



A geographic information system fiscal analysis of development patterns in Bozeman, Montana
by B Stewart Mitchell, Jr

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Earth Sciences

Montana State University

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Abstract:

Rapid population growth in and around Bozeman, Montana is creating sprawl. The community is struggling to manage the rising cost associated with sprawl and preserve the traditional quality of life. This thesis addresses the question of whether it is possible to accommodate the growth in a less costly manner and preserve the qualities that make the Gallatin Valley a desirable to place to live. Current planning practices' and zoning regulations permit only sprawl style development. However, new urbanism development patterns offer cost savings over sprawl. This thesis uses a geographic information system and a fiscal model to compare and contrast a sprawl development and a new urbanist development in Bozeman, Montana. The results demonstrate the new urbanist development generates more tax revenue and has a lower cost of services than the sprawl development.

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A thesis submitted in partial fulfillment
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APPROVAL

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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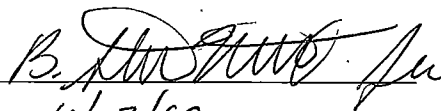
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ABSTRACT

Rapid population growth in and around Bozeman, Montana is creating sprawl. The community is struggling to manage the rising cost associated with sprawl and preserve the traditional quality of life. This thesis addresses the question of whether it is possible to accommodate the growth in a less costly manner and preserve the qualities that make the Gallatin Valley a desirable place to live. Current planning practices and zoning regulations permit only sprawl style development. However, new urbanism development patterns offer cost savings over sprawl. This thesis uses a geographic information system and a fiscal model to compare and contrast a sprawl development and a new urbanist development in Bozeman, Montana. The results demonstrate the new urbanist development generates more tax revenue and has a lower cost of services than the sprawl development.

Preamble

It was a warm spring day and I was riding in my father's car with my 10 year old eyes. I watched the endless rows of houses and stores scroll through the frame of my window. I asked my father, "How big is our town?" my father replied, "Its getting bigger every day. When I was a boy this whole area was nothing but farms and fields." I always enjoyed watching the "landscape movie" play through a car window. Every time I return to my childhood home and travel a familiar route, I am treated to a sequel, and just like a Hollywood sequel, it gets worse with every repetition. The forests and fields I loved as a child are now covered with subdivisions and mini malls. I have often wondered, if this never ending consumption is the best use of our land resources.

INTRODUCTION

The dominant pattern of land use that spreads out from most American population centers, converting farms and fields to homes and malls, is known as urban sprawl. Sprawl is low density, unplanned, inefficient, auto dependent growth (Burchell, 1997). Sprawl is the landscape signature of the American dream.

Until recently, such low density development was unquestionably accepted as progress in this country. Now, in the post modern era, some are beginning to question the merits of this type of expansion and realize this type of low density development has produced unanticipated consequences.

The drivers and consequences of sprawl represent a complex web of connections between socioeconomic factors and the landscape. The drivers of sprawl include population growth, land use conversion and zoning. Large scale land use conversion at low densities resulting from urban sprawl has been associated with low quality of life, rising tax burdens and increasing pollution (Gordon and Richardson, 1997). Moreover the sense of place is lost when the landscape becomes so homogenized, that one place becomes undistinguishable from another (Kunstler, 1993). These consequences are compounded in regions with little planning and rapid population growth. One of the most significant problems associated with urban sprawl is the cost of providing and maintaining municipal services to new low density development.

In the last ten years, there has been a growing wave of “Smart Growth” initiatives across the country (Morris, Feb. 1999). The main goal of these initiatives is to create a landscape that is less costly to the public and individuals from an economic and lifestyle perspective. Smart growth achieves these goals by encouraging or mandating land use development in a more efficient and compact pattern.

This study will quantify the costs of providing municipal services to a sprawl style development and contrast these results to the financial costs related to an alternative land use pattern known as new urbanism. New urbanism is associated with Smart Growth. The comparison of these development patterns will be conducted through the use of a Geographic Information System (GIS) model. The model results will test the hypothesis that higher density development with mixed zoning has economic benefits over low density sprawl development.

Urban sprawl, new urbanism, smart growth and land use are terms that have varying definitions in public and academic contexts. For clarity, the following definitions will be used in this thesis.

Definitions

Land use refers to how humans interact with, change and use the natural landscape of a region for various economic functions (Platt, 1996). **Land use** types are used by the United States Geological Survey (USGS) to distinguish specific types and subsets of specific land uses such as, agricultural, commercial, urban or

residential. **Subdivision** refers to the division of a tract or parcel of land into two or more lots or parcels (Kelly and Becker, 2000). **Urban sprawl** or simply **sprawl** is the unlimited outward expansion from population centers of low density, segregated, auto dependent, commercial and residential land uses (Jackson, 1987). This type of land use usually follows a path of least resistance along existing roads (Lewis, 1999).

Leap Frog development is a term used to describe sprawl development that occurs beyond the edge of existing developed land uses (Vermont Forum on Sprawl, 1999).

Smart growth is an all encompassing term that is frequently used to describe a type of land use development that seeks to decrease the negative impacts of commercial and residential land use development through higher densities, less dependence on the automobile and mixed zoning types (O'Neil, 1998). **New urbanism** is depicted as an area where homes are closer together and closer to the street, walking is made easy by attractive pathways connecting homes to shopping and community services, street systems are interconnected to reduce traffic congestion, forms and scales are comfortable and comparable and open spaces of many kinds are readily accessible (Porter, 1997).

Table 1: General characteristics of residential sprawl and new urbanist developments.

Sprawl	New Urbanist
Based on a Grid	Based on a Grid
Single type of residential land use	Mixed types of residential and commercial
Low dwelling units per acre	High dwelling units per acre

The first chapter will set the general context for the local and national landscape from the perspective of land use issues and will introduce the development patterns that will be compared by the model. The second chapter provides a detailed explanation of the software used to model the differences between the development patterns. Chapter 3 outlines the data compilation methods for the project. Chapter 4 explains the methodology used in the study. Chapter 5 will present the results of model. Chapter 6 discusses all findings and suggests areas for further research. The conclusion will be stated in the final chapter.

CHAPTER 1

GENERAL CONTEXT OF THE THESIS

The objective of this thesis is to compare the cost of providing specific municipal services and to determine the amount of tax revenue generated by two distinct land use development patterns using a GIS model. The model will compare a sprawl and new urbanist development with an equal spatial footprint. The specific aspects of these developments to be compared by the model include: the cost of municipal services, tax revenue generated, spatial properties and amount of projected future land use conversion with each development pattern.

The comparison of land use development patterns on the landscape presents a very complex task. Various large scale elements of land use must be introduced for the small scale analysis of different development patterns to be understood. The large scale elements affecting land use include population growth, specific types of land use conversion, planning and socio-economic conditions.

Population Growth

In the United States there are 3148 counties of which 838 experienced a population growth rate between 14% - 156% percent between 1990 through 1999 (ArcView® /Census, 1999). Two hundred and eleven of these counties are located in

the Rocky Mountain states: Arizona, Colorado, Idaho, Montana, New Mexico, Utah and Wyoming (ArcView® /Census, 1999). The average population growth rate of these 211 counties was 26 percent. In Montana, 17 counties grew by 14 % or more during the same period.

The population of Gallatin County expanded by 26% between 1990 and 1999 (Montana Department of Commerce, 2000). The latest wave of growth is the result of a uniquely motivated surge of immigration from other national regions (Jobes, et. al., 1992). Significantly, this migration was not motivated by economic opportunity, the historical norm in previous waves of western settlement (Jobes, et. al., 1992). Rather, the primary motivation of these new migrants was the perceived quality of life, sense of community and access to resource amenities that provide a wide array of recreational opportunities (Jobes, et. al., 1992).

From the late 1940s through the 1980s, Bozeman, the largest town in Gallatin County, grew at a relatively constant rate and retained a compact development pattern. The town's main socio-economic structure was based largely on agriculture, the retail sectors and government entities (Rasker, et.al., 1991).

Population growth in Gallatin county provides a driving factor creating shifts in land use conversion and increasing demand for public services.

Land Use Conversion

According to a recent study only 2.7% of the total area of the continental United States is urban (Imhoff, et. al. 1999). This figure suggests that a benign amount of land has been converted to urban land use. However, this study and others have found that residential, commercial, and industrial land use development has occurred on the most productive agricultural lands (Imhoff, et. al. 1999). This phenomenon is largely a result of America's agrarian heritage. Population centers historically developed in rich agricultural areas. Consequently, increasingly large tracks of land are being converted from agriculture to commercial and residential uses as urban areas continue to grow at low densities. This process is known as sprawl. The Rocky Mountain region is experiencing a new wave of land development driven by the expansion in the service, recreational, and information sectors. (Riebsame, et.a.l., 1996). As the population of Gallatin Country grows the amount of land converted from agricultural to commercial and residential land use steadily increases.

Sprawl is becoming an increasingly prevalent topic across the country. The loss of open spaces and climbing costs associated with such development have brought this issue to the forefront of public policy debate (Morris, Feb. 1999). The geographic area affected by urban sprawl can be identified as most areas surrounding established population clusters that have been, or are currently experiencing increases in land use development (American Farmland Trust, 1995).

Between 1970 and 1990, there was a 6% - 12% increase in land consumption for every 1% gain in population in metropolitan areas (American Farmland Trust, 1999). In Chicago, in the same period, the population grew by 4% while the land area devoted to urban uses increased by 46% (American Farmland Trust, 1999). These numbers support the observation that land use conversion is occurring at relatively low residential and commercial densities. In Gallatin County and western Montana more people are moving to rural areas than to incorporated areas such as cities (Johnson 1998).

Basic economic forces also encourage this type of land use conversion. Land sold for commercial and residential development has a higher value than equivalent parcels designated for agricultural use (Platt, 1996). Limiting the amount of land for this development conversion eliminates the potential for capital gain by individuals (Platt, 1996). Low density development assists in the perpetuation of land use conversion by ensuring the demand for commercial land development is higher than if land use development is done at higher densities (Platt, 1996).

Another factor driving the shift in land use patterns since WWII is the automobile (Platt, 1996). The post WWII development patterns are characterized by the improvement and extension of roads, setting stores further back from roads to allow for store front parking and homogeneous development occurring along connecting road corridors (Platt, 1996). The Highway Act of 1956 increased the spread of low density development by making previously distant land accessible to large population centers (Audriac et al, 1990).

For the last 50 years, the automobile has been an undisputed feature of American life, however many are beginning to question its real benefits (1000 Friends of Oregon, 1996). There are more automobiles on American roads than ever before and people are spending more time in their automobiles (Davis and Seskin, 1997). Although the automobile can be a great convenience and has made significant contributions to the development of our culture, it is now apparent that this contribution has come with hidden costs. These costs include pollution, cost of constructing and maintaining roadways, and individual operating costs (Bartholomew, 1993). The automobile has also been accused of decreasing the quality of life experienced by many Americans (Davis and Seskin, 1997). The time spent in an automobile reaching frequently needed services is lost to more productive uses. From 1970-1990, the U.S. Population grew by 22.5% and the number of vehicle miles traveled grew 98% (American Farmland Trust, 1999). The proliferation of the automobile has increased the amount of land use development and significantly reduced its overall density (Handy, 1992). Prior to large scale use of the automobile, population centers were designed around the distance one could walk, rather than drive.

It is important to note that an array of other factors have also contributed to the contemporary landscape. Low cost mortgage programs created under the Federal Housing Act made home ownership possible to many who could not otherwise afford to buy a home (Gerckens, 1994).

Montana and other rural areas in the Rocky Mountain region have not experienced the same high levels of low density land use conversion that occurred in the rest of the country since the 1950s due to the region's long distances to major metropolitan centers. Much of the low density land use development in this region has occurred in the last 15 years. An isoline map of well density by date in the Gallatin Valley shows developments have sprung up far from existing population clusters in the greater Bozeman area in the last 13 years (Figure 1). Low transportation costs afforded by the automobile make this type of development possible. The map depicts densities of well permits for residential use in ten year increments from 1977 through 1997. On the map there are several residential developments that appeared in the last decade in areas with little or no previous residential development.

Planning

A major influence on land use patterns that has functioned in concert with the automobile is single land use zoning (Canter, 1985). It is also known as Euclidean zoning from the precedent setting case of *Euclid vs. Amber Realty* in 1926 that upheld the validity of New York's Zoning Ordinance of 1916 (Woodruff, 1980). Euclidean zoning was introduced in the first half of this century in most large

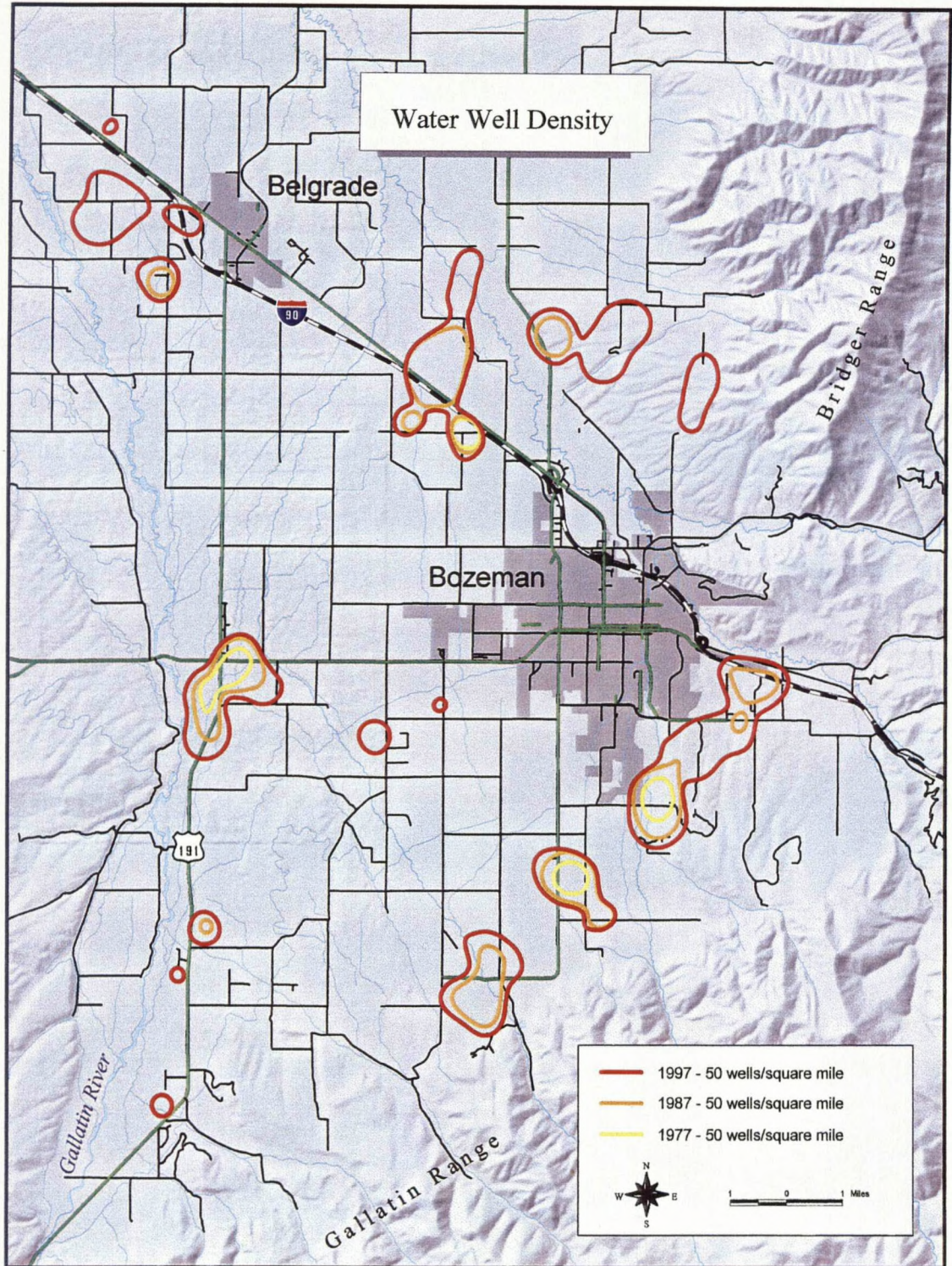


Figure 1: Map of water well density by date.

metropolitan areas (Gerckens 1994). Planning agencies embraced the concept as a rational and effective method of harmonizing different and often conflicting land uses such as industrial and residential (Platt, 1996). It also became a tool for municipalities to further subdivide residential land uses. Minimum lot sizes and housing square footage facilitated the grouping of different socio-economic classes (Lapping, 1980). Although Euclidean zoning was seemingly well intentioned at the time, only now are its unintended consequences becoming apparent.

Dividing a landscape into of homogenous land use patches is inefficient in that it increases distances between service providers and users (Davis and Seskin, 1997). The degree of inefficiency is a function of total population. As the population of an area with segregated land use grows, so does the distance individuals must travel to different types of service providers. Although Euclidean zoning exists almost everywhere in the United States, a small town with a relatively small total population will not have such great distances between residences and various services as exist in large metropolitan areas. This land use pattern contributes to the concept of small towns providing a high quality of life to its residents.

As the population grows in the rocky mountain region the demand for effective planning practices also grows. As Euclidean zoning is virtually the only paradigm in use, its reaction to rapid population growth has resulted in vast landscapes of sprawl. The debate about the causes and effects of growth planning and land use conversion has only heightened rage as powerful development interests seek to protect capital interests and local governments struggle to react to rapid growth.

As in much of the region, growth is a growing public concern in Bozeman, but there is little consensus on the drivers and impacts of growth. In fact there is a large portion of the community that believes that the management of land use conversion is best left to the free market. This sentiment seems to be the dominant political view as evidenced by the relative lack of planning in the region. Moreover, the planning that does exist is completely based on the principles of Euclidean zoning. The absence of effective local planning can compound the negative effects of rapid growth (Forman, 1995). In reality, the true land use planners are the private land owners and free market forces that derive different values for specific land-use types (Davis and Seskin, 1997). Municipal planning boards are in this situation reactive organizations. Until the rapid growth of the last decade there were few obvious land use problems in the Bozeman area. Today the local municipal planning infrastructure has been overwhelmed.

New urbanist developments have been proposed in Bozeman (Figure 2). However, they currently require special permits due to existing zoning conflicts. This special status allows any opposition to easily prevent local authorities from granting the special permitting as happened with the Wirth Designs proposal (Miller, 1998).

Traditional Neighborhood Development

Bozeman, Montana

Wirth Design Associates was commissioned by Bozeman Deaconess Health Services (BDHS) to prepare a community land use plan for 485 acres adjacent to their hospital. The objective was "To improve community health and quality of life" by providing a diverse, new development.

By working closely with the BDHS Board, we developed a plan that fully integrated the development and its uses into the physical, economic and social-cultural fabric of the Bozeman community. The mixed-use development consists of three traditional neighborhoods linked by a framework of parks, trails and open spaces. They contain a variety of uses including a variety of residential, commercial, office and special uses. Public land dedication includes 45 acres for future schools, 163 acres of parks and 91 acres of street right-of-ways.

Principle features of the plan include a transportation fabric of streets and pathways that promote pedestrian safety through the use of traffic roundabouts, narrow streets, curb bulbs and other traffic calming devices. An additional feature includes convenient town centers that facilitate neighborhood identity allowing a sense of community to take root and thrive. The BDHS Traditional Neighborhood Development utilizes proven neighborhood planning principles that have resulted in strong sustainable communities throughout the country.



WIRTH DESIGN ASSOCIATES
LAND PLANNING & URBAN DESIGN

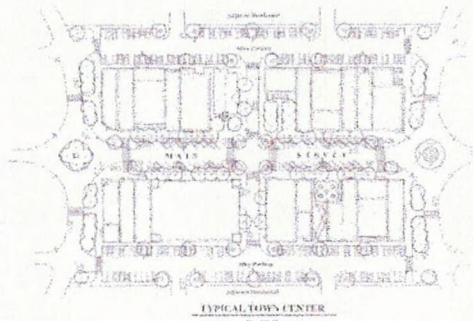


Figure 2: Proposal for a New urbanist style development in Bozeman MT.

The Development Patterns to be Compared

Robert Burchell, a leading researcher with the Center for Urban Policy at Rutgers University, defines ten elements of large scale sprawl as follows (Morris, 1999 and Downs, 1998).

- 1) Low density residential development.
- 2) Unlimited outward expansion of development.
- 3) Segregation of different types of zoning.
- 4) Leapfrog development.
- 5) No centralized ownership of land or planning.
- 6) Transportation dominated by privately owned motor vehicles.
- 7) Fragmented governance of land use between different local governments.
- 8) Varying fiscal capacity of local governments (revenue-raising capability strongly tied to property values and economic activity within municipal boarders).
- 9) Widespread commercial strip development along major roadways.
- 10) Reliance on the trickle-down process to provide housing for low income households.

It is clear that all of these elements exist and are dominating development patterns in the City of Bozeman and Gallatin Valley.

The other type of development pattern that will be analyzed is currently referred to as New Urbanist or New Urbanism. It features a combination of land use types and zoning designations including light commercial and mixed residential types, laid out in a grid with significant amounts of public open space (James Duncan and Assoc., 1999). New urbanist developments have a much higher density than is usually found in sprawl style developments. Although such developments and smart growth principles are becoming more popular in local communities, the legal, political and economic conditions that have contributed to sprawl also work against the application of smart growth principles that would allow new urbanist developments (Katz, 1993). In order for new urbanist developments to be built the opposite conditions of sprawl must exist (Burchell, 1997)(Table 2).

Table 2: General conditions of urban sprawl and smart growth.

	Conditions of Urban Sprawl	Conditions of Smart Growth
1	Weak non-centralized planning	Centralized planning authority
2	Unlimited outward expansion	Growth boundaries
3	Homogenous Zoning pattern	Mixed Zoning
4	Leapfrog Development	Infill development
5	Mostly Auto travel	Public and pedestrian travel

All conditions of smart growth as listed above need not exist in every development. A survey of recent new urbanist developments and smart growth policies reveals varying degrees of success with none possessing all the opposite

conditions of sprawl (Urban Land, 1999). The two hypothetical developments that will be compared in this study are a small scale residential sprawl and new urbanist development.

Local Landscape

Although many can describe the favorable attributes associated with a local community, few understand how land use patterns and total population contribute to these attributes. The current geographic situation in Bozeman and its high quality of life are largely due to its small total population, isolation from large metropolitan areas, and its relatively mixed and compact development patterns. This type of land use pattern makes small towns desirable places to live (Johnson and Rasker, 1995). These conditions exist due to Bozeman's exclusion from the major socio-economic shifts and resulting land use changes that were so prevalent in the rest of the country since WWII. Until about 1990, Bozeman did not experience large amount of sprawl development.

In small booming communities like Bozeman in the 1990s the building industry wields considerable economic, social, and political power as it generally represents one of the largest sectors of the local economy. The capital interests within this sector are naturally reluctant to change a currently profitable paradigm. With the dominant land use development model of sprawl the risk of development creating large physical distances between services and consumers also grows. Observation of

the landscape anywhere in the Gallatin Valley demonstrates that the growth of the last decade has produced large amounts of relatively unplanned, inefficient, low density and low quality development. This development starkly contrasts the land use pattern experienced by many Montana communities from the time of the original Anglo settlement until the mid 1980s. This compact land use pattern can still be seen in many rural Montana towns that have not experienced a recent population boom. A good example would be Three Forks, which is located on the western edge on the Gallatin Valley. The land use development pattern of town centers with mixed use surrounded first by residential land use and then a sea of agricultural or forested areas is more European than late 20th century American (Diamond and Noonan, 1996).

Unfortunately, the idea that clustered compact land use patterns and the lack of sprawl make small communities desirable places to live has not been realized by many within the local Bozeman community. Until the mid 1980s, the greater Bozeman area possessed elements of small compact mixed land use patterns. Unfortunately, as this region increasingly experiences unplanned sprawling growth, its desirable land use patterns and sense of place are being lost.

A recent study in the Bozeman area suggests that existing residential land use does not generate sufficient tax revenue to pay for the services it requires (Haggerty, 1996). The high cost of services and the impact of recent development has become a very contentious issue. Impact fees on area builders have been instituted by referendum but the measure is being challenged in court by the Southwest Montana Building Industry Association (Miller, 1999).

There is a strong correlation between the current health of the local economy and the role of the county's population growth (Johnson and Rasker, 1995). It is widely accepted that, if future growth is not managed in a manner that prevents the destruction of the traditional landscape, there could be future negative implications for the local economy (Johnson and Rasker, 1995). If Bozeman loses its traditional mixed use land use and compact development patterns, the wave of immigrants and resulting economic prosperity could be significantly diminished. Although some interests would surely relish in the decline of migration to the Gallatin Valley, the remaining residents could be left with a very expensive municipal landscape to service.

The typical model of large scale urban sprawl development throughout most of the United States relies on retail sales taxes to pay for the increasing cost of providing municipal services to low density inefficient development (Burchell, 1992). In Montana there is no sales tax to compensate for a growing deficit in public funds. As inefficient development continues to spread across the landscape, so does the demand on the tax base, and the threat of a major fiscal crisis grows.

The complex web of different human constructs and topics involved in land use conversion has been briefly introduced. Although it is beyond the scope of this project to consider all of these topics in detail, it is important to remember the scope and complexity of the issues involved in land use development. The many connections between different elements of society and the natural landscape make this a significant topic that is best examined from a geographic perspective.

Other Research

There is a significant amount of research in quantifying the costs of services and the costs of sprawl across the country by a variety of different interest groups which considered many potential areas of impact (Morris, Feb.1999). The majority of previous research has generated the similar conclusions and research difficulties (Morris, Feb. 1999). Urban sprawl is a costly and inefficient development pattern that is occurring at an alarming rate across the country (Burchel, 1994). Smart growth, new urbanism, clustered, and mixed use zoning land use provide a better quality of life while generating the necessary tax revenue to sustain the development (SEMCOG, 1997). The studies reviewed by Morris describe difficulty of quantifying costs associated with growth and land development in a consistently accurate manner. However, the majority of these studies have reached the same conclusions by so wide a margin that they exceed any realistic margin of error in quantifying costs (Morris, Mar. 1999).

The Plan

Given the current trends in Bozeman and what has occurred elsewhere in the country, it is important to quantify the specific costs associated with growth patterns and the amount of tax revenue they generate. Although this type of study has been completed in other locations it is vital to conduct a local area study to add relevance to

the results. Equally important is the comparison of current development patterns with alternative development patterns that may have more overall benefits. It is hoped that this project will provide local stakeholders with valuable information and a method of inquiry which can be used in directing future land use policy.

This thesis is designed to reduce quantification uncertainties of previous large scale impact analysis by reducing its scale and incorporating the actual costs of specific features within a GIS. The results will provide actual numbers as opposed to statistical interpretations. The calculations will reveal differences in the cost of services, tax revenue generated, spatial properties and the amount of future land use conversion associated with two distinct land use development patterns. The general development patterns analyzed exist in the real world and provide the context for understanding the fiscal differences. A third "real world" development that exists on the ground will be included as a reference for the model and the results it generates.

CHAPTER 2

THE MODEL

Urban sprawl is recognized as being a less than economically optimal land use (Diamond and Noonan, 1996), but what does this mean? What are the financial benefits of possible alternatives? Most land use models are framed in an urban economic or industrial context (Frank, 1989). These types of land use conversion models rely on statistical analysis of many variables (Frank, 1989). These models take years to construct and their hard to quantify methodologies are complex, making interpretation by the public difficult. This model will accurately define the economic characteristics of two different types of small scale developments and an actual subdivision.

This thesis focuses on quantifying the financial costs of supplying municipal services and the amount of tax revenue generated by a sprawl development and a new urbanist development in the City of Bozeman. Valley Unit, a 229 acre subdivision on the western edge of Bozeman will be used as a reference for the two hypothetical subdivisions. An actual 385 acre piece of ground currently slated for development will be used as the footprint for the two hypothetical developments, this area is shaded in yellow directly west of Valley Unit which is shaded in blue on the study area map (Figure 3).

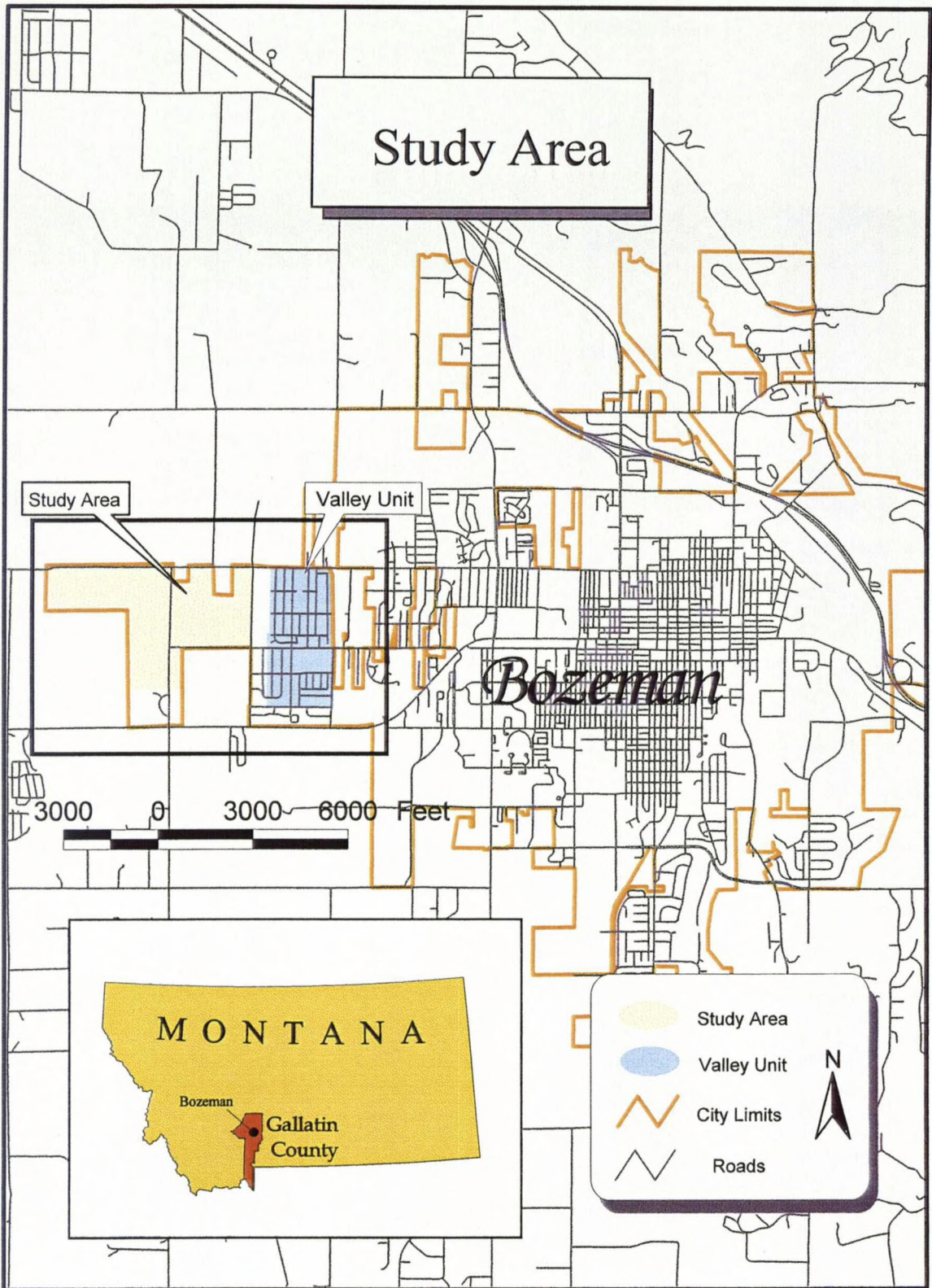


Figure 3: Study area and Valley Unit subdivision.

The GIS model has two main components. The first is ArcView®, in its standard configuration. The second component is an extension for ArcView®, SmartPlaces®. SmartPlaces® is a GIS based decision support system that employs a unique graphical interface enabling simple integration, calculation and modification of attribute data within GIS coverages. SmartPlaces® was designed to make quantification and analysis of large geographic data sets easily understood by non-geographers (Electric Power Research Institute, 1998).

The interpretation of the modeling process by non-GIS users is achieved by displaying its functions and results in a graphical manner. SmartPlaces® will be used to determine the cost of services, the amount of tax revenue generated and the spatial properties of the two hypothetical developments and Valley Unit subdivision, Valley Unit. Although ArcView® is capable of these functions it does not have a graphical interface that links several functions into one command, and the ability to perform simultaneous calculations on several different themes without adding a custom application in ArcView's® programming language Avenue®. SmartPlaces® will be employed as a spatial spreadsheet for determining the fiscal characteristics of the three developments.

SmartPlaces® has two main components: a scenario and a radix (Figure 4). The scenario contains the themes to be evaluated by the radix. The radix can calculate any tabular or spatial data within the Scenario. The scenario is fully compatible with all the functions of ArcView®.

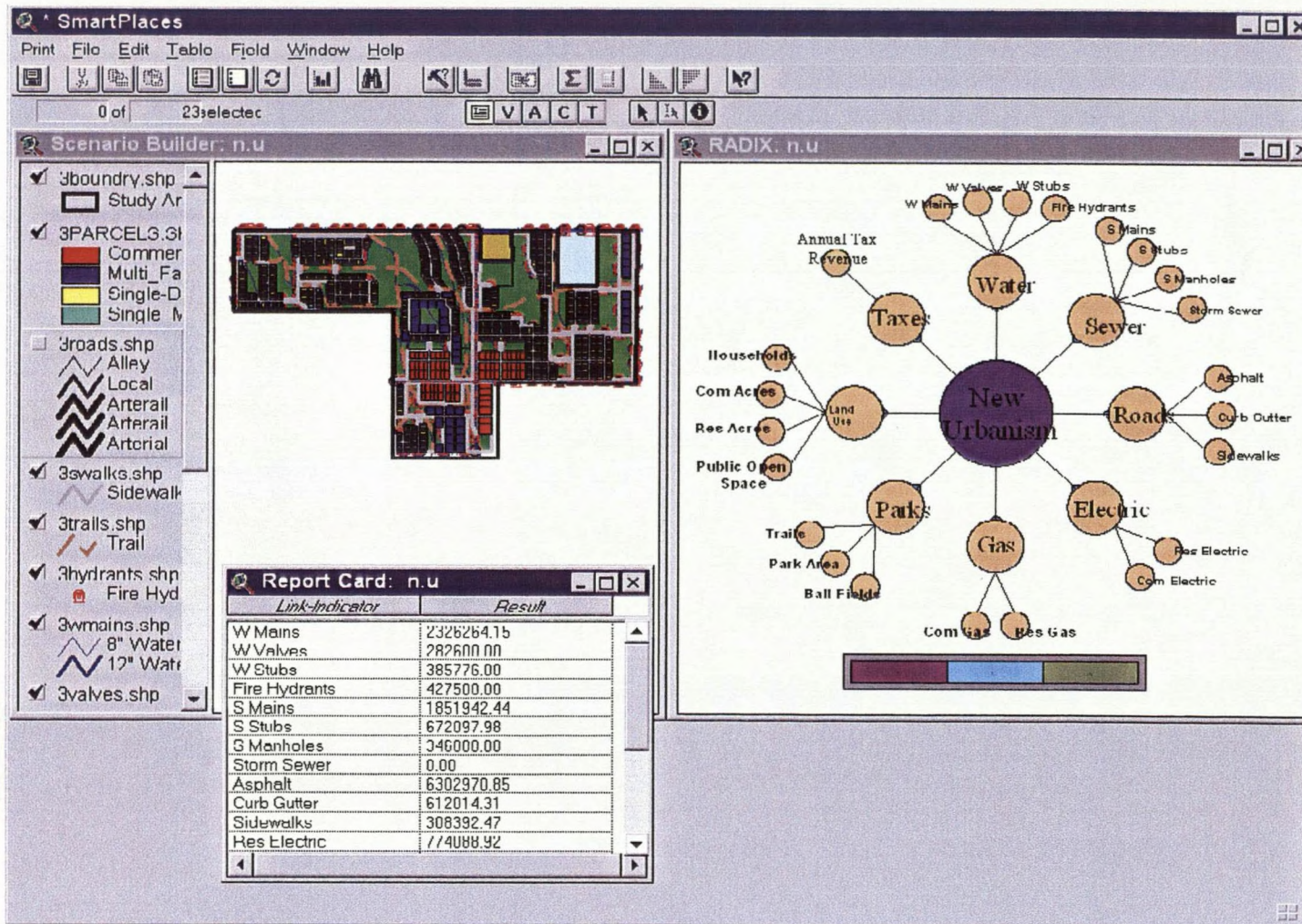


Figure 4: SmartPlaces interface with radix, scenario builder and report card in ArcView.

All of the ArcView® themes representing the Valley Unit subdivision, sprawl and new urbanist developments were loaded into an individual SmartPlaces® scenario.

The radix has many possible functions and can be best described as a graphical interface with a GIS's functionality. It allows individual, or groups of calculations to be made on the values in ArcView's attribute tables. The calculations are user defined and can be conducted on any field included in the attribute table. The radix is the interface to the functions responsible for processing user defined calculations. In this thesis, SmartPlaces® provides a graphical organization for cost, tax and spatial calculations.

The radix has three concentric rings of circles representing the core, features and indicators respectively (Figure 5). The core represents the scenario to which the radix is linked. For example, the core of the radix for the new urbanist development is labeled new urbanist and is linked to the new urbanist scenario. The next outward set of circles attached to the core represent the feature classes that will be measured. One example of a feature class is "water." The next set of outward circles represent the feature indicators that represent the specific elements of the feature class. An example of a water feature indicator is "water mains." Each indicator can be programmed to perform any one of several statistical analyses on values contained in one or several fields in a scenario themes attribute table.

After the radix has been programmed it serves two purposes. 1) The radix performs the programmed analysis and generates the output in the form of an on-screen table called a report card. 2) It allows the selection of individual, a

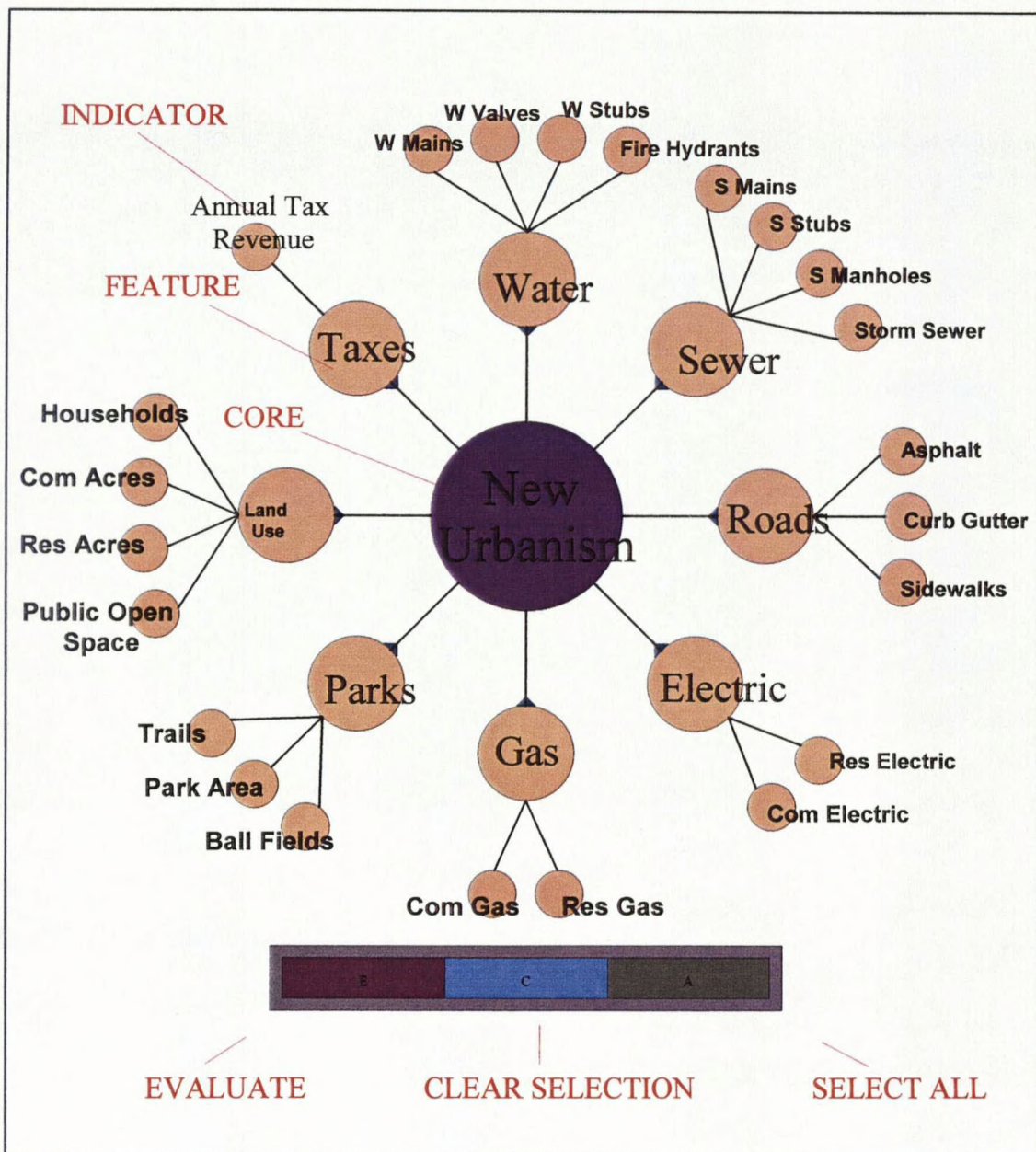


Figure 5: Example of a Smart Places Radix.

group, or all indicators to be evaluated. The radix can also be programmed to produce charts of all analysis.

In this study, SmartPlaces® is employed to sum the cost, tax and area fields for individual themes contained within each respective scenario. For example, the attribute table of the water main theme in all three scenarios contains a length field for each section of water main pipes. This table also contains a cost per length field and a cost field (Figure 6). SmartPlaces® will determine the total cost of water mains in each scenario by summing the cost field using an indicator within the given radix. This indicator is linked to the water main theme in the respective scenario.

A radix and a scenario are constructed for the two hypothetical developments and the Valley Unit subdivision. The output or report cards will be combined to create one table. This table will display the results of the spatial and fiscal comparison.

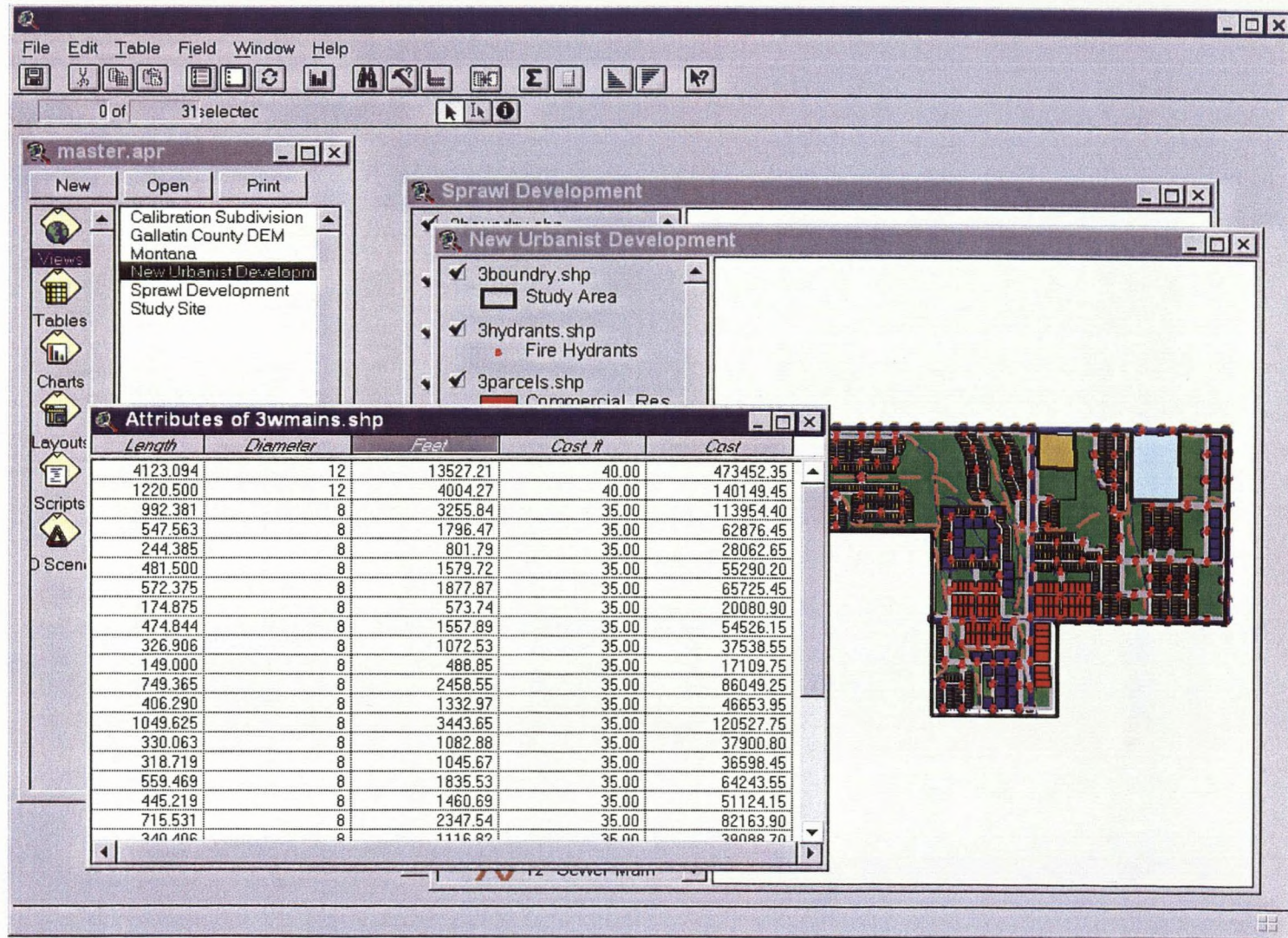


Figure 6: Example of attribute table with cost data.

CHAPTER 3

DATA

This project required a large variety of data to accurately quantify the various features associated with the different development patterns and the amount of tax revenue they generate. The Valley Unit subdivision and the two hypothetical developments represent the three basic sets of data that were required for the GIS to model spatial, cost and tax revenue differences.

Development Patterns

Two of the three developments to be compared are hypothetical in the sense that they do not actually exist on the landscape. The Valley Unit subdivision does exist on the west edge of Bozeman (Figure 7). The area immediately to the west of the Valley Unit subdivision development was used as the footprint for the hypothetical sprawl and new urbanist developments (Figures 8 and 9). The footprint is a recent annexation to the city and is currently under plans for development. The location of the study area was chosen because of its proximity to and inclusion in the City of Bozeman and the availability of AutoCAD Drawings for existing services in Valley Unit Subdivision. A GIS roads coverage for the Valley Unit subdivision and surrounding area also existed. The physical layout for the two hypothetical subdivisions, or scenarios was created to represent contrast between a single zoned

low density residential sprawl development and a higher density multi zoned, new urbanist development. The layouts were created in collaboration with the City of Bozeman Planning Department. Although these layouts do not actually exist, there are similar developments in the Bozeman area. Downtown Bozeman provides an example of what a new urbanist development would look like. Valley Center northwest of Bozeman provides an example of what the sprawl development would look like.

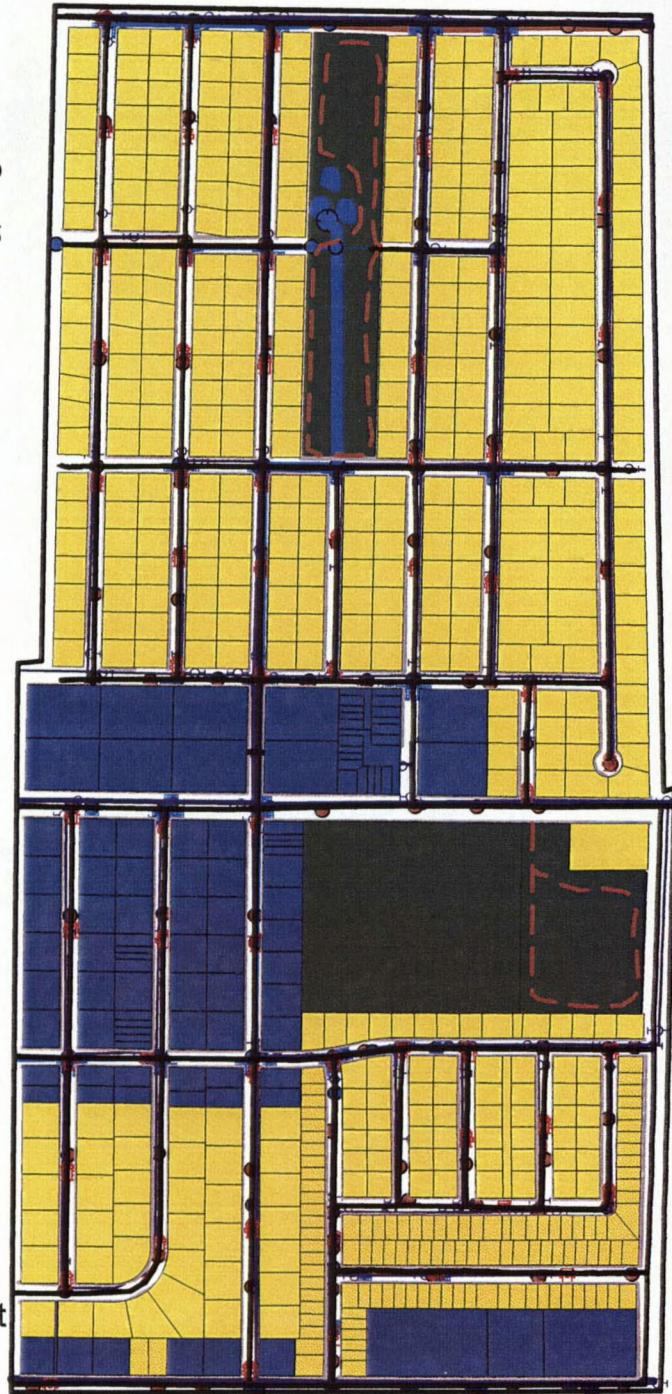
Three main types of data were required for each of the three developments, 1) spatial, 2) cost of services and 3) tax data.

The first data type collected was the spatial data of the features to be measured. These data were entered into the GIS. The second data type is the monetary cost values for each feature measured by the model. These data were attached to its respective GIS data in ArcView®. The third type was the amount of annual tax revenue generated by each specific type of land use in the two hypothetical developments and the Valley Unit subdivision. The tax data was generated by the Gallatin County Assessor's office.

General Layout and Land Use Types in the Valley Unit Subdivision

Land Use	Acres
Total Area Foot Print	229
Single Family Detached	95
Single Family Attached	9
Multi-Family	34
Commercial-Residential	0
Public Open Space	24
Roads and Sidewalks	65

Legend



Note: Scale is different compared to sprawl and new urbanist development

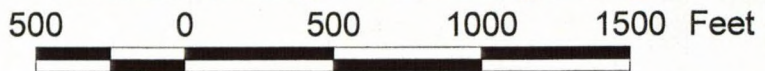


Figure 7. General layout and land use types in Valley Unit subdivision

General Layout and Land Use Types in the Sprawl Development

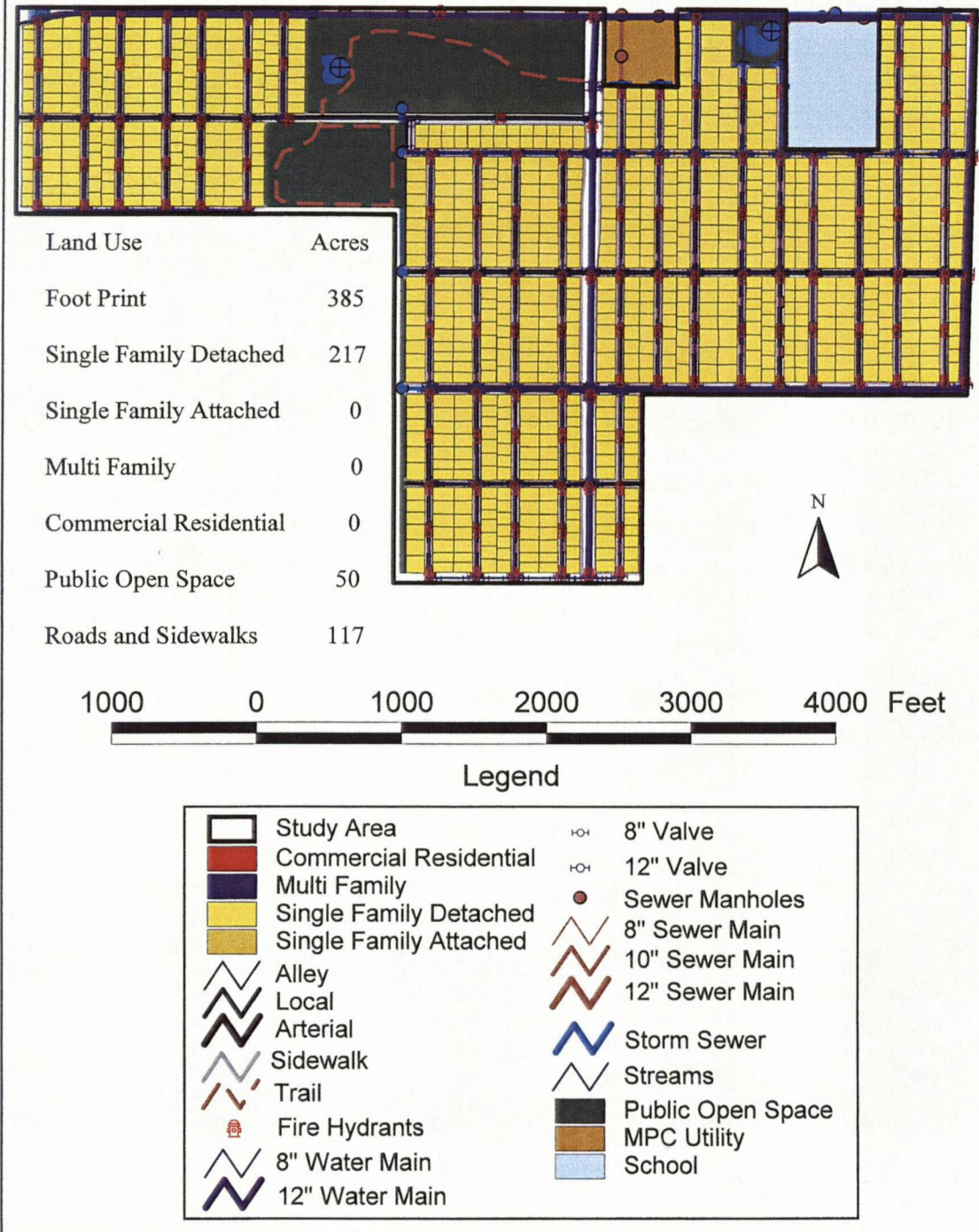
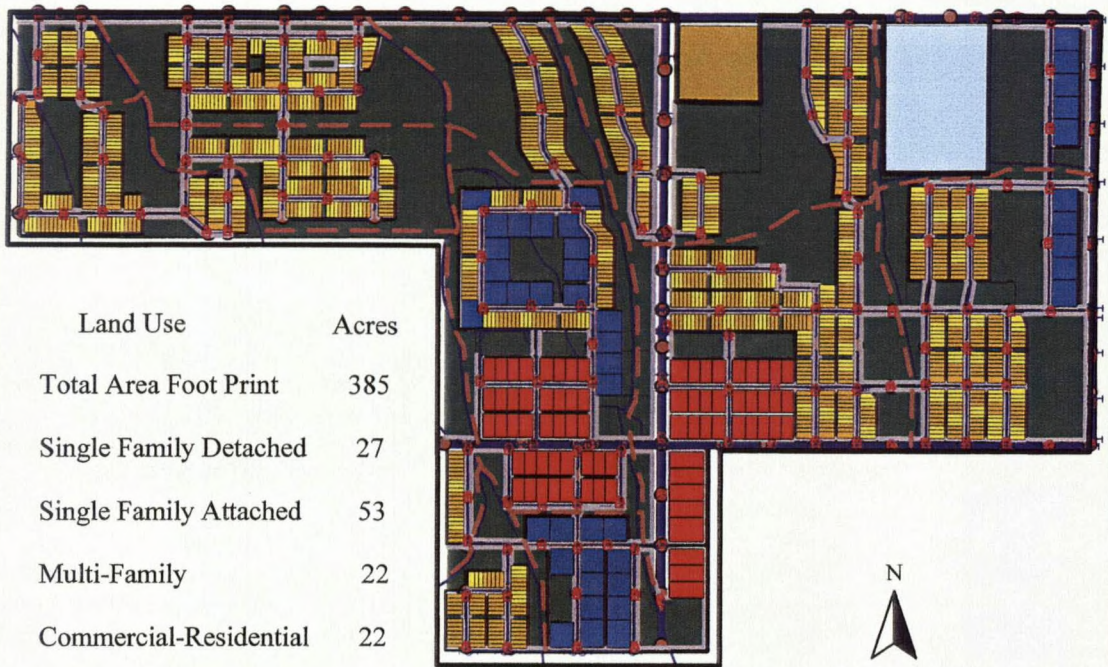
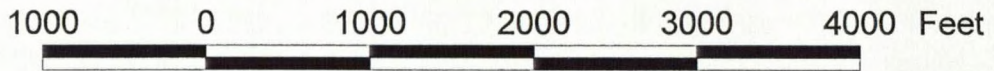


Figure 8. General layout and land use types in the sprawl development.

General Layout and Land Use Types in the New Urbanist Development



Land Use	Acres
Total Area Foot Print	385
Single Family Detached	27
Single Family Attached	53
Multi-Family	22
Commercial-Residential	22
Public Open Space	153
Roads and Sidewalks	106



Legend

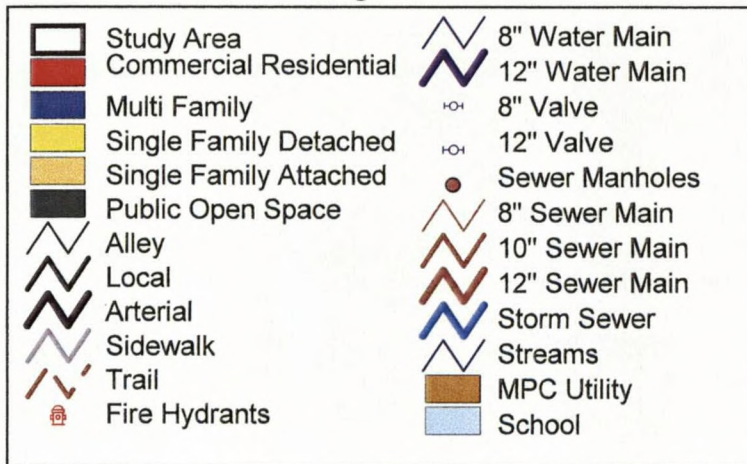


Figure 9. General layout and land use types in the new urbanist development.

Spatial Data

The first step in creating data coverages in the GIS representing the three different developments to be compared by the GIS model is to create or convert the spatial data layers into a digital form that can be imported into the GIS and given a common projection.

County roads were the only existing GIS layer for the study area. The road layer was acquired from the Gallatin County GIS Department and was in the UTM, Zone 12, NAD83 projection. All other layers were converted to this format and projection; the road layer was used as the base layer for the entire project. The roads data were collected in the 1996 Global Positioning System (GPS) road survey conducted by the Geographic Information and Analysis Center at Montana State University and represents an accurate base/reference data set.

For the Valley Unit subdivision digital layers in AutoCAD .DWG format for water, sewer and storm sewer were available from the City of Bozeman Engineering Department. These files were originally created by the engineering and construction firms which designed or installed water, sewer or roads and other services in the City of Bozeman (Table 3).

Table 3: Spatial data creation sources for Valley Unit subdivision.

Valley Unit	GIS/Shapefile	AutoCAD	Digitized	Created
Boundary				X
Fire Hydrants			X	
Parcels		X		
Public open spaces				X
Roads	X			
Sewer Mains		X		
Sewer Manholes		X		
Sidewalks				X
Storm Sewer Detention Ponds				X
Storm Sewer Inlets		X		
Storm Sewer Laterals		X		
Storm Sewer Mains		X		
Storm Sewer Manholes		X		
Storm Sewer Outlets		X		
Trails				X
Water Mains		X		
Water Valves		X		

A plat of parcels for the Valley Unit subdivision was also available in AutoCAD format from the City of Bozeman Engineering Department. Other spatial data were in the form of blue prints and this data was digitized in ArcView. Spatial layers that did not exist in any form were created as graphics using existing data as a reference in ArcView. These graphic layers were then converted into a GIS coverage.

The process of converting AutoCAD data into a GIS format proved to be problematic. All layers of data in a GIS must have a spatial reference to an actual point on the earth's surface. Although the drawings in AutoCAD were to scale, they had no geo-reference. AutoCAD files with no geo-reference are referred to as being in "paper space". Several steps were required to convert .DWG AutoCAD files within paper space into geo-referenced GIS coverages. First AutoCAD was employed to convert the files from .DWG to .DXF for import into ArcView®. Then after being

converted into a shapefile in ArcView®, the layers were converted into an ArcInfo® coverage. However, the coverages would not project in ArcInfo® even after a projection had been defined. ArcInfo® had no basis for defining a projection for a paper space layer created in AutoCAD due to the lack of a geo-reference.

A workaround was created to give the original .DXF files a geo-reference prior to initial conversion to shapefile. The original .DXF file was displayed in ArcView® and a world file was created. A world file is a spatial reference from a point in a GIS layer that is attached to the corresponding point in the AutoCAD layer. In this case a point on the road layer was used to match a corresponding point on a given AutoCAD layer. This allowed the AutoCAD layer to be displayed in its general position over the road coverage. Then with the world file on, the theme was converted to a shapefile. This gave the AutoCAD layer, now a shapefile, an actual geo-reference within the GIS environment. The shapefile was then converted into an ArcInfo® coverage. The UTM projection was defined as the projection and the layer were displayed over the road coverage. The AutoCAD coverages, now an ArcInfo® coverage still did not properly align with the base road coverage. This was due to drawing errors in the AutoCAD layers. ArcEdit in ArcInfo®, and edits tools in ArcView®, were used to move features to their appropriate locations using the road coverage as the base layer.

It is important to note that absolute positional accuracy is not a crucial factor in data development for this study. The model will measure lengths and areas of features, but does not depend on an absolute geographic position on the earth's surface to accurately measure the spatial attributes of individual features. Allowing positional

accuracy to be within 10 meters made the hand editing an acceptable element in the creation of data layers and significantly reduced the time and cost of data compilation. Therefore the accuracy of spatial measurements will be plus or minus 10 meters. The parcel layer for each of the developments and the Valley Unit subdivision were overlaid on digital ortho photographs. The distance between the edge of an individual feature and a known ground feature, such as a road, was measured Using ArcView®. The distance was generally found to be off by less than five meters.

All of the existing digital layers for the Valley Unit subdivision were incomplete to some degree and required updating. This was done with onscreen digitizing. As-built blue prints from the City Engineering Department were compared to the older original AutoCAD data sources, after they were imported to the GIS. Again using the edit capabilities of ArcView®, features in each layer were added, deleted or adjusted as necessary. After these edits were completed, these coverages were transferred back to ArcInfo® to have their topology and feature attributes reconstructed. This was done using standard commands in ArcInfo®. Each coverage was then imported back to ArcView® and converted to a shapefile. The attribute tables in the shapefiles now contained the necessary spatial attributes for each individual feature to allow for cost calculations based on spatial measurements.

All of the layers for the low density and high density development layout were created from design graphics. This was achieved by converting ArcView® graphics to a shapefile and then building their topology in ArcInfo®. All of the layers for each of the hypothetical subdivisions were created in this manner in ArcView® . Then the

layers were converted into GIS coverages using ArcInfo®. The process of using ArcInfo® to build topology and feature attributes was employed. After the physical edits to the GIS coverages were complete, cost data was added to the attribute table of each shapefile and the shapefiles were moved into the appropriate scenario in SmartPlaces® (Figure 10).

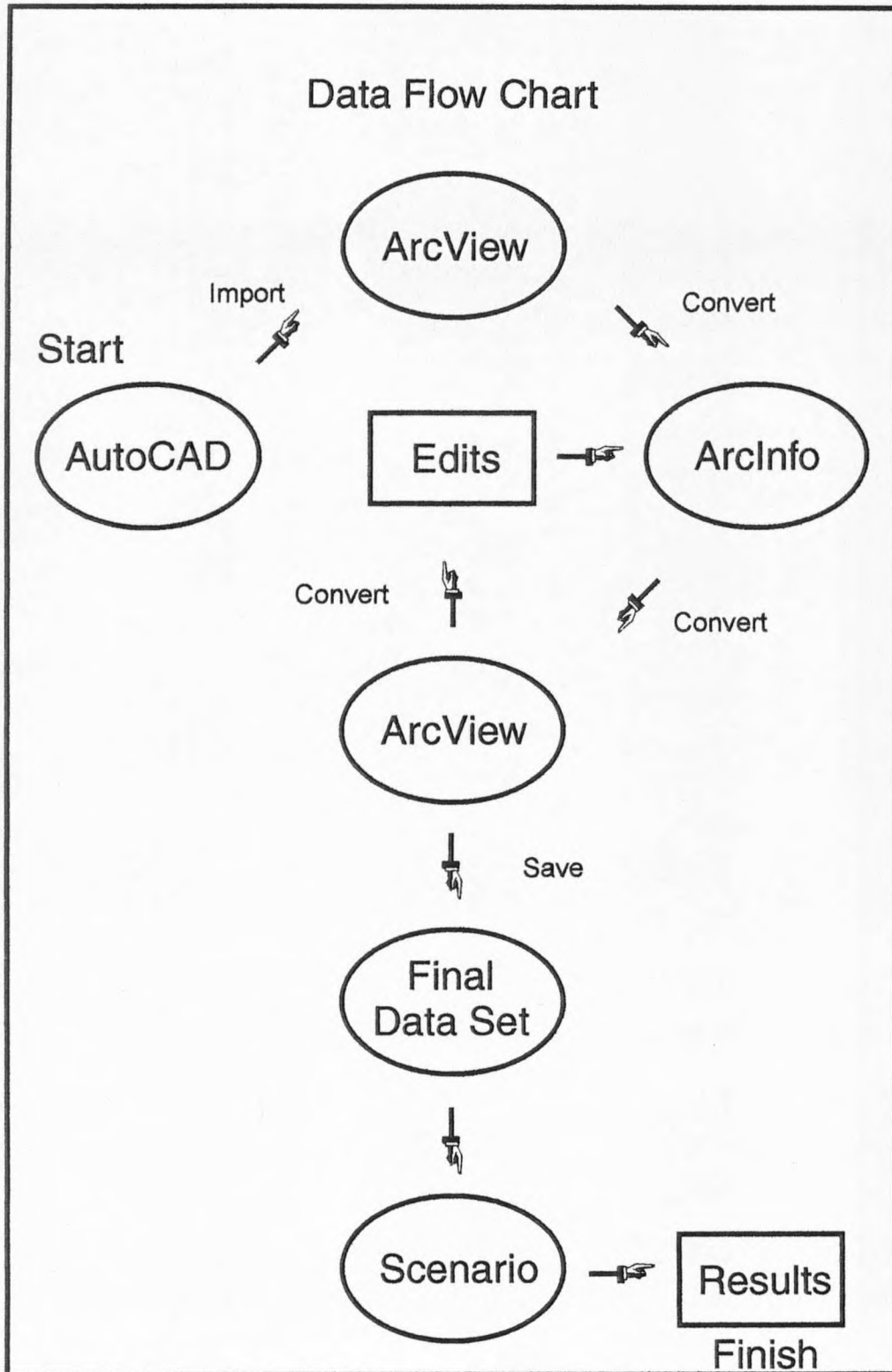


Figure 10: Data flow chart.

Cost of Services

The second main type of data needed for the model was the actual costs of the individual services to be compared. The municipal services for each of the developments include: water, sewer, roads, gas, electric and public open spaces. All of the costs include installation except for public open spaces. The cost associated with public open spaces are quantified as annual maintenance costs. For specific costs of individual features refer to Appendix 1.

Water service includes: water mains of different size, water main valves of corresponding size, water service stubs for each land use type of corresponding size and fire hydrants. The cost for each of the different services was divided into two basic categories, installation and annual maintenance costs (Appendix 1). All of these costs are typically paid by the City of Bozeman taxpayers. In some cases the city negotiates with developers during the permitting process for individual projects to pay some of the costs of constructing infrastructure. However, the costs of maintaining such on site and off site infrastructure as sewer mains and sewer treatment plant is the responsibility of the municipality. It is not crucial to the objectives of this study to define specific responsibility for every dollar of cost. It is assumed that a reduction of cost is beneficial to all interests.

Adding the actual cost value to GIS layers in each development was largely completed by hand data entry in ArcView® . The cost data for all features that were

to be compared between the two hypothetical subdivision designs and the features in the Valley Unit subdivision was provided by the City of Bozeman Engineering Department in 1998 dollars (Murray, 1999). In some cases the data were entered and organized in an Excel® spreadsheet and then imported into ArcView® as a .dbf file. This file was then joined to the appropriate feature attribute table in ArcView® .

The exceptions to the quantification of cost categories are gas and electric services for the developments. In Bozeman the developer pays the utility company a portion of the overall costs of constructing and installing gas and electric power to new developments. Most of the payment is refunded to the developer once the service is utilized by a consumer. The cost estimation for providing electric and gas services to new developments is done on a case by case basis by The Montana Power Company. The costs are dependent on many variables, such as location within the local power grid and the spatial properties of the individual development. Therefore, it was not possible to establish a generic set of costs that could be represented in the model as a GIS layer for a specific cost associated with an individual feature.

Chuck Busta of The Montana Power Company quantified the costs for providing gas and electric service to the sprawl and new urbanist development. He was given a map of the two developments and asked to determine the cost per unit for gas and electric services. The cost quantification for individual units is dependent on the parcel's land use type. It was not possible to quantify utility costs for the Valley Unit subdivision. The cost value for gas and electric service for single family detached land use in the sprawl development was used for the same land use in the

Valley Unit subdivision. The gas and electric cost for multi family land use in the new urbanist development was used for multi family land use in the Valley Unit subdivision. Appendix 2 contains the cost breakdown quantification as provided by Chuck Busta.

Tax Revenue and Land Use Types

The third main type of data required for analysis were average annual property taxes for each of the tax generating land use types in the hypothetical subdivisions. There are five generalized land use types within the two subdivisions. The land use types are: 1) single family attached, 2) single family detached, 3) multi family 4) commercial residential 5) public open space. Public open space does not generate tax revenue. The sprawl subdivision contains only single family and public open space land types. The new urbanist development contains all five. Single family detached is defined as single home on one individual lot with one household in a residence. A household is 2.5 people. The single family attached land use type represents single family attached units which can include, condominiums, town houses or row houses. Each parcel within the new urbanist development contains one household. The multi family land use type represents duplexes to multi unit apartment buildings. In the new urbanist subdivision land use of this type represents a six unit apartment building containing 6 households. Commercial residential represents a wide variety of actual uses including grocery or other retail establishments, professional office space, or a

combination of commercial and residential land use. Commercial land use are non-polluting activities with little negative impact to surrounding residences. In the new urbanist development commercial residential parcels contain one household.

An extensive analysis of all the tax records for the greater Bozeman area would have produced the most accurate quantification of the average annual property tax for each of the land use types in the model. However, this method was beyond the means of this project due to time restraints.

The average annual property tax for each of the land use types was determined by the Gallatin County Assessors office. The staff were informed of the aims of the study and given a map of the two development patterns, a definition of the land use types, and a set of photographs of different commercial and residential land use types in Bozeman. The location of the properties are shown in a map of the Bozeman area (Figure 11). The properties selected for the photographs are representative of the average financial values for each type of land use. Properties that appeared to be of extremely high or low value for inclusion in the photographs were excluded. The main purpose of the photographs was to set the land use context for quantifying the average annual property tax for each land use in the two hypothetical subdivisions (Figure 12).

The assessor was asked to define the average annual property tax for the four land use types used in the model. The assessor indicated that the properties in the photographs were indeed of average value for their respective type of land use. After the actual annual tax bill for 1999 for the properties depicted in the photos was

established, the assessor assigned a conservative average annual tax for each of the four revenue generating land use types in the two subdivisions (Table 4).

Table 4: Tax revenue generated by land use types.

Land Use Type	Annual Property Tax
Single Family Detached	\$1700
Single Family Attached	\$2000
Multi-Family	\$5000
Commercial Residential	\$7000

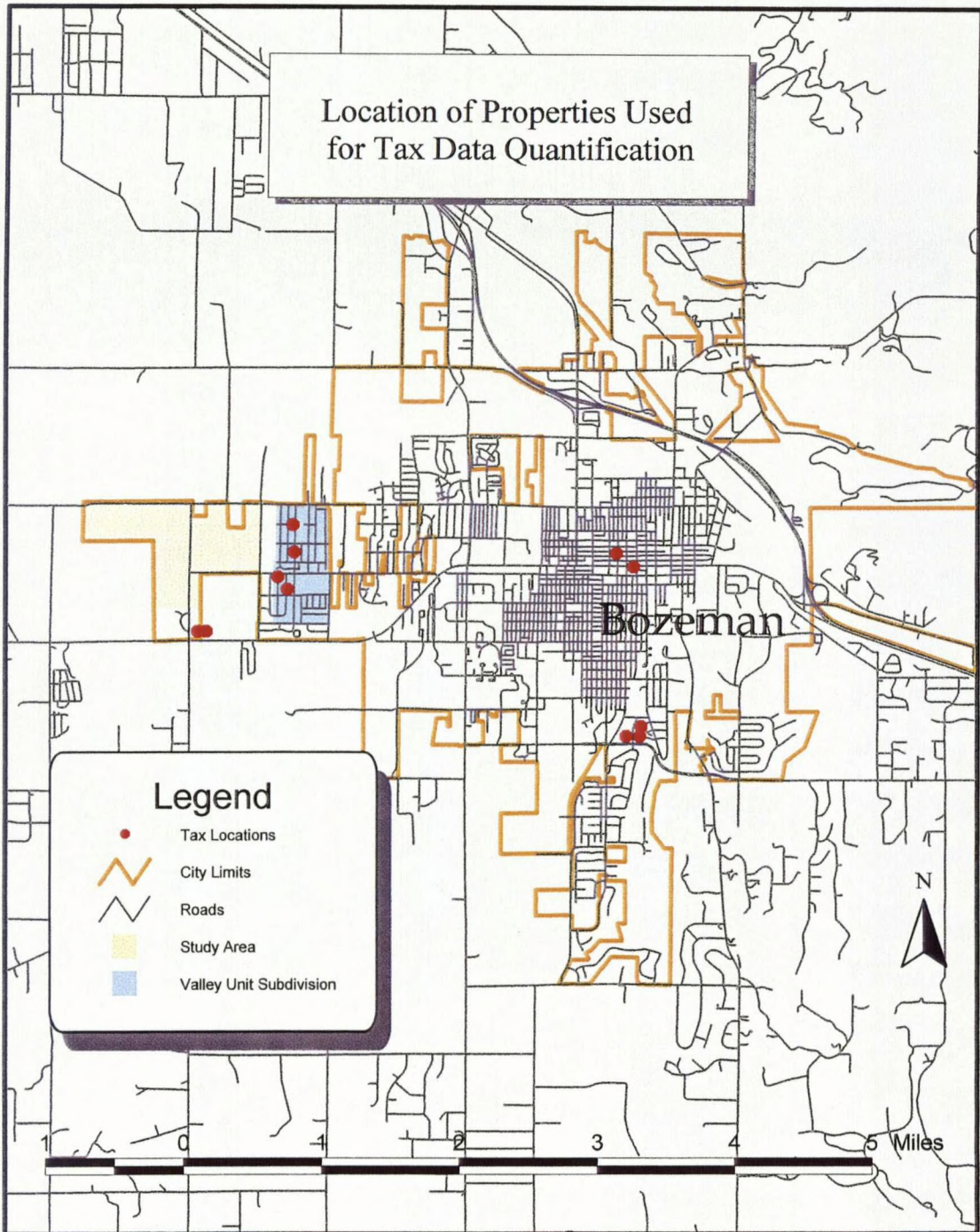


Figure 11: Location of properties used for tax data quantification.



211 N Grand

Multi Unit Office Building

\$2,300



302 Hoffman Dr

Condominium

\$1000



Kagy Korner

Retail Corner Store

\$3,220

Figure 12: Amount of 1999 annual property taxes.



211 N. Grand

Multi Unit Office Building

\$2,200



3601 Toole

Single Family Detached

\$2,300



Casey's Corner

Retail Corner Store

\$12,222

Figure 12 continued: Amount of 1999 annual property taxes.



Lovelace Building

Commercial Residential

\$7,175



111 Granite Dr.

Six-plex

\$5,000

Figure 12 continued: Amount of 1999 annual property taxes.



Valley Commons

Multi Unit Office Building

\$15,800



Hoffman Dr. Condominiums

Condominium

\$2,700



703 Pondera

Four Plex

\$3,000

Figure 12 continued: Amount of 1999 annual property taxes.

CHAPTER 4

METHODS

GIS is increasingly accepted as a valuable research tool and is gaining widespread acceptance in academic fields that have not traditionally employed GIS (Pickles, 1995). Using a GIS in this project facilitates the quantification of cost and revenue from large amounts of data and the visualization of municipal services and land use patterns which are impractical by other methods. The use of a visual interface to reference data and analyze spatial features allows the process to be accessible to a wider audience (MacEachren and Taylor, 1994). This thesis uses SmartPlaces® as described in chapter 3, and ArcView® GIS to model the fiscal properties of the sprawl and new urbanist development patterns. SmartPlaces® is used as a spatial spreadsheet to provide an extremely accurate accounting of the cost of services, tax revenue and the difference in land use patterns between the two development styles.

The less quantifiable elements of development analyses such as quality of life and environmental impacts are not considered in the model. Including these elements is beyond the scale and resources of this study. The direct comparison of well quantified costs between the two development patterns with a real world reference offers a valuable method of illustrating specific costs and benefits (Birken, 1996). The social and political interest groups in the Bozeman area that are driving most of land

use conversion are mostly concerned with the monetary issues of development. By eliminating the less quantifiable aspects the study gains a degree of credibility to the lay persons and provides a clear picture of what is being compared.

Schools have also been excluded from this study. The first rational for this exclusion is the difficulty in quantifying their cost and allocation of fiscal responsibility. In addition, although property taxes in Gallatin County have increased in the last decade and the state legislature has limited the amount annual property taxes can be increased each year, the local community continues to vote for mill levy's to increase funding for schools. This continued support of mill increase reduces the need to include school costs in this local area model.

The actual design of the sprawl and new urbanist development patterns are a representation of the most elemental characteristics of each development type. The hypothetical sprawl and new urbanist developments were created by drawing graphics in ArcView® . The actual characteristics of each development were determined by the City of Bozeman Planning Department to reflect typical examples of each type of development.

After the designs were converted into a GIS coverage using the methods described in Chapter 3 their spatial properties could then be accurately measured. The sprawl development is exclusively composed of single family detached houses with an average lot size of 0.24 acres. Residential land use occupies 217 acres out of a total of 385 acres. The dwelling units per acre (DUA) as measured in the GIS is 2.3 DUA.

The sprawl development has 51 acres of public open space. This type of development has been built in several locations in the Gallatin Valley in the last ten years.

The new urbanist development contains mixed zoning types and 3.8 dwelling units per acre. The single family attached and single family detached foot print is 103.2 acres out of a total of 385 acres. The multi family foot print is 22 acres and the commercial residential footprint is 22 acres. It has 153 acres of public open space. Storm sewer drainage is achieved by utilizing the landscape's natural drainage complimented by man made surface channels and absorption fields. This would cost the builder approximately half of the cost of traditional underground pipes (Murray, 1999).

Each of the municipal services compared by the model have specific elements. For example, the water distribution system has four different components, 1) water mains, 2) valves, 3) service stubs to individual lots and 4) fire hydrants. The water mains have two sizes, 8 inch and 12 inch with corresponding sized valves. The service stubs come in either $\frac{3}{4}$ inch and 2 inch pipe depending on the type of building being serviced commercial or residential. The fire hydrants are all the same size and type. Refer to Appendix 1 for all individual feature costs.

Once the cost per foot, cost per area, cost per unit installation or annual cost was added to the attribute tables of themes in each of the three developments, further calculations were preformed by ArcView® . For example the cost of a road of any width in all three subdivisions is \$64.00 per linear foot. After the feature attributes were calculated in ArcInfo®, a length field was added to the attribute table. The UTM

projection length units is in meters. A new field was added to the roads attribute table called feet. The data in this field resulted from multiplying the length field by English conversion factor 3.28084. Next, a cost field was added and the data in this field was generated by multiplying the cost per foot field by the feet field. This cost field was summed by SmartPlaces® to determine a total cost for roads. This process was used for each theme in both hypothetical developments and the Valley Unit subdivision.

In most cases, the cost data for a service was included in the respective attribute table of the ArcView® theme depicting the service. For example a twelve inch water main cost \$35.00 per foot to install. This cost was multiplied by each feature's length to determine cost.

The other method employed, when direct measurement was not possible due to the use of a non-spatial variable, was to attach the cost to the parcel layer. For example, the size of a water service stub depends on whether it is servicing a single family residence or a commercial property. A water service stub field was added to the parcel layer attribute table. The water stubs in each of the developments were of a fixed length. The value in this field was dependent on the type of land use cost field. The cost for individual sewer service stubs were also calculated in this fashion. This procedure was also used to attach the cost for gas and electric service to the parcel layer. The specific cost value was determined by the specific land use type classification.

After all the cost data was added and the necessary calculations by ArcView® were complete, all the themes were loaded into SmartPlaces® scenarios. This was a

relatively simple task involving copying the themes from the Valley Unit subdivision, the sprawl and the new urbanism developments view in ArcView® in the master project file into respective SmartPlaces® scenarios. The next step was to create the SmartPlaces® radix for each of the scenarios as described in chapter two.

SmartPlaces® was ready, after a radix and scenario was created for each development pattern. By selecting all indicators in a radix, SmartPlaces® performed all the calculations and produced an output table referred to as a report card (Figure 13). This was performed separately for the sprawl and new urbanist development. The report card was then exported to Excel and combined into one spreadsheet for the results. The total cost for all services in each development was calculated along with the average cost of services per household. The annual tax revenue per household was also calculated. The spatial properties were also entered into the spreadsheet for comparison.

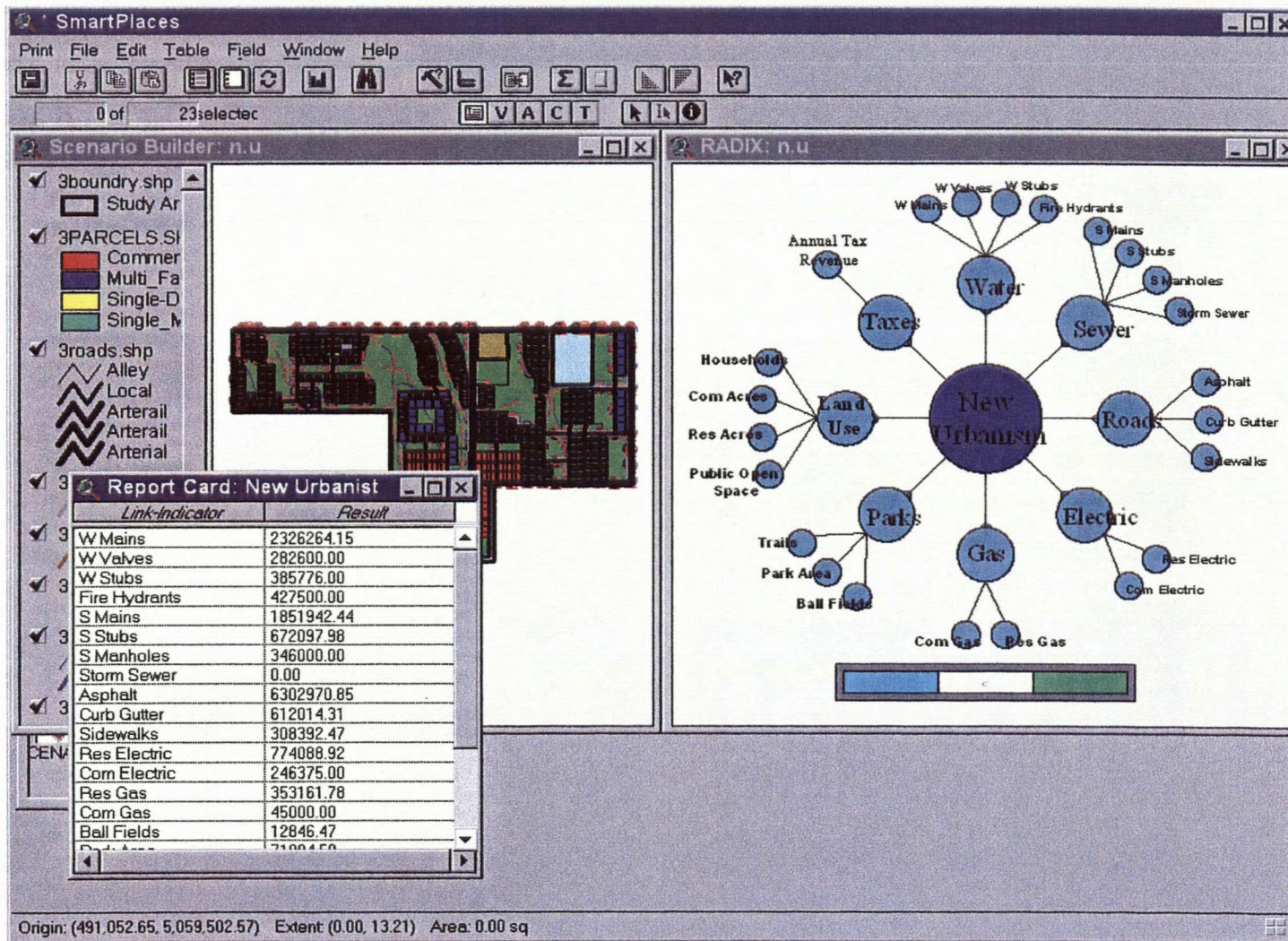


Figure 13: SmartPlaces report card for radix evaluation of the new urbanist development.

CHAPTER 5

RESULTS

The model produced three sets of results for the Valley Unit subdivision, the sprawl development and the new urbanism development. The results for each development will be shown with the three subsets of data representing the three main data types: cost of services, tax revenue and spatial properties. The results are presented in detail for all three development patterns in the table on the following page (Table 5).

Valley Unit Subdivision

The total cost of services for the Valley Unit subdivision is \$8,581,056. The cost of services per household is \$9,818. The total annual tax revenue generated by the Valley Unit subdivision is \$1,122,800. The amount of annual tax revenue generated per household is \$1,285.

The Valley Unit subdivision has a total foot print of 229 acres, 95 acres are occupied by single family detached land use, 10 acres are occupied by single family attached and 35 acres are occupied by multi-family land use. The total public open space area is 24 acres. The remaining 66 acres within Valley Unit subdivision are occupied by roadways and sidewalks. There is no commercial land use in the Valley

Table 5: Results

Cost of Services dollars	in	Valley Unit	Sprawl	New Urbanism	% diff.	Difference
Total Cost of Services		8,581,057	13,609,968	15,499,501	12%	1,889,533
Cost per Household		9,818	15,258	10,666	-43%	-4,592
Water Mains		1,314,103	2,774,437	2,326,264	-19%	-448,173
Water Valves		78,200	248,400	282,600	12%	34,200
Water Service Stubs		323,380	330,040	434,376	24%	104,336
Fire Hydrants		177,500	355,000	427,500	17%	72,500
Sewer Mains		1,138,319	1,806,731	1,851,942	2%	45,211
Sewer Manholes		216,000	220,500	346,000	36%	125,500
Sewer Stubs		404,225	412,550	672,098	39%	259,548
Storm Sewer		630,392	734,752	367,000	-100%	-367,752
Roads		2,589,535	4,076,046	6,302,971	35%	2,226,925
Curb and Gutter		391,724	666,989	612,014	-9%	-54,975
Sidewalks		175,046	333,429	308,392	-8%	-25,037
Residential Electric		717,915	1,021,340	774,089	-32%	-247,251
Commercial Electric		0	0	246,375	100%	246,375
Residential Gas		393,129	559,284	353,162	-58%	-206,122
Commercial Gas		0	0	45,000	100%	45,000
Playing Fields		3,953	5,929	12,846	54%	6,917
Park Area		13,231	50,151	71,995	30%	21,844
Trails		14,404	14,390	64,876	78%	50,486
Tax Revenue						
Total Tax Revenue		1,122,800	1,784,000	2,555,760	30%	771,760
Tax Revenue/Hhld		1,285	2,000	1,759	-14%	-241
Tax Revenue per Land Use						\$0
Single Family Detached		890,000	1,784,000	294,360	-506%	-1,489,640
Single Family Attached		34,800		1,516,400	100%	1,516,400
Multi Family		198,000		220,000	100%	220,000
Commercial Residential		0		525,000	100%	525,000
Spatial Properties (acres)						
Total Area/Footprint		229	385	385	0%	0
Single Family Detached		95	217	27	-704%	-190
Single Family Attached		10	0	54	100%	54
Multi Family		35	0	22	100%	22
Commercial Residential		0	0	22	100%	22
Public Open Space		24	51	153	67%	102
Roads and Sidewalks		66	117	107	-10%	-11
Occupied Land Use		163	268	278	4%	11
Households		874	892	1453	39%	561
Dwelling Units per Total Area		3.8	2.3	3.8	39%	1.5

Unit subdivision. The entire subdivision has a total of 874 households. Dividing the number of households by the foot print of the entire study area yields 3.8 DUA.

Sprawl Development

The total cost of services for the sprawl development is \$13,609,968. The cost of services per household is \$15,258. The total annual tax revenue generated by the sprawl development is \$1,784,000. The amount of annual tax revenue generated per household is \$2,000.

The sprawl development has a total footprint of 385 acres of which 217 acres are occupied by residential land use. There is no commercial land use in the sprawl development. There are 51.7 acres of public open space in this development. Roads and sidewalks occupy the remaining 117 acres. The entire subdivision has a total of 892 households. Dividing the total number of acres in the footprint by the total number of households yields a DUA of 2.3.

New Urbanist Development

The total cost of services for the new urbanist development is \$15,499,501. The cost of services per household is \$10,632. The total annual tax revenue generated by the new urbanist development is \$2,555,760. The amount of annual tax revenue generated per household is \$1,759.

The new urbanist development has a total foot print of 385 acres of which 27 acres are occupied by single family detached land use, 54 acres are occupied by single family attached and multi family land use occupies 22. Commercial land use in the new urbanist development occupies 22 acres. There are 153 acres of public open space in the new urbanist development. The entire development has a total of 1453 households. Dividing the total number of acres in the footprint by the total number of households yields a DUA of 3.8 (Table 5).

CHAPTER 6

DISCUSSION

This discussion will compare the results of the model for cost of services, annual tax revenue generated and spatial properties in the new urbanist development and sprawl development. The results for the Valley Unit subdivision are intended to provide a "real world" reference. The percentages in this discussion represent differences between the new urbanist results and those for the sprawl development or Valley Unit. All tabular results discussed in the first 3 sections of this chapter are in the results table (Table 5).

Cost of Services: Sprawl vs. New Urbanist

The total cost of services for the new urbanist development is 12% more than the sprawl development. However, the greater number of households in the new urbanist development results in a lower cost of services per household. Per household, the cost of services in the new urbanist development is 43% less than the per household cost in the sprawl development.

The cost of individual services is similar between the two developments. The difference in dollar amounts is approximately 1.8 million. This difference can be largely attributed to the higher cost of roads in the new urbanist development.

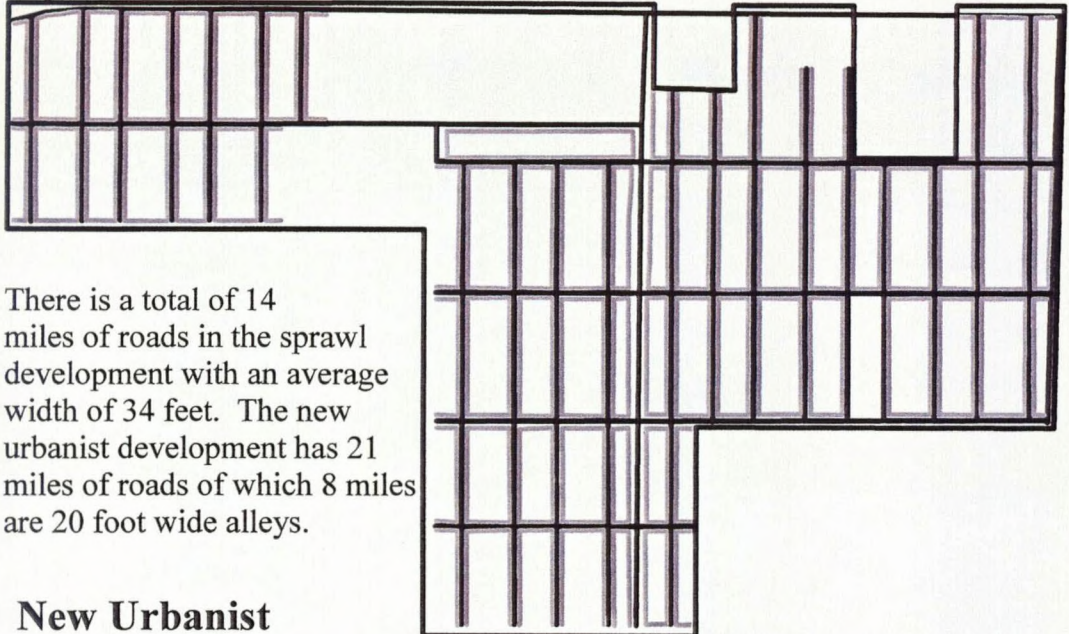
Roads for the new urbanist subdivision cost 35% more than roads in the sprawl development. Narrower roads and the use of alleyways for car park access is a major design feature of new urbanism. There is a total of 21 miles of roads with an average width of 33 feet in the new urbanist development. Of the 21 miles, 8 miles are 20 foot wide alleyways. The sprawl subdivision has approximately 14 miles of roads with an average width of 34 feet and no alleyways (Figure 14).

In addition to the cost of roads, public open space and storm water drainage represent two other notable cost differences. Large amounts of public open space is another major design element of new urbanism. The new urbanist development has 67% more public open space than the sprawl development. Therefore, the cost of this land use/service is higher in the new urbanist development, although it also represents an amenity that is integral to new urbanist design (Figure 15).

Storm water collection in sprawl style developments is usually accomplished through the use of inlets and underground piping. New urbanist developments use the natural drainage of the landscape. Runoff is directed to surface drain fields through out the development (Condon, 1996). Systems incorporating the natural landscape are about half the cost of traditional underground systems (Murray, 1999).

The water and sewer systems appear similar when displayed without the parcel layer Figures (16 and 17). However, they do have a higher cost for the new urbanist development. The remaining individual costs are similar in terms of total dollars. The differences that remain are offset by cross category differences. For example, the

Comparison of Road Features in the Sprawl and New Urbanist Development



New Urbanist

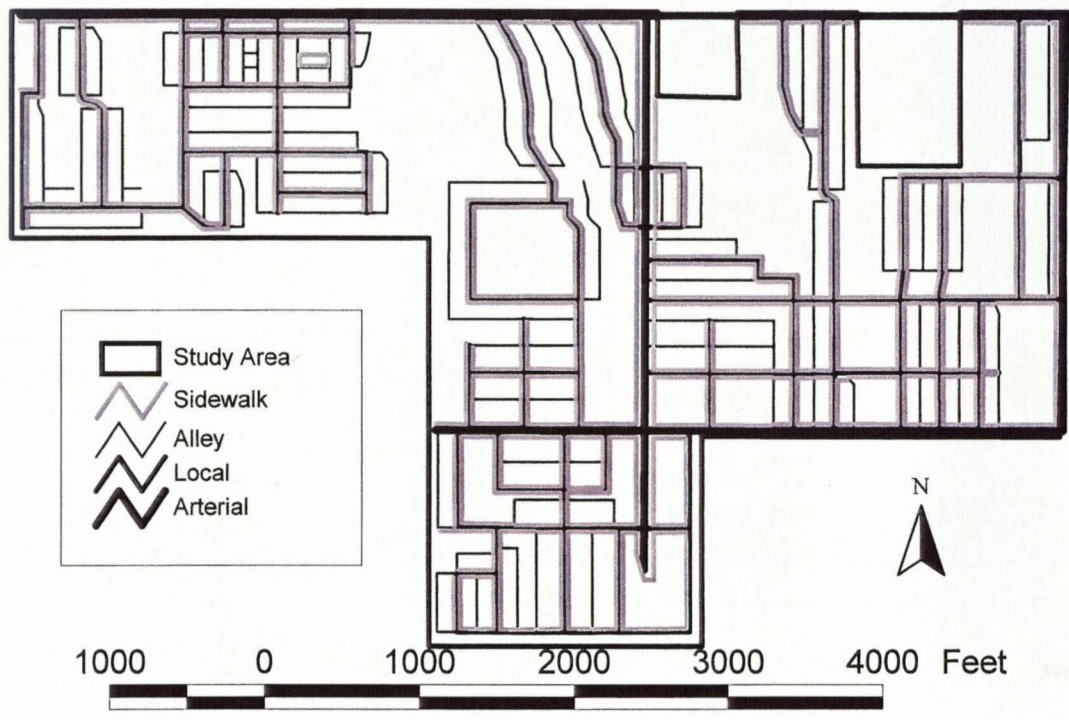


Figure 14: Comparison of road features in the sprawl and new urbanist development.

Comparison of Land Use Patterns and Types in the Sprawl and New Urbanist Developments

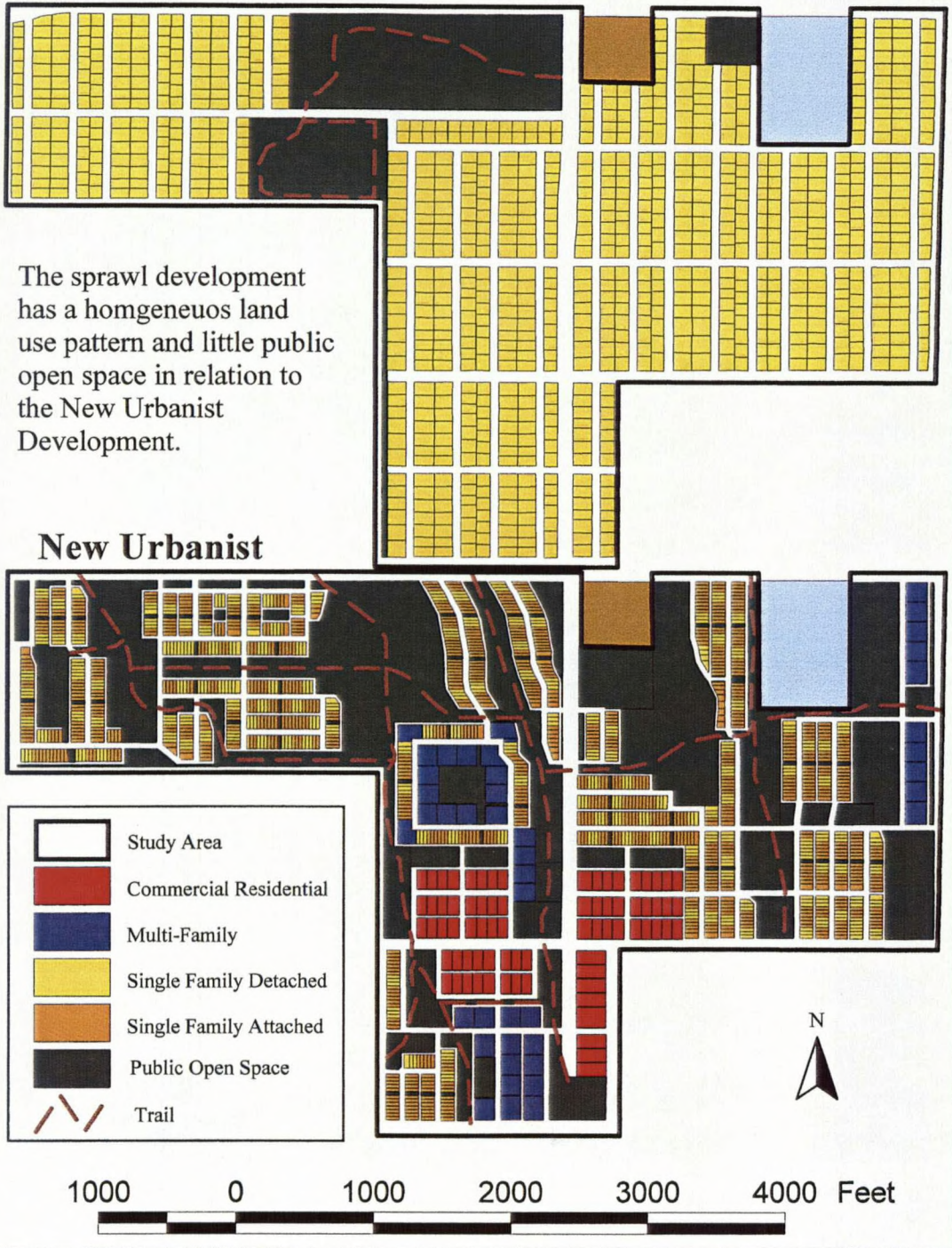
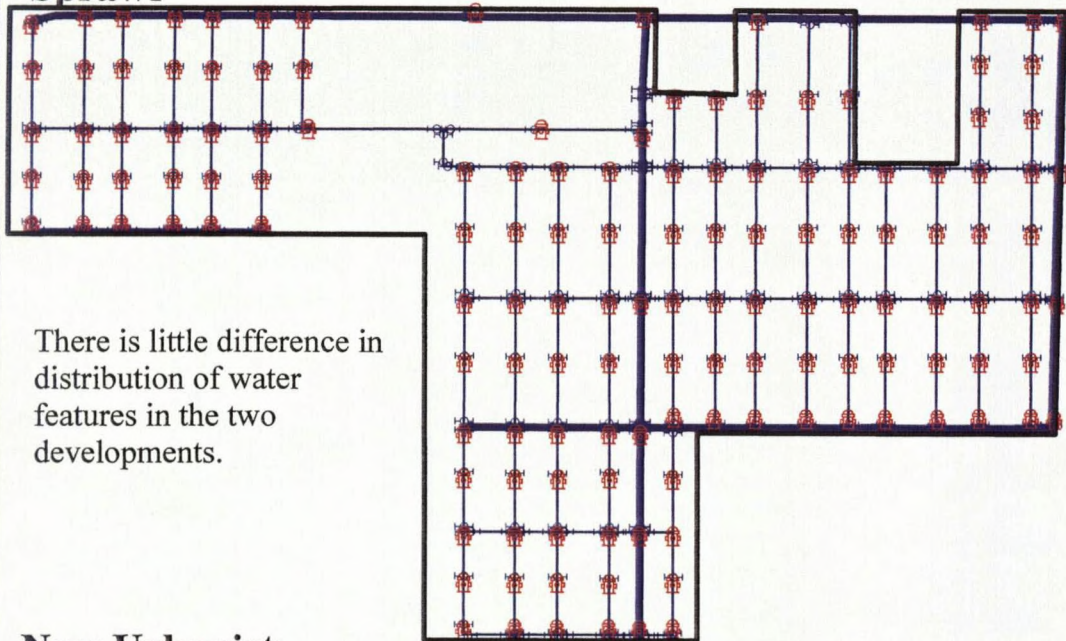


Figure 15: Comparison of land use patterns and types in the sprawl and new urbanist development.

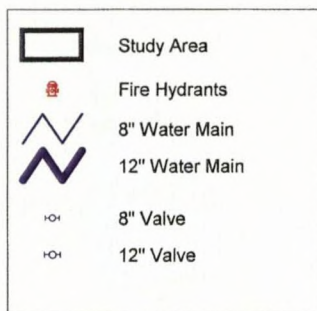
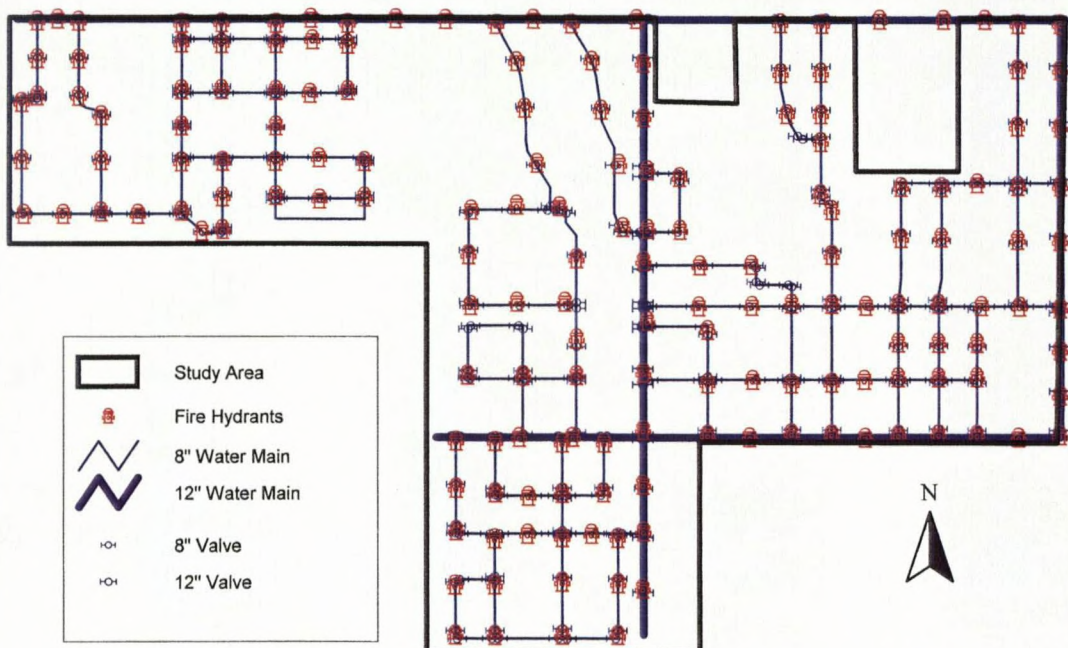
Comparison of Water Features in the Sprawl and New Urbanist Development

Sprawl



There is little difference in distribution of water features in the two developments.

New Urbanist



1000 0 1000 2000 3000 4000 Feet



Figure 16: Comparison of water features in the sprawl and new urbanist development.

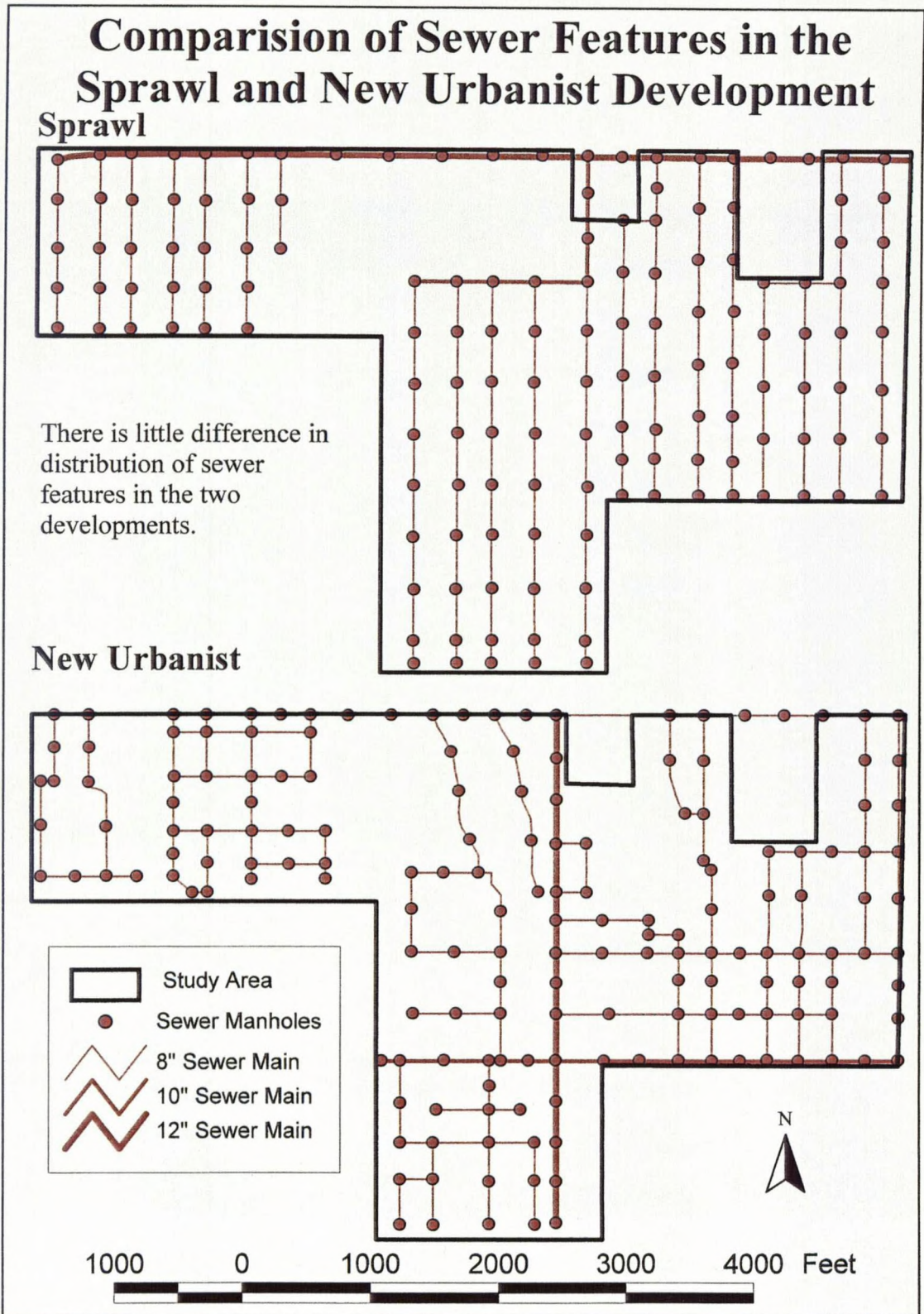


Figure 17: Comparison of sewer features in the sprawl and new urbanist development

additional cost of providing commercial gas and electric service in the new urbanist development is off set by the lower cost of residential gas and electric service.

Most cost savings in the new urbanist development are a function of density. A greater number of households on a given amount of infrastructure will reduce the per household cost of services.

The difference in the cost of services between the Valley Unit subdivision and the sprawl development appears to be proportional to the difference in their size. Although the Valley Unit subdivision was not intended to provide a control, it is interesting that it is 37% smaller than the sprawl development and the average difference in cost for individual services is 41%.

Tax Revenue

The total amount of annual tax revenue generated by the sprawl and new urbanist development is \$1,784,000 and \$2,555,760 respectively which represents a 30% difference. The amount of tax revenue generated per household by the sprawl and new urbanist development is \$1,759 and \$2,000 respectively; a 14% difference. The larger amount of annual tax revenue generated from the new urbanist development is a function of the higher density of individual properties and mixed land use types, some with higher property tax rates than single family detached.

Spatial differences in the Sprawl and New Urbanist Development

The largest spatial variables between the two developments are variety, pattern and number of land use types. The higher density of households in the new urbanist development results in significant savings in the cost of municipal services per household. A total of 3,632 people comprise 1,453 households in the new urbanist development. By contrast only 2,230 people in 892 household occupy the sprawl development. For example, a 36 in. water main that is 3,000 feet long cost \$100,000 to install. If more households use this water main, the amount of taxes spent per household decreases. Therefore, it is more cost effective for 50 households to be using the same main compared to 25 households. This higher density in the new urbanist development is achieved through smaller lot size and a mix of zoning types creating more dwelling units per acre than found in a sprawl development.

The spatial patterns of public open space are significantly contrasted in the sprawl and new urbanist developments. The new urbanist development has twice the open space acreage than that of the sprawl development (Figure 14). The new urbanist has more smaller single family attached and single family detached lots. The sprawl development contains only large single family detached lots.

For this study, the dwelling units per acre was calculated by dividing the number of household by the foot print of the total area. A dwelling unit is one

household or 2.5 people. This gives a more realistic density with regards to a new urbanist development. Historically, this figure is calculated by dividing the number of households by the area occupied by residential land use, excluding public open space. It may be appropriate in large urban areas with little public open space but does not provide an accurate depiction of density in a new urbanist development that incorporates a large amount of public open space in its design.

Future Land Use Conversion, Cost of Services and Tax Revenue

All of the discussion in this section refers to the figures in Table 6. The total population of the Gallatin Valley is projected to grow by 20,210 people by the year 2020 to a total of 84,870. To accommodate this increase, it would require 9.1 sprawl developments or 5.6 new urbanist developments. Each development has a 385 acre footprint. Multiplying the footprint by the number of households in each development yields the acres of land required to accommodate the projected increase in population under the two different land use patterns. To accommodate the new population with the sprawl pattern would require 3,489 acres or 2,142 acres with the new urbanist development, a difference of 1347 acres. The sprawl development pattern would require 63% more land to accommodate the projected population increase of the next 20 years.

In the context of this study the new urbanist development pattern is more cost efficient than the sprawl development. The percent difference between the total cost

Table 6: Future land use conversion, cost of services and tax revenue

Gallatin County Population Projections	2000	2010	2020	2000-2020
Population	64660	75080	84870	
Population Increase		10420	9790	20210
Number of New Households		4168	3916	8084
Sprawl Land Use Conversion	2000	2010	2020	2000-2020
Cost of Services per Household	\$15,258	\$63,594,559	\$59,749,591	\$123,344,150
Tax revenue per Household	\$2,000	\$8,336,000	\$7,832,000	\$16,168,000
Total Cost of Services	\$13,609,968	\$63,594,559	\$279,188,669	\$123,344,149
Total Amount of Tax Revenue	\$1,784,000	\$8,336,000	\$36,596,161	\$16,168,000
Acres Consumed		1799	1690	3489
Number of 385 Acres Blocks (study area footprint)		4.7	4.4	9.1
New Urbanism Land Use Conversion	2000	2010	2020	2000-2020
Cost of Services per Household	\$10,665	\$44,451,720	\$41,764,140	\$86,215,860
Tax revenue Per Household	\$1,759	\$7,331,512	\$6,888,244	\$14,219,756
Total Cost of Services	\$15,499,501	\$44,461,060	\$119,827,606	\$139,586,345
Total Amount of Tax Revenue	\$2,555,760	\$7,331,320	\$19,758,739	\$23,162,291
Acres Consumed		1104	1038	2142
Number of 385 Acres Blocks(study area footprint)		2.9	2.7	5.6
Percent Difference Cost of Services vs Tax Revenue		Services	Tax	% Difference
Sprawl Development		\$13,609,968	\$1,784,000	66%
New Urbanist Development		\$15,499,501	\$2,555,760	56%

of services and the total amount of tax revenue generated in the sprawl development is 66%. The percent difference between the total cost of services and the total amount of tax revenue generated in the new urbanist development is 56%.

CHAPTER 7

CONCLUSION

In this study the new urbanist development has been shown to have a lower per household cost of services and to generate more total annual tax revenue than the sprawl development financially. New urbanism provides a more cost effective and efficient land use pattern for the Gallatin Valley than sprawl, requiring less land to accommodate a given number of new households while providing areas of public open space as an integral part of the developed landscape.

SmartPlaces has been shown to be an effective tool for the used to assess the cost of proposed developments and brings a degree of objectivity to the current debate over alternatives for growth management issues. This thesis shows the adoption of a different land use paradigm to be economically beneficial. Further, if one accepts the premise that new urbanism provides a higher quality of life, this type of development could ensure that Bozeman and the Gallatin Valley will always be a desirable place to live.

The implementation of new urbanist development would require all jurisdictional authorities to create a cooperative planning authority and drastically change current zoning regulations.

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APPENDICES

APPENDIX A
COST OF SERVICES

Cost for All Individual Services to All Developments

Cost for All Individual Services to All Developments				
Roads				
	Size	Cost/ft\Unit	Type	
	Alley 20'	\$55.00	Install	
	Local 45'	\$55.00	Install	
	Arterial 1 60'	\$55.00	Install	
	Arterial 2 100'	\$55.00	Install	
	Curb & Gutter 12"	\$9.00	Install	
Sidewalks				
	Width	Cost/ft		
	Walk 5'	\$3.00	Install	
	Trails n/a	\$2.90	Install	
Public Open Spaces				
	Acres	Cost\Acre		
	Ball Field Per Acre	\$988.19	Annual	
	Park Per Acre	\$988.12	Annual	
Water				
	Dia	Cost/ft		
	Main 8"	\$35.00	Install	
	Main 12"	\$35.00	Install	
	Valve 8"	\$600.00	Install	
	Valve 12"	\$1,200.00	Install	
	Residential Service Stub 3/4"	\$20.00	Install	
	Commercial Fire Stub 2"	\$24.00	Install	
	Fire Hydrants n/a	\$2,500.00	Install	
Sewer				
	Dia.			
	Manhole n/a	\$2,000.00	Install	
	Main 12'	\$36.00	Install	
	Main 10'	\$32.00	Install	
	Main 8'	\$30.00	Install	
	Service Stub 18.5'	\$462.50	Install	
Utilities				
	Per unit	Cost		
	Residential Gas	\$271.00	Install	
	Residential Electric	\$594.00	Install	
	Commercial Gas	\$600.00	Install	
	Commercial Electric	\$3,285.00	Install	
Storm Sewer				
	Dia./Unit	Cost/ft/Unit		
	Main 15"	\$28.00	Install	
	Main 18"	\$32.00	Install	
	Main 24"	\$38.00	Install	
	Main 30"	\$50.00	Install	
	Main 36"	\$55.00	Install	
	Laterals 8"	\$63.03	Install	
	Inlets Grate	\$1,000.00	Install	
	Manholes Standard	\$1,200.00	Install	
	Detention Pond Area/c.u.	\$5.00	Install	

APPENDIX B

MONTANA POWER COMPANY GAS AND ELECTRIC COSTS

Stewart Mitchell

Date: October 28, 1999

Re: Bozeman Planning Study

Stewart, I have completed cost estimates for your study and I hope this information will help you. The information I'm going to give you is an estimate of the actual cost involved in a backbone system of electric primary and natural gas for the two options presented to me. These would not be the costs a developer would have to pay, as I have not included any excise taxes that we normally collect.

Option #1 (542 single family subdivision)

On this subdivisions I made the following assumptions.

- 1) Construction of 4000 ft. of overhead three phase primary.
- 2) All facilities would be installed at one time and not in phases as would be normal in this large of subdivision.
- 3) Electric and Natural gas systems would be installed at the same time in a joint trench.

Total cost of Electric Primary backbone.	\$620,350.00
Cost per lot.	\$1,145.00
Total cost of Natural gas backbone.	\$339,750.00
Cost per lot.	\$627.00

Option #2 (multi-use subdivision with commercial mixed with single and multi-family)

This type of subdivision is very hard to estimate cost of providing service due to the many directions it could take. Townhouses are generally less expensive than single family to service, and commercial is more expensive. Open areas provide no housing units, but generally don't shorten lengths of utilities installed. Your plan also calls for townhouses to be mixed with single family housing, and would result in no actual reduction on backbone costs.

On this subdivision I made the same assumptions as Option #1 and these additional.

- 1) Townhouses would be dispersed within the subdivision and not lumped all in one area as is normally seen.
- 2) Commercial would be considered light commercial (small stores, restaurants, etc.) and not heavy commercial (Costco, Target, etc.)

Total cost electric for commercial area.	\$246,350.00
Cost per lot (75 lots)	\$3,285.00
Total cost natural gas for commercial area.	\$45,000.00
Cost per lot (75 lots)	\$600.00
Total cost electric for remainder of subdivision	\$484,500.00
Cost per <u>unit</u> (816 units)	\$594.00
Total cost natural gas	\$220,900.00
Cost per <u>unit</u> (816 units)	\$271.00

I hope this is the data you need. If you have any questions, just give me a call and I'll try to answer them.

Sincerely,

Charles F. Busta
Senior Engineer

MONTANA STATE UNIVERSITY - BOZEMAN



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