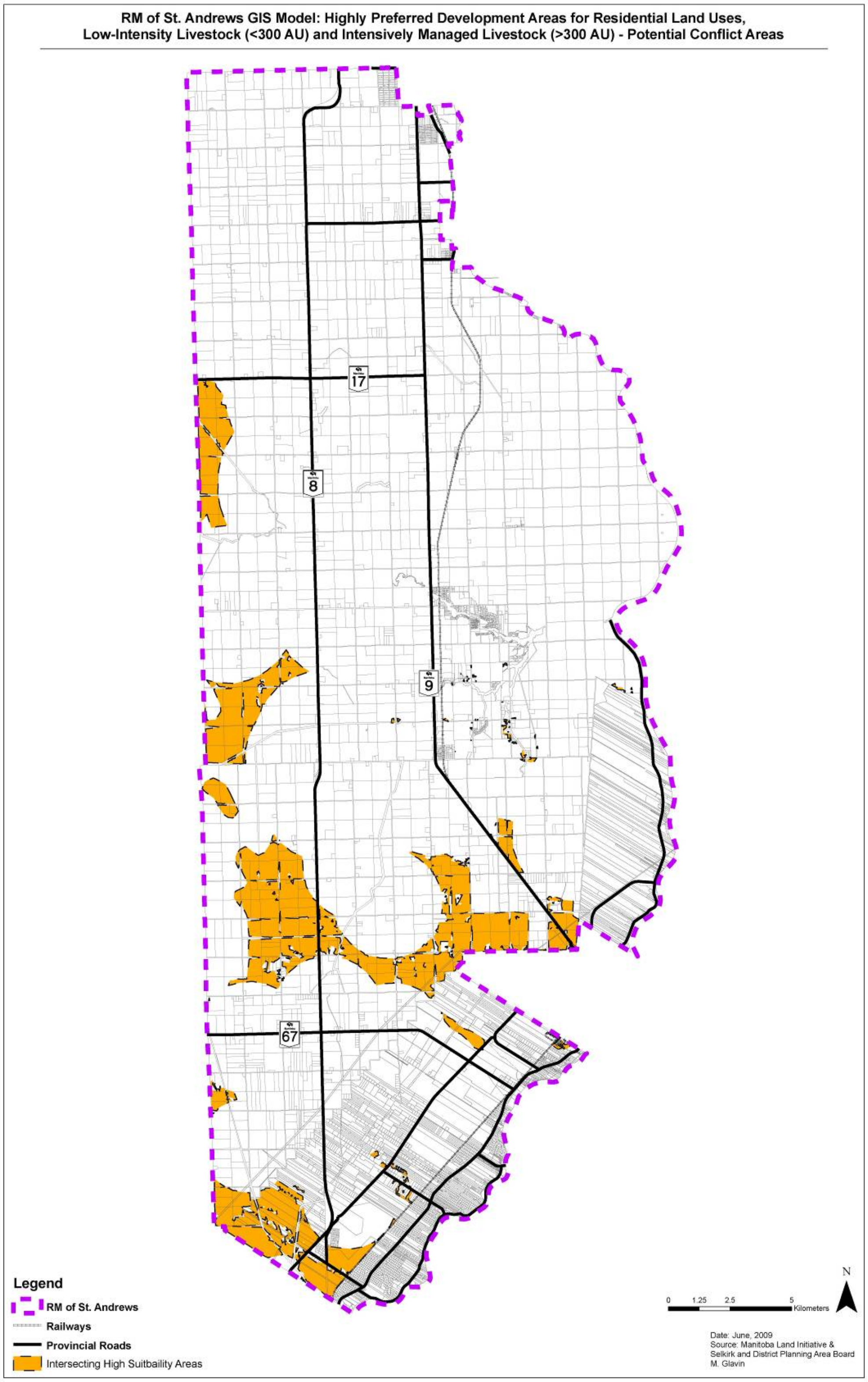
Using the three goal models for residential, intensively-managed and low-intensity livestock development, the preferred development area encompasses areas of contrast and comparison. **Map 13**¸ shows 15,401 acres of land that consists of "highly" preferred development areas for residential land use, low-intensity livestock and intensively managed livestock that overlap one another. These lands have the potential to generate conflict. The GIS LUCIS model identified preferred development areas for the three separate land uses. GIS LUCIS modeling is not intended to overwhelm planners, land use specialists, councilors and/or others with a vested interest in planning for livestock. That being said, the model is intended to assist in land use planning and not overtake the decision making process of planners and land use specialists. **Map 13** shows that there are areas where planners and land use specialists need to carefully determine the future intent of these lands.

The GIS LUCIS model has identified these lands as optimally suitable for all three forms of development – residential, low-intensity livestock and intensively managed livestock. Discussing and visualizing future land use conflict scenarios through the assistance of the GIS LUCIS planners, land use specialists and other decision makers within the Selkirk and District Planning Area can gain an understanding and insight into smart growth management for these identified lands.

The fundamental land use equation:

population ÷ gross urban density
= acres of land needed to support human settlement

To know how many acres will be required for human use in the future, one must understand the projected population for the year 2026. The average yearly growth rate from 1991-2006 for the RM of St. Andrews was 1.22%. Assuming this number remains constant over this twenty-year period, the RM of St. Andrews' population will grow by 2,722 people. The regional gross density for the RM of St. Andrews was calculated using 2006 Statistics Canada data and Selkirk and District Planning Area Board Development Plan land use data from 2006. By dividing the 2006 RM of St. Andrews non-farm rural resident population by the total acreage that is designated for settlement centre in the



Map 13 – Highly Preferred Development Areas for Residential Land Uses, Low-Intensity Livestock (<300 AU) and Intensively Managed Livestock (>300 AU)

Selkirk and District Planning Area Development Plan, a density 0.8 people per acre was identified. Plugging these numbers in to the land use equation, it is easy to calculate that an additional 3,465 acres settlement centre land will be required to support the increased rural non-farm rural resident population for the year 2026. (assuming that development will occur at a density = to the current average).

2,772 new people ÷ 0.8 people per acre = 3,465 additional settlement centre acres

The GIS LUCIS model has identified 15,401 acres of land that consists of "highly" preferred development areas for all three land uses that overlap one another. Based on the population projections for the amount of land required for future settlement centre designation, a large percentage of the land identified as overlapping "highly" preferred development areas will need to be used to support the projected population growth. As a result, the minimum separation distances from designated settlement centres (Provincial Land Use Policies, 2005) will increase substantially over time as more agricultural land is designated for non-agricultural purposes to support the projected population increase. This places an added strain on the possibility that these overlapping identified preferred development areas could be protected for livestock production. Based on the population projections and amount of land required to support this population, careful planning is required for these identified lands. Any future form of development must be carefully planned and examined to understand if it conforms to the current and intended future use of these lands. It may be appropriate that a secondary plan study be conducted for these lands. According to Section 63(1) of the *Planning Act a* board or council may, by by-law, adopt a secondary plan to deal with objectives and issues within its scope of authority in a part of the planning district or municipality, including, without limitation, any matter

(a) dealt with in the development plan by-law;

(b) dealing with subdivision, design, road patterns, building standards or other land use and development matters; or

(c) respecting economic development or the enhancement or special protection of heritage resources or sensitive lands.

The secondary plan must conform to the development plan. The added benefit of conducting a secondary plan for these identified lands is that planners and land use specialists can design a concept for how growth in this area should take place. All future development within these identified areas would have to conform to the secondary plan. It would be possible to develop policies within a secondary plan for these identified lands that would outline criteria for residential development. For instance, in the RM of St. Andrews approximately 3,500 additional acres will be required by 2026 to support the projected population at its current settlement centre population density. If within these identified lands a secondary plan policy were written that mandated future residential development must be built to a maximum gross density of 1 unit per 1.5 acre, this would essentially decrease the amount projected land required to support the future population by half. Developing residential lots at higher density is a smart growth form of development that would be easier to service by the municipality. In addition, by clustering neighbourhood developments less land is required and more land can be preserved for agricultural use. If residential development were to be clustered within parts of these identified lands, the minimum separation distances (Provincial Land Use Policies, 2005) to the nearest livestock operation would be less in comparison to if residential development were to continue at its current settlement centre population density. Careful planning will be required for these identified lands, but based on the projections of land required to support the projected population for 2026, if residential development continues at its current settlement centre population density of 0.8 people per acre, little or no land will remain for livestock production. However, if the intent of the Selkirk and District Planning Area and the RM of St. Andrews is to protect the agricultural industry and preserve the rural character of the municipality then a secondary plan should be crated for these identified areas that would ensure all future residential development take place at a higher gross density so as to limit the amount of land required for residential development. In turn, this would preserve more agricultural land and protect any current and/or future livestock operations within these identified lands.

4.13 Best Practice Measures

Given the current status of the hog industry in Manitoba as a result of the moratorium on all new and expanding hog operations within the Red River Valley region and the decline in hog market prices, the future of the industry in Manitoba is uncertain.

However, if the industry were to grow at the same rate that occurred in the late 1990's and early 2000's there will be a need for responsible hog farming becoming a more sustainable activity. There are a number of measures that can reduce odour emissions from hog and other livestock operations that include: covers for manure storage to prevent escape of harmful gas emissions, bio-filters and carbon filters on barns to reduce odour release and injection incorporation methods on fields to reduce odour production (Price, 1999). A more recent mitigating measure is the use of a positive pressure unit. This device consists of a sealed tarp over a hog lagoon that is able to capture all escaping methane gas and convert it in to useable energy (Preferred Carbon, 2009). For large-scale operations, this system is ideal because not only will it virtually eliminate all odourous gases emitted from lagoons, but useable energy can be produced over the duration of storage. Best practice measures only go so far as to reduce land use conflicts between non-farm rural residents and livestock operations. However, in light of the GIS LUCIS model example for the RM of St. Andrews and research results obtained from the focus group interviews, it is apparent that highly analytical GIS modeling can identify optimally suitable locations for opposing land uses. In turn, this has the ability to significantly reduce land use conflicts between non-farm rural residents and livestock operations.

4.13.1 Minimum Distance Separation (MDS) Forumlae

MDS is a new separation distance tool that was developed by the Ontario Ministry of Agriculture, Food and Rural Initiatives. The MDS formulae is intended to exclusively deal with odour generated from livestock facilities, such as barns and manure storages and it is not intended to address nuisance issues related to odour from the application of manure on agricultural land (Ontario Ministry of Agriculture, 2006). In Manitoba, the minimum setback distances for livestock operations (earthen manure storage) are mandated by the provincial government under the Provincial Land Use Policies (2005). As stated in the *Planning Act* (2005), a municipality may exceed the minimum the minimum separation distance with just cause but cannot go below the recommended distance. This approach is limited in the sense that a general distance is applied based on animal units and does not take in to account best practices or other relevant factors.

There are five factors to MDS that determine the separation distances for livestock operations. **Factor A** is odour potential that is based on the type of livestock. **Factor B** is nutrient units factors that is based on the number of equivalent number of animal units in the livestock facility. **Factor C** is orderly expansion factor is based on the percentage increase in the number of animal units for a proposed construction. The higher percentage, the higher the **Factor C** will be. **Factor D** is manure or material form in permanent storage factor and is based on the type of manure or material and its relative potential for producing offensive odours. A higher **Factor D** will result in higher odour potential. **Factor E** is an encroaching land use factor that is based on the degree of effect and encroaching land use might have on an existing livestock facility. The higher the encroachment factor, the higher the potential effect on a livestock facility. The data for each of these factors is entered in to MDS formulae system that uses calculated estimations for each Factor. The building base distance in metres is then calculated by multiplying **Factor A** x **Factor D** x **Factor B** x **Factor E** (Ontario Ministry of Agriculture, 2006).

5.0 Implementation of a GIS Model & Next Steps

Up to this point, the primary intent of the literature review and key informant interviews has been to develop a comprehensive understanding of land use conflicts between non-farm rural residents and livestock operations from a local, regional and national perspective and to develop a case study GIS model. Intended use of this would be to assist planners and other decision makers in formulating effective long term land use plans and reducing land use conflicts between rural residential developments and livestock operations within RM of St. Andrews. The next objective is to link this information together and demonstrate how this tool could be used by the Selkirk and District Planning Area Board and other planning offices, as well as provide recommendations for the Planning District Board going forward with the implementation of a GIS model as a decision making tool.

5.1 Focus Group Interviews

The aim of this project has been to develop a GIS model for the Selkirk and District and Planning Area Board that would aid stakeholders in complex decision-making scenarios. Please refer to **Chapter 4.0: Application of a GIS Model** and **Appendix C**: **Detailed Case Study GIS Model Development** to view the procedures and final output layers that were generated for this model. The model consists of three categories: (1) areas most suitable for residential development; (2) areas most suitable for intensively managed livestock (>300 AU); and (3) areas most suitable for low intensity livestock (<300 AU). The input variables that were chosen for each of these categories emerged from the preliminary interviews and literature review.

The following section highlights the findings from the focus group interviews. The primary intent of these interviews was to demonstrate and showcase the findings of the GIS model in order to ensure that the goals, objectives and sub-objectives chosen were appropriate and were assigned appropriate weights in the calculations to produce the final goal and suitability models.

In April of 2009, two focus groups were conducted following the development of the case study GIS mode. The participants included two land use specialists from Manitoba Agriculture, Food and Rural Initiatives (MAFRI) and two planners from the Selkirk and District Planning Area Board. The interviews were approximately 60 minutes in duration and were guided by a set of standardized questions that were developed prior to the interview process (see **Appendix F: Focus Group Questions**). The interviews followed a semi-structured approach, which provided considerable opportunity for interaction between the researcher and interviewees as discussion deviated from the initial standardized questions.

Below is a discussion of the key issues identified by the focus group participants related to the case study GIS model for this project.

5.1.1 Land Use Conflicts – How are they Currently Addressed?

Planners from the Selkirk and District Planning Area Board indicated that few applications for expansion of existing or building development of new livestock operations in the RM of St. Andrews Municipality have been submitted within the last 5 years. The freeze on all new or expanding hog operations within the Red River Valley region of Manitoba has had a drastic impact on hog production within the Selkirk and District Planning Area Board.

When reviewing a development plan for a municipality in the Selkirk and District Planning Area Board, the planners noted that the most important criteria in determining the designation of lands for residential purposes primarily focuses on the economics and servicing capabilities. The planners examine the limitations of on site waste water management and the opportunity to build on the existing infrastructure as a means of analysis for expanding designated residential land use areas. The planners noted that in recent years they have tried to avoid the dispersion of development patterns. Any new development is now examined on the basis of its ability to be in support of rehabilitation and densification of designated residential areas of the municipality. The planners recognize that there will always be fragmented non-agricultural parcels throughout the municipality. One of the planners noted that as stated in the Provincial Land Use Policies (2005) farmers are permitted to subdivide one farmstead per 80 acres of land. The planner added that in unfortunately it is common practice for those farmstead splits stay in the farm family for a few years then they are sold to an unrelated, non-farm rural resident. The sale of farmstead split parcels to non-farm practicing owners has contributed to some land use conflicts between livestock operation and non-farm rural residents. One of the planners added that in other provinces, no subdivisions, including farmstead splits for retiring farmers or children, are allowed in certain designated areas. It was noted that this approach may decrease the number of land use conflicts and preserve prime agricultural land but will in turn have impacts on the livelihoods of farmers. Farmers often rely on the sale of a farmstead parcel to supplement their retirement income.

The planners indicated that they have had to deal with land use conflicts between livestock operations and non-farm rural residents on a frequent basis. One in particular has been ongoing for approximately thirty years. And as indicated by one of the planners, there is little that can be done to rectify this matter. The hog operation was there prior to establishment of rural non-farm residences that chose to expand around the operation. Other than encouraging the livestock operation to re-locate, there is nothing that can be done from the planners' perspective. One planner also mentioned a large hog operation within the municipality that recently suffered significant fire damage. By law, the operation is allowed to rebuild to its previous size as a legal non-conforming use. However, given the operation's current location, the planners have attempted to prevent future land use conflicts by encouraging the operator to relocate to an area in the municipality where the operation would comply with the Provincial Land Use Policies (2005) minimum mutual setback requirements.

The land use specialists from MAFRI stated that over the last fifteen years, they have had to address several land use conflicts between non-farm rural residents and livestock operations on a regular basis. When the land use specialists review a subdivision application, they identify all the livestock operations within one mile of a proposed subdivision. The land use specialists determine whether a subdivision meets the mutual separation distance criteria prescribed in the Provincial Land Use Policies (2005). This analysis is preformed to minimize potential conflict between livestock operations that may be located in close proximity to proposed non-farm rural residential developments. However, it was noted that MAFRI is attempting to develop better analytical capabilities for reviewing subdivisions, development plans and zoning by-laws. Currently, when reviewing subdivisions and commenting on new development and zoning by-laws, MAFRI relies on mapping analysis that were developed from the 1950's, 1960's and 1970's.

5.1.2 Limitations to Study

There are a number of limitations associated with this project. First, the data collected for this study was primarily obtained without charge from the Manitoba Land Initiative (2003). The data obtained from this source is somewhat dated and based on orthographic photography interpretation from a large scale. It is possible that higher quality data could be obtained from private sources at a premium cost may have been more appropriate for this study.

The key informant interview process also had limitations. Participants were selected primarily based on a consultative basis between the researcher and one of the study's committee members to identify individuals that play a key role in land use planning for the study area. Farmers and individuals not directly involved in the planning process for the study area were excluded from the study. The end result is that an unknown portion of the population may have been excluded.

When creating the GIS case study model, a number of parameters and varying weighting values were assigned in each objective, sub-objective and goal model calculations. The rationale for each calculation and assigned weighted values is explained in greater detail in **Chapter 4.0: Application of a GIS Model**. The intent of this model was to provide the Selkirk and District Planning Area Board with a tool that could assist in long-term land use planning and effective optimal site analysis for both residential development and livestock operations. This model could incorporate additional layer parameters. The input layers for this case study GIS model were chosen on the basis of data availability. Another limitation to this study is that the data that was obtained from the Manitoba Land Initiative (2003) was originally collected at various scales. Combining data at different scales poses some limitations on the accuracy of certain calculations (Carr et al., 2007).

5.1.3 Utilizing a GIS Model as a Tool to Address Land Use Conflicts

The primary thrust behind the this case study was to promote the effectiveness of the GIS LUCIS model to planners from the Selkirk and District Planning Area Board and representatives from Manitoba Agriculture highly analytical tool that can assist in long range planning for the planning district. The focus group participants all indicated that the technical components of land use analysis in the Province of Manitoba have not adapted modern technological applications.

The planners noted that a GIS model used for determining optimal land uses and deciphering land use conflicts between non-farm rural residents and livestock operations would be extremely useful. They added that although costly, implementing a GIS model would be very practical for the Board since GIS is used on a daily basis and it would be very beneficial to incorporate the analysis into their current system. Both planners felt that the criteria used in determining optimal siting of both livestock operations and residential development was suitable. One planner could see the case study GIS model being used in other relevant applications that would assist in the analysis of long term land use planning for the municipality and planning district. For example, conducting multi-criteria site analysis for a variety of land uses, such as heavy industrial related uses or parks and recreation. The planners noted that the defined optimal areas for the siting of livestock operations and non-farm rural residential development would not be best served as defined policy areas in a development plan, but rather as an informative piece of background information. Developing highly analytical background information would assist in the formulation of sound policies for both agricultural and residential land uses. One planner added that when considering an application for rezoning of agricultural land to residential land use or examining a residential subdivision or processing an application for a livestock operation, each proposal is unique and has to be considered on its own merit and various elements and factors need to be taken in to consideration for each specific proposal. The planners noted that there were a number of criteria that went in to the development of the case study GIS model and that it would certainly help to guide in the decision making process. However, in order to properly analyze each rezoning application or each subdivision or each application for a livestock operation, the model would need to be calibrated and run for each specific proposal. The planners recognized that this would not be a difficult task provided the case study GIS model is used as base model and slight alterations are made in the assigned weighted values for the input parameters and if necessary, additional variables are included in the analysis for each specific proposal.

The land use specialists from MAFRI also recognized the value of the case study GIS tool and were optimistic that a similar model could be incorporated into their analysis procedures. One of the land use specialists recognized that not withstanding, all the differences in scale of data collection this case study GIS model, provides MAFRI with a strong accessible and quantifiable tool that is based on a platform that makes logical sense. The land use specialists were excited about using the case study GIS model and envisioned possibilities of the next phase in application development. One of the land use specialists worked on other GIS modeling exercises in the wildlife sector and recognized the challenges involved for identifying opportunities and constraints within the case study GIS model. The land use specialists noted that the parameters chosen for the GIS case study model, the data collected and the operations performed to combine all variables together was exceptional. The application of a GIS model for land use specials in MAFRI would be best suited for commenting on residential subdivisions, rezoning applications, development plans and zoning by-laws. According to one of the land use specialists, if MAFRI were able to use a model of this type for a large region, they would be able to accurately measure and visualize how a specific land use at fits within a defined region. For example, if the RM of St. Andrews were to have applications for livestock developments in the future this model would be able to show how it would fit within the municipality and whether the proposed site is a prime area for livestock expansion. The land use specialists noted that they often argue against policies in development plans that make provisions for exceeding the Provincial Land Use Policies (2005) mutual separation distances or even go so far as to place severe restrictions on any and all livestock. This case study GIS model can be used to help accurately identify optimal siting locations for non-farm rural and livestock operations. As municipalities within the planning district continue to transition in to “bedroom communities” and do little to protect the agricultural industry, this tool identifies lands that are and are not suitable for residential development, and lands that are and are not optimally suited for livestock development. One of the land use specialists noted that having a model such as the case study GIS would ultimately serve in protecting the livestock industry of the province and do so in a manner that could reduce the number of land use conflicts by determining optimal siting of both land uses. The land use specialists added that a GIS model has the ability to provide MAFRI with sound evidence to argue against municipalities, such as the RM of St. Andrews that have proposed to place further restrictions on livestock in their new operation. The case study GIS model was able to identify areas that were optimally suited for both livestock and residential development. The land use specialists added that if in fact the model had identified no lands as suitable for livestock development then the municipality would have just cause in proposing further limitations on livestock development. However, as the land use specialists noted, notwithstanding the limitations of different scales for the data used in each of the criteria, this model provides MAFRI with an excellent tool and strengthens the argument that livestock should be protected within the RM of St. Andrews.

One of the land use specialists added that the recent moratorium on all new or expanding hog operations that was put in place for municipalities that are within the Red River Valley is a policy. The intent of Province of Manitoba regarding the hog industry is expressed through the policy development. However, the hog moratorium was established with little scientific basis and site-specific analysis. There is insufficient water quality data to determine the impacts of any type of land use within the watershed. There has been no attempt to bring data together and conduct analysis to support the decision of the hog moratorium. The majority of the area within the case study Planning District is within the MAFRI defined special management zone and is under the hog moratorium. One of the land use specialists was excited this case study GIS model was able to incorporate all data that is available to the general public. This model was able to identify areas where hog operations and other livestock operations should optimally locate, which is contrary to provincial policy and other mandates set. Both land use specialist from MAFRI felt they would benefit in conducting their work by having a model similar to the GIS case study tool. Although it would be a costly endeavour to implement, it would not require significant amounts of training as most of the land use specialists working in MAFRI are familiar with using a GIS system.

5.2 Next Steps

Given the current state of hog prices and limits placed on expansion by the hog moratorium in the Red River Valley region, it is very difficult for an operator to sustain a viable long-term business in the hog producing industry. The RM of St. Andrews was once a municipality that was primarily agriculturally based, however, in the last 15 years there has been significant transition in to a "bedroom community" with an ever increasing demand for high price single-family residential units. The additional hardships that hog producers face in Manitoba will only contribute to the increasing decline of livestock production in the municipality and lead to the subdivision of agricultural land for non-agricultural purposes. The future of livestock within the municipality is not bright. As indicated in the future *Development Plan* for the RM of St. Andrews, any new or expanding operations above 200 animal units would require a conditional use permit and be subject to a public hearing. This exceeds the minimum conditional use standard of 300 animal units as indicated in the Provincial Land Use Policies (2005). Is there a possibility that the two uses can still exist in the municipality or has livestock production been overtaken by residential demand? The planners both agreed that in the last 10 or 15 years, land use planning within the Selkirk and District Planning Area and within the Province have changed to better address land use conflicts between rural residential dwellings and livestock operation. However, more could be done and both the planners and land use specialists were receptive at the possibility of using modern technological tools, such as a GIS model to assist in effective long term planning that in turn would ultimately reduce the likelihood of land use conflicts between rural residential dwellings and livestock operations.

The data collected for this case study was collected for the municipality of St. Andrews. The case study GIS model did not examine areas outside of the RM of St. Andrews. The future of this model is in the hands of the land use specialists from MAFRI and planners from the Selkirk and District Planning Area Board. Both recognized that this model was a valuable tool and would assist in conducting land use analysis decisions and would be more beneficial if the model was analyzed from a regional perspective. Developing a GIS model from a regional perspective, such as the planning district or hog moratorium would be an interesting area of future study that could provide both the planners and land use specialist with an additional land use analysis tool from a boarder scale.

5.2.1 Conclusions

This project has promoted the use of a GIS model as a tool to assist in routine land use decision and long-term land use planning within the RM of St. Andrews. As discussed earlier, the number of potential benefits associated with the implementation of a GIS model is considerable – optimal siting analysis, projecting future growth areas, providing sound background information for development plan policy formulation, etc. However, some barriers and challenges, including cost and limited initial training may prohibit the implementation of a GIS model as an analytical tool in both the Selkirk and District Planning Area Board and MAFRI Interlake office.

The GIS case study model is intended to provide a starting point for the Selkirk and District Planning Area Board and MAFRI in promoting the use of GIS analysis as an alternative method for conducting effective land use planning. Given the context of land use conflicts within the municipality and the hog moratorium that has been implemented for the Red River valley region, which includes the RM of St. Andrews, the use of a GIS model for conducting optimal land use siting analysis is further strengthened as a future approach to effective long term land use planning that in turn may minimize land use conflicts between non-farm rural residents and livestock operations.

References

Anderson, William D. et al. (2002). "Development at the Urban Fringe and Beyond: Impacts on Agriculture and Rural Land". *Agricultural Economic Report AER803*. USDA.

Aspinall, R.J. et al. (1993). "Geographical Information Systems for Land Use Planning". *Applied Geography*. Vol. 13. pp 54-66.

Baumel, Syd. (2002) "The Dirty Truth About Hog Farms" *Winnipeg Vegetarian Association*.

Bergstrom, John et al. (2005). *Land use problems and conflicts*. New York, NY: Routledge.

Blaiklock, J. et al. (1995). "Land Use Planning: A Decision Support System". *Journal of Environmental Planning and Management*. Vol. 38 (1). pp. 77-113.

Blaxter, Loraine et al. (2001). *How to Research (second edition)*. Philadelphia, PA. Open University Press.

Booth, Wayne C. et al. (1995). *The Craft of Research*. United States of America. The University of Chicago Press.

Bowden, Marie-Ann et al. (2002). "Comparative Standards for Intensive Livestock Operations in Canada, Mexico and the US". *Commission for Environmental Cooperation*.

Brisbin, Richard A. et al. (2003). "The Everyday Politics of Land Use and the Canadian Environment". Paper presented at the biannual meeting of the Association of Canadian Studies in the United States. Portland, Oregon. November 19-23, 2003.

Caldwell, Wayne (1999). "Planning and Intensive Livestock Facilities: Canadian Approaches" Paper presented at CIP Conference in Montreal, Quebec. June, 1 1999.

Caldwell, Wayne (2002). "Lessons from Michigan: Strategies for Regulating Intensive Livestock Operations-Right to Farm and the Role of the State". Paper presented at the National Conference: *Integrated Solutions to Manure Management*. London, Ontario. September, 2002.

Caldwell, W. (2003). "Rural non-farm development: Far-reaching cumulative effects". *Ontario Planning Journal*. Vol. 18 (5), pp 3-4.

References

Carr, Margaret H. et al. (2007). *Smart Land-Use Analysis: The LUCIS Model*. Redlands, California. ESRI Press.

City of Winnipeg (2004) *Residential Land Supply Study*.

Commissioners' Report (1999). "Large Scale Hog Production and Processing: Concerns for Manitobans". Commissioners' Report on the Citizens' Hearing on Hog Production and the Environment. Brandon, Manitoba.

Corkal, Darrell et al. (2004) "Rural Water Safety from the Source to the On-Farm Tap". *Journal of Toxicology and Environmental Health*. Part A, 67. pp. 1619-1642.

Craw et al. (1999) "Implementation of Spatial Decision Support System for Rural Land Use Planning: Integrating Geographic Information System and Environmental Models and Optimisation Algorithms". *Computers and Electronics in Agriculture*. Vol. 23. pp 9-26.

Dickson, Andrew (2008) in "Producers Prepare to Euthanize Young Pigs" by Kusch, Larry *Winnipeg Free Press*. April 11, 2008

English, Mary R. et al. (1999) "Smart Growth for Tennessee Towns and Counties" Knoxville, Tennessee. University of Tennessee Press.

Environmental Protection Agency (2009) "Brownfield Definition" http://www.epa.gov/swerosps/bf/glossary.htm. (Last viewed June, 2009).

Farm Practices Guideline for Pig Producers (2007). Manitoba Agriculture, Food and Rural Initiatives.

Fong, Wang Yui. (1973) *Methane Production from High Rate Anaerobic Digestion of Hog and Dairy Cattle Manure.* A thesis submitted for the degree of Master of Science.

Funke, Kelly. (2003) "Manure Saves Fertility Costs and Adds Weed Control". *Official Publication of Canada's Canola Growers*.

Green, D.J. (1996) "Surface Water Quality Impacts Following Winter Applications of Hog Manure in the Interlake Region, Manitoba, Canada, 1996". *Manitoba Environment*. Water Quality Management Report No. 96-14. pp. i-63.

Guilford, C. et al. (1999) *Large-Scale Hog Production and Processing: Concerns for Manitobans*. Citizens' Hearing on Hog Production and the Environment. Brandon, MB. 1999. pp.1-31.

References

Hathout, Salah (1988). "Land Use Change Analysis and Prediction of the Suburban Corridor in Winnipeg". *Journal of Environmental Management*. Vol. 27. pp. 325-335.

Hellerstein, D. (2002). "Farmland Protection: The Role of Public Preferences for Rural Amenities". *Agricultural Economic Report*. No. 815:74.

Hodge, G., & Robinson I. (2001). *Planning Canadian Regions*. Vancouver, BC. UBC Press.

Information Builders (2008). "Decision Support System". http://www.informationbuilders.com/decision-support-systems-dss.html (Last viewed July, 2008).

Jain, Dharmesh et al. (1995). "Spatial Decision Support System for Planning Sustainable Livestock Production". *Computer, Environment and Urban Systems*. Vol. 19 (1). 1995.

Jopling, David. (1998) *The Development and Evaluation of a Rural Environmental Planning Strategy for the Selkirk and District Planning Area*. A thesis submitted f for the degree of Master of City Planning. University of Manitoba.

Knight, David B. et al. (1972). "Office Parks: The Oak Brook Example". *Land Economics*. Vol. 48 (1). pp. 65-69.

Kusch, Larry (2008) "Producers Prepare to Euthanize Young Pigs" *Winnipeg Free Press*. April 11, 2008

Li, Xia et al. (2002). "Neural-Network Based Cellular Automata for Simulating Multiple Land Use Changes Using GIS". *International Journal of Geographical Information Science*. Vol. 16 (4). pp. 323-343.

Longley et al. (2001) *Geographic Information Systems and Science*. John Wiley and Sons Ltd. England. MacDonald et al. "Livestock Decision Support Tool for the Rural Municipality of Clanwilliam". Prairie Farm Rehabilitation Administration.

Lorch, Brian (2002). "Growth Beyond the Perimeter: Population Change in Manitoba's Capital Region". *Institute of Urban Studies*. University of Winnipeg. Research Highlight 2002-1.

Lynch, Kevin (1960) "The Image of the City". Cambridge, Massachusetts. Massachusetts Institute of Technology.

Lysenko, George (2004) *One More Time: What is a Geographic Information System?* The Ontario Planning Journal. Vol. 19 (3). pp. 30-31.

References

MacDonald et al. (2001) "Livestock Decision Support Tool for the Rural Municipality of Clanwilliam". Prairie Farm Rehabilitation Administration.

Mackenzie, Jody et al. (2005). "Public Involvement Processes, Conflict and Challenges for Rural Residents near Intensive Hog Farms". *Local Environment*. Vol. 10 (5). pp. 513-524.

Macleod, Cedric John. (2003) *The Effects of Liquid Hog Manure Application and Tillage Systems on the Rate of Cereal Crop Residue Decomposition in Clay Soils*. A thesis submitted for the degree of Master of Science. University of Manitoba. Manitoba Assessment (2006). Selkirk Assessment Office.

Manitoba Agriculture (2006) "Land Use Planning for Livestock Development". Manitoba Agriculture, Food and Rural Initiatives.

Manitoba Agriculture: Livestock Manure Storage (2005) "Livestock Manure Storage". http://www.gov.mb.ca/agriculture/livestock/publicconcerns/cwa01s13.html (Last viewed July, 2008).

Manitoba Agriculture: Manure Storage and Handling (2006). "Livestock Manure and Mortalities Regulation". http://www.gov.mb.ca/conservation/envprograms/livestock/pdf/app_for_registration_of_msf_sept_2006.pdf (Last viewed July, 2008).

Manitoba Agriculture (2006) Siting Livestock Production Operations. Manitoba Agriculture, Food and Rural Initiatives. http://www.gov.mb.ca/agriculture/livestock/publicconcerns/cwa03s01.html (Last viewed September, 2007).

Manitoba Agriculture (2005) Land Application of Manure. Manitoba Agriculture, Food and Rural Initiatives. http://www.gov.mb.ca/agriculture/livestock/publicconcerns/cwa01s06.html (Last viewed June, 2007).

Manitoba Intergovernmental Affairs and Trade (2008). "Land Use Planning in your Community: Role of Local Government". http://www.gov.mb.ca/ia/programs/land_use_dev/documents/12926_planning.pdf (Last viewed July, 2008).

Manitoba Land Initiative (2003). http://www.mli.gov.mb.ca

Manitoba Pork Council. (2006) *Laws, Rules & Regulations.* http://www.manitobapork.com/index.cfm?pageID=5 (Last viewed April, 2006).

References

Mcdougall, Anthony. (2000) *Effects of Size and Business Arrangement on the Profitability of Hog Farrowing Operations in Manitoba*. A thesis submitted for the degree of Master of Science.

McHarg, Ian (1969) "Design with Nature". New York. John Wiley and Sons Inc.

McHarg, Ian et al. (1998). "To Heal the Earth: Selected Writings of Ian McHarg". Washington, D.C. Island Press

Morgan D.L. and Kreuger R.A. (1993) 'When to use focus groups and why' in Morgan D.L. (Ed.) *Successful Focus Groups*. London: Sage

National Roundtable on Environment and Economy (1998). "Greening Canada's Brownfield's".

Niverville (2006). Manitoba Community Profiles. http://www.communityprofiles.mb.ca/cgi-bin/csd/index.cgi?id=4602046 (Last viewed June, 2006).

Northcott, David (2008). "Slaughtered Hogs to Feed Hungry" *Winnipeg Free Press* by Wiebe, Lindsey. April23, 2008.

Novek, Joel (2002). *Intensive Hog Farming in Manitoba: Transnational Treadmills and Local Conflicts*. Research Report from the University of Winnipeg.

Novek, Joel (2003). "Intensive Livestock Operations, Disembedding, and Community Polarization in Manitoba". *Society and Natural Resources*. Vol. 16. pp. 567-581.

Odum, Eugene (1969) "The Strategy of Ecosystem Development". *Science*. Vol. 164 (3877). pp. 262-270.

Ontario Ministry of Agriculture (2006). "Minimum Distance Separation Formulae: Implementation Guidelines". Ministry of Agriculture, Food and Rural Affairs. Publication 707.

Perry, James (2003). "This Little Piggy Went to the Global Market". *The Manitoban*. February 12, 2003.

Planning Act (2005) C.C.S.M.c. Page 80. Manitoba. http://web2.gov.mb.ca/laws/statutes/ccsm/p080e.php. Last viewed July, 2009.

Plohman, Gary. (2001) "Measurement of Odour Emissions from Hog Operations in Manitoba". *Elite Swine Inc.*

Preferred Carbon (2009) http://beyondagronomy.com/preferredcarbon.htm. Last viewed June, 2009.

References

Price, Jeff. (1999) *Sustainability of Land Use for Future Intensive Hog Operations in the Central Region of Manitoba*. A thesis submitted for the degree of Master of City Planning.

Provincial Land Use Policies (2005). Recommended Siting Criteria for Livestock Operations. MR 193/2005.

Rance, Laura (2008). "Hog Plant Debate Rouses Strong Feelings". *Winnipeg Free Press*. Section B9. April 5, 2008.

Richmond, H. (2000). "Metropolitan Land Use Reform: The Promise and Challenge of Majority Consensus" in B. Katz *Reflections on Regionalism*. Washington, DC. Brookings Institution. pp 9-39.

Royal LePage Stevenson Advisors (2004) "Impact of Intensive Livestock Operations on Manitoba Rural Residential Property Values: Five Case Study Locations. Prepared for Manitoba Pork Council.

Selkirk and District Planning Area Board (2007) http://www.selplan.net (Last viewed: April, 2007).

Statistics Canada: Census of Agriculture (2001). http://www.statcan.gc.ca/ca-ra2001/index-eng.htm (Last viewed June, 2007).

Statistics Canada: Census of Agriculture (2006). http://www.statcan.ca/english/agcensus2006/index.htm. (Last viewed September, 2008).

Statistics Canada: Marriage Database (2006). http://www40.statcan.ca/l01/cst01/famil53a.htm. (Last viewed April, 2008).

Statistics Canada: Census of Population (2006). http://www12.statcan.ca/english/census/index.cfm. (Last viewed April, 2008).

Thompson, Peggy S. (1981). *Urbanization of Agricultural Land*. Edmonton, AB. Environmental Council of Alberta.

Vandean, Theresa (2003). *The Negative Social Impacts of Manitoba's Hog Industry and the Implications for Social Sustainability*. Research Report for Manitoba Legislative Internship Prorgamme.

Wiebe, Lindsey (2008). "Slaughtered Hogs to Feed Hungry" *Winnipeg Free Press*. April 23, 2008.

Appendices

Appendix A: Glossary of Terms

Anaerobic Digester – An enclosed vessel in which micro-organisms break down organic materials (e.g. manure and other organic materials), in the absence of oxygen, resulting in the production of biogases, consisting primarily of methane and carbon dioxide. (Ontario Ministry of Agriculture, 2006)

Animal Unit – One animal unit is defined as the number of livestock required to excrete 73 kg (160 lbs) of nitrogen in a 12 month period (Manitoba Agriculture: Manure Storage and Handling, 2006)

Decision Support System (DSS) – Decision support systems are a specific class of computerized information system that supports business and organizational decision-making activities. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions (Information Builders, 2008).

Earthen Manure Storage – Are often incorrectly called “lagoons”. Earthen manure storage are engineered structures used for the storage of liquid livestock manure. Design specifications for earthen manure storage structures are developed to address the site's geological conditions. The regulation allows a seepage rate under earthen manure storage structure no greater than 3 cm/year and only then where there is at least 5 metres of clay naturally located under the structure. This seepage rate is set to protect the groundwater located below the clay. Where soil at a given location does not have enough natural clay, a clay liner must be installed. If a shallow aquifer is located beneath the area, the earthen manure storage structure must be built with a plastic liner. A monitoring well system used to detect leaks is required anytime a liner is used. Producers must install concrete ramps in the earthen manure storage structures to provide access for equipment. Grass must be seeded on the sides of earthen manure storage structures to prevent erosion from rainfall. Earthen manure storage structures, when designed to meet current standards and operated to maintain the structural integrity of their floors, walls, and liners, are secure for storing manure (Manitoba Agriculture: Livestock Manure Storage, 2005).

Farm Capital – Farm capital includes the value of all farmland, buildings, farm machinery and equipment (including passenger vehicles used in the farm business), and livestock and poultry (Statistics Canada: Census of Agriculture, 2006).

Grower/Finish – A livestock operation where pigs weigh between a weanling and a finisher, approximately 23-113 kilograms (Farm Practices Guidelines for Pig Producers, 2007).

Animal Units[1] (A.U.)	Barn Capacity or Animal Places				
	Sows, Farrow-Finish (110 – 115 kg)[2]	Sows, Farrow-Weanling (5 kg)[2]	Sows, Farrow-Nursery (23 kg)[2]	Weanlings (5 – 23 kg)[2]	Grower/Finishers (23 – 113 kg)[2]
10 - 100	8 - 80	32 – 319	40 – 400	303 – 3030	70 – 699
101 – 200	81 – 160	323 – 639	404 – 800	3061 – 6061	706 – 1399
201 – 300	161 – 240	642 – 958	804 – 1200	6091 – 9091	1406 – 2098
301 – 400	241 – 320	962 – 1278	1204 – 1600	9121– 12121	2105 – 2797
401 – 800	321 – 640	1281 – 2556	1604 – 3200	12152 – 24242	2804 – 5594
801 - 1600	641 – 1280	2559 – 5112	3204 – 6400	24273 – 48485	5601 – 11189
1601 – 3200	1281 – 2560	5115 – 10224	6404 – 12800	48515 – 96970	11196 – 22378
3201 – 6400	2561 – 5120	10227 – 20447	12804 – 25600	97000 – 193939	22385 – 44755
6401 – 12800	5121 – 10240	20450 – 40895	25604 – 51200	193970 – 387879	44762 – 89510
12801 and greater	10241 and greater	40898 and greater	51204 and greater	387909 and greater	89517 and greater

Source: Farm Practices Guidelines for Pig Producers, 2007

Livestock Operation – A livestock operation means a permanent or semi-permanent facility or non-grazing area where at least 10 animal units of livestock are kept or raised either indoors or outdoors, and includes all manure collection facilities, but does not include an auction mart (Planning Act, 2005).

Manure Spreadfield – Under the Livestock Manure and Mortalities Management Regulation 238/2006, any manure that is land applied in Manitoba must be used as a fertilizer for crop production. Classes 6, 7 and unimproved organic soils are not considered suitable for manure application. The Livestock Manure and Mortalities Management Regulation 238/2006 prohibits manure application to these soils. Applying manure during the winter is a concern because manure can runoff and enter water more easily when applied to frozen or snow-covered ground than when applied during the cropping season. Under the Livestock Manure and Mortalities Management Regulation, winter spreading is between November 10 of one year and April 10 of the next. All new operations (those that were built after March 30, 2004) and operations that are 300 animal units or greater are prohibited from winter spreading. New operations and operations that are 400 animal units or greater must comply with the prohibition on winter spreading immediately. Operations that are between 300 and 399 animal units in size have until November 10, 2010 to comply but these operations must comply with the winter spreading setbacks in **Table 1**. Existing small operations (less than 300 animal units) are also allowed to land apply manure in the winter but they too must adhere to the regulatory setbacks (**Table 1**). Regardless of farm size, no manure can be spread during the winter on land with a slope of greater than 12 percent (Manitoba Agriculture: Manure Application, 2006).

Required Distance (metres) from Watercourses, Sinkholes, Springs and Wells for Winter Manure Spreading, (Between November 10 and April 10)	
Slope	*Surface Applied (No Incorporation)*
less than 4%	150
4 – 6%	300
6 – 12%	450
Greater than 12%	Prohibited

Source: Manitoba Agriculture: Manure Application, 2006

Manure Storage Facility – A structure, earthen storage facility, molehill, tank or other facility for storing manure or where it is stored, and includes any permanent equipment or structures in or by which manure is moved to or from the storage facility, but does not include (Livestock Manure and Mortalities Regulation, 2006).

a) a field storage site;
b) a vehicle or other mobile equipment used to transport or dispose manure;
c) a gutter or concrete storage facility;
d) a collection basin, or;
e) a composting site for manure or mortalities;

Prime Agricultural Land - Land comprised of mineral soil determined by Manitoba Agriculture to be of dryland Agricultural Capability Class 1, 2 or 3 and includes a land unit of one quarter section or more or a river lot, 60% or more of which is comprised of land of dryland Agricultural Capability Class 1, 2 or 3 (Provincial Land Use Policies, 2005).

Provincial Land Use Policies (PLUPs) – The Provincials Land Use Policies (PLUPs) set out the Province's interest in land and resources. These policies guide local and provincial authorities in preparing land use plans and making sustainable land use and development decisions (Manitoba Intergovernmental Affairs and Trade, 2008).

Appendix B: Data Collection

The following GIS bio-physical data layers for the Study Area have been complied using existing data from the Manitoba Land Initiative (2005), the Selkirk and District Planning Areas Board and through field observations. This data was used as the basis for the creation of the GIS LUCIS model.

B.1 Basemap Features

The basemap is a digital map to which all other information is plotted or corrected. Essentially the basemap is the frame upon which the rest of the data is placed. Two separate sources of information were utilized for creating the basemap for the RM of St. Andrews. These are the National Topographic Survey (NTS) sheets and orthographic photography with the associated quarter section grid. The parcel map and property ownership data was obtained from the Selkirk and District Planning Area Board.

B.1.1 Rural Residences

Non-farm rural resident locations were used to determine which areas are excluded from considering optimal livestock operation siting. Non-farm rural resident locations were identified through orthographic photography, tax role entries, and the assistance of Selkirk and District Planning Area Board Staff.

B.1.2 Livestock Operations

Understanding the location and size of existing livestock operations is helpful for conducting land use planning. This information assists planners in decision making matters, this includes the direction and scope of future expansion of the livestock industry. Information on operation type, size and location was acquired by a mail out survey from the Selkirk and Planning Area Board.

An agricultural inventory survey was originally conducted in 2001 by Prairie Farm Rehabilitation Administration (PFRA) for parts of the province of Manitoba. Some of the information contained within the data consisted of farm owners addresses, type of farm operations, livestock types, numbers of livestock and numbers of animal units. This data was made available to Manitoba Intergovernmental Affairs and Trade, which was then provided to the Selkirk and District Planning Area Board. It was discovered by Manitoba Agriculture that this dataset contained errors.

Subsequently, a survey was sent out to all livestock farmers that made up the 2001 PFRA dataset as part of the livestock inventory study for the District's Development Plan review. The questionnaire asked farmers what type and subtype of livestock operation they own, the total number of each animal type at the operation and the total number of animal units at the operation. If animal units were not provided, they were calculated using the *Animal Unit Summary Table* (see below). A total of 156 surveys were sent out to livestock farmers in West St. Paul, St. Andrews and St. Clements. This practicum used the data that were obtained from the livestock inventory study in 2006.

ANIMAL UNIT SUMMARY TABLE	A.U. Produced By One Livestock	Livestock Producing One A.U.
Dairy		
Milking cows, including associated livestock	2.000	0.5
Beef		
Beef cows, including associated livestock	1.250	0.8
Backgrounder	0.500	2.0
Summer pasture/replacement heifers	0.625	1.6
Feeder cattle	0.769	1.3
Hogs		
Sows, farrow to finish	1.250	0.8
Sows, farrow to weanling	0.313	3.2
Sows, farrow to nursery	0.250	4.0
Weanlings	0.033	30.0
Growers/finishers	0.143	7.0
Boars (artificial insemination operations)	0.200	5.0
Chickens		
Broilers	0.0050	200
Roasters	0.0100	100
Layers	0.0083	120
Pullets	0.0033	300
Broiler Breeder Pullets	0.0033	300
Broiler Breeder Hens	0.0100	100
Turkeys		
Broilers	0.010	100
Heavy Toms	0.020	50
Heavy Hens	0.010	100
Horses (PMU)		
Mares, including associated livestock	1.333	0.75
Sheep		
Ewes, including associated livestock	0.200	5.0
Feeder lambs	0.063	16.0

Source: Provincial Land Use Policies (MR 193/2005)

B.1.3 Land Features

Land use describes the principle natural surface characteristics of the land base. The characteristics defined are classified in separate categories as defined by the MLI (2001) land use classifications. The way land is presently being utilized affects decisions about manure application and facility placement. Land use can determine the possibilities or limitations for livestock expansion or development. For example, the availability of fields suitable for manure application (annual cropland, forages and grassland) within an economical distance from an operation could limit the size of the proposed livestock operation. Land use information is derived from satellite imagery that has a resolution of $30m^2$. Satellite imagery was obtained from Radarsat International in 2001 from the Manitoba Land Imitative.

B.1.4 Surface Characterization

Soil types for the study area, were assessed based upon surface texture standard USDA soil texture abbreviations (normally the first 15cm) from the MLI (2003). Soils of a municipality are an important natural resource for the community. The soils database and maps are important for making decisions about agriculture capability of the land, risk of leaching and suitability for many uses including agriculture, industrial, construction and recreational. The soils database information contains information about soil texture, drainage, permeability, percentage of slope, plus many other characteristics and interpretations. All soil and soil related data was derived from the Manitoba Land Initiative (2003).

B.1.5 Manure Application Sensitivity

There are certain characteristics of soil and landscape that may make areas unsuitable for manure application if no mitigation practices are carried out. Areas with hazards, high and severe risk of erosion, wetlands and or intermittent water bodies, may pose problems for surface or ground water contamination from manure. These areas need more detailed on-site evaluation so recommendations can be made for the appropriate manure application methods to reduce the potential for nutrient contamination.

B.1.6 Nitrogen Utilization

Under a sustainable fertility management system, manure application rate is determined by the crop's nutrient requirement and by the nutrient content of the soils as well as the manure. The amount of land available for manure application depends on the amount of nitrogen it can utilize. Annual nitrogen utilization (N-utilization) depends on the crop type and, in the case of annual crops, soil texture. By overlaying the land use data with the soil texture data, annual nitrogen utilization potential for the RM can be determined.

Crop	Soil Type	Recommended (kg/ha)
Forages, established stands:		
Alfalfa	All types	250
Grasses	All types	165
Grass-Alfalfa mixtures	All types	195
Annual Crops	Medium to heavy soils	90
	Light Soils	65

*Taken from the Farm Practices Guidelines for Poultry Producers in Manitoba, Manitoba Agriculture and Food

The calculation of total potential N-utilization is an estimate. These numbers do not take into account setback requirements from watercourses and water bodies, wells, residences and communities and property lines. Also, some areas may be unsuitable for manure application due to other limitations, for example, grassed areas shown on the map such as farmyards, grasses, waterways and areas of steep slopes (along Red River and the many streams and creeks). Because of the assumption of forages to be alfalfa/grass fields, there may be some pure alfalfa stands present which has a higher n-utilization rate than a mixed stand. Also, the N-utilization for annual crops is general; some crops have higher demand for N than the general rating.

B.1.7 Water Quality Management Zones for Nutrients

The nutrient management groups reflect the capacity of different soil characteristics to sustain agricultural activity and assess the risk of nutrient loss to leaching or surface run off.

Source information is based upon agricultural capability ratings as derived from 1:20,000 and 1:50,000, detail mapping of the Selkirk and District Planning Area and has been developed by the Manitoba Agriculture, Food and Rural Initiatives.

Manitoba landscapes have been separated into four zones based on the principal factors that influence run-off and leaching potential. These factors largely define agricultural capability and include such things as land slope, topography, soil texture, permeability, distance to ground water, erosion potential, soil characteristics and crop yield potential. The Canada Land Inventory Soil Capability Classification for Agriculture, with modifications made for Manitoba's conditions, defined criteria for these factors in seven classes. These seven classes were then placed into four categories to become the proposed Water Quality Management Zones for Nutrients.

Zone 1:

These are highly productive agricultural lands. Within Zone 1, there is a relatively low risk of nitrogen loss to surface or groundwater when good management practices are followed but there is a relatively high risk of phosphorus loss to surface water especially during spring run-off. Application of nutrients in Zone 1 should be managed in a way that prevents over-application while optimizing crop production and thereby, minimizing the potential for loss to ground or surface water.

Zone 2:

These are moderately productive agricultural lands. There is a limited risk of nutrient loss to ground or surface water when good management practices are followed. These lands have medium-texture loamy sands, sands with poor water holding capability, slope between 10% and 15%, or other factors that may lead to a limited risk of nutrient leaching run-off. Because of the risk of nutrient loss to ground or surface water from Zone 2, total annual nitrogen applications should be reduced in comparison to Zone.

Zone 3:

These are marginally productive lands with a moderate risk of nutrient loss to surface or ground water. Among other factors, these lands have coarse sands and slope between 15% and 30%. Zone 3 is only suitable for perennial forage crops, including alfalfa, grasses, alfalfa-grass mixtures and pastures. Because of the potential for nutrient loss to ground or surface water, total annual nutrient application in Zone 3 should be reduced in comparison to Zone 2 and be restricted to the growing season.

Zone 4:

These are generally non-productive agricultural lands that present a significant risk of nutrient loss to surface of ground water. Zone 4 includes areas with steep slopes, surface bedrock stabilized or active sand dunes, marshes, swamps, bogs and fens. There should be no application of nitrogen or phosphorus in areas identified as Zone 4.

Appendix C: Detailed Case Study GIS Model Development

C.1 Identifying Lands Physically Suitable for Residential Land Use

C.1.1 Identifying Soils Suitable for Residential Land Use

In identifying soils most suitable for residential land use, two soil characteristics were chosen – water erosion risk and drainage classification. These two layers were downloaded from the Manitoba Land Initiative (MLI 2003) for the RM of St. Andrews as vector layers and then converted in to raster layers. The Province of Manitoba assesses water erosion risk under a five-class system: negligible (< 6 tonnes/ha/year), low (6-11 tonnes/ha/year), moderate (11-22 tonnes/ha/year), high (22-33 tonnes/ha/year), and severe (> 30 tonnes/ha/year). The drainage classification is defined by Agriculture and Agri-Food Canada's Research Branch: very poor, poor, imperfect, moderately well, well and rapid. This model involved a two step process. Firstly, the water erosion risk layer was reclassified using the Reclassify Tool in ArcGIS 9.2 (see **Table 14**). The old values were reclassified based on geometric interval to the new values shown in the table below. The value range of 1 to 9 was used, with 1 representing the lowest suitability and 9 being the highest suitability.

Table 14 - Water Erosion Risk Reclassified Values
Source: Manitoba Land Initiative, 2003

Old Values	New Values
N - Negligible (<6 t/h/y)	9
L - Low (6-11 t/h/y)	8
M - Moderate (11-22 t/h/y)	7

Next, the drainage classification was reclassified using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in the table below. The value range of 1 to 9 was used, with 1 representing the lowest suitability and 9 being the highest suitability (see **Table 15**). The rationale for this decision is that building within areas that are well drained is easier from a construction, landscaping and maintenance perspective. Poorly drained areas may require additional drainage work to be completed thus incurring additional costs to a developer.

Table 15 – Drainage Classification Reclassified Values Source: Manitoba Land Initiative, 2003	
Old Values	**New Values**
Well	9
Imperfect	8
Rapid	4
Poor	3
Very Poor	2
Water	1
Marsh	1
Urban, Modified, Unclassified	1

The reclassified water erosion risk layer and the reclassified drainage classification layer were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(recerosion * 0.2) + (recdrainage * 0.8)*. The reclassified erosion risk layer was multiplied by a weight of 0.2 and the reclassified drainage classification layer was multiplied by a weight of 0.8. The drainage classification layer was given a greater weight value because of the added costs that drainage mitigation would incur upon a potential developer. The sub-model shown below outlines the methods used in producing the output map for *sub-objective 1.1.1: identifying soils suitable for residential land use* (see **Figure 16**). The rationale for this decision is quite simple – building within areas that pose significant risk to water erosion may impede additional costs to a developer, including such expensive endeavors as bank stabilization projects.

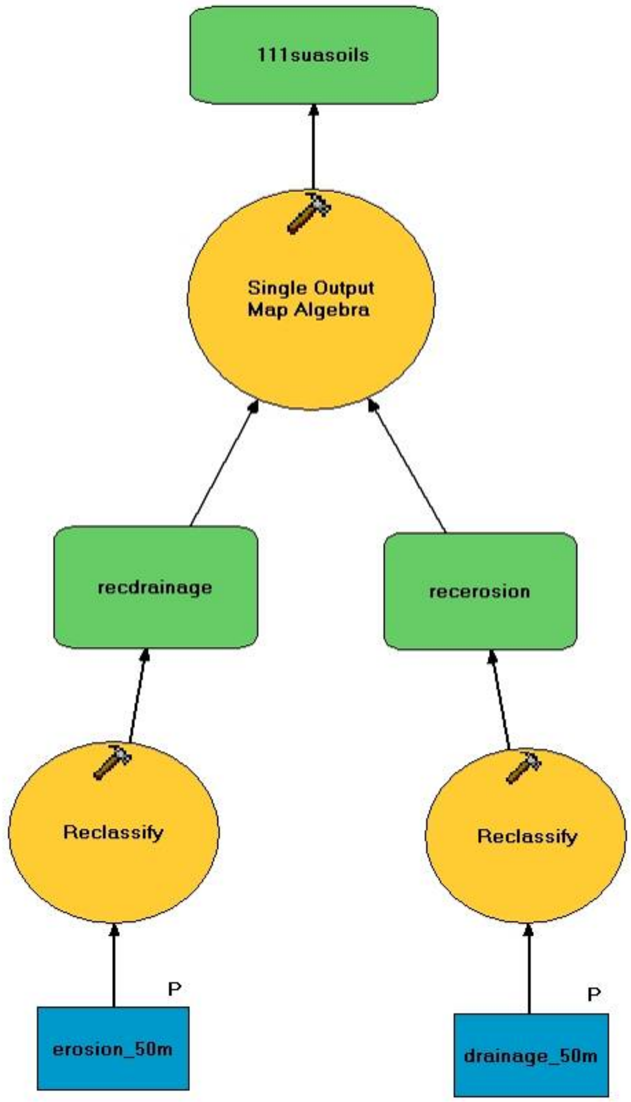


Figure 16 - 1.1.1 Suitable Soils for Residential Development Sub-Model

C.1.2 Identifying Lands Free of Flood Potential

In identifying the lands free of flood potential a vector layer that showed flood risk areas for the RM of St. Andrews was first converted in to a raster layer. This layer revealed that flood risk areas exist primarily adjacent to the Red River. Next, all of the cells that posed a risk of flooding were reclassified based on geometric interval using the Reclassify Tool in ArcGIS 9.2 and assigned a value of 1 (low suitability) and all other cells were assigned a value of 9 (high suitability) (see **Table 16**). The sub-model shown in **Figure 17** outlines the methods used in producing the output map for *sub-objective 1.1.2: identifying lands free of flood potential*. The rationale for this decision is quite simple – building within wetlands or flood risk areas is more costly and is discouraged by insurance companies and Provincial Land Use Policies (2005).

Table 16 – Lands Free of Flooding Reclassified Values Source: Selkirk and District Planning Area Board, 2006	
Old Values	**New Values**
Flood Risk Areas	1
No Flood Risk Areas	9

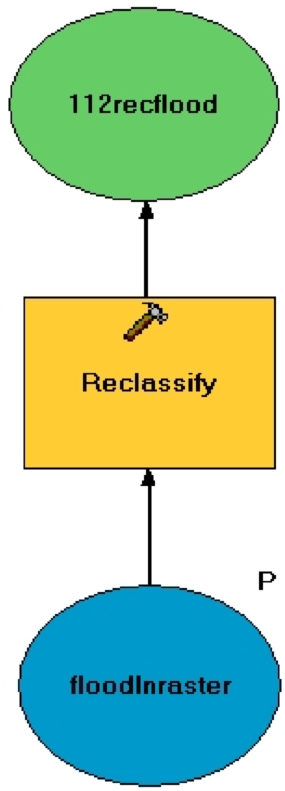


Figure 17 - 1.1.2 Lands Free of Flood Potential Sub-Model

C.1.3 Identifying Quiet Areas

In identifying quiet areas, three input vector layers were chosen – the distance from major highway roads, the distance from railroads and the distance from airports. The railroads and major roads were selected from the topographic data that was downloaded from the Manitoba Land Initiative (2003) for the RM of St. Andrews. These selected features were converted in to two new vector layers. The property ownership layer provided by the Selkirk and District Planning Area Board (2006) was used to select the St. Andrews airport were selected and made in to a new vector layer.

This sub-model involved a three step process. Firstly, the Euclidean distance operation was run in ArcGIS 9.2 on the major highway roads, the railroads and the identified airport parcels vector layers. This produced three separate layers that visually showed incremental distances from the major highway roads, railroads and airports. Next, the newly created layers that showed incremental distances from the major roads, the railroads and the selected airport parcels were reclassified using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in **Table 17, 18** and **Table 19**. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability.

Table 17 – Distance in metres from Major Highway Roads Reclassified Values
Source: Manitoba Land Initiative, 2003

Old Values	New Values
0 - 341.129213	1
341.129213 - 584.593093	2
584.593093 - 925.722306	3
925.722306 - 1403.695221	4
1403.695221 - 2073.406577	5
2073.406577 - 3011.772089	6
3011.772089 - 4326.562151	7
4326.562151 - 6168.77916	8
6168.77916 - 8750	9

Table 18 – Distance in metres from Railroads Reclassified Values
Source: Manitoba Land Initiative, 2003

Old Values	New Values
0 - 962.41415	1
962.41415 - 1784.661769	2
1784.661769 - 2747.07592	3
2747.07592 - 3873.550445	4
3873.550445 - 5192.052314	5
5192.052314 - 6735.315956	6
6735.315956 - 8541.655958	7
8541.655958 - 10655.918301	8
10655.918301 - 13130.59375	9

Table 19 – Distance in metres from Airports Reclassified Values Source: Selkirk and District Planning Area Board, 2006	
Old Values	**New Values**
0 - 6872.791618	1
6872.791618 - 12878.156865	2
12878.156865 - 18125.575054	3
18125.575054 - 22710.707934	4
22710.707934 - 26717.143628	5
26717.143628 - 31302.276509	6
31302.276509 - 36549.694698	7
36549.694698 - 42555.059945	8
42555.059945 - 49427.851563	9

The reclassified major highway roads, the reclassified railroads and the reclassified selected airport parcels layer were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(recmajrds * 0.4) + (recair * 0.25) + (recrail * 0.35)*. The reclassified major highway roads layer was multiplied by a weight of 0.4, the reclassified railroads layer was multiplied by a weight of 0.35 and the reclassified selected airport parcels layer was multiplied by a weight of 0.25. The major highway roads were given the greatest weight value followed by the railroads and the selected airport parcels. This decision was made based on traffic volumes. More vehicular traffic exists on major highways within the RM of St. Andrews than railroad and air travel. The air travel traffic within the RM of St. Andrews is for the most part, single engine propeller planes that are relatively quiet. The sub-model shown in **Figure 18** outlines the methods used in producing the output map for *sub-objective 1.1.3: identifying quiet areas*. The rationale for this decision is that these three identified areas produce a significant amount of noise. Developing residential land uses near existing major roads, railroads and selected airport parcels may be less appealing to a potential buyer because of the noise pollution generated.

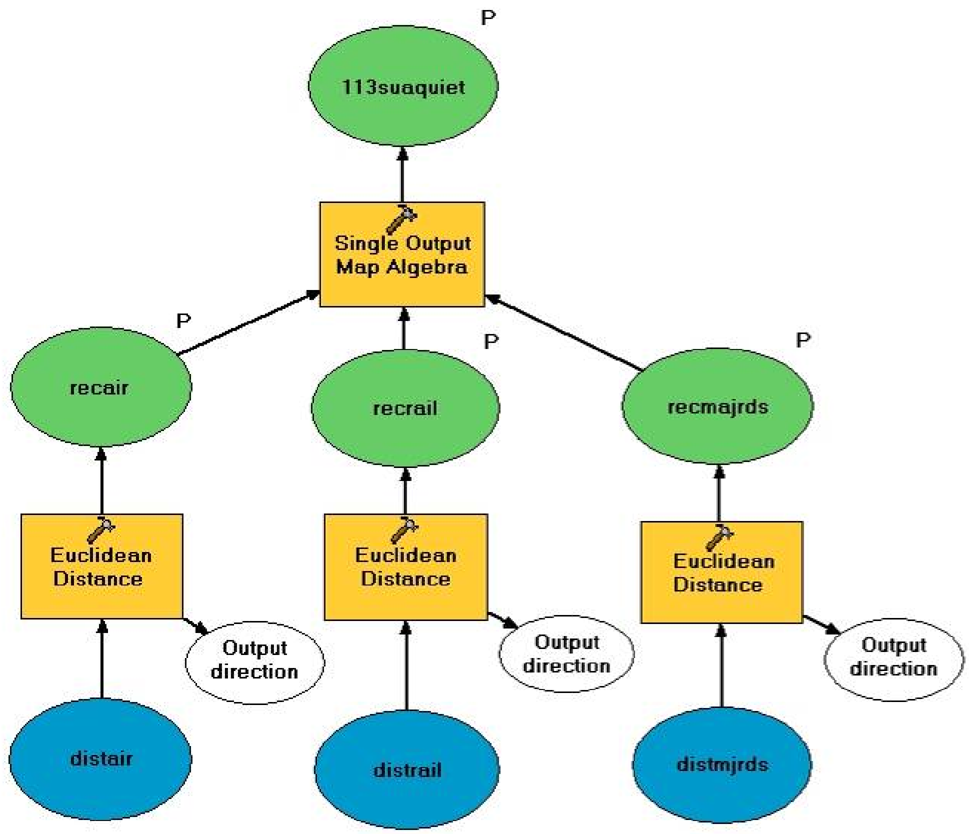


Figure 18 - 1.1.3 Quiet Areas Sub-Model

C.1.4 Identifying Lands Free of Hazardous Waste

In identifying lands free of hazardous waste two input vector layers were chosen – the distance from hazardous lands and the distance from open pit livestock lagoons. Hazardous lands include landfills and open pit sewage lagoons. Both layers were created through orhtographic photography interpretation and parcel ownership map identification.

This sub-model involved a three-step process. Firstly, the Euclidean Distance operation was run in ArcGIS 9.2 on the two vector layers – identified hazardous lands and open pit livestock lagoons. This produced two separate layers that visually showed incremental distances from the identified hazardous lands and open pit livestock lagoons. Next, the newly created layers that showed incremental distances from the identified hazardous lands and open pit livestock lagoons were reclassified using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in **Table 20** and **Table 21**. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability.

Table 20 – Distance in metres from Identified Hazardous Lands Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0 - 1813.644754	9
1813.644754 - 3295.008115	8
3295.008115 - 4504.968006	7
4504.968006 - 5493.248785	6
5493.248785 - 6703.208676	5
6703.208676 - 8184.572038	4
8184.572038 - 9998.216792	3
9998.216792 - 12218.676254	2
12218.676254 - 14937.202148	1

Table 21 – Distance in metres from Identified Open Pit Livestock Lagoons Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0 - 1813.644754	9
1813.644754 - 3295.008115	8
3295.008115 - 4504.968006	7
4504.968006 - 5493.248785	6
5493.248785 - 6703.208676	5
6703.208676 - 8184.572038	4
8184.572038 - 9998.216792	3
9998.216792 - 12218.676254	2
12218.676254 - 14937.202148	1

The reclassified hazardous lands and the reclassified open pit livestock lagoons were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(reclivlag * 0.75) + (rechzlnds * 0.25).* The reclassified open pit livestock lagoons layer was multiplied by a weight of 0.75 and the reclassified hazardous lands was multiplied by a weight of 0.25. The open pit livestock lagoons were given a greater weight value because the immediate surrounding areas create a larger area of hazardous waste lands. The sub-model shown in **Figure 19** outlines the methods used in producing the output map for *sub-objective 1.1.4: identifying lands free of hazardous waste*. The rationale for this decision is that these identified areas contain hazardous waste and are odourous. Developing residential land near areas that contain or produce hazardous waste may pose limitations on residential development as an environmental impact assessment may be required.

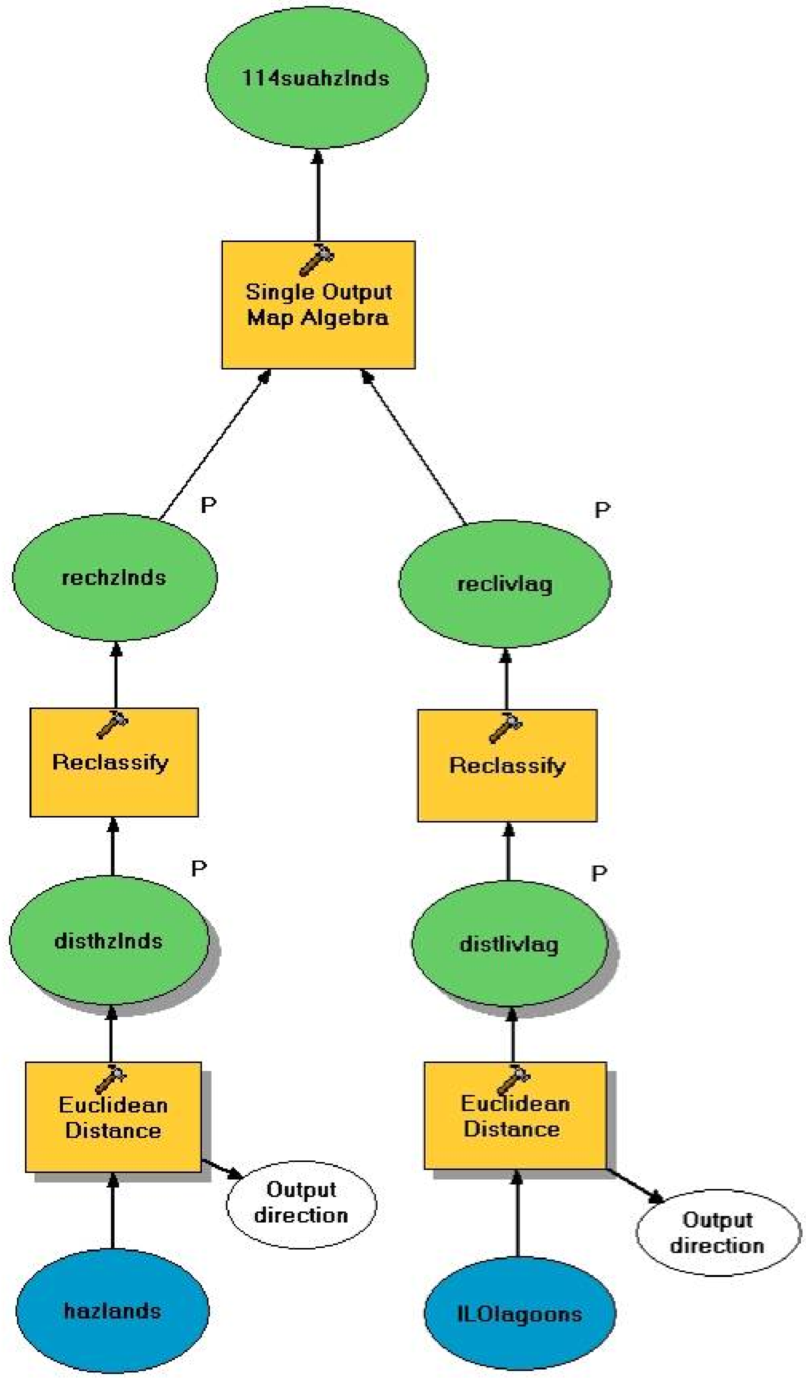


Figure 19 - 1.1.4 Lands Free of Hazardous Waste Sub-Model

C.1.5 Identifying Lands with Good Air Quality

In identifying lands with good air quality two input vector layers were chosen – the distance from hazard lands and the distance from all identified livestock operations within the RM of St. Andrews. The hazard lands in this sub-model included open pit sewage lagoons, open pit livestock lagoons and landfills.

This sub-model involved a three-step process. Firstly, the Euclidean Distance Operation was run in ArcGIS 9.2 on the two vector layers – identified hazard lands and all identified livestock operations. This produced two separate layers that visually showed incremental distances from the identified hazard lands and identified livestock operations. Next, the newly created layers that showed incremental distances from the identified hazard lands and identified livestock operations were reclassified using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in **Table 22** and **Table 23**. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability.

Table 22 – Distance in metres from Identified Hazard Lands Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0 - 1436.159484	9
1436.159484 - 2416.071415	8
2416.071415 - 3084.679187	7
3084.679187 - 3540.879727	6
3540.879727 - 4209.487499	5
4209.487499 - 5189.39943	4
5189.39943 - 6625.558914	3
6625.558914 - 8730.395071	2
8730.395071 - 11815.244141	1

Table 23 – Distance in metres from Identified Livestock Operations Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0 - 948.5165	9
948.5165 - 1501.446164	8
1501.446164 - 1823.771831	7
1823.771831 - 2011.668849	6
2011.668849 - 2333.994516	5
2333.994516 - 2886.92418	4
2886.92418 - 3835.44068	3
3835.44068 - 5462.561829	2
5462.561829 - 8253.787109	1

The reclassified hazard lands and the reclassified livestock operations layers were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(reclagwste * 0.5) + (recdisilos * 0.5).* The reclassified hazard lands and reclassified livestock operations were both multiplied by equal weights of 0.5 and combined to create a final layer showing that identified lands with good air quality. The sub-model shown in **Figure 20** outlines the methods used to produce the output map for *sub-objective 1.1.5: identifying lands with good air quality*. The rationale for this decision was that these identified areas are odourous. Developing residential land near areas that may conflict with environmental and Provincial Land Use Policies (2005) minimum setback requirements from livestock operations, may result in land use conflicts between opposing land uses.

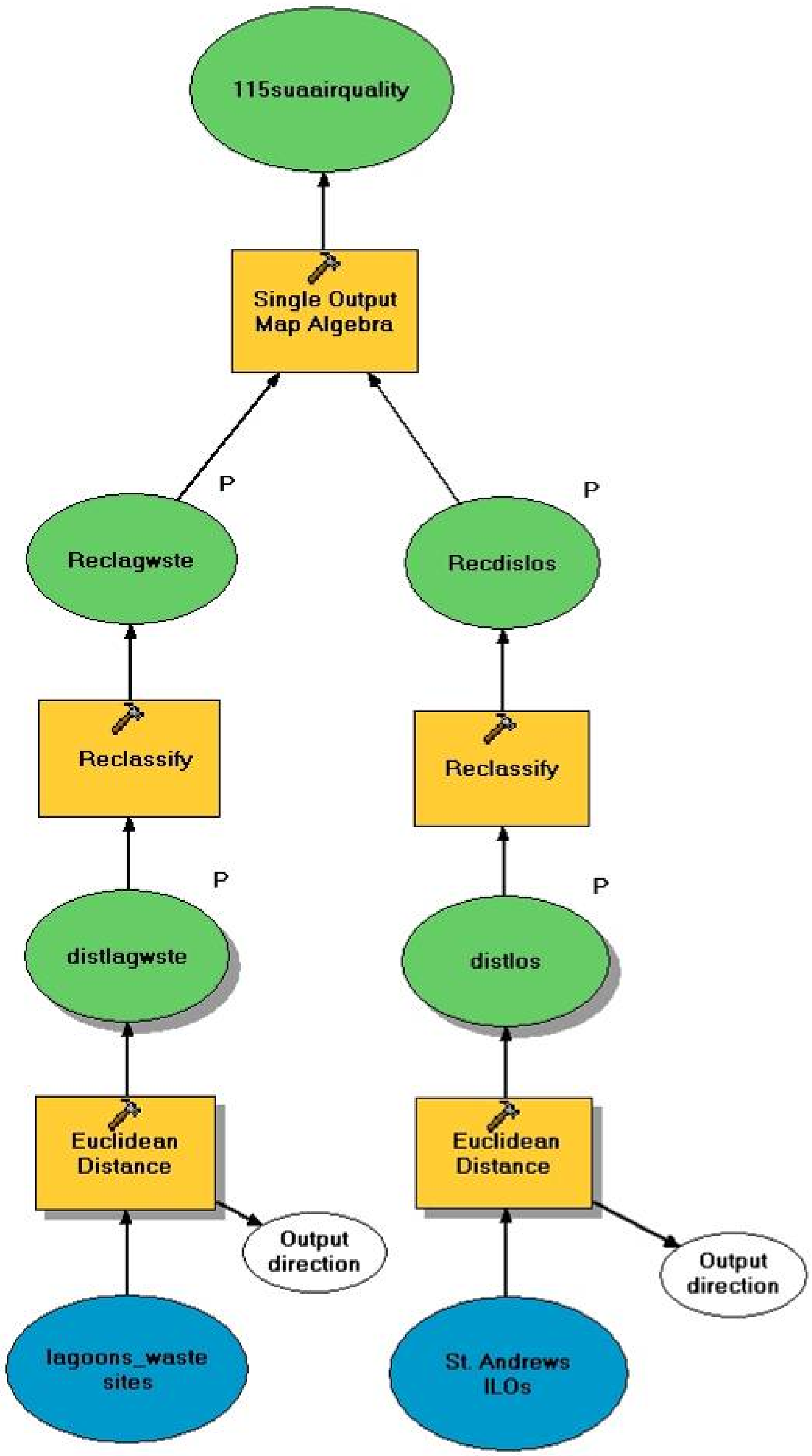


Figure 20 - 1.1.5 Lands with Good Air Quality Sub-Model

C.1.6 RESIDENTIAL OBJECTIVE 1.1 MODEL: Identifying Lands Physically Suitable for Residential Land Use

The sub-objectives 1.1.1 to 1.1.5 highlighted the methodologies and approaches of how each of their sub-model were created. These five sub-models – 1.1.1 soils suitable for residential land use, 1.1.2 lands free of flood potential, 1.1.3 quiet areas, 1.1.4 lands free of hazardous waste and 1.1.5 lands with good air quality were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(111suasoils * 0.2) + (112recflood * 0.35) + (113suaquiet * 0.25) + (114suahzlnds * 0.15) + (115suair * 0.05).* The sub-objective 1.1.2 lands free of flood potential was given the greatest weight value because developing on flood risk lands poses the greater risk and highest amount of additional cost to build at risk homes above flood elevation. The *sub-objective 1.1.3 quiet areas* were given a weighted value of 0.25. As mentioned earlier, the noise pollution generated from major roads, railroads and selected airport parcels may inhibit development of nearby lands. The *sub-objective 1.1.1 soils suitable for residential land* use were given a weighted value of 0.2. This weighted value was chosen because building within areas that may be at risk to water erosion and poor drainage can create additional development costs. The *sub-objectives 1.1.4 lands free of hazardous waste* was given a weight of 0.15 and the *sub-objective 1.1.5 lands with good air quality* was given a weight of 0.05. These two sub-objectives were given lesser weights because development within these identified areas may not result in additional development costs but may deter perspective home owners. The Single Map Output Algebra calculation model for identifying lands suitable for residential land use is shown in **Figure 21**. The results of the *residential objective 1.1 model: identifying lands physically suitable for residential land use* are shown in **Map 14** below.

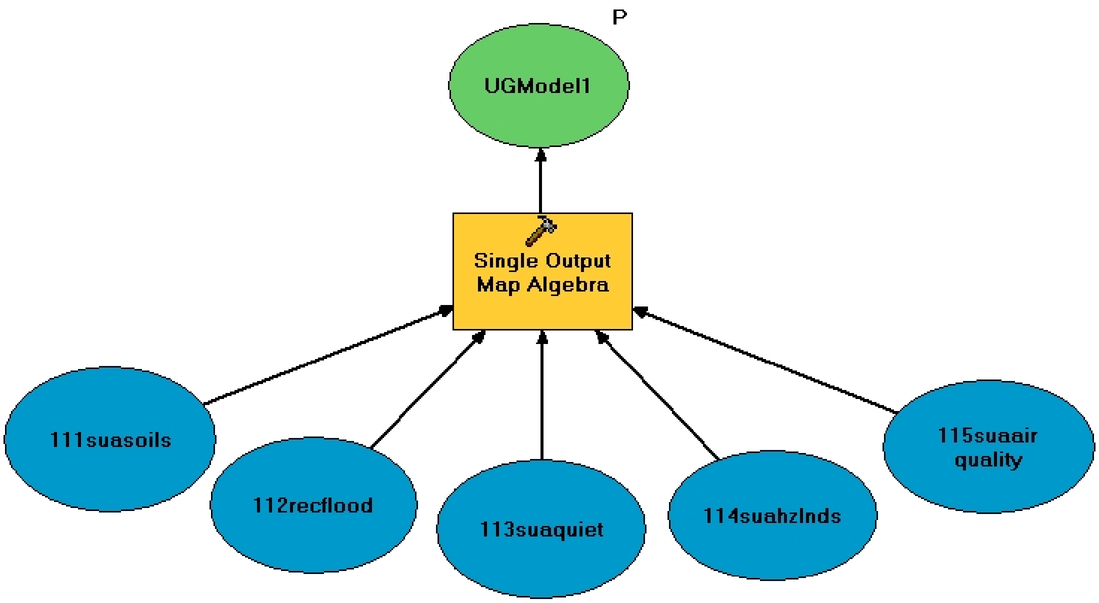
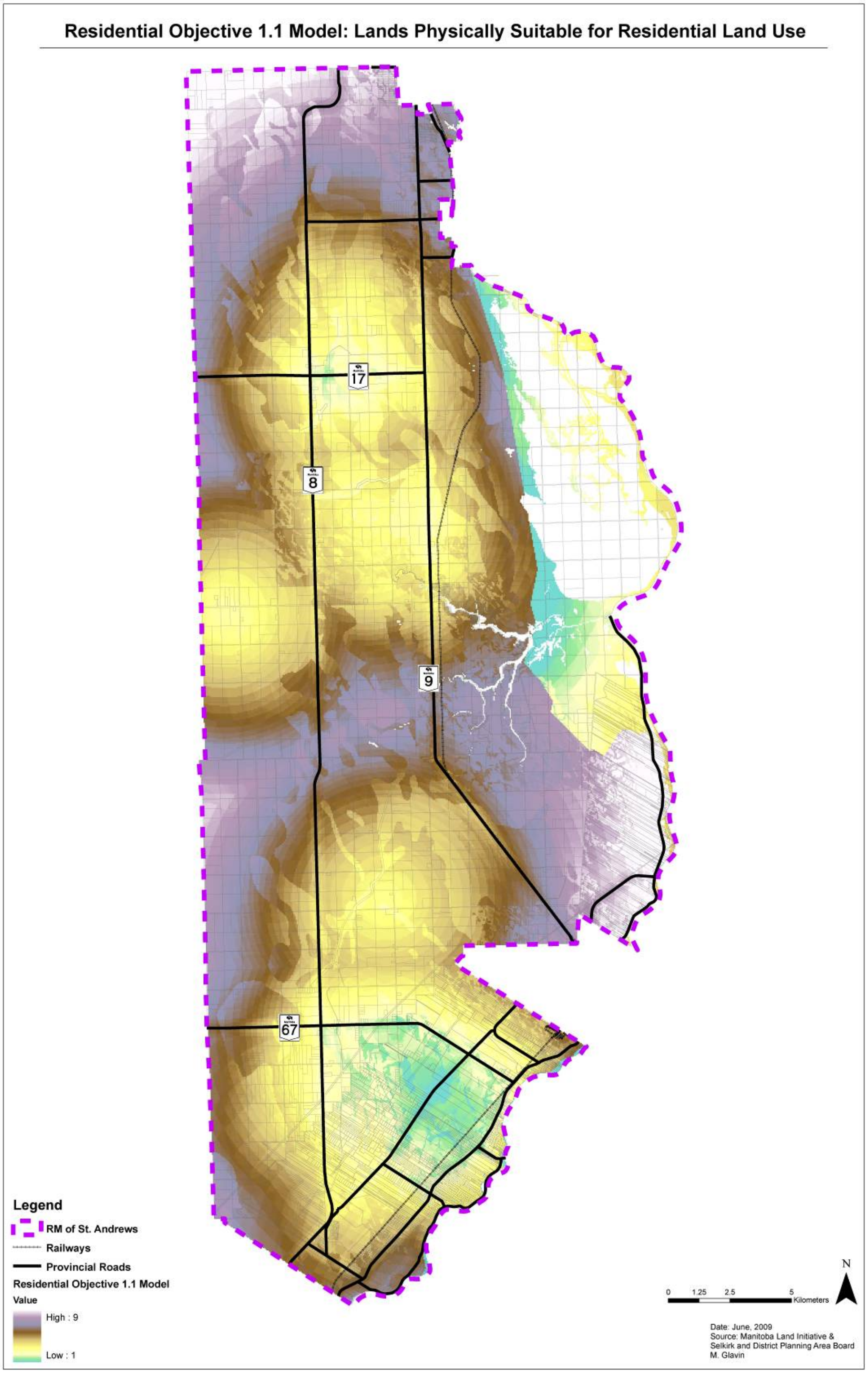


Figure 21 – Residential Objective 1.1 Model



Map 14 – Residential Objective 1.1 – Lands Physically Suitable for Residential Land Use Raster Map

C.2 Identifying Lands Economically Suitable for Residential Land Use

C.2.1 Identifying Lands in Close Proximity to Existing Residential Developments

In identifying the lands in close proximity to existing non-farm rural residential developments a vector layer that highlighted existing residential lands uses for the RM of St. Andrews was created by selecting designated residential areas within the development plan and zoning by-law for the RM of St. Andrews. The Euclidean Distance Operation was run in ArcGIS 9.2 on the identified existing residential areas layer. This produced one layer that visually showed incremental distances from the existing residential land uses. Next, the newly created layer that showed incremental distances from the identified non-farm rural residential developments was reclassified using the Reclassify Tool in ArcGIS 9.2.

Next, all of the cells were reclassified based on geometric interval using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in the table below. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability (see **Table 24**). The sub-model shown in **Figure 22** outlines the methods used to produce the output map for *sub-objective 1.2.1: lands in close proximity to existing residential developments*. The rationale for this decision is simple – building residential units near existing residential land uses makes logical sense from both a planning and servicing perspective.

Table 24 – Distance in metres from Identified Existing Residential Developments Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0 - 637.482856	9
637.482856 - 1400.60404	8
1400.60404 - 2314.124986	7
2314.124986 - 3407.687236	6
3407.687236 - 4716.774235	5
4716.774235 - 6283.862685	4
6283.862685 - 8159.80081	3
8159.80081 - 10405.458258	2
10405.458258 - 13093.701172	1

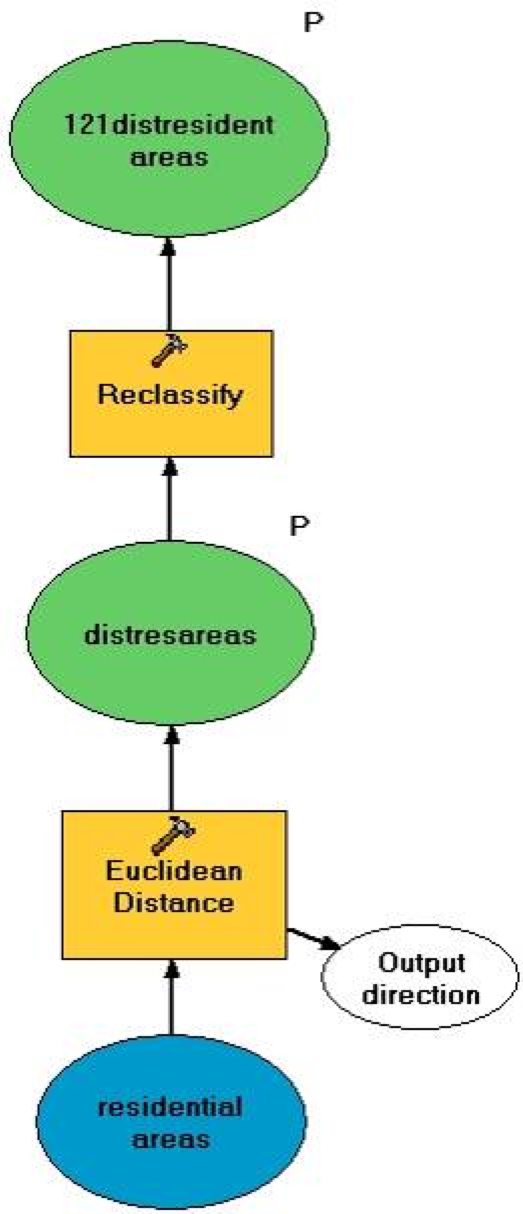


Figure 22 – 1.2.1 Lands in Close Proximity to Existing Residential Development Sub-Model

C.2.2 Identifying Lands in Close Proximity to Schools

In identifying the lands in close proximity to schools, all of the existing elementary, secondary and high schools within the RM of St. Andrews and City of Selkirk were identified using orhtographic photography interpretation and parcel ownership map identification. A vector layer was created using a point symbols for the locations of all the identified schools. The Euclidean Distance Operation was run in ArcGIS 9.2 on the identified schools layer. This produced a layer that visually showed incremental distances from the identified schools. Next, the newly created layer that showed incremental distances from the identified schools was reclassified using the Reclassify Tool in ArcGIS 9.2.

Next, all of the cells that were reclassified based on geometric interval using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in **Table 25**. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability. The sub-model shown in **Figure 23** outlines the methods used to produce the output map for *sub-objective 1.2.2: lands in close proximity to schools*. The rationale for this decision is that schools are an attractive service to families. Residents like to be located near community services. From a servicing and bussing cost perspective, it is more efficient to locate housing close to existing schools.

Table 25 – Distance in metres from Identified Schools Reclassified Values

Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0 - 3895.359863	9
3895.359863 - 6695.149765	8
6695.149765 - 9251.479675	7
9251.479675 - 12294.729568	6
12294.729568 - 15703.169449	5
15703.169449 - 19111.609329	4
19111.609329 - 22641.779205	3
22641.779205 - 26293.679077	2
26293.679077 - 31162.878906	1

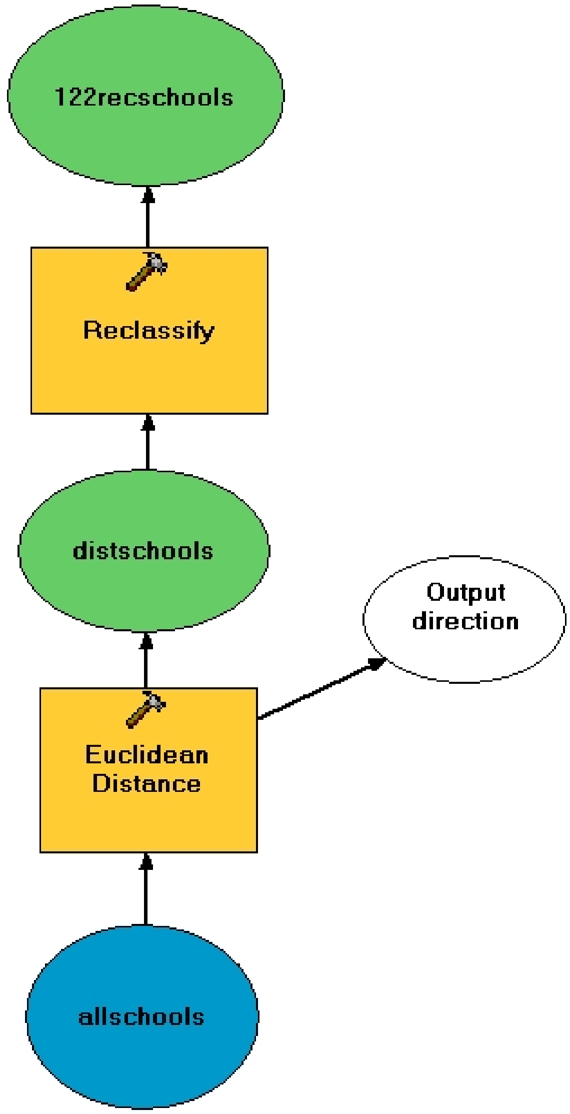


Figure 23 – 1.2.2 Lands in Close Proximity to Schools Sub-Model

C.2.3 Identifying Lands in Close Proximity to Hospitals

In identifying the lands in close proximity to hospitals, all of the existing hospitals and health care facilities within the RM of St. Andrews and City of Selkirk were identified using orhtographic photography interpretation and parcel ownership map identification. A vector layer was created using a point symbols for the locations of all the identified hospitals. The Euclidean Distance Operation was run in ArcGIS 9.2 on the identified hospitals layer. This produced one layer that visually showed incremental distances from the identified hospitals. Next, the newly created layer that showed incremental distances from the identified hospitals was reclassified using the Reclassify Tool in ArcGIS 9.2.

All of the cells that were reclassified based on geometric interval using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in **Table 26**. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability. The sub-model shown in **Figure 24** outlines the methods used to produce the output map for *sub-objective 1.2.3: lands in close proximity to hospitals*. The rationale for this decision is that hospitals and health care facilities are vital to serving a community. They serve the needs of all spectrums of the community and some residents like to be located near health care services.

Table 26 – Distance in metres from Identified Hospitals Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0 - 8120.506909	9
8120.506909 - 13538.04396	8
13538.04396 - 17152.314353	7
17152.314353 - 19563.548527	6
19563.548527 - 21172.185848	5
21172.185848 - 23583.420022	4
23583.420022 - 27197.690415	3
27197.690415 - 32615.227466	2
32615.227466 - 40735.734375	1

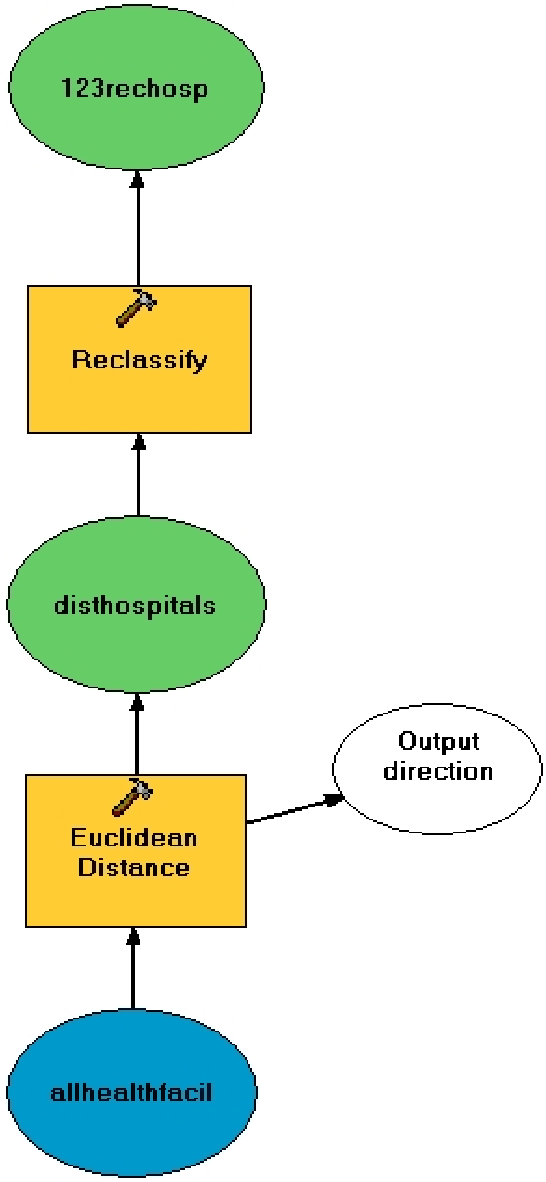


Figure 24 – 1.2.3 Lands in Close Proximity to Hospitals Sub-Model

C.2.4 Identifying Lands in Close Proximity to Major Roads

In identifying the lands in close proximity to major roads, existing all weather residential roads within the RM of St. Andrews were identified using orhtographic photography interpretation and Manitoba Land Initiative (2003) data. A vector layer was created by selecting the all-weather roads within the municipality. The Euclidean Distance Operation was run in ArcGIS 9.2 on the identified major roads. This produced one layer that visually showed incremental distances from the identified major roads. Next, the newly created layer that showed incremental distances from the identified major roads was reclassified using the Reclassify Tool in ArcGIS 9.2.

All of the cells that were reclassified based on geometric interval using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in **Table 27**. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability. The sub-model shown in **Figure 25** outlines the methods used to produce the output map for *sub-objective 1.2.4: lands in close proximity to major roads*. The rationale for this decision is that developing residential lots near or on existing all weather residential roads is more cost effective from both a development and serving perspective.

Table 27 – Distance in metres from Identified Major Roads Reclassified Values
Source: Manitoba Land Initiative, 2003

Old Values	New Values
0 - 8120.506909	9
8120.506909 - 13538.04396	8
13538.04396 - 17152.314353	7
17152.314353 - 19563.548527	6
19563.548527 - 21172.185848	5
21172.185848 - 23583.420022	4
23583.420022 - 27197.690415	3
27197.690415 - 32615.227466	2
32615.227466 - 40735.734375	1

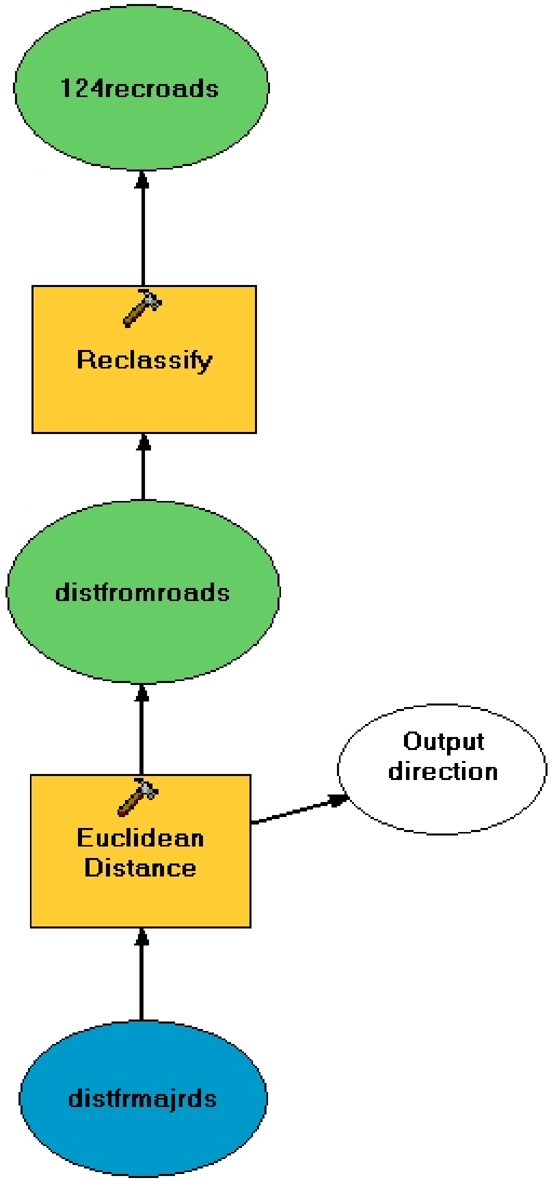


Figure 25 – 1.2.4 Lands in Close Proximity to Major Roads Sub-Model

C.2.5 Identifying Lands in Close Proximity to Parks, Recreational Sites, Protected Conservation Lands and Cultural/Historic Sites

In identifying lands in close proximity to parks, other recreational opportunities, protected conservation lands and cultural/historic sites four input vector layers from both the RM of St. Andrews and City of Selkirk were chosen using orhtographic photography interpretation and Manitoba Land Initiative data (2003). These layers include parks, recreational facilities (including hockey rinks, curling rinks, community centres and golf courses), conservation lands (including Oak Hammock Marsh) and historic sites (including Lower Fort Garry National Historic Site).

This sub-model involved a three-step process. Firstly, the Euclidean Distance Operation was run in ArcGIS 9.2 on the four vector layers – identified parks, recreational facilities, conservation lands and historic sites. This produced two separate layers that visually showed incremental distances from these four layers. Next, the newly created layers that showed incremental distances from the identified parks, recreational facilities, conservation lands and historic sites were reclassified using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in **Table 28, Table 29, Table 30** and **Table 31**. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability. The sub-model shown in **Figure 26** outlines the methods used to produce the output map for *sub-objective 1.2.5: identifying lands in close proximity to parks, recreational sites, protected conservation lands and cultural/historic sites.* The rationale for this decision is that parks, recreational facilities, conservation lands and historic sites all serve to benefit a community and people want to reside near these assets. These four land uses not only serve as a beneficial asset to the community, but also attract outside visitors.

Table 28 – Distance in metres from Identified Parks Recreational Sites Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0 - 5023.607926	9
5023.607926 - 8859.163124	8
8859.163124 - 11787.632838	7
11787.632838 - 14023.537271	6
14023.537271 - 15730.663901	5
15730.663901 - 17966.568334	4
17966.568334 - 20895.038048	3
20895.038048 - 24730.593245	2
24730.593245 - 29754.201172	1

Table 29 – Distance in metres from Identified Recreational Facilities Reclassified Values Source: Selkirk and District Planning Area Board, 2006	
Old Values	**New Values**
0 - 2803.510039	9
2803.510039 - 4437.792484	8
4437.792484 - 5390.483601	7
5390.483601 - 5945.846822	6
5945.846822 - 6898.537939	5
6898.537939 - 8532.820384	4
8532.820384 - 11336.330423	3
11336.330423 - 16145.577787	2
16145.577787 - 24395.542969	1

Table 30 – Distance in metres from Identified Conservation Lands Reclassified Values Source: Manitoba Land Initiative, 2003	
Old Values	**New Values**
0 - 104.910636	9
104.910636 - 268.104959	8
268.104959 - 454.612756	7
454.612756 - 664.434028	6
664.434028 - 909.225512	5
909.225512 - 1200.643945	4
1200.643945 - 1620.286489	3
1620.286489 - 2179.80988	2
2179.80988 - 2984.124756	1

Table 31 – Distance in metres from Identified Historic Sites Reclassified Values Source: Selkirk and District Planning Area Board, 2006	
Old Values	**New Values**
0 - 5554.089051	9
5554.089051 - 10090.602614	8
10090.602614 - 13795.97268	7
13795.97268 - 16822.474669	6
16822.474669 - 20527.844735	5
20527.844735 - 25064.358298	4
25064.358298 - 30618.447349	3
30618.447349 - 37418.362031	2
37418.362031 - 45743.550781	1

The reclassified parks, reclassified recreational facilities, reclassified conservation lands and reclassified historic sites layers were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(recarch * 0.2) + (recconlnds* 0.1) +*

*(recprk * 0.3) + (recrec * 0.4).* The reclassified parks layer was multiplied by a weight of 0.3, the reclassified recreational facilities layer was multiplied by a weight of 0.4, the reclassified conservation lands layer was multiplied by a weight of 0.1 and the reclassified historic sites layer was multiplied by a weight of 0.2. The recreational facilities were given the greatest weight value followed by the parks, the conservation lands and lastly, the historic sites. Theses weighted values were chosen based on the services that best serve the community's needs. A portion of Oak Hammock marsh falls within the municipal boundary. This eco-tourism site attracts a large number of outside visitors. The Lower Fort Garry National Historic site also attracts a large number of outside visitors annually. The identified recreational sites not only serve the recreational needs of the community and outside visitors, but also serve as a place for communal social gathering. The RM of St. Andrews has very few designated parks. However, parks and greenspace provide a wide range of benefits that serve to improve the community's quality of life.

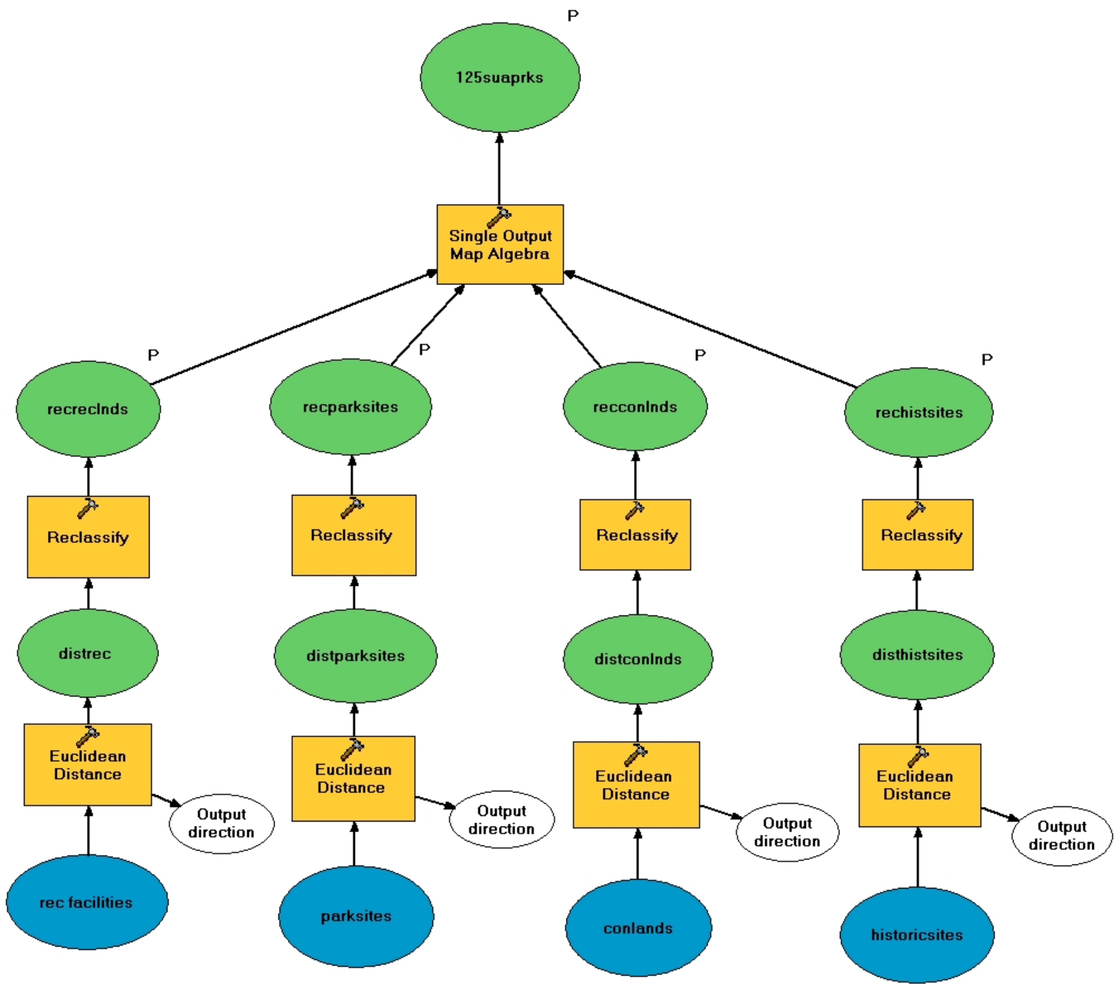


Figure 26 – 1.2.5 Lands in Close Proximity to Parks, Recreational Sites, Conservation Lands and Cultural/Historic Sites Sub-Model

C.2.6 Identifying Lands with Values Suitable for Residential Land Use

A land value dataset of the entire municipality was combined with the parcel ownership layer. The assessed land value was divided by each respective parcel size to give the land value per acre. This layer was reclassified into 9 geometric interval categories using the Reclassify Tool in the Spatial Analyst Tools of ArcGIS 9.2. The values in this dataset ranged from $0 to $300,115. The highest value range ($116,790 – $300,115) was assigned a value of 9, while the lowest range ($0 – $2,344) was assigned a value of 1 (see **Table 32**). The sub-model shown in **Figure 27** outlines the methods used to produce the output map for *sub-objective 1.2.6: identifying lands with values suitable for residential land use*. The underlying assumption is that the more valuable the land, the greater the likelihood that people would prefer to develop in to residential housing. The highest land values within the RM of St. Andrews are situated within the exiting residential land use clusters and surrounding areas. From this perspective, it would make logical sense both from a planning and servicing perspective that any future residential development would cluster around exiting residential land uses that are of higher land values.

Table 32 – Assessed Land Values/Acre (in $) Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0 - 2344.648438	1
2344.648438 - 11723.242188	2
11723.242188 - 23446.484375	3
23446.484375 - 35169.726563	4
35169.726563 - 53926.914063	5
53926.914063 - 80890.371094	6
80890.371094 - 112543.125	7
112543.125 - 161780.742188	8
161780.742188 - 300115	9

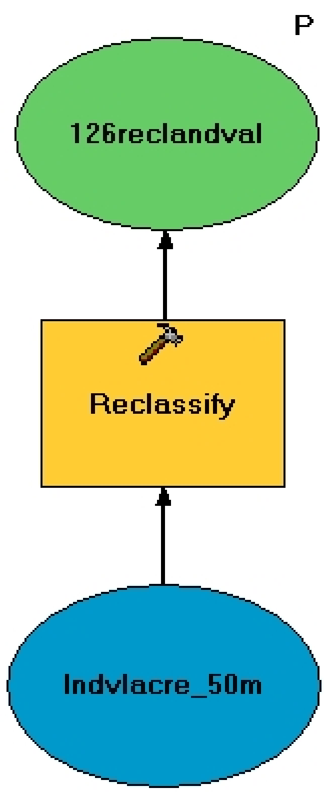


Figure 27 – 1.2.6 Lands with Values Suitable for Residential Land Use Sub-Model

C.2.7 RESIDENTIAL OBJECTIVE 1.2 MODEL: Identifying Lands Economically Suitable for Residential Land Use

The sub-objectives 1.2.1 to 1.2.5 highlighted the methodologies and approaches of how each sub-model was created. These five sub-models – *1.2.1 lands in close proximity to existing residential developments, 1.1.2 lands in close proximity to schools*, *1.1.3 lands in close proximity to hospitals*, *1.1.4 lands in close proximity to major roads*, *1.2.5 lands in close proximity to parks, recreational sites, protected conservation lands* and *cultural/historic sites* and 1*.2.6 lands with values suitable for residential land use* were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(121distresidentareas * 0.25) + (122recschools * 0.13) + (123rechosp * 0.07) + (124recroads * 0.24) (125suaprks * 0.10) + (126reclandval * 0.21).* The *sub-objective 1.2.1 lands in close proximity to existing residential developments* was given the greater weight value because clustering development around existing residential is more cost effective to service and limits conflicts with opposing land uses. The *sub-objective 1.2.4 lands in close proximity to major roads* were given a weighted value of 0.24. Similar, to the previous sub-objective, developing residential land uses on existing all weather roads is cheaper and easier to service than constructing new roads for residential development. In addition, building on existing all weather roads helps promote infill development and clustering of residential land uses and community services, in turn, decreasing the likelihood of conflicts with opposing land uses. The sub-objective *1.2.6 lands with values suitable for residential land use* was given a weighted value of 0.21. This weighted value was chosen because the highest land values per acre within the RM of St. Andrews are situated within the existing residential cluster and immediate surrounding areas. Furthermore, it makes logical sense from both a long term planning and municipal servicing perspective that any future residential development would cluster around exiting residential land uses that are of higher land values. The *sub-objectives 1.2.2 lands in close proximity to schools* was given a weight of 0.13 and the sub-objective *1.2.3 lands in close proximity to hospitals* was given a weight of 0.07. Although these services are vital to serving the community's needs, these two sub-objectives were given lesser weights because they are simply amenities that attract people to a community and do not necessarily incur any additional development costs. The Single Map Output Algebra calculation model for identifying lands economically suitable for residential land use is shown in **Figure 28**. The results of the *residential objective 1.2 model: identifying lands economically suitable for residential land use* are shown in **Map 15** below.

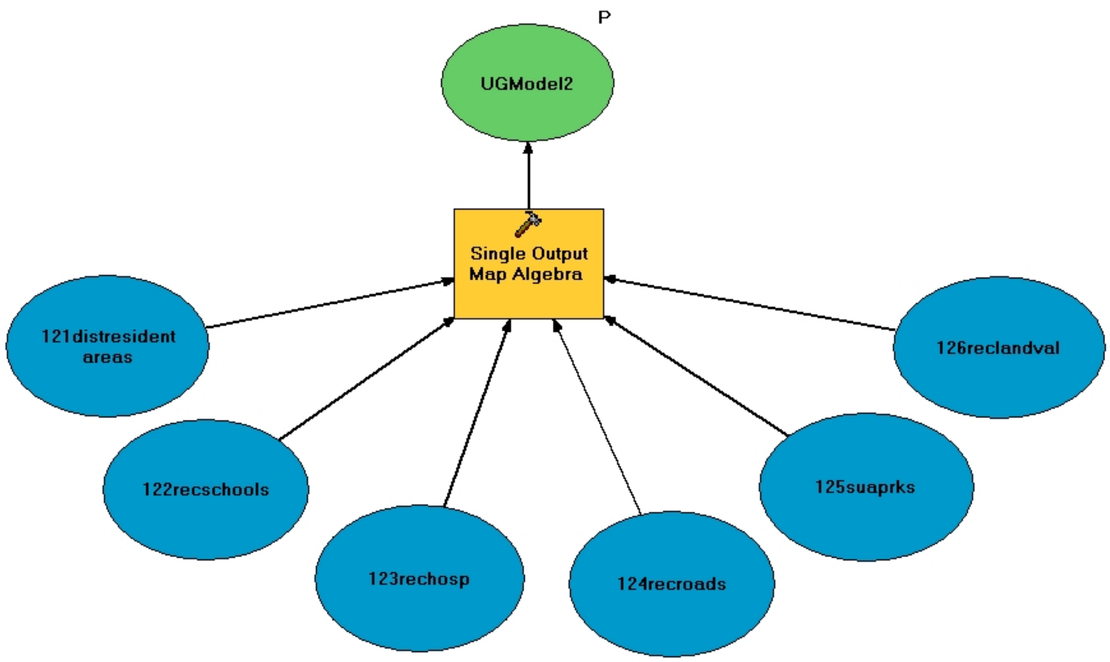
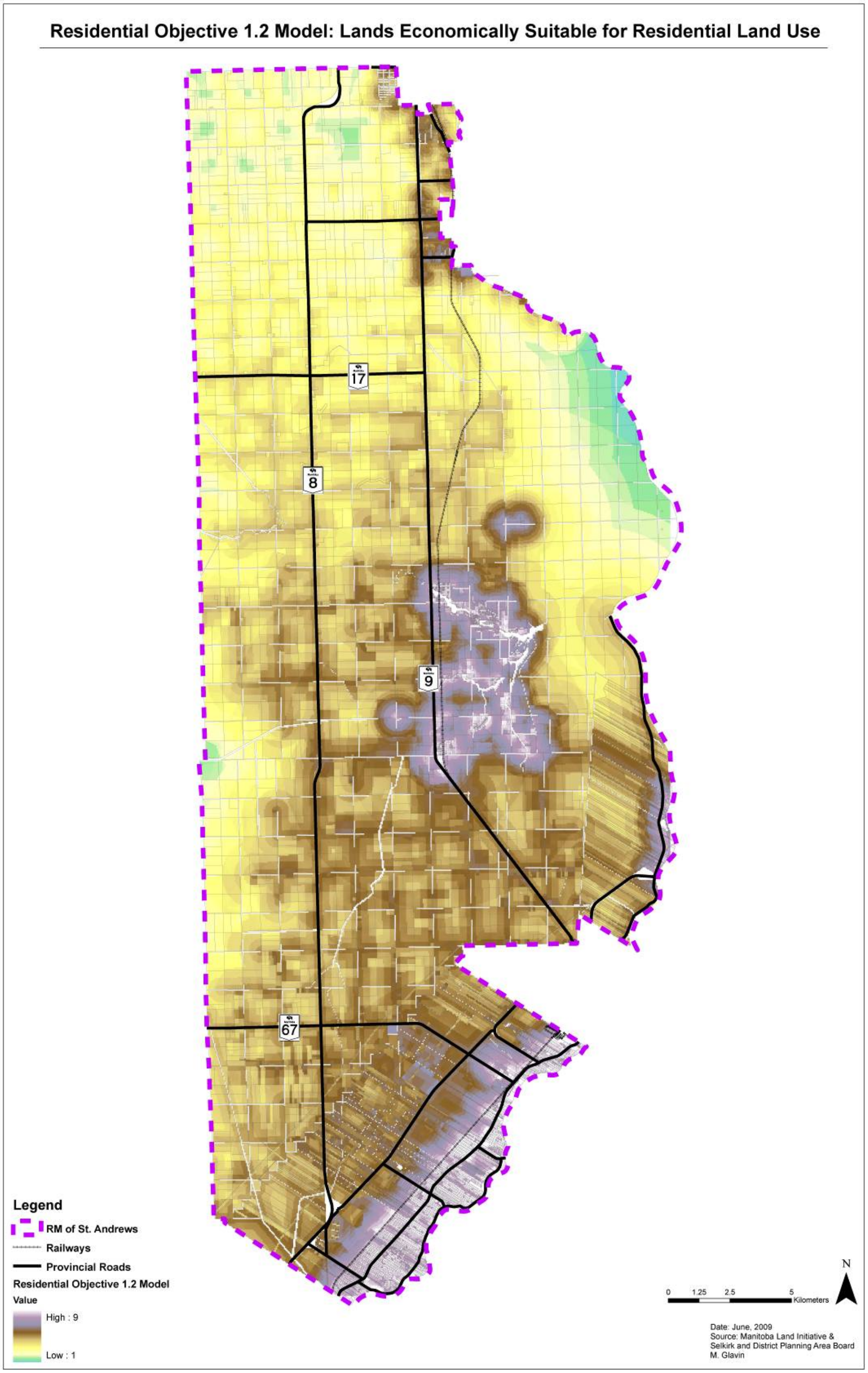


Figure 28 – Residential Objective 1.2 Model



Map 15 – Residential Objective 1.2 – Lands Economically Suitable for Residential Land Use Raster Map

C.3 Identifying Lands Physically Suitable for Intensively Managed Livestock (>300 Animal Units)

C.3.1 Identifying Nutrient Management Areas Suitable for Intensively Managed Livestock

In identifying nutrient management areas suitable for intensively managed livestock, a vector layer containing the water quality zones for the RM of St. Andrews were obtained from Manitoba Water Stewardship. The nutrient management groups reflect the capacity of different soil characteristics to sustain agricultural activity and assess the risk of nutrient loss to leaching or surface run off. Manitoba landscapes have been separated into four zones based on the principal factors that influence run-off and leaching potential. Zone 1 is the most productive and least susceptible to nutrient loss, while Zone 4 is the least productive and most susceptible to nutrient loss.

The nutrient management vector layer was converted in to a raster layer. All of the cells that were highlighted as nutrient management areas for the RM of St. Andrews were reclassified using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in the table and figure below. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability (see **Table 33**). The sub-model shown in **Figure 29** outlines the methods used to produce the output map for *sub-objective 2.1.1: nutrient management areas suitable for intensively managed livestock*. The rationale for this decision is that Zones 1 and 2 are the most productive lands and least susceptible to nutrient loss. These designated zones can accommodate more intensive nitrogen application and as such, are more suitable for intensively managed livestock. Zone 3 was given a new value of 5 since it is recommended that the application of manure within Zone 3 take place during the growing season. Limited application of nitrogen is recommended within this zone. Manure application and livestock production is not recommended within Zones 4.

Table 33 – Nutrient Management Areas (Water Quality Zone) Reclassified Values Source: Manitoba Water Stewardship, 2005	
Old Values	New Values
Zone 1	9
Zone 2	9
Zone 3	5
Zone 4	1
Water	1

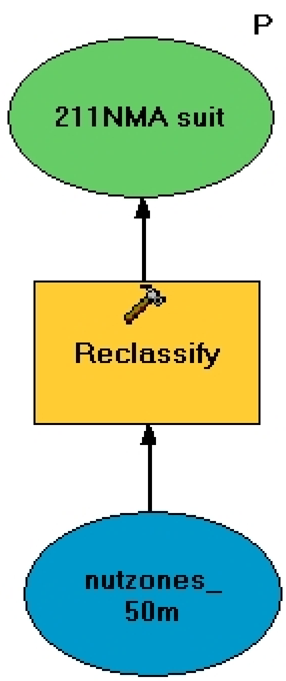


Figure 29 – 2.1.1 Nutrient Management Areas Suitable for Intensively Managed Livestock Sub-Model

C.3.2 Identifying Existing Intensively Managed Livestock Lands as Suitable

Existing suitable lands for intensively managed livestock lands within the RM of St. Andrews were identified using orhtographic photography interpretation and parcel ownership map identification. Existing intensively managed livestock parcels and surrounding parcels that are able to accommodate limited expansion were identified as suitable based on compliance of the Provincial Land Use Policies (2005) minimum setback requirements and location within water quality management zones 3 and/or 4.

These selected parcels were converted in to a vector layer that showed existing suitable lands for intensively managed livestock for the RM of St. Andrews.

Next, all of the cells that were not highlighted as suitable existing intensively managed livestock lands were reclassified using the Reclassify Tool in ArcGIS 9.2 and assigned a value of 1 (low suitability) and all other cells were highlighted as suitable for existing intensively managed livestock were assigned a value of 9 (high suitability) (see **Table 34**). The sub-model shown in **Figure 30** outlines the methods used to produce the output map for *sub-objective 2.1.1: suitable existing intensively managed livestock lands*. The rationale for this decision is quite simple – expansion of intensively managed livestock within the RM of St. Andrews must comply with the Provincial Land Use Policies (2005) minimum setback requirements and should be located on lands that accommodate large amounts of nutrient application.

Table 34 – Suitable Existing Intensively Managed Livestock Lands Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
Identified Suitable ILO Lands >300 AU	9
Remaining Lands	1

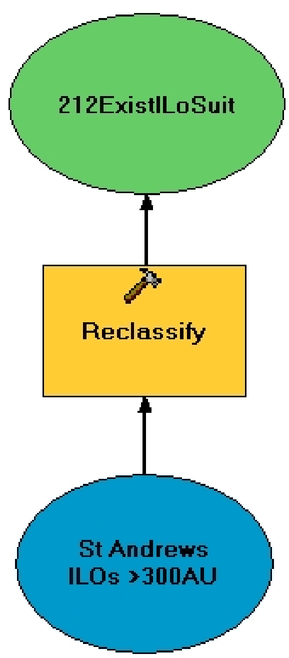


Figure 30 – 2.1.2 Suitable Existing Intensively Managed Livestock Lands Sub-Model

C.3.3 AGRICULTURAL OBJECTIVE 2.1 MODEL: Identifying Lands Physically Suitable for Intensively Managed Livestock

The two sub-models – *2.1.1 nutrient management areas suitable for intensively managed livestock* and *2.2.1 suitable existing intensively managed livestock lands* were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *CON(21ExistILO Suit EQ 9, 9, 212NMA suit)***.** The CON function was used to control the output value for each cell based on whether the cell value evaluates to true or false in a specified conditional statement. In this case, if a cell is found to be in the suitable existing intensively managed livestock lands (suitability equals 9), then it will be assigned a new value of 9 otherwise it will be assigned a new value of 1 (non suitability equals 1). Similarly, if a cell is found to be in the nutrient managed areas suitable for intensively managed livestock (suitability equals 9), then it will be assigned a new value of 9 otherwise it will be assigned a new value of 1 (non suitability equals 1). The Single Map Output Algebra calculation model for identifying lands physically suitable for intensively managed livestock land use can be seen in **Figure 31**. The results of the *agricultural objective 2.1 model: identifying lands physically suitable for intensively managed livestock* are shown in **Map 16** below.

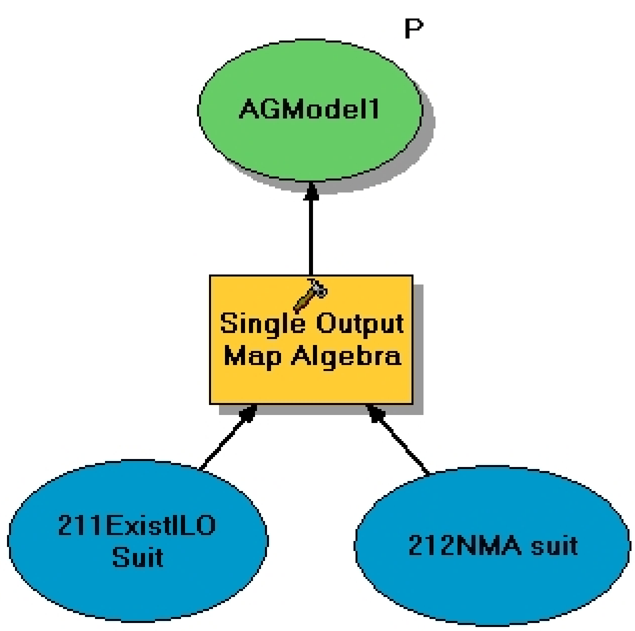
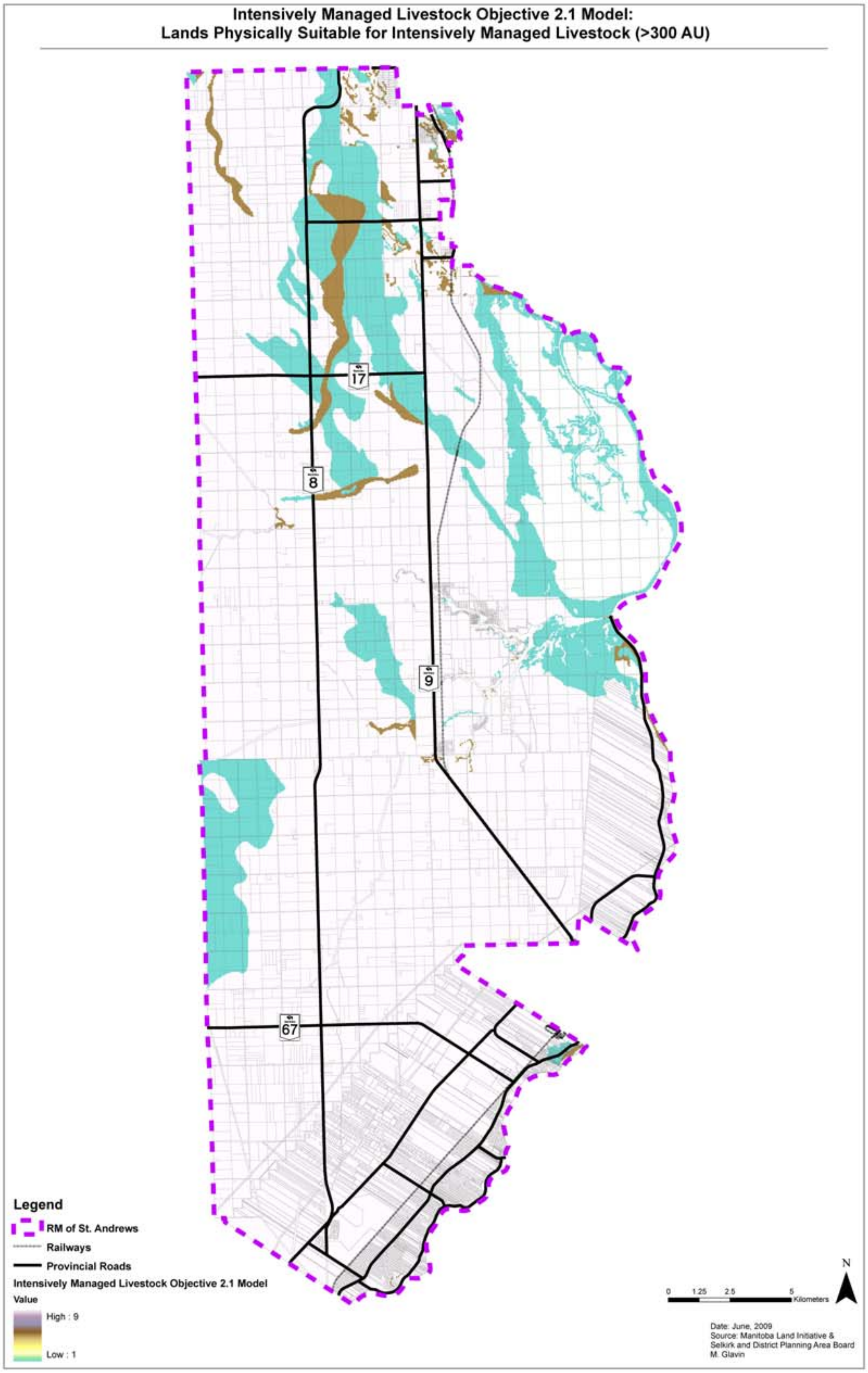


Figure 31 – Agricultural Objective 2.1 Model



Map 16 – Agricultural Objective 2.1 – Lands Physically Suitable for Intensively Managed Livestock (>300 AU) Raster Map

C.4 Identifying Lands Economically Suitable for Intensively Managed Livestock (>300 Animal Units)

C.4.1 Identifying Lands in Close Proximity to Meat Processing Facilities

Existing meat processing facilities within the city of Winnipeg were identified through orhtographic photography interpretation. Vector layer point symbols were placed at the location of all of the identified meat processing facilities within the city of Winnipeg.

The Euclidean Distance Operation was run in ArcGIS 9.2 on the newly created vector layer that showed the locations of the identified meat processing facilities in the city of Winnipeg. This produced a single layer that visually showed incremental distances from the identified meat processing facilities within the city of Winnipeg. Next, the newly created layers that showed incremental distances from the identified meat processing facilities within the city of Winnipeg were reclassified using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in the tables below. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability (see **Table 35**). The sub-model shown in **Figure 32** outlines the methods used to produce the output map for *sub-objective 2.2.1: lands in close proximity to meat processing facilities*. The rationale for this decision is that it is more costly to transport livestock greater distances to meat processing facilities. With the uncertain future in fuel prices, livestock producers may wish to expand or locate on lands that are located closer to meat processing facilities.

Table 35 – Distance in metres from Identified Lands in Close Proximity to Meat Processing Facilities Reclassified Values
Source: Manitoba Water Stewardship, 2005

Old Values	New Values
15366.359375 - 23029.921495	9
23029.921495 - 29431.774266	8
29431.774266 - 34779.642303	7
34779.642303 - 39247.050966	6
39247.050966 - 42978.956846	5
42978.956846 - 47446.36551	4
47446.36551 - 52794.233546	3
52794.233546 - 59196.086317	2
59196.086317 - 66859.648438	1

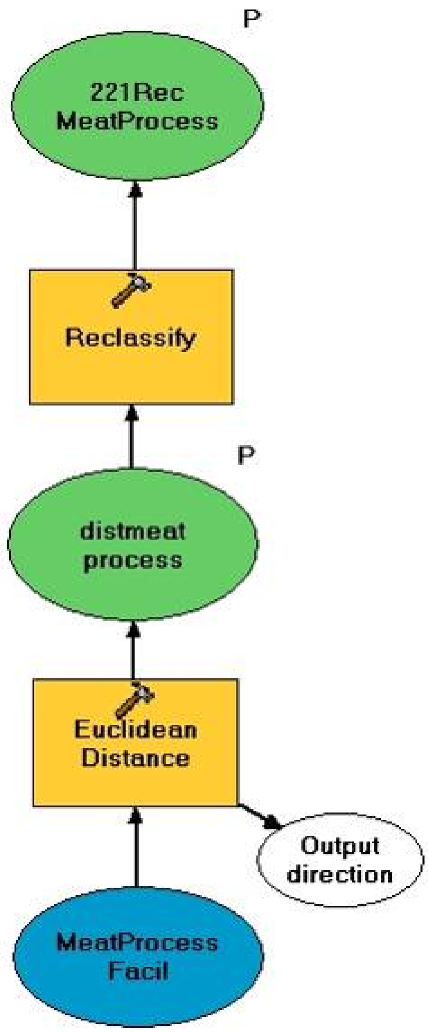


Figure 32 – 2.2.1 Lands in Close Proximity to Meat Processing Facilities Sub-Model

C.4.2 Identifying Lands that are in Close Proximity to Potentially Troublesome Adjacent Land Uses

A vector layer for all identified livestock operations within the RM of St. Andrews was used for identifying the lands in close proximity to potentially troublesome adjacent land uses. The Euclidean Distance Operation was run in ArcGIS 9.2 on the identified livestock operations vector layer. This produced one layer that visually showed incremental distances from the identified livestock operations.

Next, the layer that showed incremental distances from all the identified livestock operations in the RM of St. Andrews was reclassified using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in the table and figure below. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability (see **Table 36**). The sub-model shown in **Figure 33** outlines the methods used to produce the output map for *sub-objective 2.2.2: lands in close proximity to potentially troublesome adjacent land uses*. As non-farm rural residential dwellings locate closer to livestock operations and/or as livestock operations expand or locate near non-farm rural residential dwellings, conflicts between these lands uses may ensue. The distances used in this model are based on incremental distances and not the minimum separation distances based on animal units as specified in the Provincial Land Use Policies (2005). This model uses the assumption that the closer a livestock operation is to a rural residential dwelling, the greater the likelihood of conflicts.

Table 36 – Distance in metres from Identified Livestock Operations in the RM of St. Andrews Reclassified Values
Source: Manitoba Water Stewardship, 2005

Old Values	New Values
0 - 948.5165	1
948.5165 - 1501.446164	2
1501.446164 - 1823.771831	3
1823.771831 - 2011.668849	4
2011.668849 - 2333.994516	5
2333.994516 - 2886.92418	6
2886.92418 - 3835.44068	7
3835.44068 - 5462.561829	8
5462.561829 - 8253.787109	9

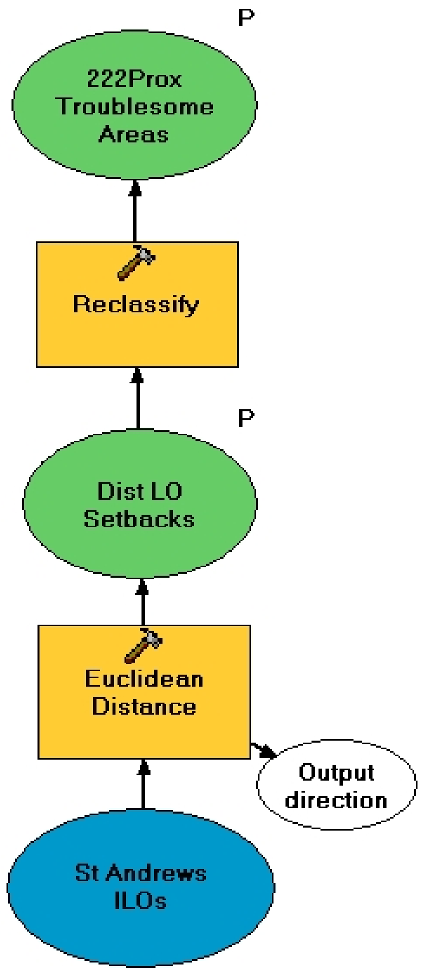


Figure 33 – 2.2.2 Lands in Close Proximity to Potentially Troublesome Adjacent Land Uses Sub-Model

C.4.3 Identifying Lands with Values Suitable for Intensively Managed Livestock

A land value dataset of the entire municipality was combined with the parcel ownership layer. Similar to identifying the lands with values suitable for residential land use, the assessed land values for the municipality were divided by each respective parcel size to give the land value per acre. This layer was reclassified into 9 geometric interval categories using the Reclassify Tool in the Spatial Analyst Tools of ArcGIS 9.2. The values in this dataset ranged from \$0 to \$300,115. The value range of 1 to 9 was used, with 9 representing the highest suitability and 1 being the lowest suitability. The highest value range (\$116,790 – \$300,115) was assigned a value of 1, while the lowest range (\$0 – \$2,344) was assigned a value of 9 (see **Table 37**). The sub-model shown in **Figure 34** outlines the methods used to produce the output map for *sub-objective 2.2.3: lands with values suitable for intensively managed livestock*. The underlying assumption is that the less valuable the land, the greater the likelihood that this land is still maintained for agricultural purposes and has not been encroached upon by residential development so as to inflate its assessed value. As mentioned earlier, the highest land values within the RM of St. Andrews are situated within the exiting residential land use clusters and surrounding areas. From this perspective, it would make logical sense that any future expansion or development of intensively managed livestock operations should be located in the areas of the municipality with lower assessed value per acre.

Table 37 – Assessed Land Values/Acre (in $) Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
0 - 2344.648438	9
2344.648438 - 11723.242188	8
11723.242188 - 23446.484375	7
23446.484375 - 35169.726563	6
35169.726563 - 53926.914063	5
53926.914063 - 80890.371094	4
80890.371094 - 112543.125	3
112543.125 - 161780.742188	2
161780.742188 - 300115	1

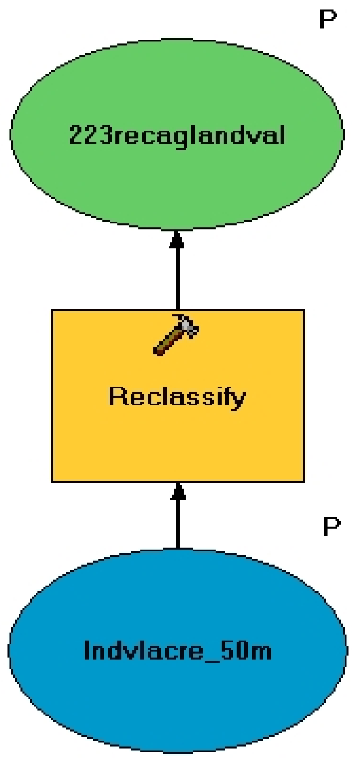


Figure 34 – 2.2.3 Lands with Values Suitable for Intensively Managed Livestock Sub-Model

C.4.4 AGRICULTURAL OBJECTIVE 2.2 MODEL: Identifying Lands Economically Suitable for Intensively Managed Livestock

The three sub-models – *2.2.1 lands in close proximity to meat processing facilities*, *2.2.2 lands in close proximity to troublesome adjacent land uses* and *2.2.3 lands with values suitable for intensively managed livestock* were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(221Rec MeatProcess * 0.2) + (222Prox Troublesome Areas * 0.4) + (223recaglandval * 0.4).* The reclassified lands that are in close proximity to potentially troublesome areas layer and reclassified suitable land values for intensively managed livestock layer were both multiplied by a weight of 0.4, while the reclassified distance from meat processing facilities layer was multiplied by a weight of 0.2. The identified lands with values suitable for intensively managed livestock layer and the lands in close proximity to troublesome adjacent land uses were given the highest weighted value because the results from these layers play a significant role in land use conflict mitigation. Ensuring that intensively managed livestock operations are located on lands that ensure the long term sustainability will minimize conflict with adjacent land uses. The Single Map Output Algebra calculation model for identifying lands economically suitable for residential land use can be seen in **Figure 35**. The results of the *agricultural objective 2.2 model: identifying lands economically suitable for intensively managed livestock* are shown in **Map 17** below.

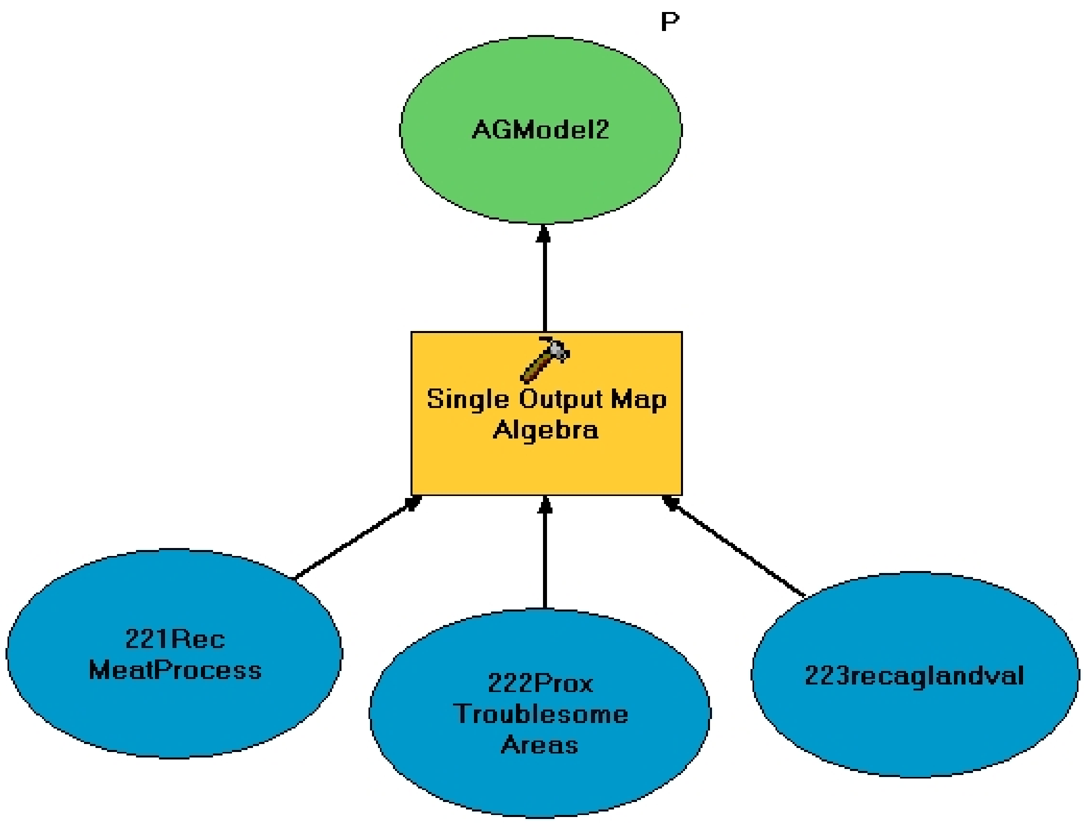
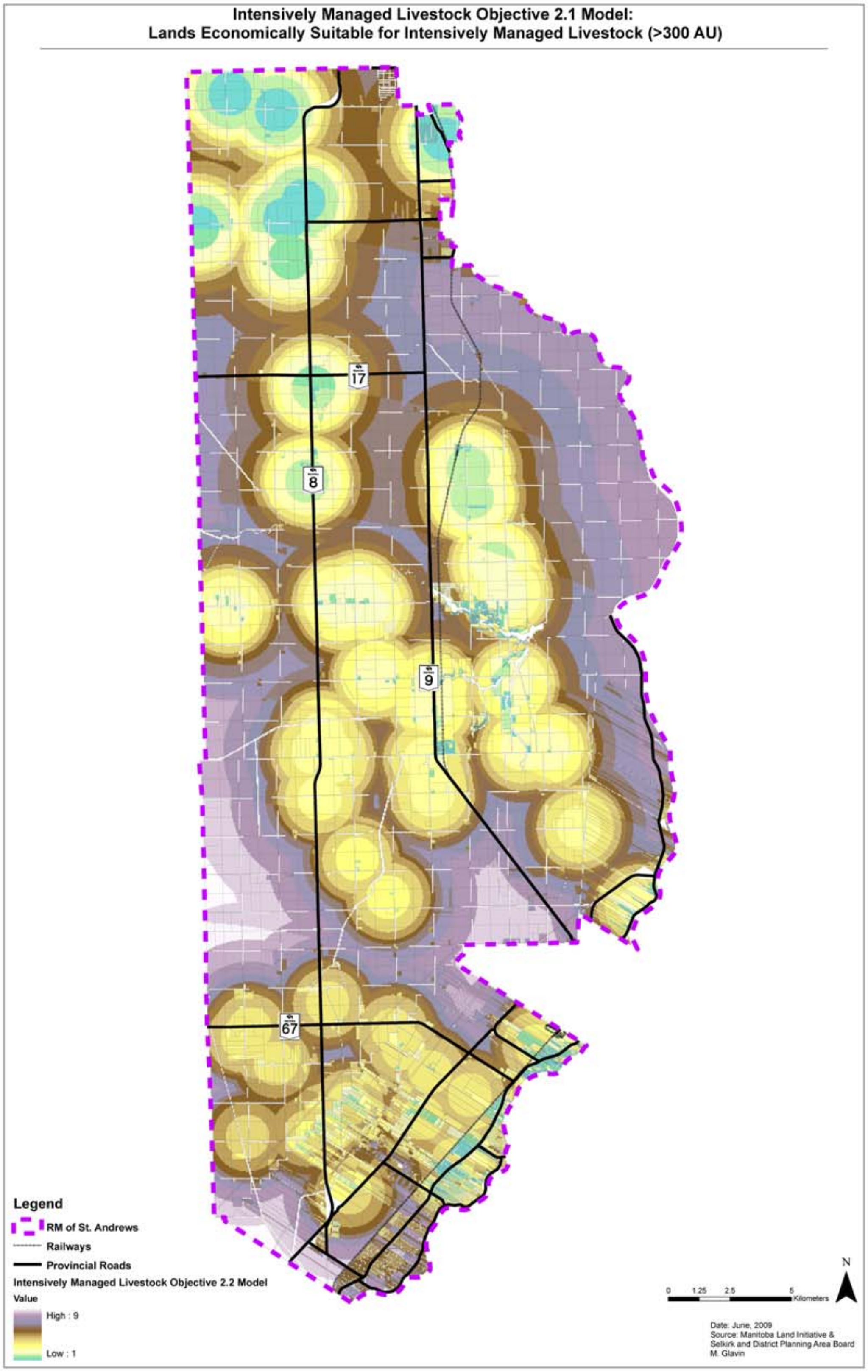


Figure 35 – Agricultural Objective 2.2 Model



Map 17 – Agricultural Objective 1.2 – Lands Economically Suitable for Intensively Managed Livestock (>300 AU) Raster Map

C.5 Identifying Lands Physically Suitable for Low-Intensity Livestock (<300 Animal Units)

C.5.1 Identifying Soils Most Suitable for Low-Intensity Livestock

In identifying soils most suitable for low-intensity livestock, the surface texture characteristics were downloaded from the Manitoba Land Initiative (2003) for the RM of St. Andrews as vector layers and then converted in to a raster layer based on the soil classification attributes. The general soil groups provide a very simplified overview of the soil information contained in the digital soil map. The hundreds of individual soil polygons have been simplified into broad groups of soils.

The soils layer was reclassified using the Reclassify Tool in ArcGIS 9.2. The old values were reclassified based on geometric interval to the new values shown in the table below. The value range of 1 to 9 was used, with 1 representing the lowest suitability and 9 being the highest suitability (see **Table 18**). The sub-model shown in **Figure 36** outlines the methods used to produce the output map for *sub-objective 3.1.1: soils suitable for low-intensity livestock*. A majority of the RM of St. Andrews is comprised of clay based, fine loamy and coarse loamy soils or Agricultural Soil Class 1, 2 and 3 which are the most productive agricultural soils. Heavy-textured soils, such as clay soils, are most suitable for livestock production and manure application since they have much slower infiltration rates than light textured soils. Manure application rates on these soils tend to avoid ponding or runoff (Farm Practices Guidelines for Pig Producers, 2007).

Table 38 – Soil Types Reclassified Values
Source: Manitoba Land Initiative, 2003

Old Values	New Values
Clayey	9
Fine Loamy	8
Coarse Loamy	7
Water	1

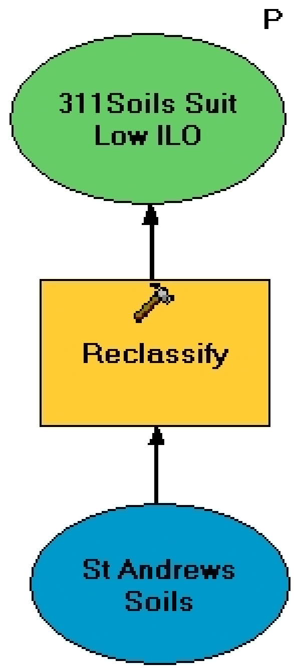


Figure 36 – 3.1.1 Soils Suitable for Low-Intensity Livestock Sub-Model

C.5.2 Identifying Existing Low-Intensity Livestock Lands as Suitable

Existing suitable lands for low-intensity livestock lands within the RM of St. Andrews were identified using orhtographic photography interpretation and parcel ownership map identification. Existing low-intensity parcels and surrounding parcels that are able to accommodate limited expansion were identified as suitable based on compliance will the Provincial Land Use Policies (2005) minimum setback requirements and located in areas of clay based soils and/or Agricultural Soil Class 1, 2, or 3. These selected parcels were converted in to a raster layer that showed existing suitable lands for low-intensity livestock in the RM of St. Andrews.

Next, all of the cells that were not highlighted as suitable existing low-intensity livestock lands were reclassified using the Reclassify Tool in ArcGIS 9.2 and assigned a value of 1 (low suitability) and all other cells were highlighted as suitable for existing low-intensity livestock were assigned a value of 9 (high suitability) (see **Table 39**). The sub-model shown in **Figure 37** outlines the methods used to produce the output map for *sub-objective 3.1.2: suitable existing low-intensity livestock lands*. Similar to the rationale for intensively managed livestock – expansion of low-intensity livestock within the RM of St. Andrews must comply with the Provincial Land Use Policies (2005) minimum setback requirements and should be located on lands that have much slower infiltration rates and can accommodate nutrient application.

Table 39 – Suitable Existing Low-Intensity Managed Livestock Lands Reclassified Values
Source: Selkirk and District Planning Area Board, 2006

Old Values	New Values
Identified Suitable ILO Lands <300 AU	9
Remaining Lands	1

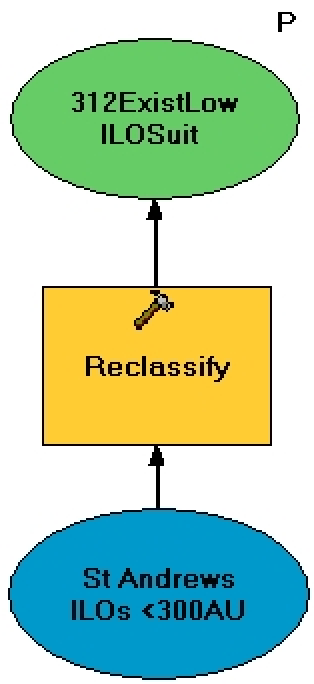


Figure 37 – 3.1.2 Suitable Existing Low-Intensity Livestock Lands Sub-Model

C.5.3 AGRICULTURAL OBJECTIVE 3.1 MODEL: Identifying Lands Physically Suitable for Low-Intensity Managed Livestock

The sub-models – *3.1.1 soils most suitable for low-intensity livestock* and *3.2.1 suitable existing low-intensity livestock lands* were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *CON(312ExistLowILOSuit EQ 9, 9, 311Soils Suit Low ILO).* The CON function was used to control the output value for each cell based on whether the cell value evaluates to true or false in a specified conditional statement. In this case, if a cell is found to be in the suitable existing low-existing livestock lands (suitability equals 9), then it will be assigned a new value of 9. Similarly, if a cell is found to be in the soils suitable for low-intensity livestock (suitability equals 9), then it will be assigned a new value of 9. The Single Map Output algebra calculation model for identifying lands economically suitable for residential land use can be seen in **Figure 38**. The results of the *agricultural objective 3.1 model: identifying lands physically suitable for low-intensity livestock* are shown in **Map 18** below.

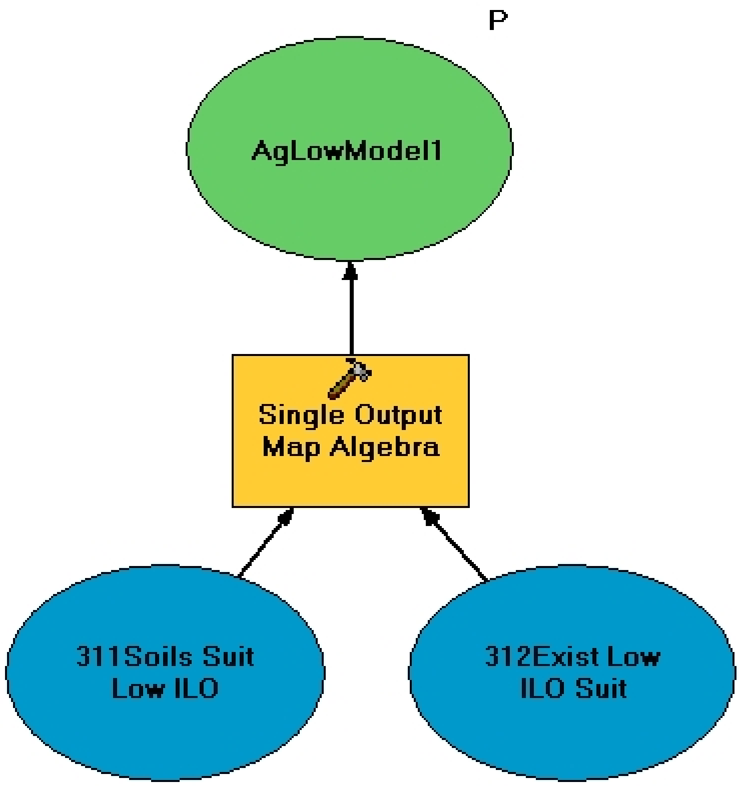
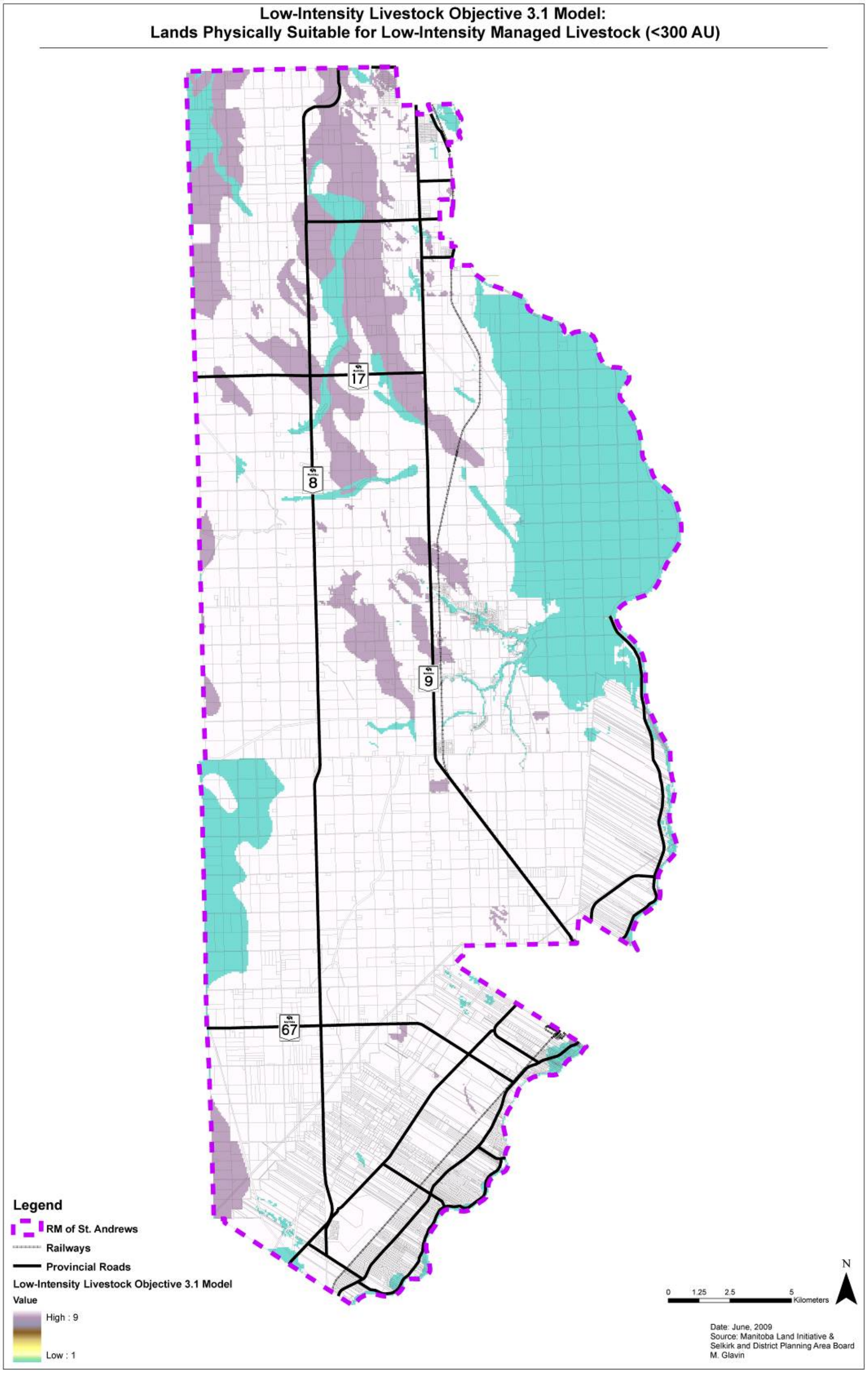


Figure 38 – Agricultural Objective 3.1 Model



Map 18 – Agricultural Objective 3.1 – Lands Physically Suitable for Low-Intensity Livestock (<300 AU) Raster Map

C.6 Identifying Lands Economically Suitable for Low-Intensity Livestock (<300 Animal Units)

In identifying lands most economically suitable for low-intensity livestock, a series of characteristics were analyzed to determine suitability. Similar to the objective model used to identify lands physically suitable for low-intensity livestock, this objective model is comprised of a series of stand alone sub-models. The sub-models for identifying lands most suitable for residential land use include identifying lands in close proximity to meat processing facilities and identifying lands with values suitable for low-intensity livestock. To produce the final objective model for identifying lands economically suitable for low-intensity livestock, the two sub-models – lands in close proximity to meat processing facilities and lands with values suitable for low-intensity livestock was combined through a series of calculations. The details of the objective model and all calculations for each sub-model are shown below.

C.6.1 Identifying Lands in Close Proximity to Meat Processing Facilities

The same calculation that was used in sub-model *2.2.1: identifying lands in close proximity to meat processing facilities* for intensively managed livestock was used for this sub-model. The old values were reclassified based on geometric interval to the same new values that were chosen in the sub-model 2.2.1. These values are shown in **Table 40**. The sub-model shown in **Figure 39** outlines the methods used to produce the output map for *sub-objective 3.2.1: lands in close proximity to meat processing facilities*.

Table 40 – Distance in metres from Identified Lands in Close Proximity to Meat Processing Facilities Reclassified Values
Source: Manitoba Water Stewardship, 2005

Old Values	New Values
15366.359375 - 23029.921495	9
23029.921495 - 29431.774266	8
29431.774266 - 34779.642303	7
34779.642303 - 39247.050966	6
39247.050966 - 42978.956846	5
42978.956846 - 47446.36551	4
47446.36551 - 52794.233546	3
52794.233546 - 59196.086317	2
59196.086317 - 66859.648438	1

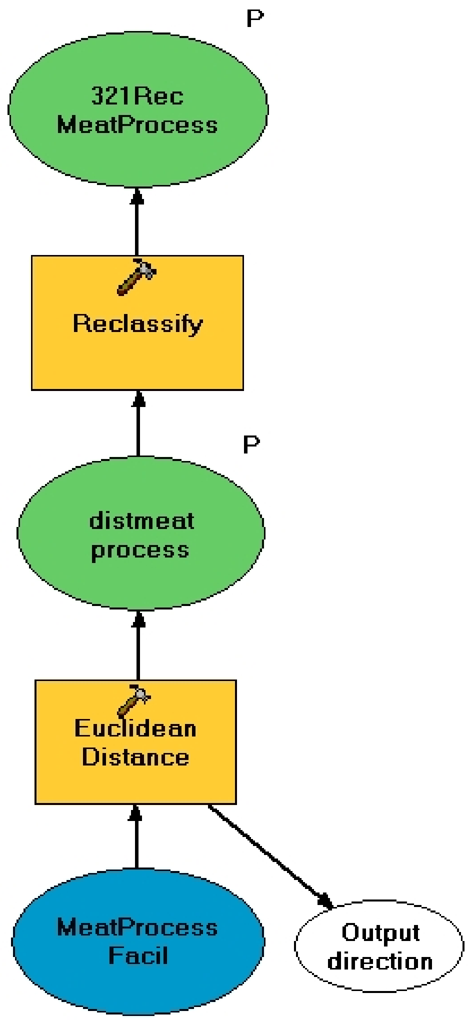


Figure 39 – 3.2.1 Lands in Close Proximity to Meat Processing Facilities Sub-Model

C.6.2 Identifying Lands with Values Suitable for Low-Intensity Livestock

The same calculation that was used in sub-model *2.2.3: identifying lands with values suitable for intensively managed livestock* was used for this sub-model. The old values were reclassified based on geometric interval to the same new values that were chosen in the sub-model 2.2.3. These values are shown in **Table 41**. The sub-model shown in **Figure 40** outlines the methods used to produce the output map for *sub-objective 3.2.2: lands with values suitable for low-intensity livestock.*

Table 41 – Assessed Land Values/Acre (in $) Reclassified Values Source: Selkirk and District Planning Area Board, 2006	
Old Values	**New Values**
0 - 2344.648438	9
2344.648438 - 11723.242188	8
11723.242188 - 23446.484375	7
23446.484375 - 35169.726563	6
35169.726563 - 53926.914063	5
53926.914063 - 80890.371094	4
80890.371094 - 112543.125	3
112543.125 - 161780.742188	2
161780.742188 - 300115	1

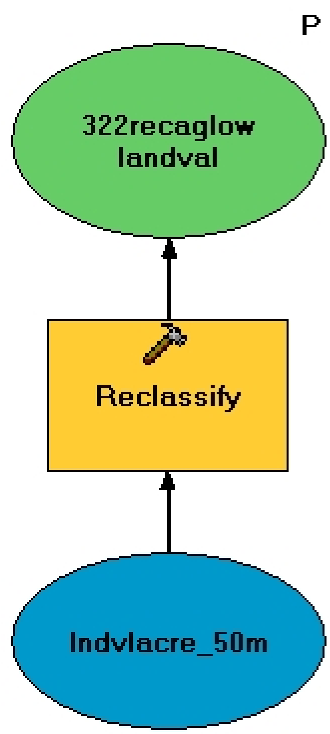


Figure 40 – 3.2.2 Lands with Values Suitable for Low-Intensity Livestock Sub-Model

C.6.3 AGRICULTURAL OBJECTIVE 3.2 MODEL: Identifying Lands Economically Suitable for Low-Intensity Managed Livestock

The two previously discussed sub-models – *3.2.1 lands in close proximity to meat processing facilities*, *3.2.2 lands with values suitable for low-intensity livestock* were combined using the Single Output Map Algebra Tool within the Spatial Analyst Toolsets of ArcGIS 9.2. Within the Single Map Algebra Tool, the following equation was used: *(322recaglowlandval * 0.75) + (321RecMeatProcess * 0.25).* The reclassified suitable land values for intensively managed livestock layer were both multiplied by a weight of 0.75, while the reclassified distance from meat processing facilities layer was multiplied by a weight of 0.25. Similar to the objective 2.2 model for intensively managed livestock, the identified lands with values suitable for low-intensity livestock layer were given the highest weighted value because the results from these layers play a significant role in land use conflict mitigation. Locating low-intensity livestock on lands that ensure the long term sustainability will minimize conflict with adjacent land uses. The Single Map Output algebra calculation model for identifying lands economically suitable for residential land use can be seen in **Figure 41**. The results of the *agricultural objective 3.2 model: identifying lands economically suitable for low-intensity livestock* are shown in **Map 19** below.

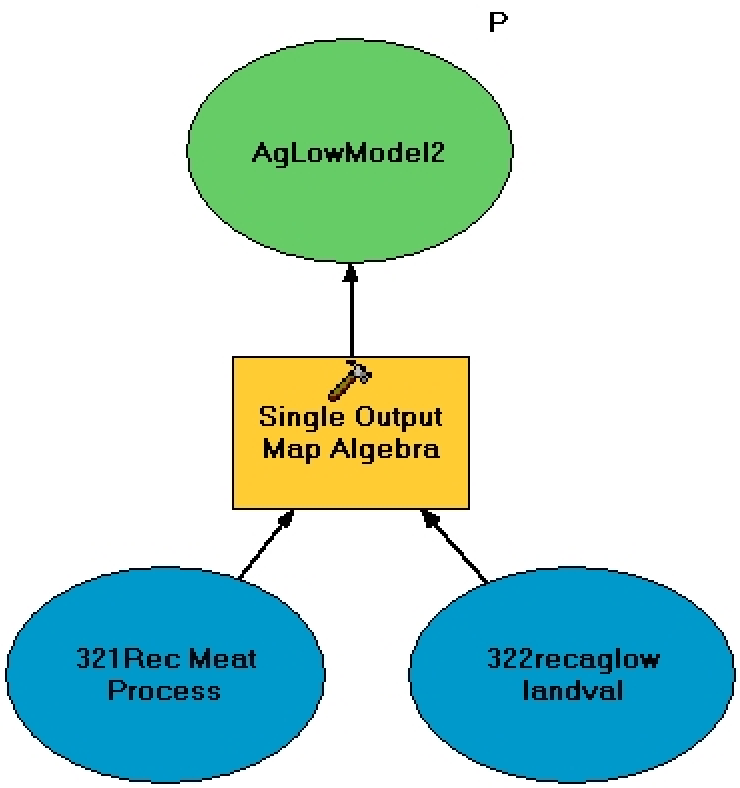
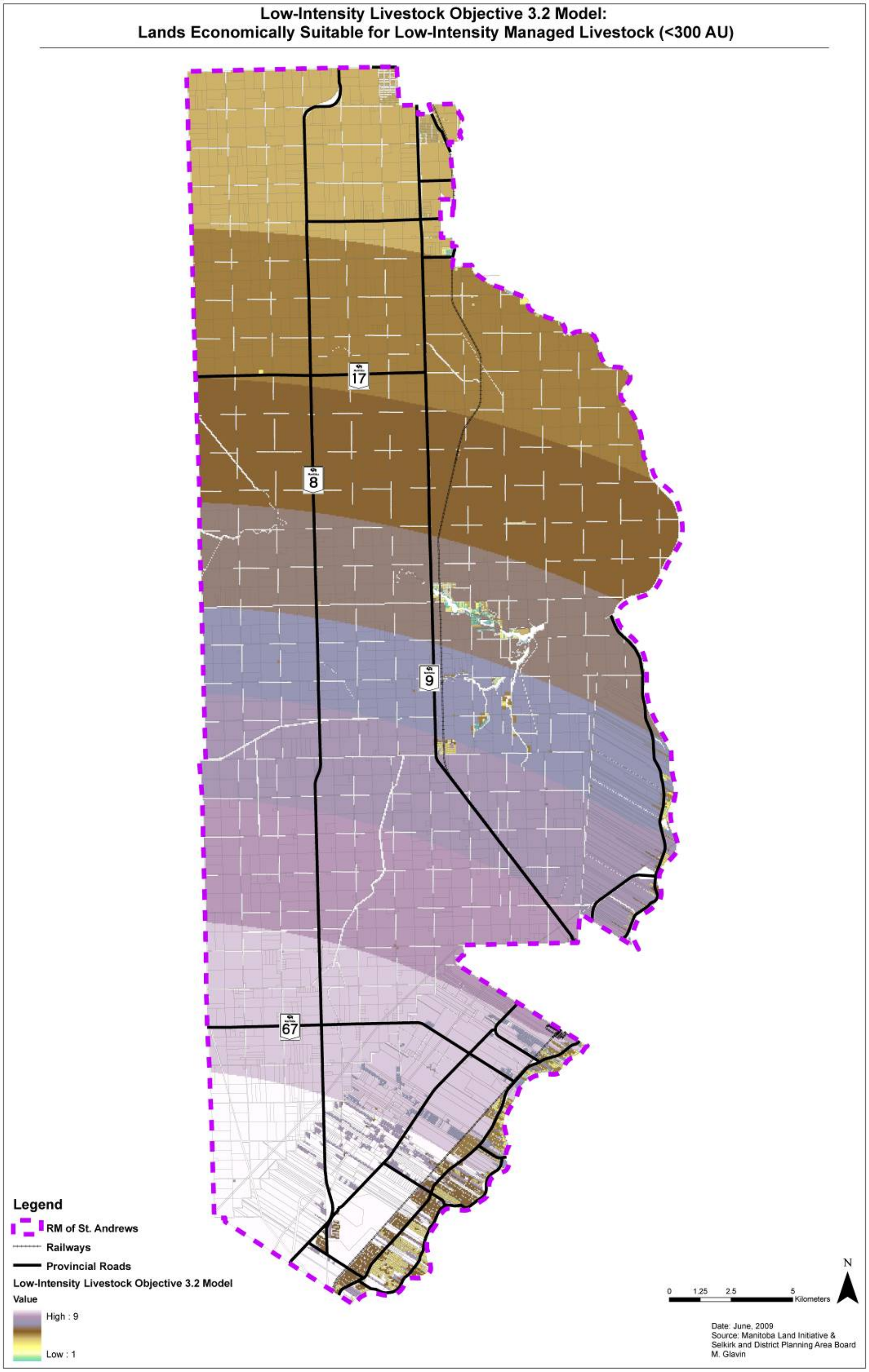


Figure 41 – Agricultural Objective 3.2 Model



Map 19 – Agricultural Objective 3.2 – Lands Economically Suitable for Low-Intensity Livestock (<300 AU) Raster Map

Appendix D: Consent Forms

UNIVERSITY OF MANITOBA

Faculty of Architecture

City Planning
201 Russell Building
84 Curry Place
Winnipeg MB
R3T 2N2
Tel: (204) 474-6578
Fax: (204) 474-7532

STATEMENT OF INFORMED CONSENT – KEY INFORMANT INTERVIEWS

Statement of Informed Consent
Key Informant Participants

Research Project Title: Reducing Conflict between Rural Residential Developments and Hog Operations: A Decision Support Tool for the Selkirk and District Planning Area, Manitoba

Researcher: Matthew Glavin, (770-6900), mattglavin67@hotmail.com

Advisor: Dr. Richard Milgrom, (204) 474-6868, milgrom@cc.umanitoba.ca

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This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. Please do not hesitate to ask for further details or clarification on any of the material presented below. Please take the time to read this carefully and to understand any accompanying information.

Project Description

The past few years have seen dramatic changes in agriculture, which have created challenges for traditional family farms. But it has also seen the emergence of new opportunities to diversify the rural farm economy through value added organic production and diversification into livestock operations. Diversification and changing farm economics have introduced concerns about the growth and location of livestock operations and potential impacts that larger scale livestock operations may have upon the quality of life enjoyed by communities, as well as their impacts upon the natural environment. In the past, livestock production was primarily a part of mixed farming operation. It has now become a specialized industry where operations have become much larger and more capital intensive than farms of thirty years ago. These factors led to situations where land use conflicts have occurred and continue to occur.

Purpose of the Study

This research focuses on two objectives: The first step develops to develop a GIS model and minimum distance separation formulae which will be used as tools to identify land use resolution strategies in the RM of St. Andrews, Manitoba. The second consists of obtaining information from selected participants, including key stakeholders involved in planning, municipal council members and District Board members. This research is being conducted as part of a requirement for the completion of the Master of City Planning Program at the University of Manitoba.

The interviews will be conducted with the interview guide (approved by the Ethics Board at the University of Manitoba), and the focus group interview will last no longer than one hour and a half. The interview will be audiotaped and notes taken by the researcher for the purposes or reliability and analysis at a later date.

Consent

Only the researcher and his supervisor will have access to notes and audiotapes used during the interview. Data gathered may also be considered for future use in research papers. Data gathered will be securely stored in the home of the researcher, and will be destroyed following completion of the practicum. Once published, you will have access to the practicum report at the University of Manitoba library.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

If you have any questions or concerns after this interview is complete, please feel free to contact Dr. Ian Wight at (204) 474-7051, Department Head, Department of City Planning, Faculty of Architecture, University of Manitoba, Winnipeg, MB, R3T 5V6, or myself at (204) 770-6900, 707-1305 Taylor Ave., Winnipeg, MB, R3M 2K6.

This research has been approved by the Joint-Faculty Research Ethics Board (JFREB). If you have any concerns or complaints about this project you may contact the above-named persons of the Human Ethics Secretariat at (204) 474-7122, or email margaret_bowman@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

Risks and Benefits

There are minimal risks to the subjects identified. Issues regarding anonymity and confidentiality (particularly in the case of educational photographic or video documentation) are addressed below. This practicum does not address personal or confidential issues.

Audio-Taping

In some cases, and with your permission, activities, interviews or other kinds of sessions may be audio-recorded and transcribed at a later date for research purposes, so that analyzing the material at a later date will be completed with greater ease and efficiency. Such audio-recordings will be kept in a secure place, and destroyed after they have been transcribed. *Your name or any other personal information will not be included in any publicly disseminated materials arising from the study unless such permission has been explicitly granted.*

Use of Data, Secure and Destruction of Research Data

Information collected from participants will be incorporated into class presentations and final reports by the students. All information will be treated as confidential and stored in a private and secure place, and subsequently destroyed at the end of the course. The researcher will be responsible for destroying the data.

Thank-you for giving your time to participate in this interview. Your responses are very valuable to this research project and are greatly appreciated.

Participant's Signature: ____________________________________ Date: ___________

Participant's Printed Name: _________________________________

Researcher's Signature: ____________________________________ Date: ___________

UNIVERSITY OF MANITOBA

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STATEMENT OF INFORMED CONSENT – FOCUS GROUP INTERVIEWS

Statement of Informed Consent
Focus Group Participants

Research Project Title: Reducing Conflict between Rural Residential Developments and Hog Operations: A Decision Support Tool for the Selkirk and District Planning Area, Manitoba

Researcher: Matthew Glavin, (770-6900), mattglavin67@hotmail.com

Advisor: Dr. Richard Milgrom, (204) 474-6868, milgrom@cc.umanitoba.ca

---

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

Project Description

The past few years have seen dramatic changes in agriculture, which have created challenges for traditional family farms. But it has also seen the emergence of new opportunities to diversify the rural farm economy through value added organic production and diversification into livestock operations. Diversification and changing farm economics have introduced concerns about the growth and location of livestock operations and potential impacts that larger scale livestock operations may have upon the quality of life enjoyed by communities, as well as their impacts upon the natural environment. In the past, livestock production was primarily a part of mixed farming operation. It has now become a specialized industry where operations have become much larger and more capital intensive than farms of thirty years ago. These factors led to situations where land use conflicts have occurred and continue to occur.

Purpose of the Study

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The interviews will be conducted with the interview guide (approved by the Ethics Board at the University of Manitoba), and the focus group interview will last no longer than one hour and a half. The interview will be audiotaped and notes taken by the researcher for the purposes or reliability and analysis at a later date.

Consent

Only the researcher and his supervisor will have access to notes and audiotapes used during the interview. Data gathered may also be considered for future use in research papers. Data gathered will be securely stored in the home of the researcher, and will be destroyed following completion of the practicum. Once published, you will have access to the practicum report at the University of Manitoba library.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

If you have any questions or concerns after this interview is complete, please feel free to contact Dr. Ian Wight at (204) 474-7051, Department Head, Department of City Planning, Faculty of Architecture, University of Manitoba, Winnipeg, MB, R3T 5V6, or myself at (204) 770-6900, 707-1305 Taylor Ave., Winnipeg, MB, R3M 2K6.

This research has been approved by the Joint-Faculty Research Ethics Board (JFREB). If you have any concerns or complaints about this project you may contact the above-named persons of the Human Ethics Secretariat at (204) 474-7122, or email margaret_bowman@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

Risks and Benefits

There are minimal risks to the subjects identified. Issues regarding anonymity and confidentiality (particularly in the case of educational photographic or video documentation) are addressed below. This practicum does not address personal or confidential issues.

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Use of Data, Secure and Destruction of Research Data

Information collected from participants will be incorporated into class presentations and final reports by the students. All information will be treated as confidential and stored in a private and secure place, and subsequently destroyed at the end of the course. The researcher will be responsible for destroying the data.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the course project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and/or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

This practicum has been approved by the Joint Faculty Research Ethics Board (JFREB) of the University of Manitoba. If you have any concerns or complaints about this project you may contact the above-named persons or the Human Ethics Secretariat at 474-7122. A copy of this consent form has been given to you to keep for your records and reference.

Thank-you for giving your time to participate in this interview. Your responses are very valuable to this research project and are greatly appreciated.

Participant's Signature: ____________________________________ Date: ___________

Participant's Printed Name: _________________________________

Researcher's Signature: ____________________________________ Date: ___________

Appendix E: Key Informant Interview Questions

Reducing Conflict between Rural Residential Developments and Hog Operations: A Decision Support Tool for the Selkirk and District Planning Area, Manitoba

Matthew Glavin
Master of City Planning, University of Manitoba

Introduction: The primary intent of the focus group questions is to gain a greater appreciation of how conflicts between rural residential development and livestock operations are perceived in the RM of St. Andrews, MB and to aid in the development of a GIS decision support tool and minimum separation distance formulae for accurately analyzing land use conflicts on a spatial level.

1. Based on my understanding, as outlined by the *Planning Act* (2005), the RM of St. Andrews must identify areas where livestock operations are permitted, permitted up to a certain size and not permitted. They must also identify the separation distances in the zoning by-law for livestock operations (earthen manure storage) based on the Provincial Land Use Policies. They may exceed this number but cannot go below it.

    a. Is this an accurate summary of how the RM of St. Andrews has created their separation distances for livestock operations?
    b. Does the RM of St. Andrews follow this methodology very closely when creating its policies for separation distances for livestock operations? Why or Why not?
    c. Are there any advantages or disadvantages to this methodology?

2. Without revealing names or location, has the RM of St. Andrews experienced any recent land use conflicts between a livestock operation(s) and a residential dwelling(s)?

    a. If yes, how was it addressed?
    b. If yes, was the conflict resolved?
    c. If yes, was it resolved in a timely and efficient manner that ensures no future land use conflicts will occur with this specific example?
    d. If yes, is there anything that the RM of St. Andrews or the Selkirk and District Planning Area Board could have done differently to prevent or handle the situation differently?

3. With the current moratorium on new or expanding hog operations in the Red River valley region that was imposed by the Provincial Government in April, 2008, do you feel that this decision will minimize land use conflicts in the RM of St. Andrews?

    a. Do you feel that this decision is beneficial or negative to the RM of St. Andrews? Please explain your answer

4. Based on my understanding, the separation distances for livestock operations (earthen manure storage) is based on the number of animal units which are calculated using the Animal Unit Summary Table from the Provincial Land Use Policies (2005). Each type of animal is given a different animal unit. The total number of animal units per operation will determine the separation distance for each livestock operation based on the Provincial Land Use Policies (2005).

    a. Is this an accurate summary of the how the Provincial Government determines the criteria for separation distance for livestock operations?
    b. Do you feel these guideline distances are appropriate? Please explain.
    c. What do you feel are the most important criteria in determining separation distances from livestock operations and the nearest residential dwelling? For example, should more consideration and analysis on separation distances be given to those operations that follow best practices such as anaerobic digesters that convert manure in to electricity or operations that use charcoal filters and eliminate a large percentage of offensive odour? Please give several examples and explain in detail each.

5. Would the RM of St. Andrews aid in having the capability to conduct detailed environmental land analysis similar to that of a technical review committee for a new or expanding operation that is applying for a building permit that exceeds 300 animal units?

    a. If yes, what environmental factors and criteria would be taken in to consideration for determining the siting of a livestock operation?
    b. Which factors and criteria would be most important and why?

Appendix F: Focus Group Questions

Reducing Conflict between Rural Residential Developments and Hog Operations: A Decision Support Tool for the Selkirk and District Planning Area, Manitoba

Matthew Glavin
Master of City Planning, University of Manitoba

Introduction: The primary intent of this component of the focus group interviews is to demonstrate the GIS decision support tool using the LUCIS model for the RM of St. Andrews.

1. Could you please explain your current and past employment or activities and how it relates to land use planning and siting of livestock operations?

2. Please discuss the extent of land use conflicts between rural residential dwellings and livestock operations within the RM of St. Andrews.
    a. What are they major factors that contribute to these conflicts?

3. Could you describe the process for designating land uses in the RM of St. Andrews? More specifically, when formulating the development plan and zoning-by law what criteria are used and/or public input is used to designate lands a specific use?
    a. How has land use planning changed within the planning district and RM to address land use conflicts between rural residential dwellings and livestock operations?

4. Based on the demonstration of the LUCIS model using varying nominal weighting factors to various environmental classifications, which were identified by key informants; does this model show an accurate representation of lands that may be suitable for the siting of livestock operations, residential land uses? Please explain.

    a. Are the criteria shown in the model for evaluating potential land use conflicts too exhaustive?
    b. If permitted, where do you believe future livestock operations should be located? Is this the same as what is reflected in the development plan?
    c. Where do you believe future residential development should be located? Is this the same as what is reflected in the development plan?
    d. Would a GIS model, such as the one shown be practical for determining optimal land uses and visually seeing potential conflict between rural residential development and livestock operations in the RM of St.

Andrews? Could you see this model being used for analyzing other issues that the municipality may have? If so, how? Could these optimal areas be designated as policy areas?

5. Do you have any other ideas or comments regarding the GIS decision support tool that was developed to analyze land use conflicts between rural residential development and livestock operations?