SAUDER
School of Business

Real Estate Division

LESSON 10

Geographic Information Systems (GIS)

Note: Selected readings can be found under "Online Readings" on your Course Resources website

Assigned Reading

1. UBC Real Estate Division. 2014. *BUSI 344 Course Workbook*. Vancouver, BC: UBC Real Estate Division. Lesson 10: Geographic Information Systems (GIS)

Recommended Reading

1. Ordnance Survey. 2003. *The GIS Files*. Ordnance Survey is the national mapping agency of Great Britain.

2. Von Mayer, N. 2004. GIS *and Land Records: The ArcGIS Parcel Data Model*. New York: ESRI Press.

3. Wikipedia: "Geographic information system". Details on the history and technology of GIS.

4. Urban and Regional Information Systems Association. 1999. *GIS Guidelines for Assessors, Second Edition*. Park Ridge, IL: Urban and Regional Information Systems Association.

5. What is GIS? *www.gis.com*. June 16, 2007.

6. UBC Real Estate Division. 2010. "Sources of Maps and Aerial Photographs: Federal and Provincial Offices".

7. Anzaldi, D. 2006. "Appraiser Friendly GIS: Keeping the Focus on the User". *Fair and Equitable*. August 2006. Discusses GIS from an end user perspective, focusing on practical applications for people involved in real estate. Three examples are covered in detail: sale research; quality assurance; and document retrieval.

Learning Objectives

After completing this lesson, the student should be able to:

1. discuss the evolution of geographic information systems (GIS) and its common uses;

2. describe the basic components of GIS;

3. explain how data is stored and accessed in a GIS from a user perspective;

4. identify various map types and how they are incorporated within GIS;

5. describe the use of attributes within GIS;

6. list and explain the various tools offered through GIS;

7. describe common applications for GIS in real property valuation and assessment;

8. explain the benefits of pursuing an enterprise solution approach to GIS development;

9. describe a variety of real estate applications that can benefit from the use of GIS; and

10. describe mapping systems and their possible applications in assessment.

Instructor's Comments

The focus throughout the course so far has been on statistical applications in real estate. In this lesson, we switch gears somewhat, to focus on Geographic Information Systems (or GIS). GIS is an increasingly popular and powerful computer application in real estate.

Computerized GIS has been around for 30 years, but it is still in many ways in its infancy, not yet in everyday use for the typical practitioner. However, GIS is becoming much more common and for many is an indispensable tool. GIS can be used interactively with many other types of software including spreadsheets and statistical packages.

Land-based data displayed in map form is used constantly throughout the world. Consider the following examples:

- a vacationer using the Internet for driving directions;
- a climatologist tracking important climate changes;
- a big box retailer looking for the perfect location for a new outlet;
- a Municipal disaster recovery team developing natural disaster plans;
- a real estate broker looking for homes in a different market area for relocating clients;
- a firefighter looking for a water hydrant location;
- an appraiser using GIS to verify property features, such as those with super mailboxes; and
- a City Assessor reporting to municipal council on the average tax dollar change by neighbourhood resulting from a property reassessment.

In all of the examples above, the integration of data, people, hardware, software, and methods (applications) create a geographic information system. GIS is all about taking advantage of the visual power of maps by incorporating more and different types of data, as well as a user friendly interface. The goal is to create dynamic and interactive maps.

Public, government, and business organizations are all taking advantage of GIS as the technology evolves and its potential capabilities become apparent. GIS is scalable, with users varying from individual appraisers on a single stand-alone PC to multinational corporations on client-server or intranet/internet-based platforms. In real estate, assessment organizations are probably the major contemporary user of GIS, but it is becoming increasingly accessible and useful for other real estate professionals.

In this lesson we will:

- introduce GIS and describe its history and evolution;
- illustrate GIS by showcasing a number of diverse GIS applications; and
- examine several real estate applications of GIS.

GIS is a highly technical field, drawing on theory from both mapping/geography and information systems. Our goal is a quick overview of GIS with a focus on benefits for end users – we have been purposely light on theory. For those who want more depth and background on what goes on beneath the surface in GIS, we suggest reviewing the recommended readings and the more detailed analysis in the BUSI 444 course.

History and Evolution of Geographic Information Systems

In the 1930s and 40s, geographical analysis was conducted by manually overlaying different types of similarly sized maps. Key users included the military/defense departments.

In the early 1960s, geographic analysis was increasingly adopted by urban and regional governments as a part of planning and administration. Since that time, geographic analysis has become commonplace, in part because hardware and software advances have made automated graphics and spatial data processing more accessible and user friendly.

A geographic information system (GIS) is a computer-based tool for mapping and analysis. GIS technology integrates computer database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These capabilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

Loosely defined, a GIS is any information system that integrates, stores, edits, analyzes, shares, and displays data that refers to or is linked to a physical (or geographic) location.

Geographic information can be accessed, transferred, transformed, overlaid, processed, and displayed using numerous software applications. For example, mountains have attributes like elevation and area, while countries have attributes like poverty, growth rates, and age groups. GIS works with large databases to manage these associations, which as a whole are known as *geographically referenced information.* Once a GIS has finished the often elaborate process of associating attribute data with geographic features, the results can be visualized in the form of a map.

Clearly, map making and geographic analysis are not new, but a GIS performs these tasks better and faster than manual methods. As well, before GIS technology, only a few people had the skills necessary to apply geographic analysis to help with decision making and problem solving. These useful techniques are becoming increasingly accessible to laypeople and to non-technical real estate professionals.

Today, GIS is a multi-billion-dollar industry employing hundreds of thousands of people worldwide. GIS is taught in schools, colleges, and universities throughout the world. Professionals in every field are increasingly aware of the advantages of thinking and working geographically. As the famous saying goes, "a picture is worth a thousand words". GIS gives us a picture to better understand data.

GIS Components

Figure 10.1: Components of a GIS

A working GIS integrates five key components:

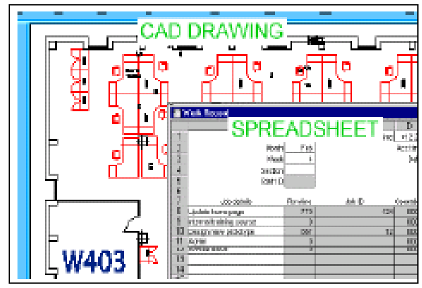
- Hardware
- Software
- Data
- People
- Methods

Hardware

The computer hardware needed to run a GIS varies from centralized computer servers to desktop computers used in stand-alone or networked configurations.

Software

Figure 10.2: GIS Software



GIS software provides the functions and tools needed to store, analyze, and display geographic information. GIS packages have evolved from a combination of two well-established types of software:

- The way in which map geometry is handled is based on graphics and computer-aided design (CAD) technology – a series of geocoded lines, points, and polygons.
- The way in which attribute information is handled has been developed from conventional spreadsheet and database technology.

Key software components for GIS include:

- tools for the input and manipulation of geographic information;
- a database management system (DBMS);
- tools that support geographic query, analysis, and visualization; and
- a graphical user interface (GUI) for easy access to tools.

Some examples of common GIS software include:

- Intergraph – GeoMedia
- ESRI – ArcView
- AutoDesk – AutoCAD
- MapInfo
- MicroStation

If you are interested in more information on any of these GIS software packages, you may wish to search and review their websites.

Data

Data is the most important component of a GIS, because without geographic data, there is nothing to analyze. Geographic data and related tabular data may be collected in-house, purchased from a commercial data provider, or a combination of both. Data sources include Canada census, GPS (global positioning system) points, digital elevation models, and municipal tax data and digitized maps. Data integrity is crucial, as data is useless if inaccurate or outdated. Because data can be difficult and expensive to gather, organize, and manage, this can be a major impediment to individual private use of GIS. This explains why the traditional key users of GIS tend to be local government, assessment agencies, or large corporations, since these have the staff and resources to either gather or purchase sufficient data.

However, this narrow focus is changing. As the GIS community grows, more and more users require similar sets of data. Through standardization and improved data management, organizations can share in data use and costs, decreasing the data burden for each individual organization. A striking example of this is within government itself, where different levels of government require access to similar data and can both improve data integrity and reduce costs by agreeing to work together. Another example is in web-based applications, where data costs can be spread much more widely by promoting useful applications to the general public.

People

GIS users range from technical specialists who design and maintain the system, to end users who apply it to real-world issues in performing their everyday work. The technical specialists may be computer programmers or geography/mapping specialists. The end users can be non-experts, who learn the software and apply it to their own tasks. Just as you don't need to be a computer programmer to use a word processing program, you don't need to be mapping expert to run a GIS – as long as you have well-written user-friendly applications designed for this purpose.

Methods

GIS is neither one technology nor a single application, but many evolving technologies applied to the needs of a variety of institutions, organizations, groups, and individuals. A successful GIS requires a well-designed plan and rules of operation, specific to the context and the user requirements. The defining characteristic of GIS is its spatial aspect, focusing on *where* questions regarding our built and natural environments.

Just as real estate is a focus of many related professions, interest and involvement in GIS cuts across diverse disciplines and professions including:

anthropology	engineering	medicine
archaeology	epidemiology	meteorology
architecture	forestry	physics
assessment and taxation	geodesy	planning
astronomy	geography	public administration
cartography	geology	statistics
computer science	geomorphology	surveying
demography	history	
ecology	mathematics	

Each of these areas share an interest in geographic analysis, but each has its own specific set of questions related to the *where* of real estate. The GIS methods adopted for each of these user groups will vary in scope, scale, and functionality.

The following text box describes two related computer mapping systems and explains how these are differentiated from GIS.

Computerized Mapping Systems

Most computerized mapping systems can be categorized as:

- computer-assisted drafting systems (CAD),
- automated mapping/facilities management systems (AM/FM), or
- geographic information systems (GIS).

All three require a base grid with x-y coordinates and permit the mapping of cartographic features such as points, lines, and polygons. Overlapping map layers, each containing a specific kind of information, are used in all three. All offer the ability to change scale, update maps readily, print or plot maps as needed, and display and store text (such as names, labels, dimensions, and other labeling data).

Computer-Assisted Drafting Systems (CAD) are suitable for traditional mapping functions. They provide the same kind of map as a manually produced and manually drafted map but are made and maintained electronically. They are usually created by digitizing or scanning a manually prepared map or entering actual legal descriptions.

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Automated Mapping/Facilities Management Systems (AM/FM) differ from CAD systems in that they feature sophisticated databases capable of storing and manipulating related attribute information; however, because they were developed primarily for utilities, they best serve networking functions and are limited in their ability to analyze relationships between different layers other than through visual inspection (overlapping of layers).

Geographic Information Systems (GIS) were developed for spatial analysis needs such as planning, natural resources, and land records management. GIS can completely integrate spatial data and attribute data among different layers. The GIS approach is ideal for multipurpose users.

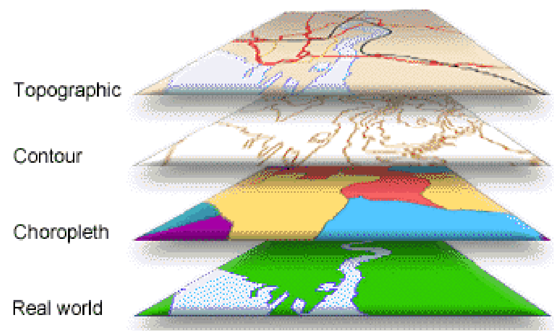
Of the three computerized mapping systems, GIS is the most commonly used by the real estate industry.

Maps: The Basis of GIS

The story of GIS begins in the world of maps. A map is a simplified visual representation of real things from the real world. However, maps can model the world in more than one way – consider the figure below.

- *Topographic* maps show physical surface features, such as roads, rivers, and buildings.
- *Contour* maps use lines to group together locations that have the same attribute value, for example, height above sea level or isobars showing air pressure.
- *Choropleth* maps use shading, patterns, or colours to highlight areas characterized by some general common feature, for example, political maps or agricultural crop types.

Figure 10.3: Types of Maps



Multiple Layers

The power of GIS lies in its ability to integrate and create different layers of information for a geographical area. A conventional map-maker must balance information and clarity, displaying sufficient detail to make the map useful, but not so much that it becomes cluttered and confusing. GIS removes this problem because many different layers of information can be added and shown in different combinations and in a different order. At the click of a mouse, different data layers can be switched on and off so that many different views can be created for the same location.

The image below illustrates how GIS can display different layers of information at the same time. All three maps are for the same geographic area.

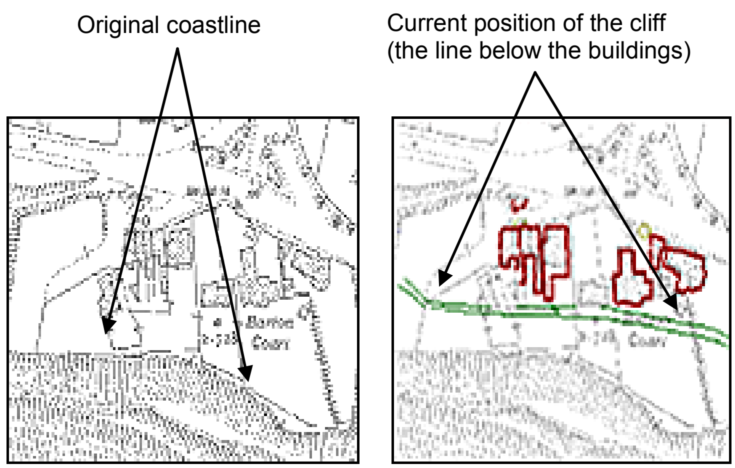
Figure 10.4: Multiple Layers

1) Communication network map **2) Relief map** **3) Urban growth**

- Map 1 illustrates a communication network map by switching on just the towns, roads, and railways.
- Map 2 generates a view of the relief of the area by switching on just the contours and rivers.
- Map 3 gives a view of both layers together. This might help analyze the spread of urbanization in relation to communication networks and relief.

Another benefit of mixing and matching different layers is that by combining mapping for the same area surveyed at different times, you can identify any changes. The example below shows the changes to an area as the coast eroded over time.

Figure 10.5: Identifying Changes Over Time



These two simple examples show how different messages can be portrayed within a GIS by showing a mixture of feature layers. The most sophisticated GIS users are likely to be working with hundreds of layers for a particular geographical location. Using different combinations, the display can serve a wide range of purposes that could only otherwise be achieved by producing a whole set of different paper maps.

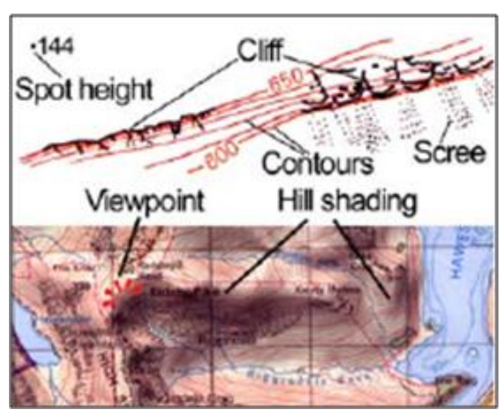
Three-Dimensional Maps

The physical world exists in three dimensions and conventional maps are uncompromisingly flat. Two-dimensional (2-D) representations of a real landscape require imagination and interpretation. One of the exciting benefits of GIS is its capability to produce dynamic and attractive three-dimensional (3-D) maps.

Map makers can use a variety of visual symbols to show height information and create the illusion of an undulating surface. The example to the right highlights this:

- Contours
- Spot height symbols
- Hill shading
- Cliff and slope symbols
- Viewpoint symbols

Figure 10.6: Use of Visual Symbols in Maps

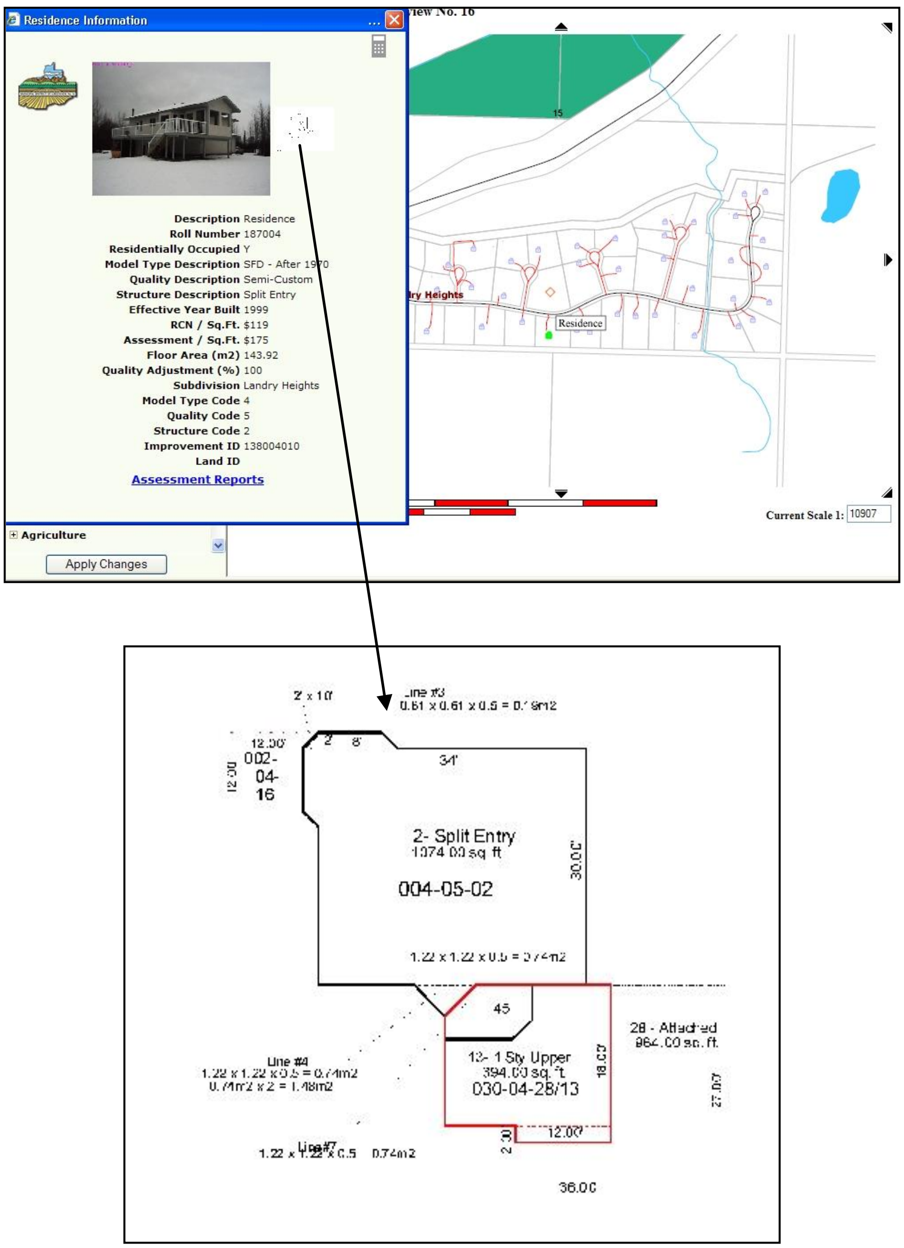


Adding Attribute Information

The maps shown in GIS are intelligent – the features know their own identity. The term *attribute* describes any piece of information about an object that can be stored in addition to its geographic properties. GIS can tell you not just the shape of a feature, but also what it is and any other information that may exist about it.

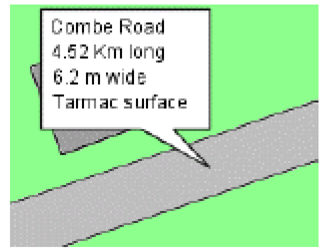
A conventional map may depict a building footprint with a blue line and may record its address using a blue text label. In contrast, a GIS stores this information within the map data itself. The figures below illustrate this. When you view the neighbourhood map, you click on the property under investigation to view its attributes. On the pop-up attribute window, you can then click on the building footprint to get a detailed sketch of the house.

Figure 10.7: Property Data in GIS



Any information that relates to a place on the ground can be loaded into a GIS and analyzed. For instance, a road may have a number, a name, a maximum width, a surface type, and a speed limit, all of which can be displayed by clicking on the road.

Figure 10.8: Road Attributes



GIS can go well beyond conventional maps in storing and transmitting attribute information because you are no longer restricted by map space. Tabular information can be stored for each object in a database that operates beneath the map layers. This allows a nearly infinite array of attributes to be recorded. All GIS have simple tools for examining features. For example, clicking on an object with your mouse displays a full set of attributes without that information having to be on screen all the time. The object of interest can be identified by the visual map graphic and then the object can tell you its own attributes.

Most GIS also enable the user to view the data in tabular form without necessarily using map graphics at all. This is equivalent to using typical spreadsheet software. Often, you may know the name of an object but not necessarily where it is. In this case, you can use the table to find the object and then switch to the map to see where it is.

The GIS forms a constant link between the attributes and the geographical properties of each of the features: you can get either one of these if you know something about the other. This is the basis of the many location-finding mapping services on the Internet: you can generate a map for any location because there is a data layer with a link between the postal code or zip code attribute and the geographical coordinates.

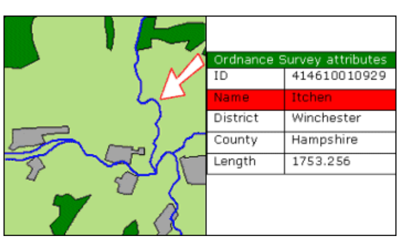
Any organization that holds information about geographical objects can load that information into a GIS as long as they have some map data containing the relevant objects. Your GIS might start simply, with only map data, such as a line indicating a highway numbered 5. However, you can build the GIS by linking to any piece of information that may exist about the object from other systems. Once a feature is loaded into a GIS, any piece of information about that object can be linked to it. This can lead to very powerful GIS applications.

For this to work, it is necessary to have some kind of common referencing system so that the correct record in the geospatial data can be matched with the corresponding record in the non-geospatial data. For example, a property tax assessment organization might specify a unique identification number for each property and then "geo-code" this for GIS use.

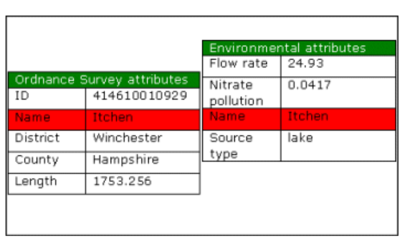
Consider the example below, showing data on a river from two different databases. Because the databases both have the river's name as "Itchen", the data from each can be combined into one table.

Figure 10.9: GIS Tables

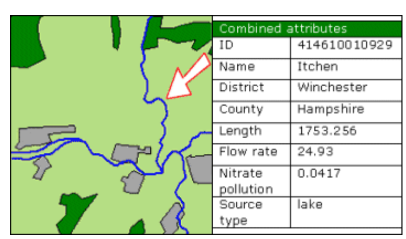
A. This shows attribute data about a river and a map showing its location.



B. These show the attribute data and the environmental data. Notice the different information stored in each table and the common reference.



C. This shows all the information joined together and its location on the map.



This provides the ability to link other attributes (such as environmental information) to the map. However, this kind of application is very much dependent on the ability to establish links between the entities in the two sets of information. It is typically preferable to use a numerical referencing system understood by all users, in order to identify specific features clearly and without ambiguity. Using text names can fail if one set of information has a misspelled name or if there are duplicate entries.

Selective Queries

The most common way for computer users to make sense of large volumes of data and provide answers to specific problems is through the use of spreadsheets and databases. GIS allows similar analysis, only with the added advantage of displaying results in a geographical context. Not only can you identify which records satisfy a particular set of criteria, but you can also see where they are in relation to each other.

Data stored in tables is usually very difficult to digest all at once. It is necessary to filter out irrelevant information and focus only on what is most relevant to the issue at hand. For example, imagine you are visiting an unfamiliar city. You might have a map showing the city centre and the restaurant locations. This would be more helpful than a map showing every commercial property in the city, so cluttered with information that you cannot possibly hope to find somewhere to eat.

You can query the features in GIS map layers by selecting and viewing just those that satisfy particular criteria. Your query can be as simple or complicated as you like, as long as the data fields are there to interrogate.

GIS Tools

GIS offers a flexible and sophisticated tool for analyzing attributes related to geography. GIS can understand location elements of map data, manipulate information about shapes and structures, and work with attribute information to store intelligence about objects. It is the fusion of these functions that makes GIS so powerful. We will now look at a variety of different ways in which GIS can provide practical solutions.

Unlocking the Information

All organizations have information locked away in various databases. GIS can help uncover the full value of this information. It is estimated that approximately 80% of all information held in databases anywhere in the world contains some kind of geographic element. For example, records in a database can be tied to a particular location on the ground, such as an address, building, property, or road junction. There are trends and relationships hidden in this geographic data and GIS can help to reveal them.

Many government and business organizations use GIS as a central part of their activities, and the range of applications is extraordinary. For example:

- Utilities – leak management, service planning, network planning;
- Central government – census, environmental planning, health service areas;
- Local government – property assessment and taxation, refuse collection, street lighting;
- Emergency Services – crime locations, route finding;
- Military – battlefield simulations;
- Retail – travel time for catchment areas, store site location;
- Financial – insurance flood risk, property values; and
- Target Marketing – demographic profiles.

One of the best ways to analyze data is to produce colour-coded maps that reveal patterns in data which may otherwise be missed.

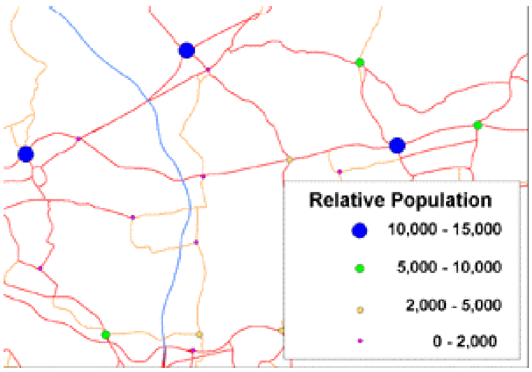
Thematic Maps

GIS are flexible in displaying map information because, unlike a paper map, not all information must be visible at the same time. In a GIS, you can also change how an object is depicted depending on its attributes. This function is known as thematic mapping. Thematic maps are common in atlases, such as shading a map in different colours to distinguish various ranges of altitudes. Another thematic map could use colours to represent the number of seats held by different political parties. A GIS can build these kinds of maps automatically and interactively, allowing customized maps to better meet the user's requirements.

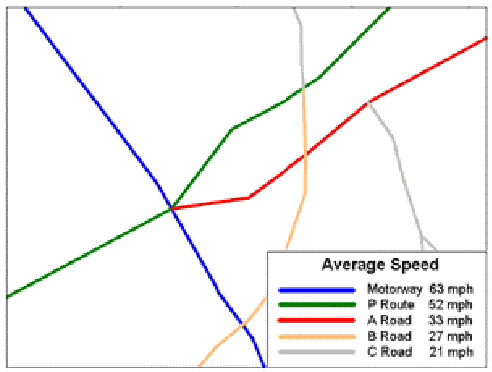
Thematic maps allow visualization of trends in data by integrating data from a wide range of different sources. For example:

Figure 10.10: Examples of Thematic Maps

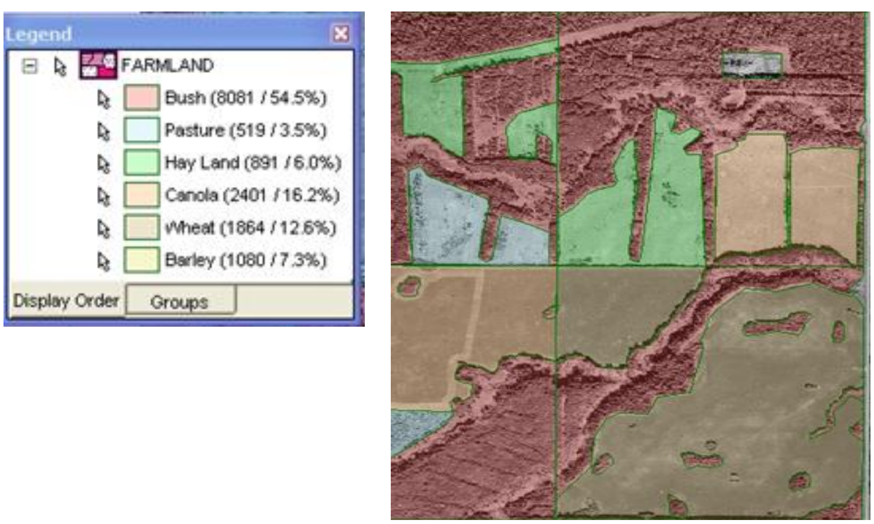
Different sized point symbols to show the relative population of towns.



A display of a road network with different colours to show average traffic speeds.



A map of a farmer's fields showing a different colour for each type of crop grown.



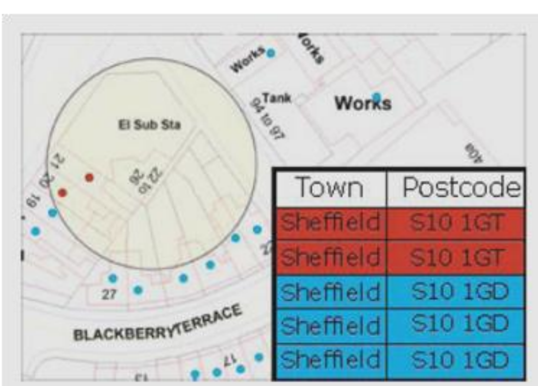
Thematic maps can be quickly and easily created using GIS. As well, the maps are dynamic, in that they can be automatically updated as data values change with time. As a result, you can use this kind of mapping to monitor changing situations, such as traffic flow or property assessment values. The figure below shows the percentage increases in assessed value for a neighbourhood – the large changes stand out as the brightest colours.

Figure 10.11: Thematic Map Showing Value Changes

Spatial Queries

A spatial query means selecting data based on the geometry of objects. For example, most GIS will offer several selection tools, such as drawing a circle in order to select all objects falling inside it. In the example below, the analyst selected a circle spatial query on the map in order to view the addresses noted from within the circle.

Figure 10.12: Circle Spatial Query



GIS can provide information on particular features in the map data and analyze these in relation to each other. This goes beyond the visual analysis of thematic mapping, allowing interrogation of specific properties. As an example, this technique could be used by emergency services to quickly identify all houses within 500 metres of a dangerous chemical spill.

Buffers

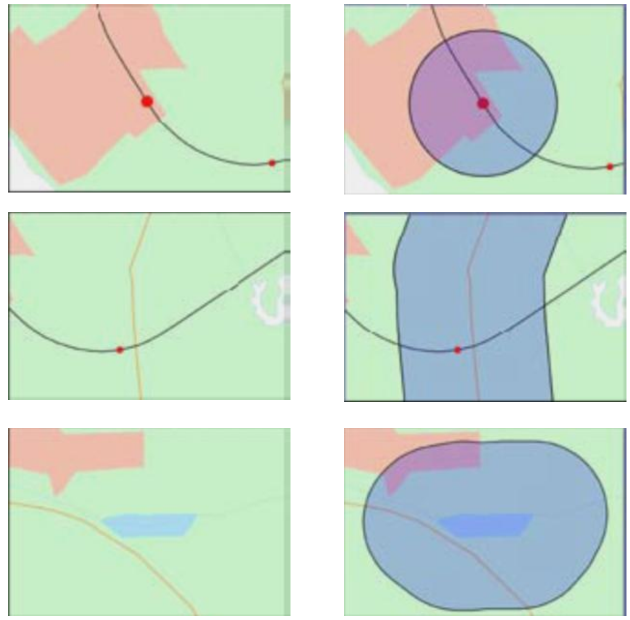
A GIS can be used to generate buffer zones and then identify all features that lie within a particular distance. A buffer is specified on a map based on a point, line, or area (see graphic below). The buffer object represents the total area within a certain distance of a given feature.

Figure 10.13: Buffers

Example of a point buffer

Example of a line buffer

Example of an area buffer

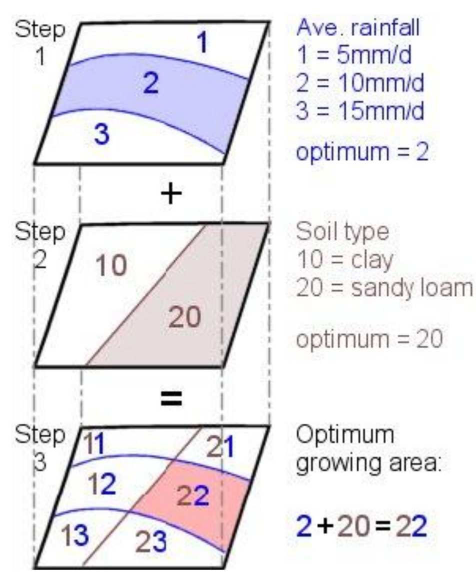


An example of a buffer zone analysis might involve selecting all addresses within a 200 metre buffer of a busy road and then comparing the assessments with data about sale prices. By comparing the two sets of data, you can determine if there is a statistically negative or positive relationship between the assessed values and sale prices for properties in this area. This might help you determine if road proximity is a significant contributor to market value and if these properties have been assessed accurately.

Overlay Operations

A key advantage of being able to layer data in a GIS is to carry out overlay operations. You can place layers on top of each other and then select all objects from one layer that lie within an object from another layer. These can be quite complex, but simply mean combining layers of data to create one new layer (similar to the way a mathematical calculation may first calculate interim answers, then use these answers to create a final answer).

Figure 10.14: Overlay Map



In the example to the right, a farmer needs a certain level of rainfall and type of soil to successfully grow a crop. By combining the rainfall map and the soil type map, it is much easier to find the best location. In this example, the GIS assigns a numeric value to each soil type and to the amount of rainfall. On the resulting map (Step 3), it is easy to see the location of the optimum growing area.

By combining layers of information, the farmer creates a useful new map. Consider a similar example from commercial real estate: a big box retailer might use maps of socioeconomic status, traffic patterns, and competitor locations to pinpoint an optimal new location. Similarly, a restaurant chain might use a similar technique to identify the next location for its fast-food restaurant.

Spatial querying can be used in many different ways to help understand the world around us. Often, the answer to a particular problem can only be unravelled by comparing two layers of information in a way that would be almost impossible to achieve without the GIS software. However, a caution about GIS analysis: keep in mind that the results from GIS can only be as accurate as the data used for the query. Just as you learned in statistical analysis, the GIGO principle also applies in GIS: garbage in, garbage out.

GIS Base Components

The first phase of the GIS implementation is creating the base features that will serve as a foundation for the subsequent phases. The base features of a GIS often include:

- Cleansed parcel data
- Creation of integration tools
- Installation of a GIS viewing application

Cleansed Parcel Data

The parcel layer is the most important layer in any GIS. Because it is the foundation for many other layers, it deserves special attention to ensure it is precise and accurate.

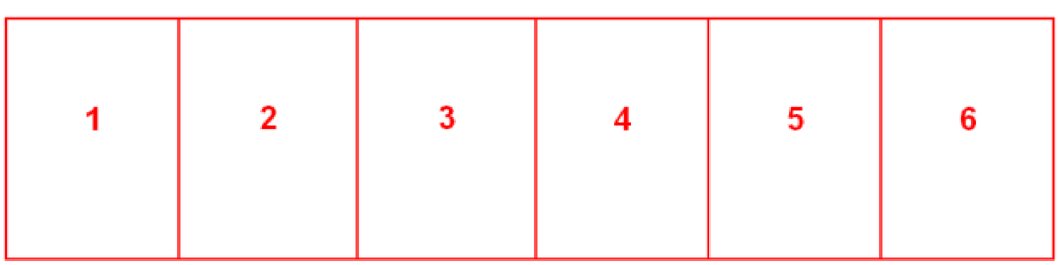
There are three different types of parcel layers in an assessment GIS:

Survey Layer – shows lot lines. The information typically comes from government registries.

Title Layer – shows ownership information. This layer uses a GIS-ready dataset that defines ownership for each parcel, as indicated on Certificates of Title or Deeds registered with the government. The Certificate of Title may refer to multiple lots or a portion of a lot – see example below. This layer is often used for municipal and emergency response planning.

Assessment (Tax) Layer - municipal assessment parcels representing areas defined by municipal government legislation. Assessment parcels can include multiple titled properties (e.g., tied together by one building) or properties not held under title or properties not spatially represented in the above Titles layer (e.g., Manufactured Home communities, industrial leases, municipal leases, crown leases, railway leases, and condominiums).

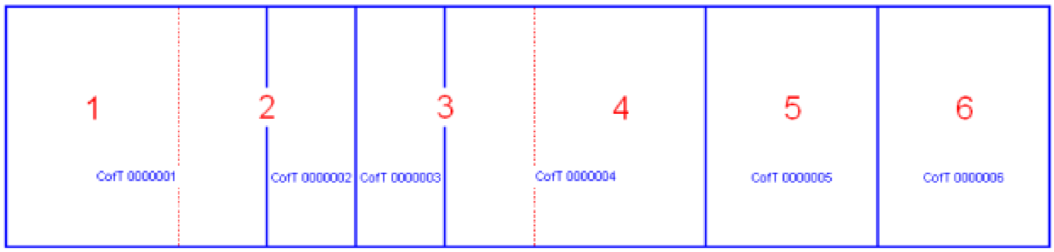
Figure 10.15: Parcels



Survey Narrative Description is simply Plan 0000 and Block 1 Lots 1 thru 6

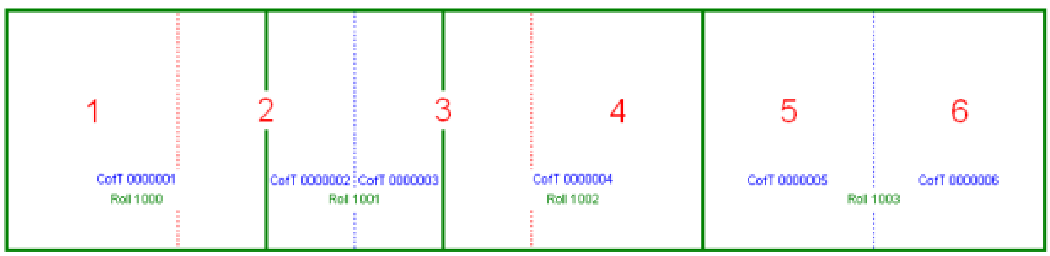
continued on next page

Figure 10.15: Parcels *(continued)*



Title Narrative Descriptions (All descriptions below would be of Plan 0000 Block 1)

- CofT 0000001 is Lot 1 & West 1/2 of lot 2
- CofT 0000002 is East 1/2 of lot 2
- CofT 0000003 is West 1/2 of lot 3
- CofT 0000004 is East 1/2 of lot 3 and lot 4
- CofT 0000005 is lot 5
- CofT 0000006 is lot 6



Assessment Narrative Descriptions (All descriptions below would be of Plan 0000 Block 1)

- **Roll 1000 is CofT 0000001 /Lot 1 & West 1/2 of lot 2**
- **Roll 1001 is CofT 0000002 & CofT 0000003 /East 1/2 of lot 2 & West 1/2 of lot 3 and is tied by building**
- **Roll 1002 is CofT 0000004 /East 1/2 of lot 3 & lot 4**
- **Roll 1003 is CofT 0000005 & CofT 0000006 /Lot 5 & 6 and is tied by building**

All of the above are types of "parcels". Different types of parcels relate to different business processes. For example, tax parcels relate specifically to the municipal assessment/taxation process.

Creation of Integration Tools

The success and overall operability of an enterprise solution is predicated by its ability to effectively integrate current and reliable data from the various municipal business systems. Integration tools exchange data between the central data repository and each business system, allowing the information to flow freely between data sources with minimal human intervention. These help keep the information current, while at the same time perserve the integrity of the data's originating system.

The data contained in the enterprise solution's central repository is often copied from each respective business system for three reasons:

1. spatially enabling data sometimes requires that the underlying data be stored in a different format/manner than the originating data;

2. provide redundancy of critical business system data (in case of a business system failure); and

3. ensure that the core business systems operate and perform unhindered from/by the enterprise solution.

Under special circumstances, the enterprise solution can connect directly to a business system's database. However, great care and attention must be taken to ensure that the integrity of the data is maintained and also that the enterprise solution can still function and access useful information if one or more of the business systems were to crash or go down unexpectedly.

Installation of a GIS Viewing Application

Many GIS applications for accessing, editing, and maintaining spatial data are complex and require a large amount of training. In the enterprise solution approach, the editing and maintenance of GIS data is left to trained specialists, but end users can access information with GIS viewing tools on a read-only basis. Web-based GIS viewing tools provide a quick and easy means to provide access.

A web-based GIS viewer typically consists of two main components: 1) the application engine and 2) the user interface.

The engine provides all the data access, data querying, and map rendering capabilities found in the end product. Essentially, the engine performs all of the complex calculations and tasks that allow the user interface to function. There are many types of engines available for organizations of various sizes and purposes. One of the main differences between engines is the format in which they will accept data.

The user interface is designed with the end-user in mind and is specially tailored in each organization. The main goal of the user interface is to provide non-GIS specialists with access to GIS-based data while hiding the complex, behind-the-scenes querying and calculations of the application engine that makes the GIS operate.

Ortho Photography

Many GIS have an orthographic photo layer (also referred to as an "ortho photo" or "ortho-rectified photo"). "Ortho" is from a Greek word meaning "straight" or "correct". Orthographic projection is a means of representing a three-dimensional object in two-dimensions, in this case representing the curved, three-dimensional surface of the earth as a two-dimensional photo.

Ortho photography is aerial photography in which all of the distortion in the photographs, caused by camera angle and varying ground relief, has been removed. The result is a "scale corrected" aerial image. A series of ortho photos can be physically joined or "sewn" together using imagery software, creating a seamless image layer for a geographic area of interest (e.g., neighbourhood or rural area). After this process, the photos are spatially correct and can be added as a data layer to a GIS. The parcel map, or any other data layer in the GIS, can then be overlaid on top of the ortho photo layer without distortion or obvious errors.

Ortho photos in a GIS can help identify where new improvements exist or areas that require re-inspection or further follow-up when out in the field.

GIS Applications

To this point in the lesson, we examined what a GIS is and the basics for how a GIS can be used. Put simply, GIS can be used to speed up any process that formerly relied upon paper maps. Furthermore, a GIS allows geographical information to be used in unprecedented ways. It is important to appreciate that GIS does not always provide exact answers to problems, but by identifying trends based on geography, GIS can reveal patterns that can help us make informed decisions. Similar to statistical analysis tools, GIS can improve decision-making, but it cannot make decisions for us.

The rest of this lesson will outline practical applications for how GIS can be used to improve everyday life. While GIS is becoming integral to real property assessment, the importance of integrating databases and mapping is also expanding to other agencies and offices well beyond the assessment function. In the following pages we explore not only the tools GIS offers for mass appraisal and for assessment administration, but also look beyond assessment to the wider "enterprise solutions" GIS may offer.

Network Analysis

The simplest example of network analysis is to choose two points on the network and ask the GIS to calculate the shortest path between them, considering both distances and times involved.

This basic concept can be used to help build complex navigation systems or plan extensive distribution services. Alternatively, it could be used for applications as simple as optimizing property inspection or flower delivery routes.

Figure 10.16: Example of a Network Analysis

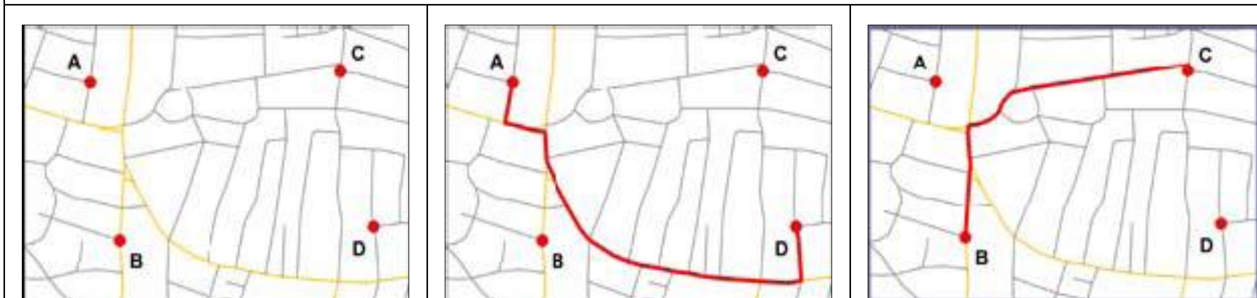


Figure 10.17: In-Car Navigation

In-Car Navigation

Navigation systems can be built for motorists by applying the principles of network analysis to accurate road data. Many cars now have electronic devices that provide driving instructions, either as a simple map display or by audio messages. These in-car-navigation tools are specialized, miniature GIS combined with Global Positioning System (GPS) technology. Because the data has attributes for road names and numbers, intelligent instructions can be provided (for example, "take right turn Exit 34 at next interchange").

In-car navigation requires up-to-date map data and extra information to make the data model behave like the real world: you need to know which roads are one-way streets or where there are no-left-turn signs. By using unique identifiers in the road data so that each link in the network can be pinpointed, additional information can be built into the system. Furthermore, it is possible to receive real-time information about traffic conditions as you drive, so that you get advance warning if there are hold-ups due to road construction or an accident.

What is GPS?

The Global Positioning System (GPS) is a global navigation system powered by a network of satellites orbiting the earth. The satellites send precise microwave signals to GPS receivers on earth which interpret these signals to establish geographic locations on the earth's surface.

Figure 10.18: Satellites in Orbit

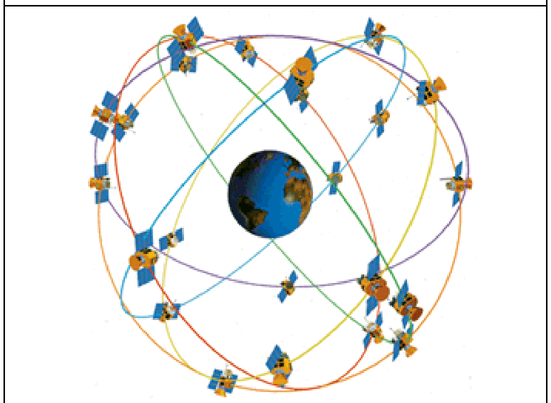
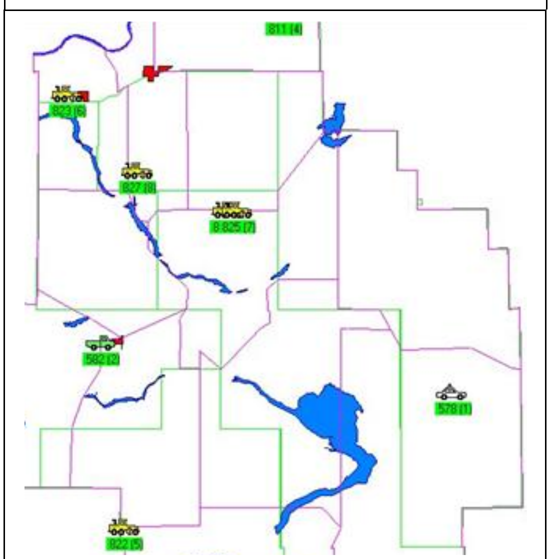


Figure 10.19: Tracking Vehicle Movement by GIS



A GPS receiver measures when the signal was sent against when it was received and uses triangulation with other satellites to determine location, time, and velocity information. Signals from a minimum of three satellites are required for a GPS receiver to establish its location. The more satellites the receiver is able to receive signals from, the more reliably can a location be determined. The orbits of the satellites around the earth are set up in such a way that a minimum of six satellites are (theoretically) always within line of sight from any point on the earth's surface (however this is not always the case depending on nearby features such as terrain, cloud cover, or buildings).

GPS is used extensively as a navigation guide and is a useful tool for map-making, land surveying, and more. Typical retail/consumer GPS receivers can provide a location that is accurate within 3-5 metres of its actual location, while survey-grade and military-grade GPS receivers are capable of providing locations that are much more precise, often within centimetres of its actual location.

Assessors and appraisers, emergency responders, maintenance vehicle drivers, and their respective supervisors all find handheld or vehicle-mounted GPS systems very useful for improving task efficiency and for monitoring status and activities.

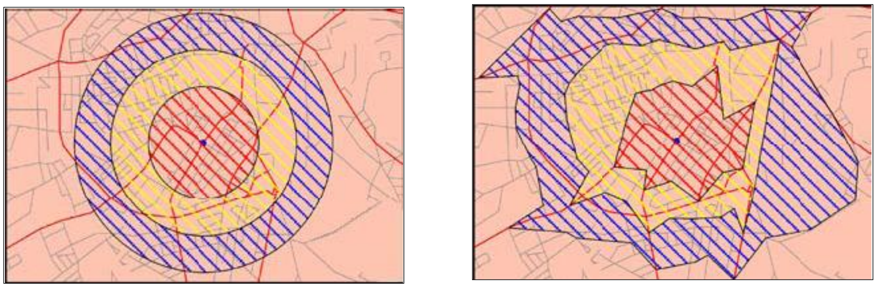
Drive-Time Analysis

Another benefit of network analysis is the ability to calculate drive-times, which identifies travel distance and length of time. For example, consider a drive-time map for pizza delivery, showing a central point surrounded by a series of circles estimating how long it takes to get to places within that radius. A paper map method would likely assume an as-the-crow-flies route to each location.

In contrast, a GIS can be much more accurate, using network analysis to generate isochrones (lines that join up points of equal travel time) that take into account the true road network and give a proper measure of how far you can get over a set time. This can even take into account the average speed on each road, so that the area appears stretched along faster roads.

Figure 10.20: Typical and GIS Drive-Time Maps

Typical drive-time map GIS drive-time map

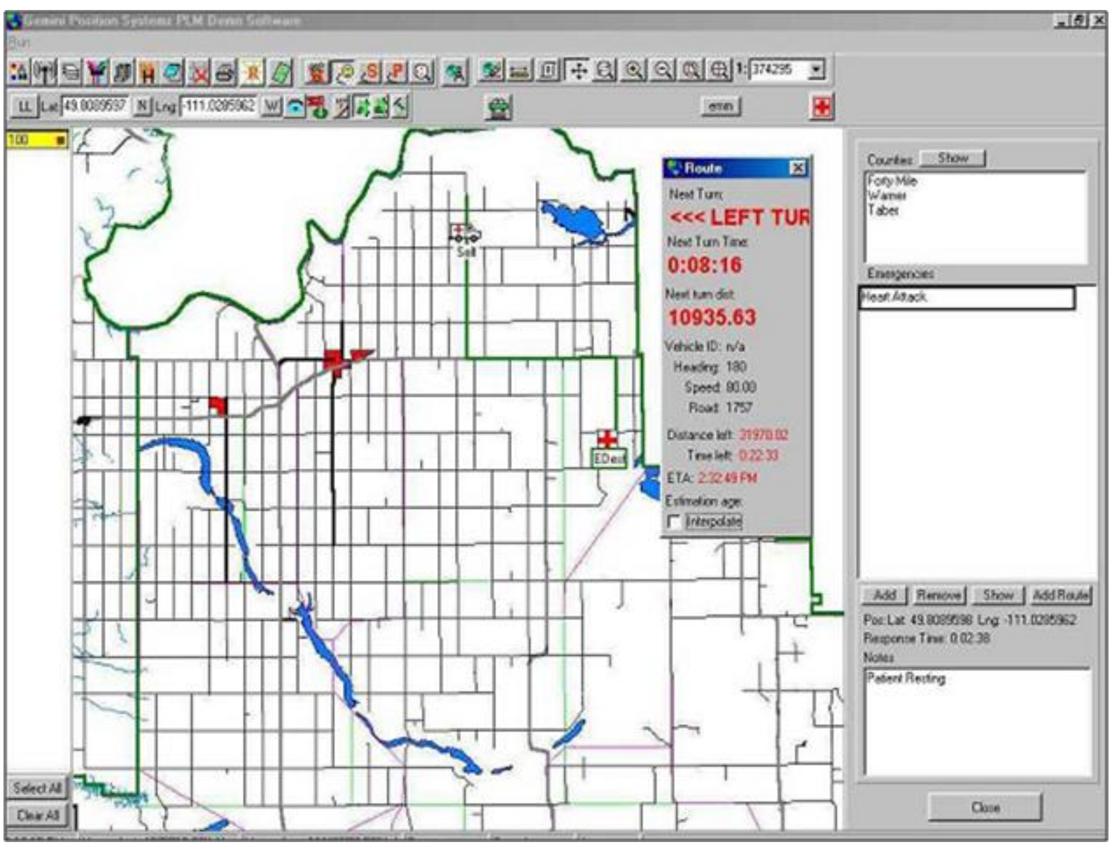


Many different organizations use this kind of drive-time analysis to plan their operations, from the site of a new store to the planning of distribution networks. Emergency services also uses this. For example, when planning a new fire hall, they will use drive-time analysis to look for soft spots in their response coverage.

Automated Vehicle Locating

A GIS combined with GPS allows for the real-time tracking of vehicles. This can be used for emergency services or for transportation companies.

Figure 10.21: Real-Time Vehicle Tracking



Road Conditions

Weather and road-related data can be built into a GIS, so that drivers can log on to maps and get up-to-the minute road conditions. The user cursors over the highway and the related text conditions are displayed. For a Manitoba example, go to *http://tgs.gov.mb.ca/roadinfo* and try it out.

Figure 10.22: Road Conditions

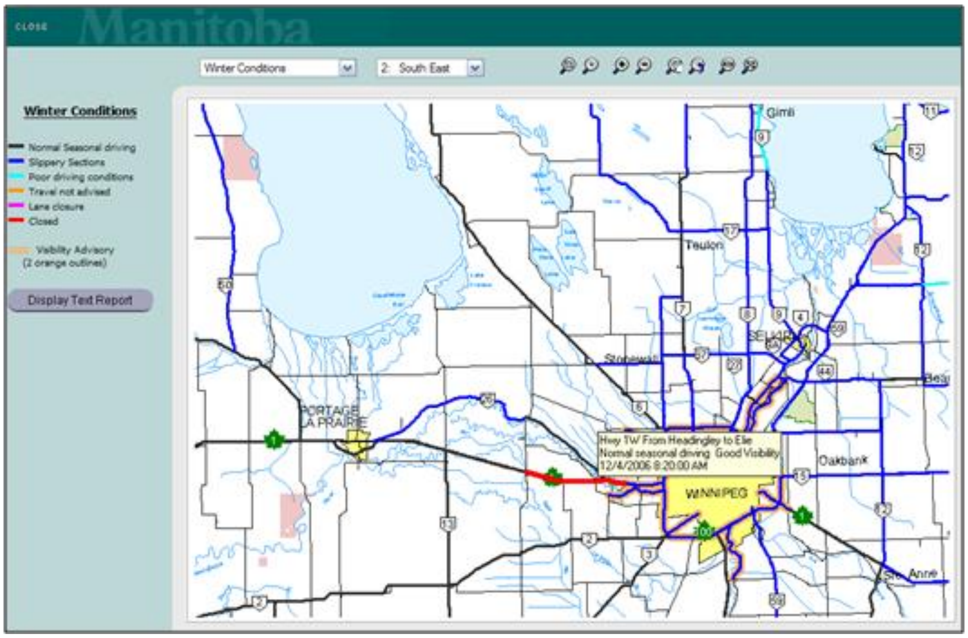
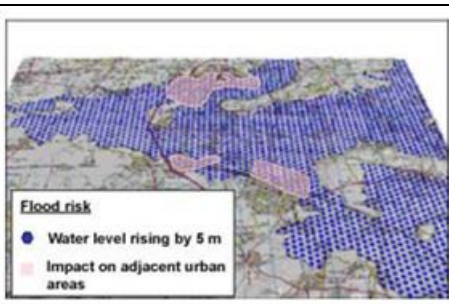


Figure 10.23: Emergency Services

Emergency Services

Emergency services dispatchers use GIS to call up detailed maps of area around an incident. By tracking the vehicles in real-time and using route-finding GIS functions, the controller can identify the best vehicle to attend and give directions for the fastest way to the incident. They can even store historical information and look for incident patterns.

Figure 10.24: Flood Risk



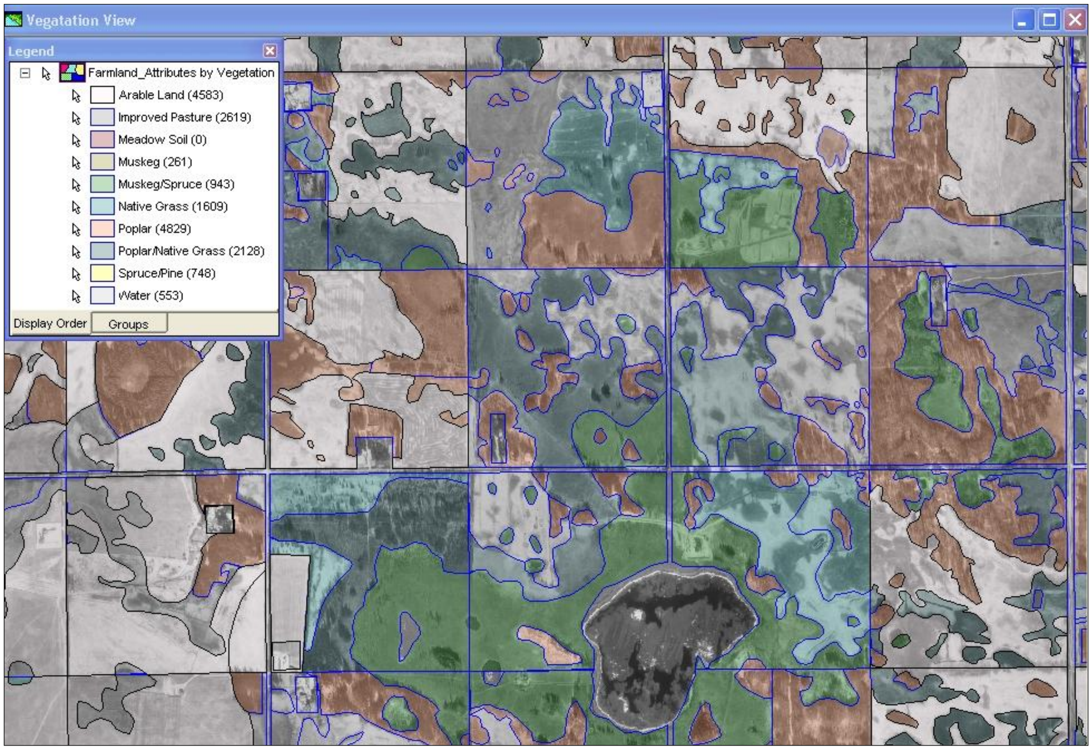
Flood Risk

A computer model of changing water levels can be built using 3-D height data and map data for river features. This can be used for predicting flood patterns and identifying areas in danger. By combining this model with address data, the likelihood of individual properties being flooded can be assessed. This is not just of environmental concern, but of great value to insurance companies.

Agricultural Land Analysis

The analysis of farmland requires detailed information on soil type, drainage, land cover, and land use. Similar information is needed for mineral resources and forestry. The example below shows agricultural land overlaid with vegetation type.

Figure 10.25: Agricultural Land Analysis



This example also highlights the beneficial possibilities of cooperation between agencies. For example, the farmland map could also be used to assist in fire risk management, using tree coverage as a fuel source. Cooperation between assessors and planning and zoning offices can facilitate acquisition of information on new structures, the demolition of old structures, and changes in land use and zoning.

Environmental Impact Analysis

GIS can be used to simulate the construction of a new feature which may have an impact on an area's natural beauty. For example, consider a plan to build a wind farm. A realistic 3-D model can be created and viewed from all angles. This will help identify the optimal location for the wind farm both in terms of best wind and minimizing environmental impact.

Figure 10.26: Environmental Impact Analysis

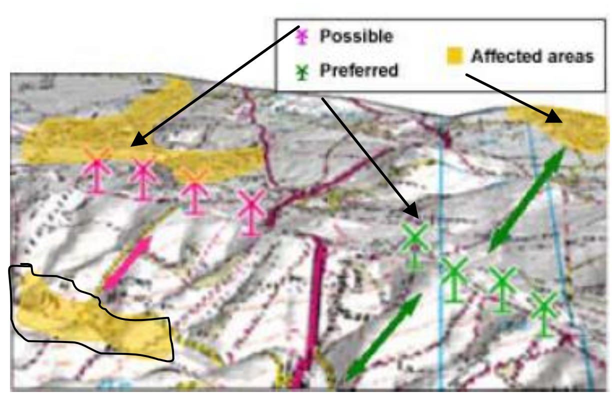


Figure 10.27: Retail Location Analysis

Retail Location Analysis

Supermarket chains use GIS to help site new stores and to plan their distribution networks. By comparing how many people live within 15-minutes drive-time of a particular location with the number of supermarkets already trading in that area, the GIS can identify suitable locations within an optimized catchments area. Supermarket chains also use socio-economic data to create profiles of the people in their catchments areas to help them understand which other parts of the country are likely to be successful growth areas.

Internet Mapping Sites

The Internet and computerized maps work well together. Maps provide the visualization of information, while the Internet provides access to the information.

There are literally millions of webpages containing map images. Although this on its own does not really constitute GIS, there are some features that, when used in conjunction with map-based image content, can replicate some simple GIS-like functions within a standard webpage. Links between the map and text are created to provide a GIS feel when querying the map.

There has been a remarkable explosion in the last few years of websites offering the creation of maps for anywhere in the world, to any level of detail, based on user-defined parameters. The basic function of these sites is fairly standard: the user has a range of options for selecting a location, including place name, postal code or zip code, full address and grid location. There will be a zoom function and an ability to move around at a given scale in any direction. The key point is that the map image delivered to the page is generated dynamically on the server; it is not a pre-prepared static image.

The range of Internet mapping sites is very diverse: some use purpose-built software, some use off-the-shelf Internet GIS software, some use raster imagery, some generate custom maps from vector data,[1] and some provide printer-friendly versions.

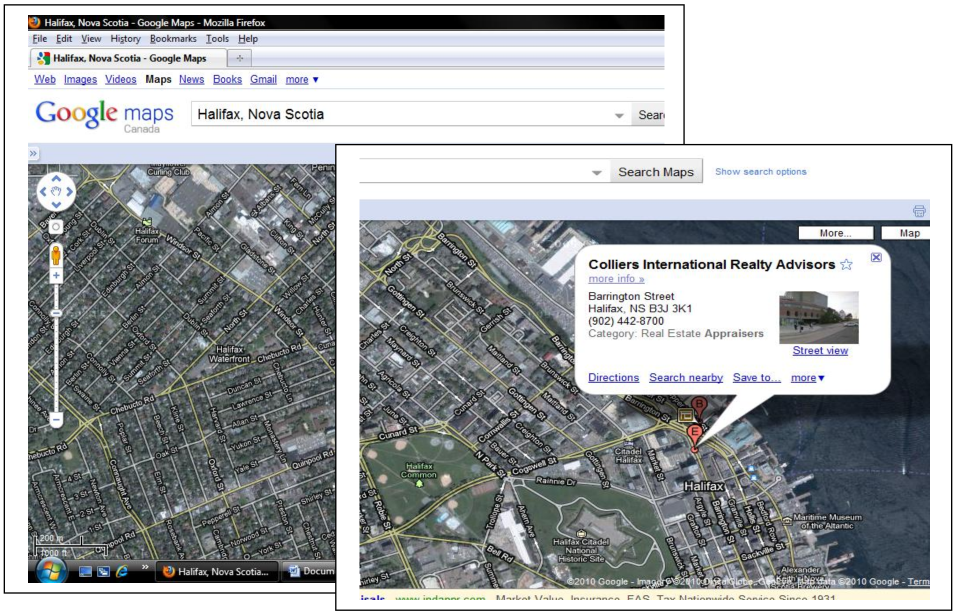
For some examples, go to the following websites:

- *www.earth.google.com*
- *www.maps.google.com*
- *worldwind.arc.nasa.gov*
- *www.maps.bing.com*
- *www.mapquest.com*

Below is an example from Google Maps for the city of Halifax. You can select the image as a road map or satellite image, as shown below. The maps integrate with Google's database, providing a powerful GIS function. Try typing "Halifax appraisers" in the search box above the map. The program then adds place markers for appraisers; clicking on the marker brings up tabular data for the specific appraisal firm including a link to its website.

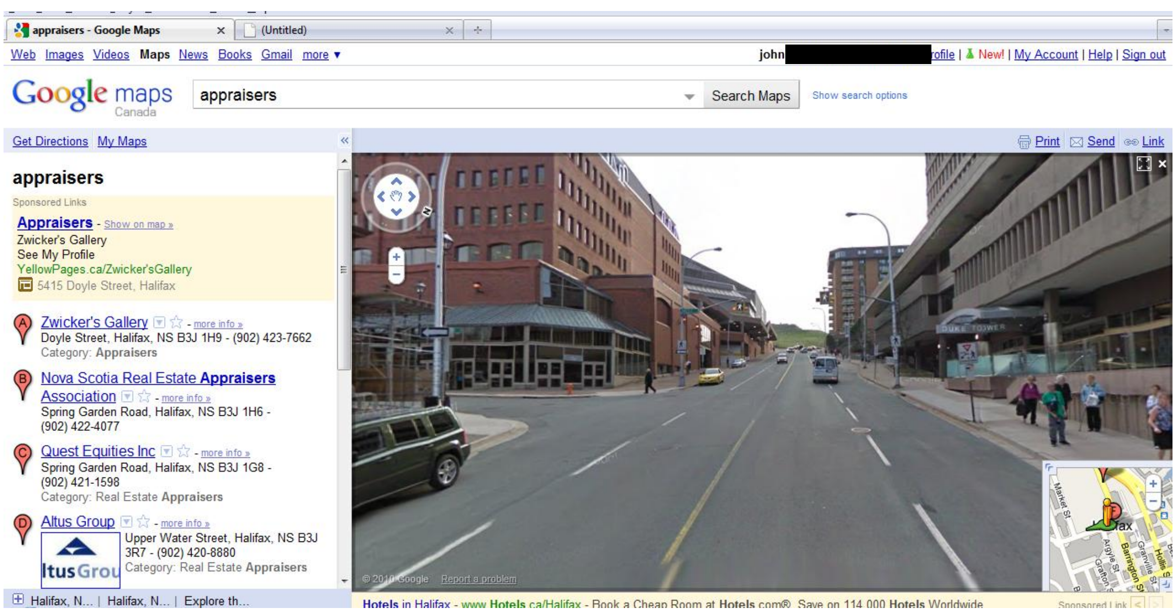
[1] Raster and vector images are two kinds of computer graphics. Raster images are composed of individual pixels (tiny dots make up the graphic), while vectors are composed of paths (the graphic is made up of lines, curves, and polygons based on mathematical equations).

Figure 10.28: Google Maps – Example of Business Search



Google Maps also provides a "Street View" application for many Canadian cities, allowing users to view street level imagery, with the ability to pan and zoom. A very powerful real estate tool!

Figure 10.29: Google Maps – StreetView



Google Earth is another powerful mapping program that can be downloaded from *http://earth.google.com*. It allows dynamic satellite map searches of any spot on the planet. North American and European urban areas typically offer the highest resolution images, right down to cars in driveways. Google Earth offers 3-D capabilities, with tilt and rotate tools. It is fun (and informative) to do 3-D "fly-bys" of landscapes and buildings. The program also provides several GIS overlays for businesses. The example below shows a 3-D image of Vancouver, overlaid with street names and hotels.

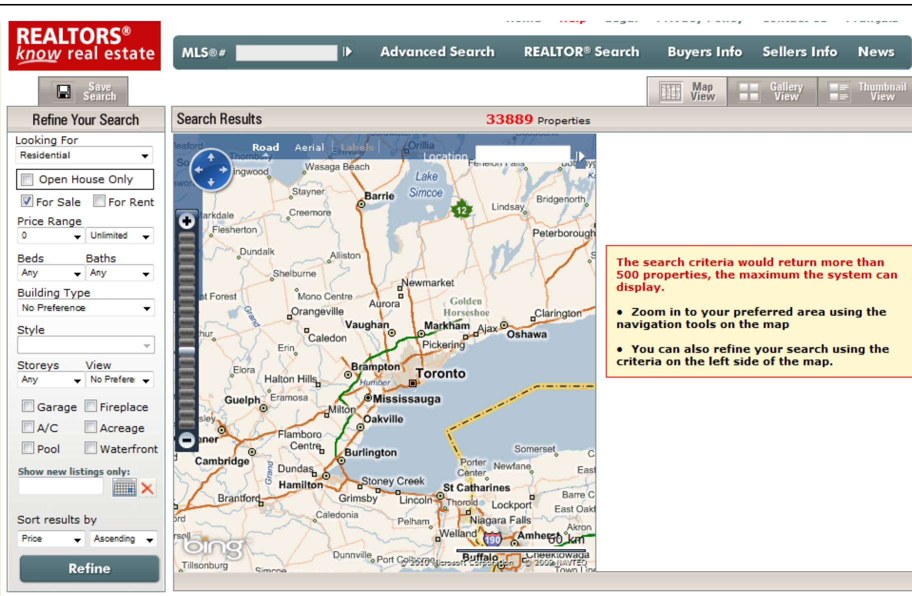
Figure 10.30: Google Earth Example

Real Estate Sales

GIS is an excellent tool for providing information to potential real estate purchasers about properties for sale in a particular area. By allowing selection based on characteristics such as price, number of rooms, or type of house, the display can instantly show the range of properties meeting the customer's requirements. The system can then go on to provide information about the local amenities such as schools, shops, and recreation facilities. Several of these systems are available on the internet.

For one example, you may wish to try searching for a property in Canada using the Multiple Listing Service: *www.REALTOR.ca*. The example below shows how the database is queried by interacting with the map to narrow down the geography and then refining the search based on a number of attributes.

Figure 10.31: REALTOR.ca



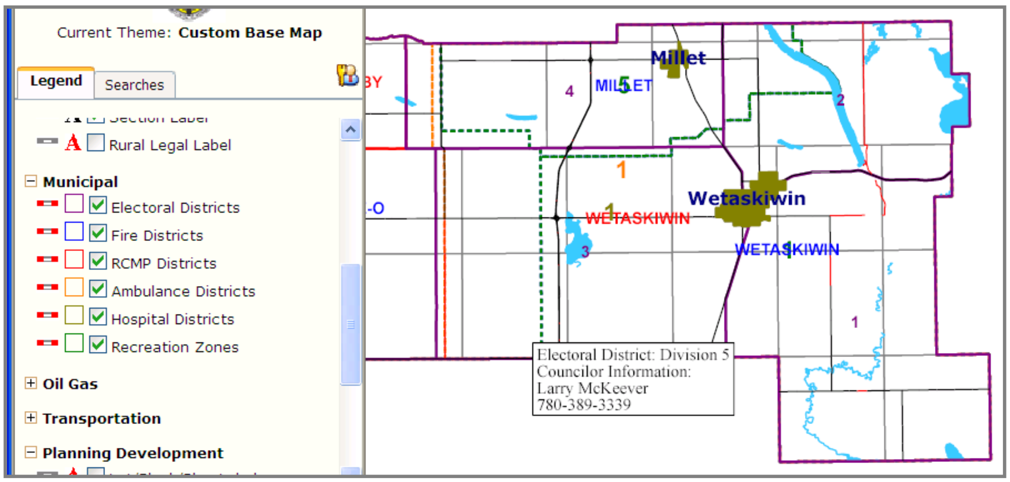
GIS Uses for Government Administration

Administrative boundaries show emergency response districts, service areas, and so on. They are generally more flexible than property boundaries and electoral boundaries. They are set by specific departments of local, provincial, and federal governments.

The raw data for these boundary layers can come from an organization's Planning and Development department, the Agricultural Services department, the Public Works department, and other departments such as Protective Services and Recreation/Tourism.

The GIS example below illustrates administrative boundaries such as electoral districts, fire districts, RCMP districts, ambulance districts, municipal districts, and recreation zones.

Figure 10.32: Administrative Boundaries



GIS Uses for Transportation and Infrastructure

Public works departments manage many types of data that can be included in the organization's GIS. Since the majority of public works GIS data is road or roadside-related, it requires a spatially-enabled road network in order to display, on the map, its work activities. They may include the following:

General Activities:

- Approaches
- Road work
- Roadside furniture such as signs, culverts, bridges, and guard rails.
- Routing (fleet and emergency services dispatch)

Urban-Specific Activities:

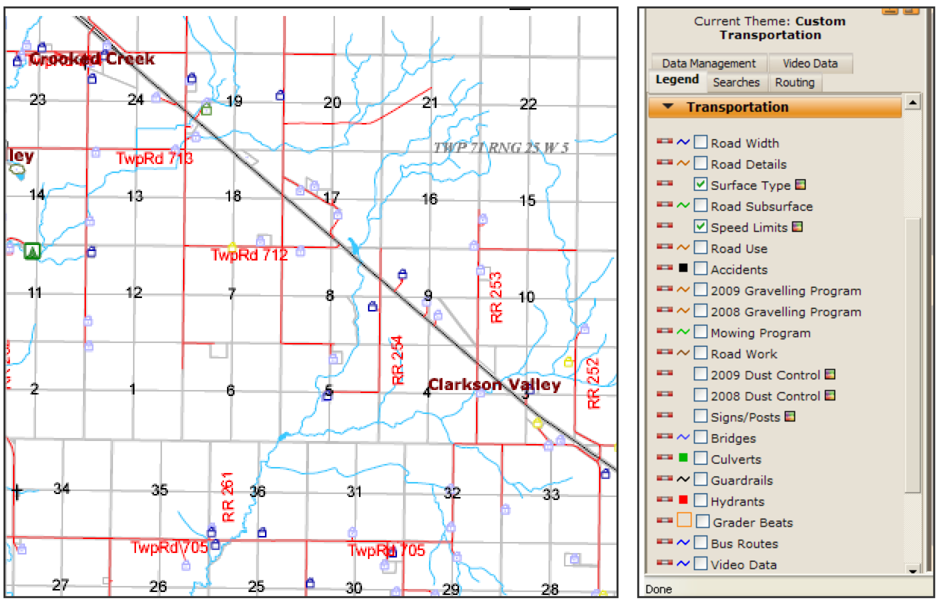
- Pavement crack filling
- Paving
- Snow removal
- Street sweeping

Rural-Specific Activities:

- Gravelling programs
- Road use agreements
- Grader beats
- Brushing
- Spraying
- Dust control
- Road bans

The example below illustrates a Single Line Road Network (SLRN)[2] in a GIS, along with the transportation features that can be displayed.

Figure 10.33: Single Line Road Network



Infrastructure Asset Inventory

Public works departments can also use GIS to manage the organization's infrastructure assets. GIS can be used to spatially-enable the organization's inventory of infrastructure assets such as:

- Signs
- Posts
- Culverts
- Gas/water/sewer lines/valves
- Hydrants
- Man-holes/catch-basins
- Street lighting/traffic lights
- Curbs/gutter and sidewalk panels
- Guide rails
- Trees
- Road conditions
- Control boxes
- Utility boxes

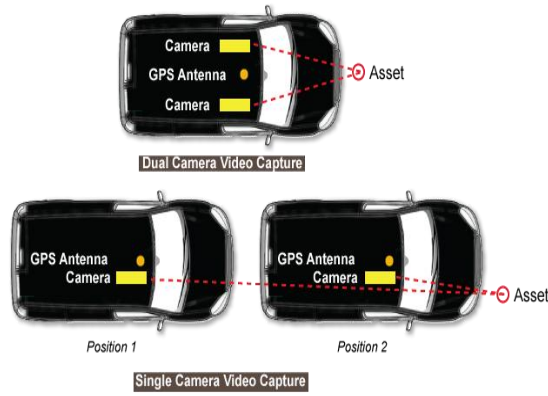
[2] A Single Line Road Network (SLRN) is used to manage road-related information in a GIS. A SLRN is made up of intelligent geo-spatial segments that represent the centre-line of a road network. A SLRN is the foundation for all road-related GIS data sets and applications such as Automated Vehicle Location (AVL) and Infrastructure Management Systems (IMS). The National Road Network (NRN) is a spatial compilation of all the Provincial and Municipal roads across Canada and provides the base for many municipal Single Line Road Networks. The National Road Network is maintained by GeoBase (*www.geobase.ca*).

All of these asset types can be given precise GPS locations, attributes, and condition ratings to promote the effective management of the organization's infrastructure assets.

Video Data Collection (VDC) is used to collect this data. A vehicle equipped with precision GPS records and digital video cameras drives the municipality's roads and captures all roadside assets within the view of the cameras. Precision video data can be captured from multiple directions simultaneously and at normal driving speeds. The data is then downloaded, reviewed, and processed in an office environment. Technicians can determine the GPS locations and dimensions of any object that is visible in two frames of video.

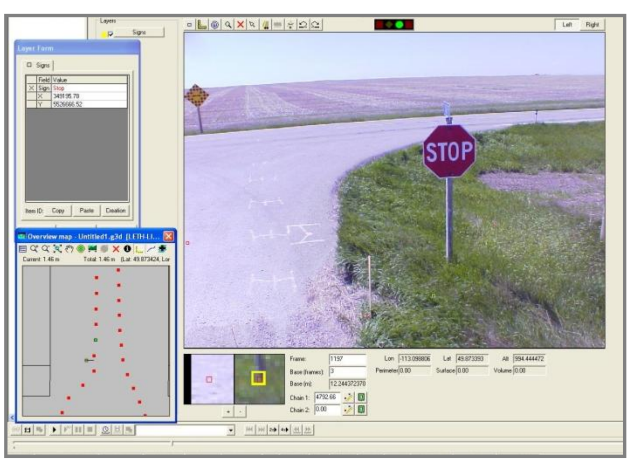
Figure 10.34: Video Data Collection

A sample Video Data Collection vehicle



Triangulation is used to calculate geographic positions and asset dimensions.

Any feature that is visible in two frames of the digital video can be collected. Urban property pictures can also be captured and exported for assessment services.



Using video data, GIS technicians can identify, attribute, and export the data into a GIS-ready format, all from an office environment.

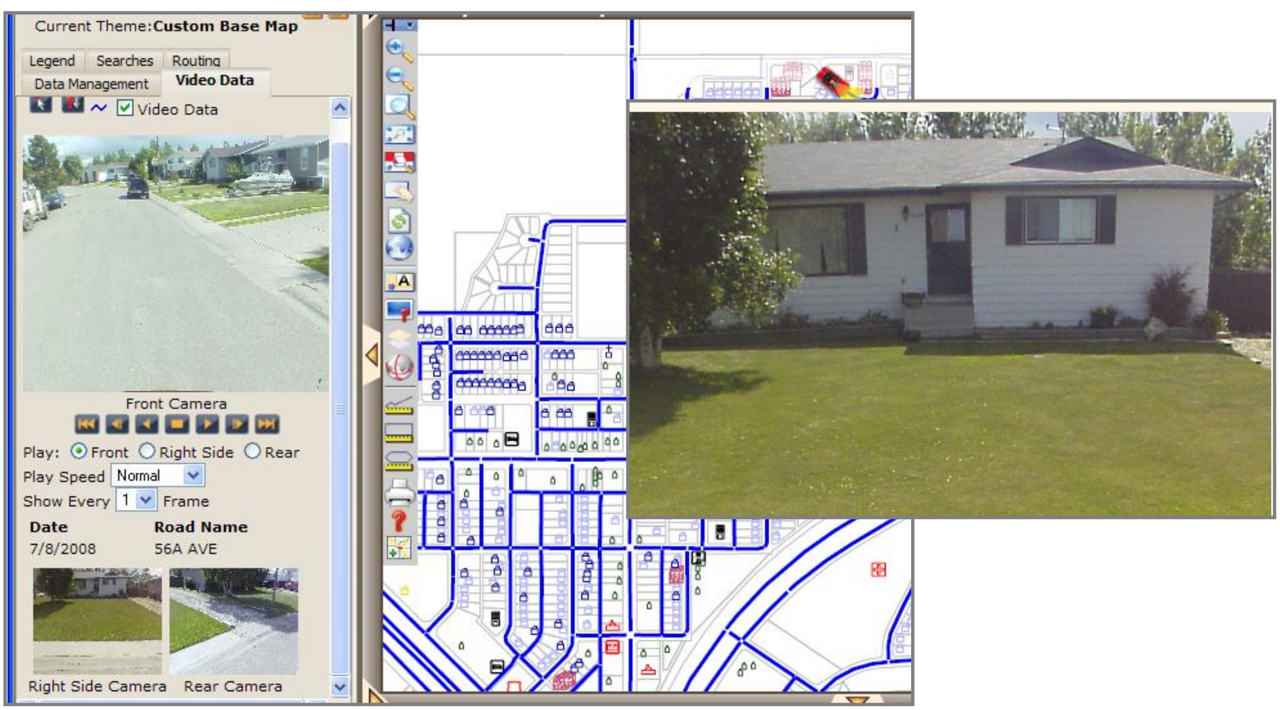
Video Data Collection technology can be used to perform the following:

- Inventory roadside infrastructure assets: signs, guardrails, and light poles
- Inventory urban equipment: drainage, fire hydrants, and manhole covers
- Review asset maintenance: review the condition of sidewalks, curbs, gutters, and road surfaces
- Take road lane measurements
- Create/validate Single Line Road Networks (for vehicle location and automated dispatch applications)
- Inventory electric distribution networks and telecommunication infrastructures
- Municipal property assessment/re-inspections: extract still images for each property

Video Data Collection offers the following advantages over traditional methods of data collection:

- Collect data faster and more safely
- Collect more information for one object at one time
- Measure objects from video footage
- Capture and attribute objects from the comfort of an office environment
- Re-process video at later dates to collect missed or additional objects
- Compare video footage from different time periods to compare the changes

Figure 10.35: Video Data Collection and GIS



An example of how VDC information can be incorporated into the GIS. Clicking on any frame of the video opens a larger version of the photo. This is particularly useful for property re-inspections.

Linear Referencing

Linear referencing is a way to create and manage road-related data. It uses the single line road network as a base and then creates linear events that are attached to a segment of the road network.

A linear event can be any attribute related to or near the road. For example:

- Speed limits
- Surface types
- Gravel programs
- Road work
- Signs
- Bridges
- Culverts
- Guardrails

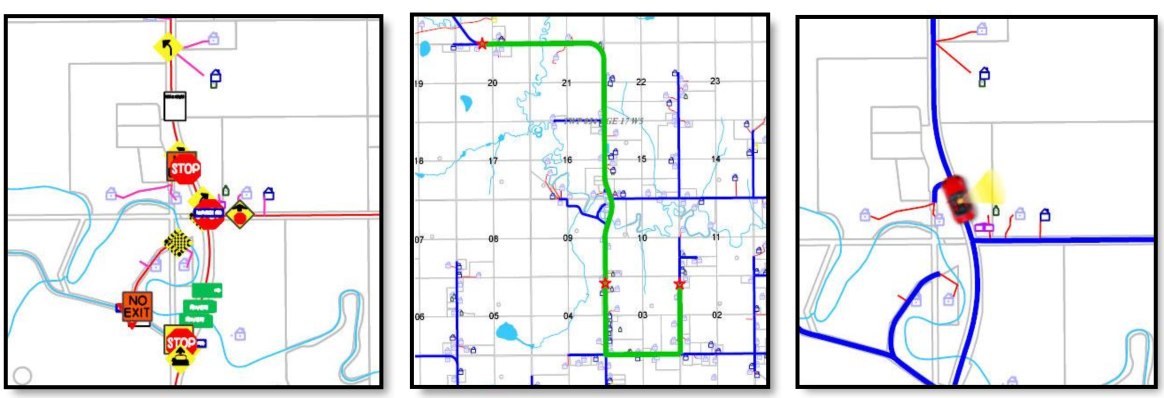
Benefits to the user:

- Create start and end points for a linear event (such as a speed limit) by clicking start and end points on the map or by entering start and end co-ordinates.
- Create offsets for infrastructure asset linear events (such as support structures or guardrails) that are located off the roadway.
- Run a validation tool to ensure there are no invalid event gaps or overlaps. For example, you cannot have an overlap in speed limits.

Advantages to users:

- The linear referencing functionality can be integrated into the Infrastructure Management System for infrastructure costing and maintenance management.
- There is less data storage required because events are attribute-based.
- It is simple to create and maintain events, can use mass populating.

Figure 10.36: Linear Referencing



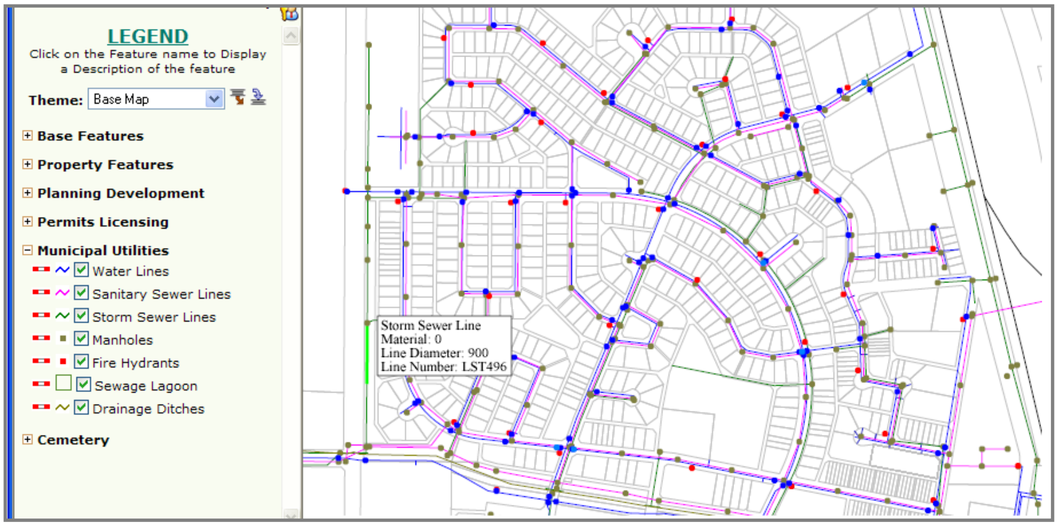
Linear Events Routing Video Logging

Linear referencing is useful in infrastructure asset inventorying, routing, video logging, and more

Underground Assets

GIS developers can incorporate all infrastructure asset types into the system. The as-built drawings for water, sanitary sewer, and storm sewer lines are digitized and then incorporated into topographically correct data layers.

Figure 10.37: Underground Assets



The preferred format of the as-built drawings for underground infrastructure asset data is as follows, from best to worst:

- **Geo-referenced digital data**. This format is preferred because it requires minimal digitizing and data cleansing to produce the data in GIS format. If the organization does not have this data, it may be able to obtain it from their engineering consultants. Many new engineering plans are or can be provided in a digital geo-referenced format. However, legacy plans may not exist in digital format. Nearly all GIS and CAD data formats are acceptable for submitting this type of data.

- **Non-geo-referenced digital data**. This format requires more time and effort than geo-referenced digital data, but still saves developers from having to completely digitize the drawings. Again, this data can sometimes be obtained from the organization's engineering consultants.

- **Hard copy plans**. If digital data is not available, the underground infrastructure assets will be digitized using the hardcopy plans. This is the most time-consuming of the options. Depending on how the plans were drawn, they could be scanned into a static digital format and digitized using a process called "heads-up" digitizing. Or they could be digitized conventionally, by hand using a digitizing table/tablet.

GIS Uses for Agricultural Services

Organizations can incorporate all types of agricultural data into the GIS. For example, no spray zones, spraying routes, chemical types, weed infestations, crop types, and crop outputs.

Farmland Assessment Digitizing

Farmland assessment was traditionally a time-intensive process, requiring assessors to draw the farmland fields on each parcel on hardcopy reproductions of a municipality's ortho photos. Each field would then be rated, its area estimated, its arability/soil ratings determined, and then recorded on farmland assessment sheets before being input into the assessment/CAMA system. Every time the municipality chose to update its farmland assessment, the entire process would have to be re-done from scratch using the municipality's latest ortho photos. Conducting a full assessment would take many months, sometimes years to complete.

Since this method is such a large undertaking, municipalities often do not have sufficient time or resources, or enough cost-benefit, to keep their farmland assessment information as up-to-date as the rest of their assessment data. Therefore, this assessment dataset, although an important aspect of the municipality's assessment, is often maintained to a lesser extent than it should be.

GIS technology, however, is revolutionizing how farmland assessments can be performed and maintained. Rather than drawing on hardcopy ortho photos, farmland fields are digitized into their own GIS data layer using the ortho photo as the background. As the fields are digitized into GIS polygons, their areas are automatically calculated and their attribute information entered directly into the GIS layer. Once all the farmland fields are digitized and attributed, the information is then imported into the Assessment/CAMA system.

The digitized farmland data layer then becomes the starting point for any subsequent updates to the municipality's farmland assessment. This eliminates the time-consuming drawing of fields and estimating their areas, making regular farmland assessment more feasible. Farmland assessment updates require only a new set of ortho photos, a copy of the farmland GIS data layer, and the assessor to review all the parcels in the municipality and make adjustments to the farmland field polygons where the new ortho photos indicate changes to the fields. Since all of this data is managed digitally, once the updates are done, the farmland assessment information is re-imported into the Assessment/CAMA system to automatically update the farmland assessment information.

The example below shows farmland fields spatially enabled into GIS polygons. These polygons are then linked to field attribute data contained in the CAMA system, allowing the farmland assessment process to be managed and maintained digitally. Clicking on a field displays the linked associated farmland information.

Figure 10.38: Spatially Enabled Parcels

Roll Number	206784
Rural Legal	NE-33-69-26-5
Urban Legal	
Address	
Field Type	Arable
Irrigated	N
Total Rating	38
Total Area	157
Total Assessment	20771
Group ID	138040047
Field 1 ID	138022710
Field 1 Soil Group	Grey Luvisol
Field 1 Area	110
Field 1 Rating	37.5
Field 1 Actual Use Value	14438
Field 2 ID	138022711
Field 2 Soil Group	Dark Grey
Field 2 Area	47
Field 2 Rating	38.5
Field 2 Actual Use Value	6333
Field 3 ID	

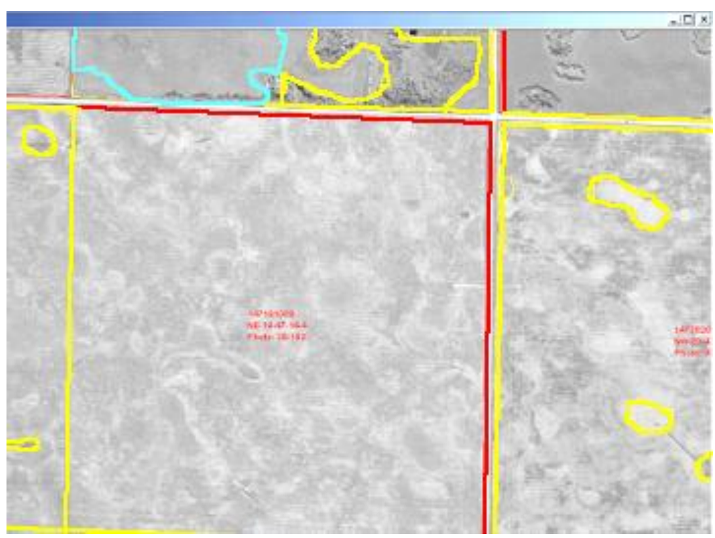
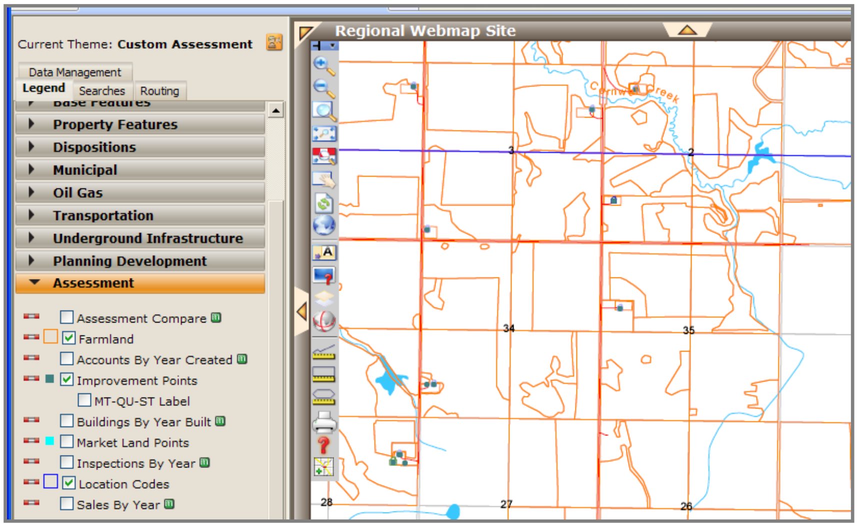


Figure 10.39: Attribute linkage through GIS



The agriculture/farmland theme of this GIS shows characteristics
such as arable ratings and pasture ratings

Mobile Data Collection and GIS

Collecting information electronically/digitally while workers are in the field is a very efficient and accurate way of collecting GIS-ready data. Using electronic forms, spreadsheets, and/or databases instead of paper-based forms and notes makes the data collected in the field much more transportable and allows it to be quickly and easily integrated into an organization's business systems.

Consider the example of a municipality conducting weed inspections and recording weed infestation areas. The inspector is given a tablet PC loaded with GIS software, GIS data, and electronic forms. A tablet PC is laptop computer that can be transformed into a tablet and operated using, instead of a mouse, a stylus which is a pen-shaped device used to draw or write on pressure sensitive computer screens. Equipment such as this lends itself well to collecting GIS-ready data in the field.

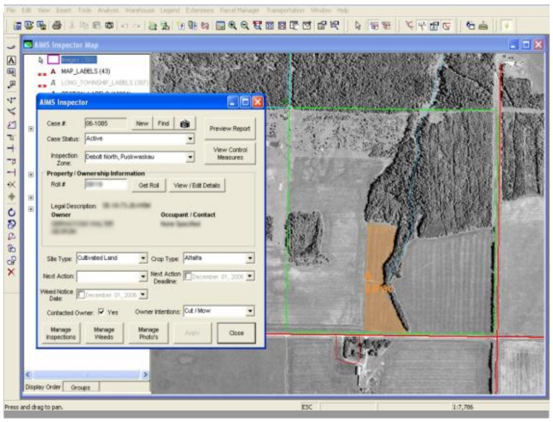
Figure 10.40: Tablet PC

The weed inspections data is incorporated into the GIS so that infestation areas and patterns can be quickly and easily diagnosed and addressed.

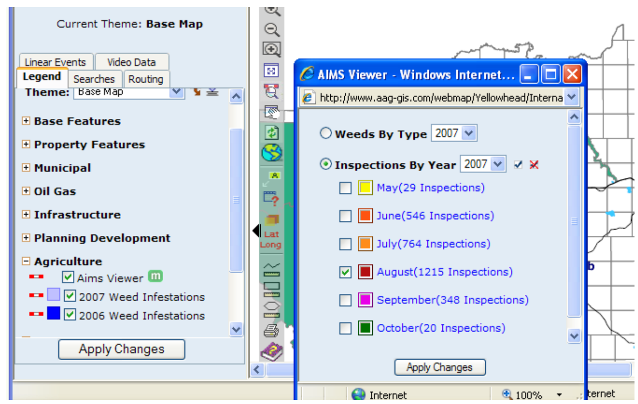
Infestation data recorded on paper can be manually incorporated into the GIS. Some inspectors use a tablet PC with a copy of their municipality's weed inspection database, update it with new weed inspection information, and then synchronize it back into the municipality's master database upon return to the office.

However, an automated approach allows all weed inspection and case information (including sketches of infestation areas) to be entered directly into the database using digital forms that not only speed up the data collection/input process, but also provides data consistency across multiple weed inspectors.

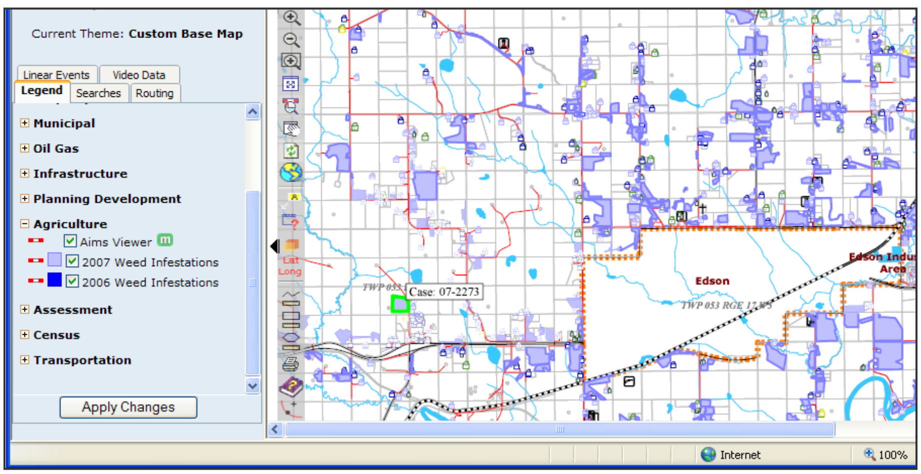
Figure 10.41: Digital Forms and GIS



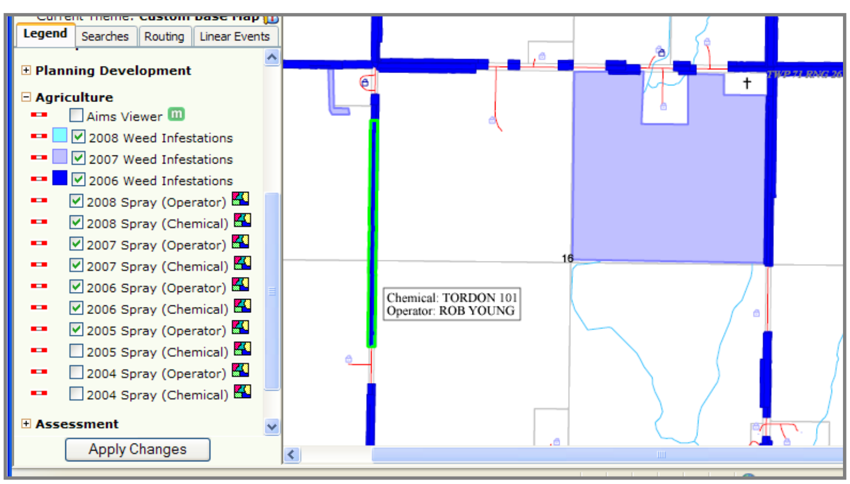
Using electronic forms in conjunction with
GIS Data and software



This GIS can display weeds by type or inspections
by year and month



This screenshot shows weed infestations by year



The spraying history / Weed infestations by type

Agriculture Uses of Automated Vehicle Location (AVL)

An organization's agricultural vehicles can be set up with AVL equipment to record their movements and activities, such as:

vehicle speed
chemical type(s) (on sprayer vehicles)
chemical coverage
targeted weed(s)
condition warnings such as excessive wind or vehicle speeds.

Figure 10.42: System Components of AVL in a Roadside Sprayer Vehicle

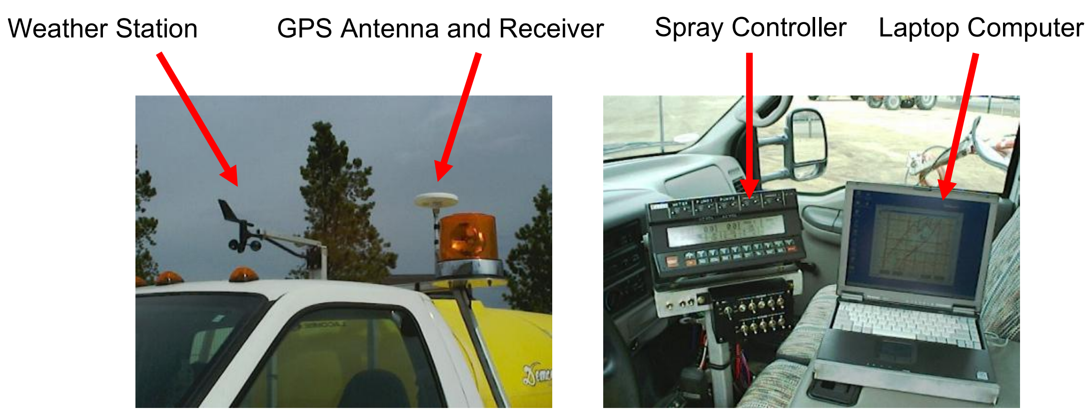
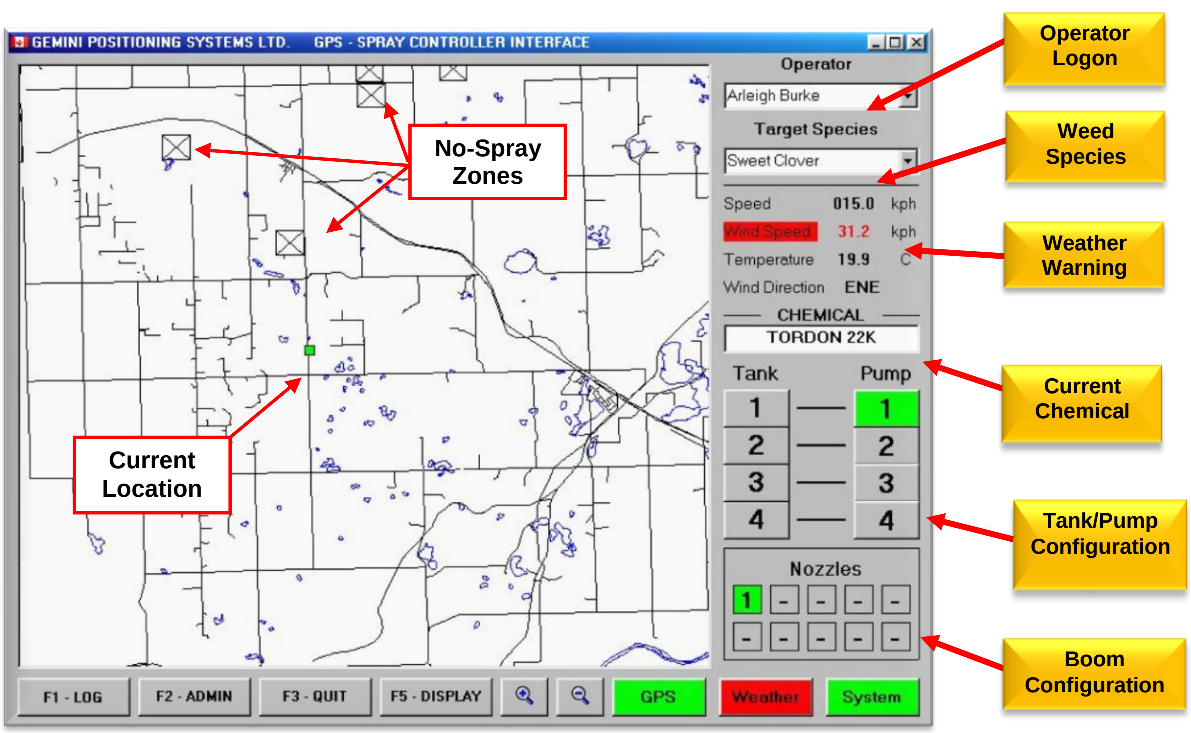


Figure 10.43: Operator Display Component of an AVL in a Roadside Sprayer Vehicle



GIS and Protective Services

Automated vehicle location (AVL) systems are used extensively in protective services.

AVL can be used in Special Constable Vehicles for monitoring location (helps to comply with "Work Alone" legislation) and to collect data on vehicle speed, when the flashers were activated, what roads were travelled and when, and so on. This information is valuable for incident reporting and reconstruction of events for evidence submissions. Hot buttons installed into the AVL system can also be used to identify incident locations or notify dispatch of a specific event (such as an officer leaving the vehicle).

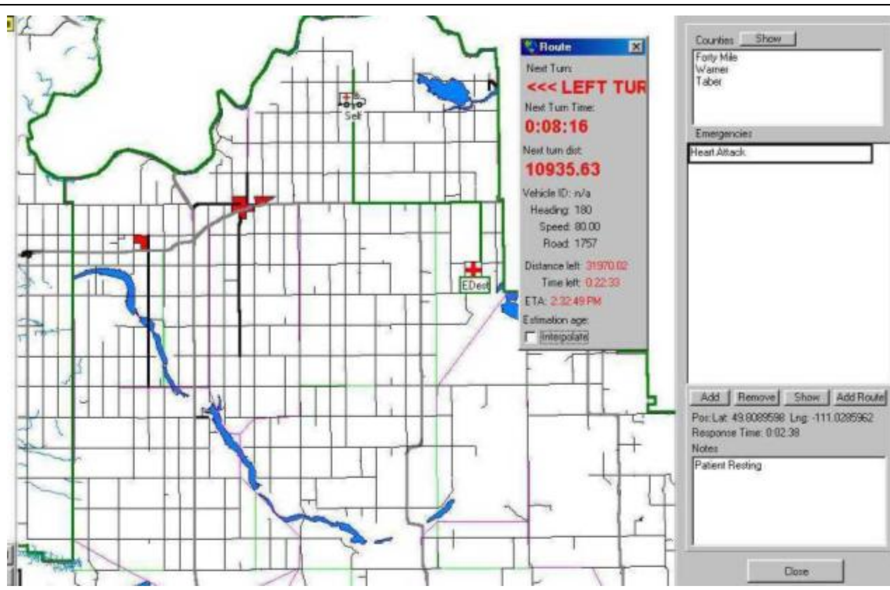
Figure 10.44: Routing Display Installed in an Emergency Services Vehicle

Fire vehicles and ambulances can be equipped with AVL equipment that will dispatch them to a specific location and provide navigation information on the shortest or fastest route depending on road conditions and maximum road speeds. Emergency service vehicles can be re-routed to another location or along another route if the dispatch operator receives additional information about route conditions such as road closures, construction, or flooding. All this can be done while the dispatch operator monitors each vehicle's movement in real-time. While the vehicle is dispatched, it is continually collecting information about its speed and location. This information is stored within the AVL software and can be used to generate reports on response times.

Incident Tracking

Protective Services personnel can use GIS technology to track the locations of incidents they respond to. They can enter attributes such as incident type, actions taken, and incident severity. These incidents can then be displayed on a map and queried in multiple ways to conduct various types of analysis or to identify the number of incidents responded to in a given time period.

Figure 10.45: AVL system using GIS data to provide route planning and tracking for emergency vehicles



Local Features and Services

Local features and services can be created as GIS data layers and made available to the public via a public web viewer site linked to the organization's existing web site. These may include:

- Points of interest: landmarks, historical locations
- Municipal facilities: arenas, landfills, municipality buildings
- Recreational facilities: ball diamonds, soccer fields, campsites, golf courses, hiking/biking trails

Much of this data already exists in the municipality's CAMA (computer-assisted mass appraisal) system and therefore it would likely take minimal effort to re-purpose it into easy-to-use, easy-to-access data layers for the public's use.

GIS can also aid in planning and managing park and recreation facilities and resources. For example, they can be used to:

- measure geographic, environmental, and socioeconomic attributes in relation to an existing or planned park or recreational facility;
- describe the spatial distribution of socio-demographic attributes in a given residential area;
- discover potential market segments;
- examine spatial relationships between existing recreational or natural resources and distances traveled from origins of potential visitors;
- use network analysis to minimize traveling time and find an optimal route;
- derive new variables (e.g., population density) from existing datasets; or
- track concealed damage of a forest fire in a national park.

Figure 10.46: GIS showing locations of a museum, ball diamond, library, and campground

GIS Applications in Assessment and Valuation

Real estate is a multi-disciplinary field, built upon foundations of geography, law, economics, and business finance. At its basis, real estate is focused on land, which means geography is crucial. Maps are an important part of real estate practice since exact location and boundaries are necessary to value or sell a property. For property taxes, an effective assessment system must have accurate information on exactly what is owned, in order to ensure all taxable land is assessed and no land is assessed twice.

As the computing requirements of GIS become more accessible and data sharing becomes more the norm (although often fee-based), the use of GIS is becoming more widespread. As discussed, real estate sales is starting to adopt GIS for its visual capabilities in marketing. Appraisers and consultants are increasingly using GIS as a research and reporting tool.

The focus of this section is to illustrate a variety of uses for GIS in real property valuation and assessment. While many of the examples are from assessment organizations, we encourage readers to consider how these applications can be extended to other areas of real estate. Many of these processes are equally useful to any value-focused area of real estate, and these applications will become increasingly accessible in future with the continued reduction of data and computing barriers.

An old adage is that the three most important real estate attributes are location, location, and location. GIS helps appraisers and assessors to better visualize location. While tables of data can provide extensive raw information, maps add a visual dimension in illustrating the distribution pattern of high and low values.

The following are appraisal-related processes that a GIS can help with:

- Market analysis to highlight the impact of location on value
- Evaluating the distance or drive-time to suppliers and customers to help users determine the most efficient location for a warehouse, plant, or shopping centre
- Evaluating the development potential of a parcel of land by overlaying boundary lines with characteristics such as soil type, topography, and flood data

The following are assessment-specific processes that a GIS can assist with:

- **Assessment Compare***: displays changes in the assessment base from year to year, illustrating the assessment change for specific properties, identifying new accounts or new buildings, displaying the assessor's inspection locations, displaying sales relied upon in the analysis.
- **Improvement Points***: illustrates every building assessed within the municipality. These are derived from the assessment records that are updated annually.
- **Market Land Points***: provides every market land record within the assessment system.
- **Location Codes***: illustrates the divisions the assessor uses to help break-down a larger area into specific market locations.

* Terminology Note: This lesson uses some vendor-specific terminology that may not be universally-applied terms. These terms are defined within this lesson to explain the GIS processes to be illustrated, but please note they may differ depending on the assessment agency/appraiser/GIS supplier.

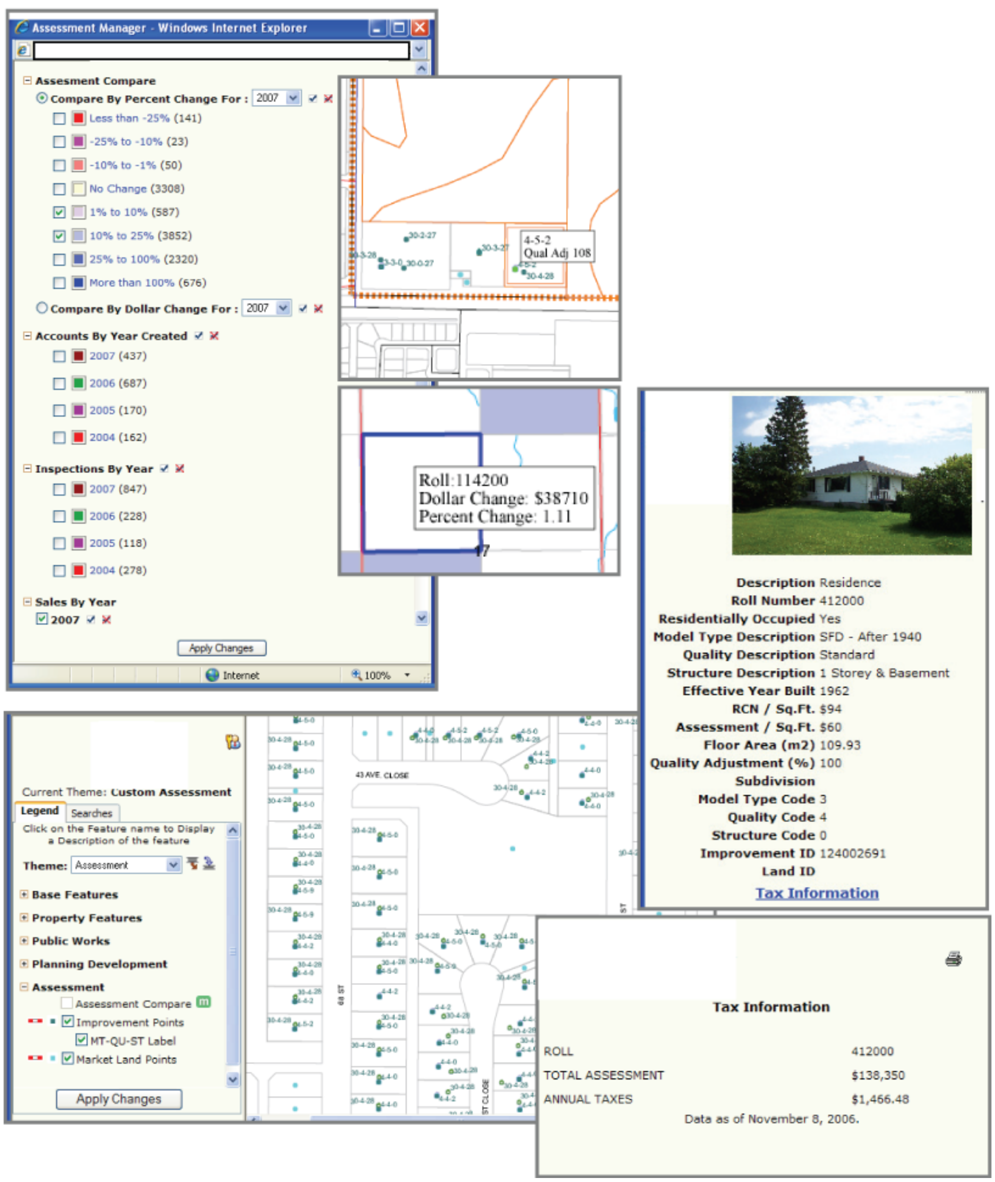
Using a GIS in data collection can improve the subsequent data exploration and analysis. For example, an orthographic photo layer of a GIS can show how positive/negative influences, such as roadways or parks, interact with a property or group of properties. By attaching a photo of the property to the roll number and linking them within the GIS, it is easy and quick to check for exterior upgrades.

GIS can also be used to plan and prioritize a large field data collection project. Assessors can plan next year's field work by viewing a thematic map of areas that have not been inspected as of a certain date.

A GIS can link an organization's tax and financial information and assessment information with other data sets such as development permits and subdivision applications, public works, and recreation/tourism services.

Because a GIS incorporates so many levels and types of data, assessors often become data custodians for a large amount of data used by other departments such as Planning and Development.

Figure 10.47: Sample Screenshots of GIS used for assessment and appraisal



Valuation-Focused GIS Applications

Appraisers are increasingly using satellite and oblique aerial imaging to view and verify property structures.

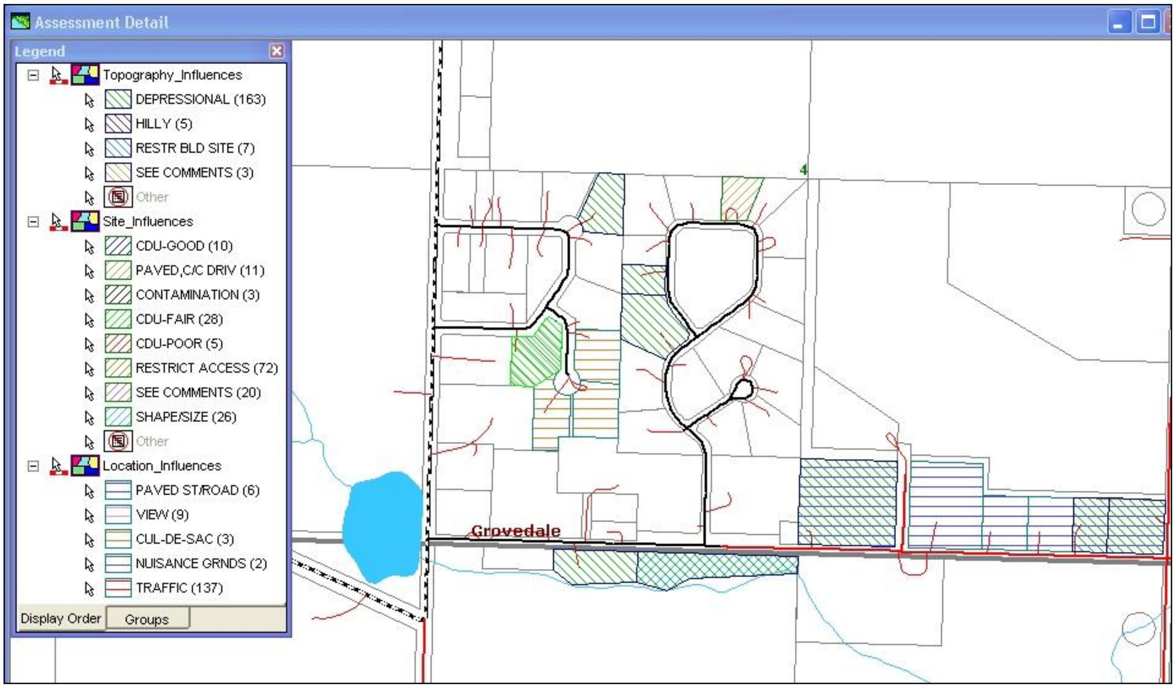
Figure 10.48: Satellite Imagery

Viewing repeated images of the same property over time allows the appraiser to identify changes in structures and use. The figure below illustrates how change detection software can automatically identify changes to existing or new structures. The image at left is older, updated on the right. You can see the rectangular building has been rebuilt and the L-shaped structure near the bottom demolished.

Figure 10.49: Change Detection

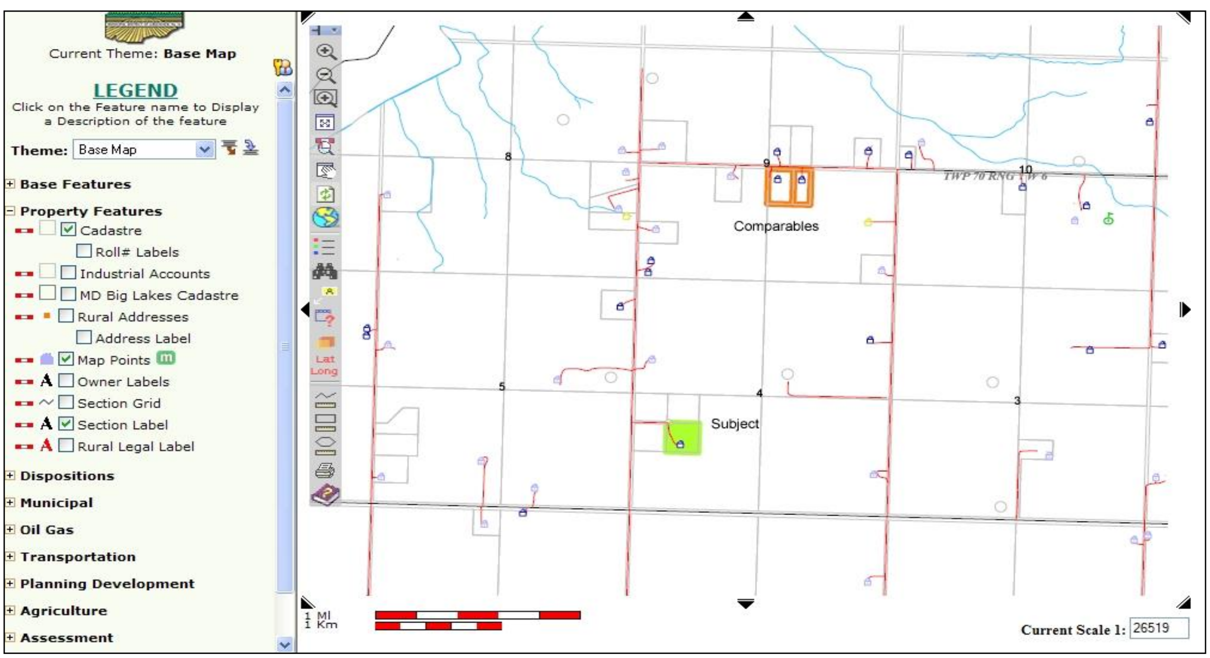
Appraisers can use influence mapping to quickly analyze property characteristics of interest related to topography, site attributes, location, and others.

Figure 10.50: Influence Mapping



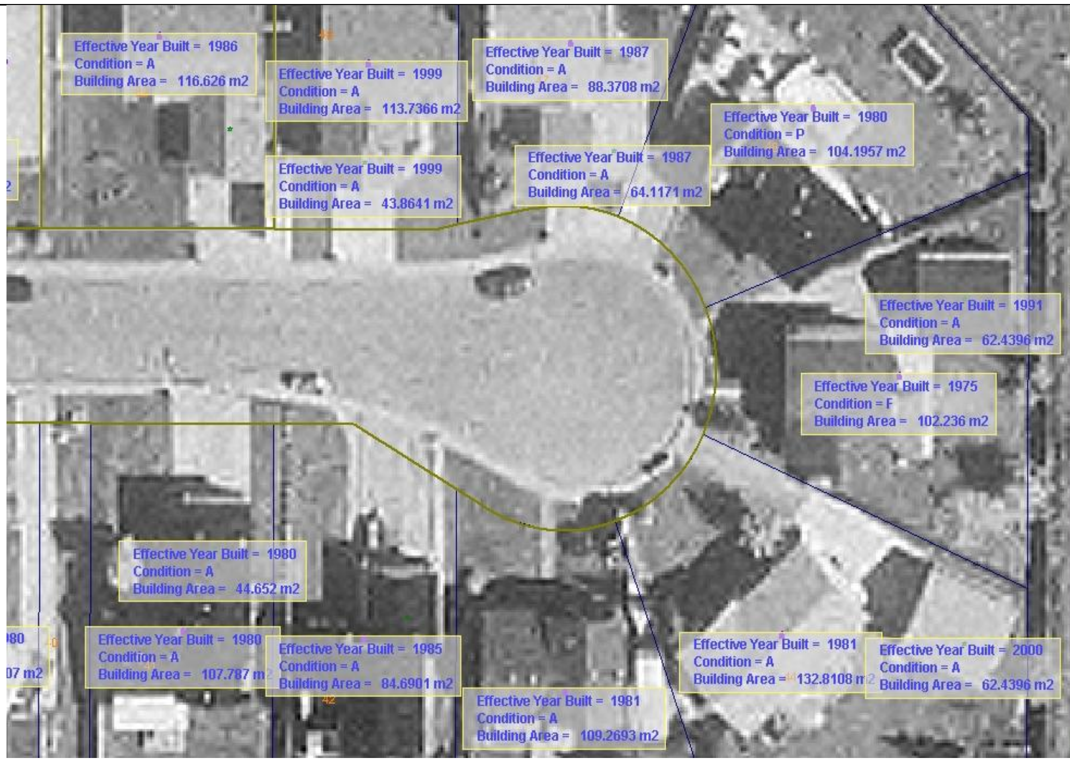
GIS can be used to highlight the location of comparables and proximity to influences that might affect value.

Figure 10.51: Comparable Sales Map



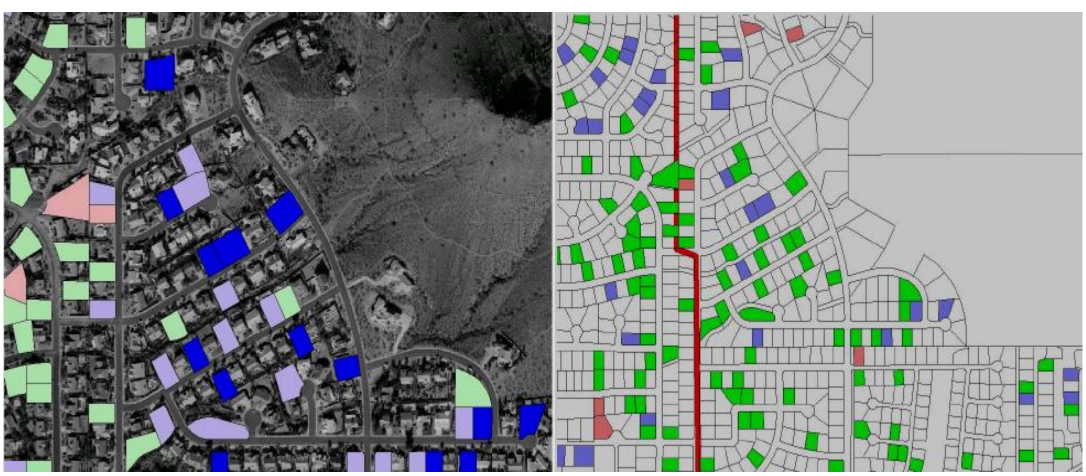
The figure below illustrates how the appraiser can quickly review the age, condition, and size of properties, which helps to quickly identify comparables.

Figure 10.52: Comparable Sales Map with age, condition, and size attributes



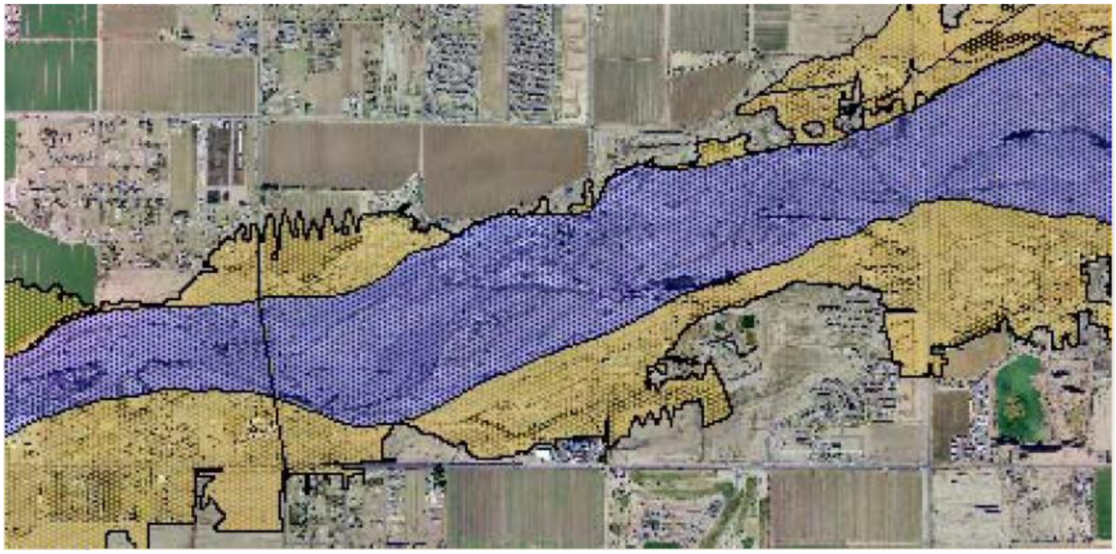
The figure below illustrates a neighbourhood analysis, showing two views of the same neighbourhood with aerial photography and thematic mapping. The colours and shading can represent property characteristics such as assessed value, sale price, age, and size, which can be useful in defining neighbourhood boundaries or comparable sales.

Figure 10.53: Neighbourhood Analysis



The figure below illustrates a flood plain, showing the average annual high water mark (in blue in center) and the 100-year high point (wider boundary, in yellow). This helps the appraiser determine what deduction may be necessary for flood risk for a given property. This highlights again how GIS can integrate data from numerous sources – this type of map could help in analyzing zoning; soils; airport "nuisance" zones; school districts; political jurisdictions; and other physical, social, governmental, and economic divisions.

Figure 10.54: Flood Plain Analysis



An appraiser can add distance analysis to the models by including such variables as distance to work, schools, shopping, churches, recreation, and other attractive and unattractive features. The figure below illustrates an analysis of value influence centres and location value response surface analysis.

Figure 10.55: Value Influence Centres

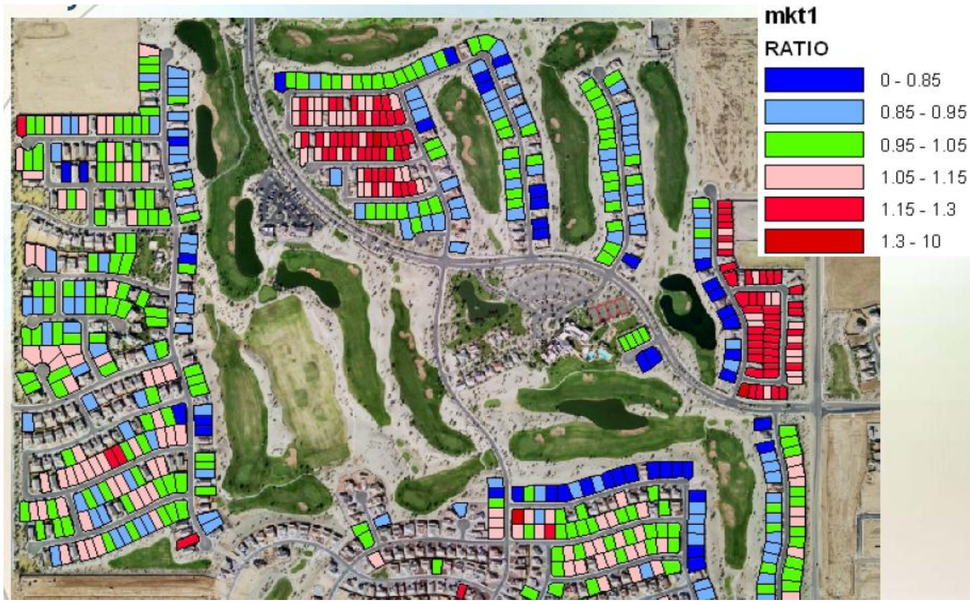
Assessment-Specific GIS Applications

We will now illustrate some GIS applications of specific benefit to assessment organizations.

Once the preliminary assessment roll is complete, the assessor can use GIS to quickly and easily isolate problem areas. The map below highlights where there may be problems with high and low appraisal/assessment ratios.

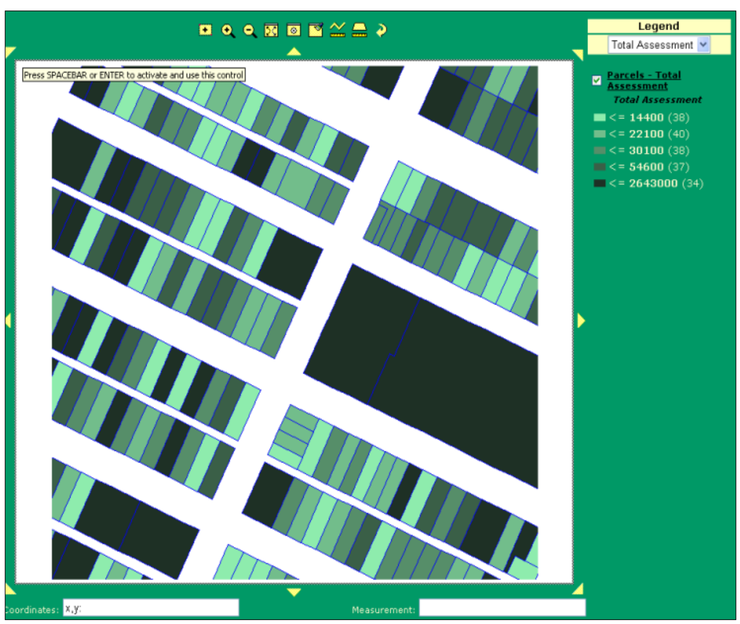
The neighbourhoods in top centre and middle right are both bright red, indicating high ratios. For some reason, these properties appear to be over-valued, so the assessor will want to review them to find out why. Similarly, the blue line of properties towards bottom right from centre, along the golf course, appear to be significantly under-valued.

Figure 10.56: Assessment to Sale Price Ratio (ASR) Analysis



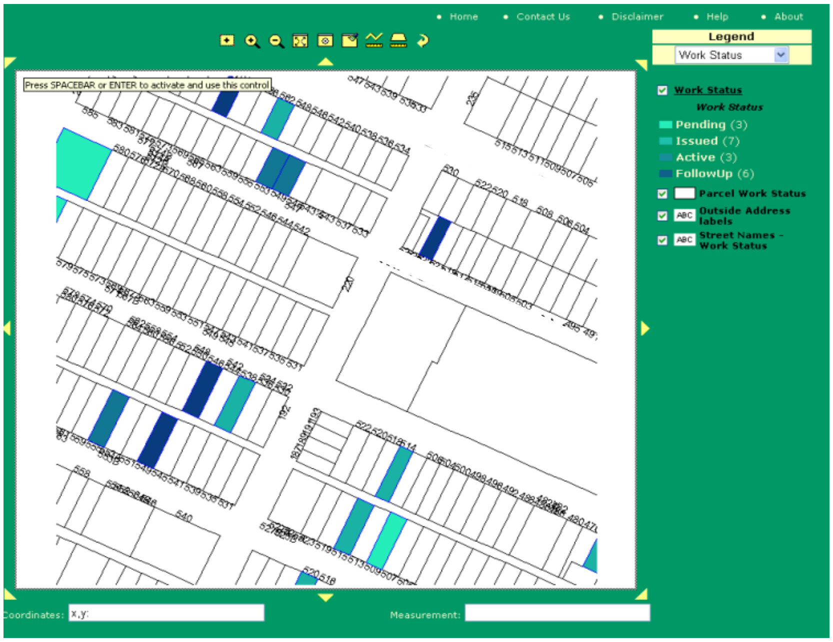
The figure below displays property assessments by value, which can also help with quality control.

Figure 10.57: Property Assessments by Value



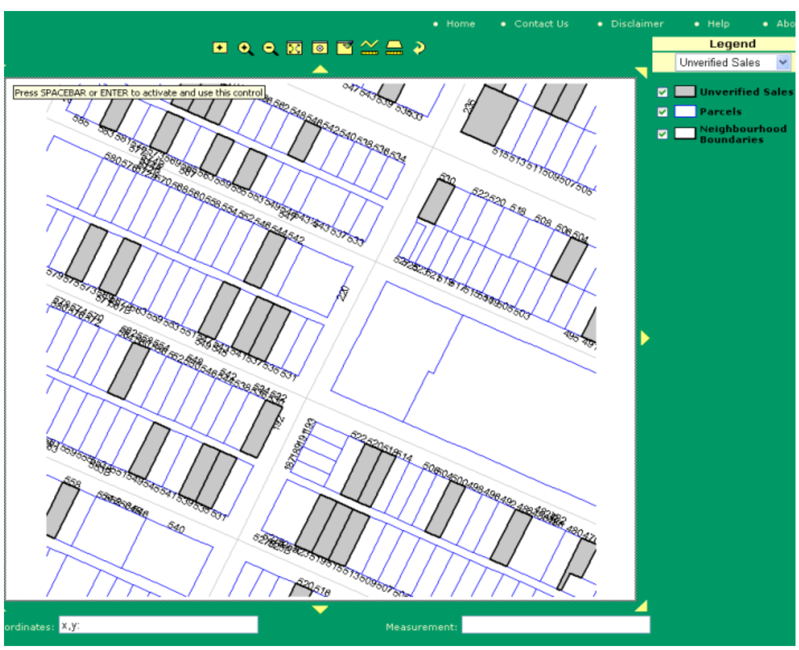
The figure below identifies properties by permit status, indicating the need for inspections. If the assessment records and planning departments are linked by GIS, it is easier for both organizations to keep records up to date.

Figure 10.58: Permit Status



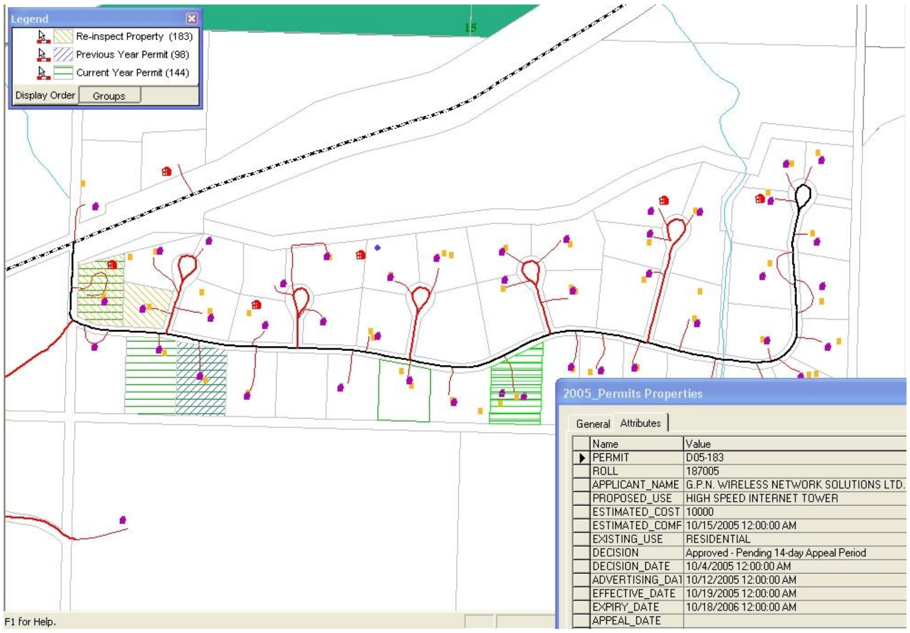
The figure below highlights property sales that need to be "verified" by inspection. This is a helpful quality control check for assessment staff.

Figure 10.59: Inspection Required Map



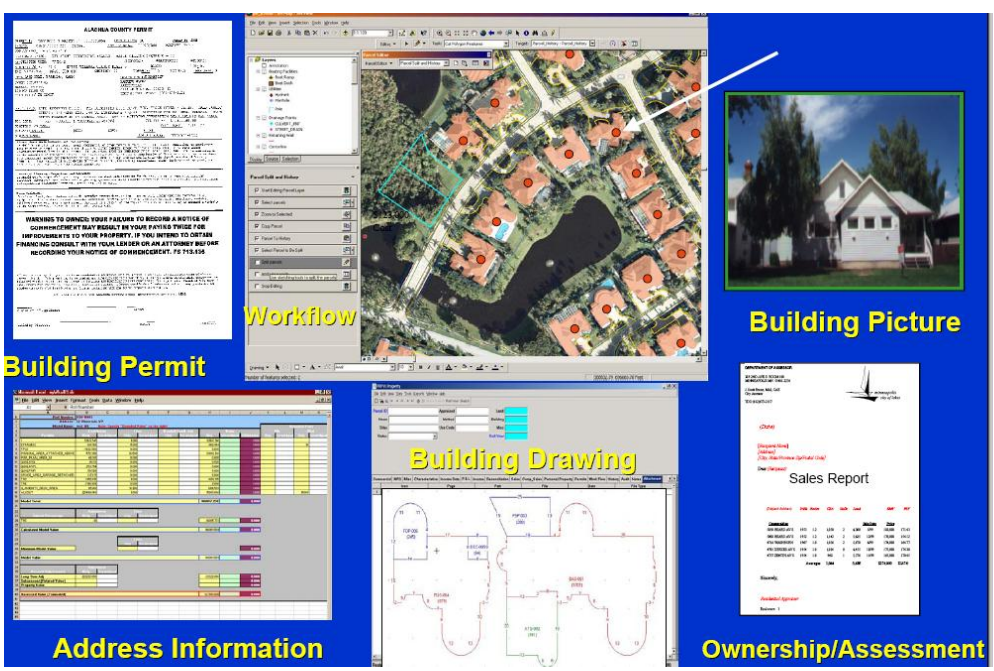
GIS can also help with general office functions. For example, consider the following map that develops an optimal routing plan for field inspections.

Figure 10.60: Field Inspection Routing Map



Finally, GIS can aid in customer service – having all the information about a particular property in electronic form is an aid in assisting property owners. The assessment jurisdiction (or office) can also consider some level of public access to assessment information using web-based GIS format. This can contribute to keeping the assessment function as open and transparent as possible.

Figure 10.61: Property Information at a Glance



Future Issues for GIS

Maps and geocoded data are the primary needs for effective GIS. A key to further advancements in GIS is the cost effective availability and continued updating of accurate and comprehensive location-based information.

Multi-User GIS Systems

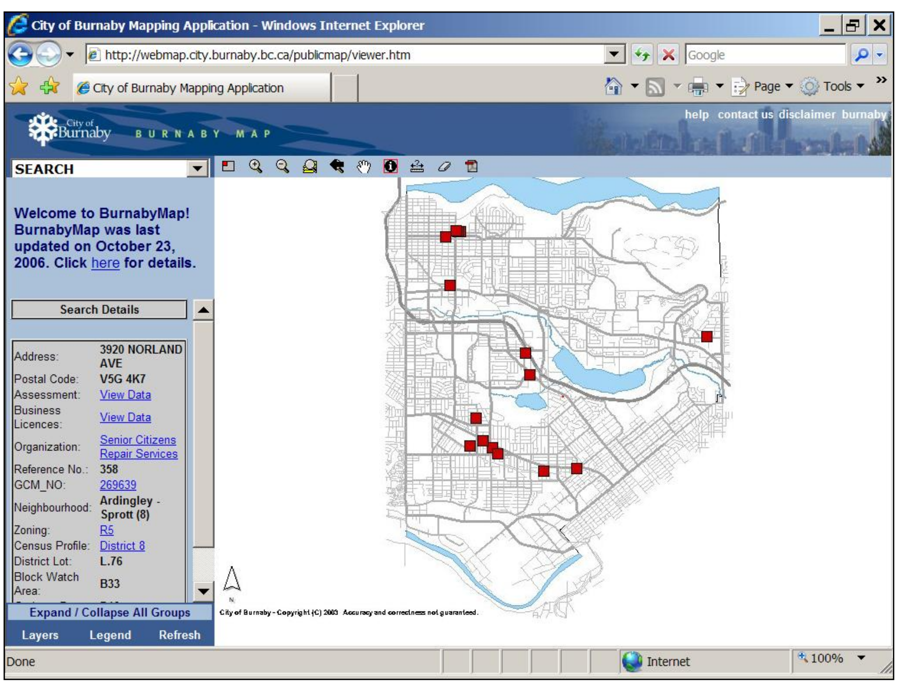
As discussed earlier, collaboration among organizations can bring numerous GIS benefits. A multi-user system reduces duplication of effort in updating records. For example, if the highway engineer's office changes road right-of-way widths in one layer, the system can adjust parcel boundaries, areas, and the accompanying property assessment records.

An assessment office may be responsible for maintenance of the parcel map or property line layers, but shares parcel data with the recorder's office. The computerized system makes it possible to ensure that all parcel splits and deed descriptions filed are accurate and mapped before the recorder accepts them; no erroneous descriptions would then be received by the assessor.

The parcel records can also be used by the tax collector's office. Analysis of the attribute data on property tax delinquency makes it possible to produce a map for the collector's use in locating parcels with delinquent taxes. This map might then be used for routing purposes to serve notices on delinquent owners.

The information gathered and shared by these numerous groups makes for a very powerful GIS. This data could possibly be expanded further through collaboration with private firms too. Accessibility could potentially be strengthened by some form of public access. For example, some jurisdictions have sold limited data to private firms, who then repackage it and offer public access for a fee. Others have created publicly accessible websites displaying a wealth of GIS data (see below for City of Burnaby example; this GIS offers numerous layers of data, with this map showing seniors' services as an example). Diversifying the users of a GIS can benefit both the inputs and outputs of this system: cost effective access to data and a means to spread the costs over a larger user group.

Figure 10.62: City of Burnaby Public Website Example



Interoperability of GIS

One of the ultimate goals of the GIS industry is to have full *interoperability* between web-based geographic datasets, meaning information stored at different locations on the web can be viewed together in single applications. For example, some GIS products have web-based client server versions of their software, sometimes with the capability of standard desktop software that can load files stored centrally on the Internet. Using this system, you could be looking at your locally held map files and then overlay layers read from several different websites. Complete interoperability would mean web-based applications that can read all data files from any location on the Internet, irrespective of data formats or the software being used.

Consider a real estate application of interoperability: you are an appraiser inspecting houses. Traditionally, you might print out hard copy forms, make notes on them, and then transcribe them later in your office. Instead you might have a tablet personal computer (PC) with maps and real-time connection to the property database. You locate the property on the PC, review its image and existing data, and then update any changes to the property or additional considerations from the inspection. This can be done in real-time with all of the data needed to complete the inspection.

There are numerous challenges ahead before this level of interoperability can become a reality. One of the major issues is developing a common standard that all the many providers of data, software, and hardware can agree upon. The Open GIS Consortium (OGC) is dedicated to the creation of standards towards interoperable geospatial systems.

Conclusion

This lesson has illustrated that geographic information systems (GIS) offer powerful tools for mapping and analysis of location-based data. The user interacts with a map and accesses data by overlaying or merging layers. The visual data access is intuitive and the researcher can quickly and easily gather useful information.

Government agencies were the first adopters of GIS applications related to real estate, given the expense of gathering data and technological hurdles. In recent years, cooperation among these agencies has led to more efficient use of mapping information. As computer technology becomes less expensive and more powerful, and data becomes more widely available, the benefits of GIS are beginning to extend beyond planning and assessment groups.

The use of GIS is becoming increasingly widespread; this is in a large part due to web-based applications such as Google Maps. Many organizations provide GIS data to the general public, either without charge or for a fee. GIS can also be found in other forms such as the GPS systems in cars or AVL systems in law enforcement vehicles.

GIS is a multi-billion dollar industry utilized by a diverse range of disciplines and professions. Organizations can unlock the full value of their databases by using GIS to discover trends and relationships hidden in their geographic data.

GIS data can be a valuable addition to the research undertaken in property valuation, consulting, and many other property value-related assignments. GIS aids in the analysis of the impact of location on value, evaluating development potential, and layering other important geographic information. It is an important tool for appraisers and assessors to better visualize a given location.

Review and Discussion Questions

1. What are the key elements needed to create a GIS?

2. In what ways does a geographic information system offer a more powerful tool than conventional maps?

3. What is a thematic map? Provide an example.

4. Identify the main differences between computer-assisted drafting (CAD) systems, automated mapping/facilities management systems (AM/FM), and geographic information systems (GIS).

5. What is an attribute and why is it important to a GIS?

6. A young couple is looking to purchase a property. They would like to be within five kilometres of their favourite park, but prefer to be at least three kilometres from the highway. They want a house with at least three bathrooms and a lot larger than two acres. How might they use GIS to find suitable properties? (In your answer, you may make any necessary assumptions regarding access to data and computer systems).

7. Provide four examples of how GIS might be used in real property appraisal.

8. Explain what buffers are and give an example for each type of buffer.

9. Provide an example of how you would use an overlay.

10. The lesson describes several examples of web-based GIS, for real estate or otherwise. Visit these sites or others you are aware of and critique their GIS. Visit the course discussion forum and share your thoughts with your classmates.

11. Can you think of ways that you might use GIS in your work, now or in future? What aspects do you see as most beneficial to your work? What do you see as the biggest challenges standing in the way of you using GIS? Or, for the real estate industry in general? Discuss on the course discussion forum.

12. Can small appraisal firms afford to develop their own real estate GIS? What are the barriers? Is it more cost effective to contract this out to a mapping firm? Is this likely to change in future?

13. You have been engaged by a client who owns a 20-acre property on the rural fringe of a major Canadian centre. The client requires consulting advice on the redevelopment potential of this property to determine its marketability to potential investors. Select one or more specific online GIS (mapping) tools offered by a city, province, the Federal Government, or a private business, and discuss on the course discussion forum how you might use this tool to meet the client's goal.

ASSIGNMENT 10

LESSON 10: Geographical Information Systems (GIS)

Marks: 1 mark per question.

1. Which of the following is NOT an example of GIS software?

   (1) MapInfo
   (2) AutoDesk
   (3) MicroStation
   (4) All of the above are examples of GIS software.

2. Which of the following GIS applications is LEAST likely to improve delivery efficiency?

   (1) A typical drive-time map for flower delivery showing a central point surrounded by a series of concentric circles.
   (2) A drive-time map for pizza delivery with isochrones taking into account the true road network.
   (3) A road conditions map showing real-time traffic flow and obstacles.
   (4) A GIS that calculates the optimal routing plan for a property inspector, such that travel time is minimized.

3. The process of viewing only the GIS map layers that satisfy your particular needs is known as:

   (1) a selective query.
   (2) unlocking the information.
   (3) a spatial query.
   (4) overlay operations.

4. Selecting all properties within a 3 km radius of an popular shopping mall and then comparing their assessed values with data about sale prices is an example of a(n):

   (1) point buffer zone analysis.
   (2) line buffer zone analysis.
   (3) area buffer zone analysis.
   (4) None of the above.

5. Your client is a young urban professional looking to buy a house. To determine the optimal area, you have created a map that combines information on the average age of the population in several neighbourhoods, with average household income. This is an example of:

   (1) a buffer.
   (2) an overlay operation.
   (3) a selective query.
   (4) thematic mapping.

Assignment 10 continues on next page

6. Which of the following statements about computerized mapping systems is/are true?

   A. Computer-assisted drafting does not permit the mapping of polygons.
   B. AM/FM systems have databases that store attribute information.
   C. GIS can completely integrate spatial data and attribute data among different layers.
   D. AM/FM systems best serve networking functions.

   (1) Statements A and B are true.
   (2) Statements A, C, and D are true.
   (3) Statements B, C, and D are true.
   (4) All of the above statements are true.

7. Which of the following does NOT incorporate a GIS application?

   (1) Network Analysis
   (2) Drive-Time Analysis
   (3) Break-Even Analysis
   (4) Environmental Impact Analysis

8. Which of the following statements regarding attribute information is FALSE?

   (1) An attribute is any piece of information about an object that can be stored in addition to its geographic properties.
   (2) Numerical referencing or coding systems prevent all users from identifying specific features with complete certainty.
   (3) GIS may allow users to view data in tabular form without any maps, graphics, or geographical representations.
   (4) A selective query allows users to view just those particular map layers that satisfy given criteria.

9. The process of changing how an object is depicted on a map depending on its attributes is known as:

   (1) thematic mapping.
   (2) spatial querying.
   (3) buffering.
   (4) attribute modification.

10. Using GIS to calculate the optimal routing plan for a property inspector, such that travel time is minimized, is known as:

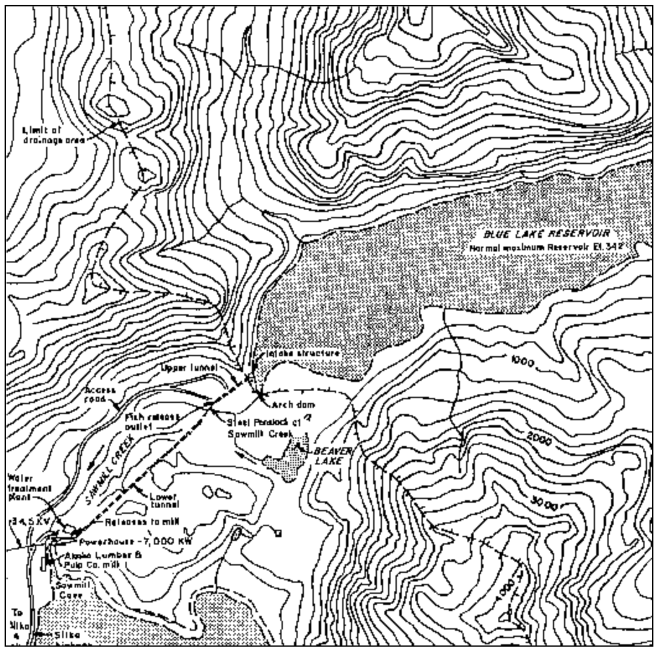
   (1) in-car navigation.
   (2) network analysis.
   (3) impact analysis.
   (4) location analysis.

Assignment 10 continues on next page

11. Which of the following is TRUE with regards to multi-user GIS systems?

(1) A disadvantage of public access is that GIS development and maintenance costs can be spread over a larger base.
(2) The duplication of effort in multi-user systems makes them cost-prohibitive.
(3) Different data formats can make it difficult to share date.
(4) All of the above are true.

12. Consider the following map image:



This is an example of:

(1) computer-aided design.
(2) a contour map.
(3) a choropleth map.
(4) AM/FM.

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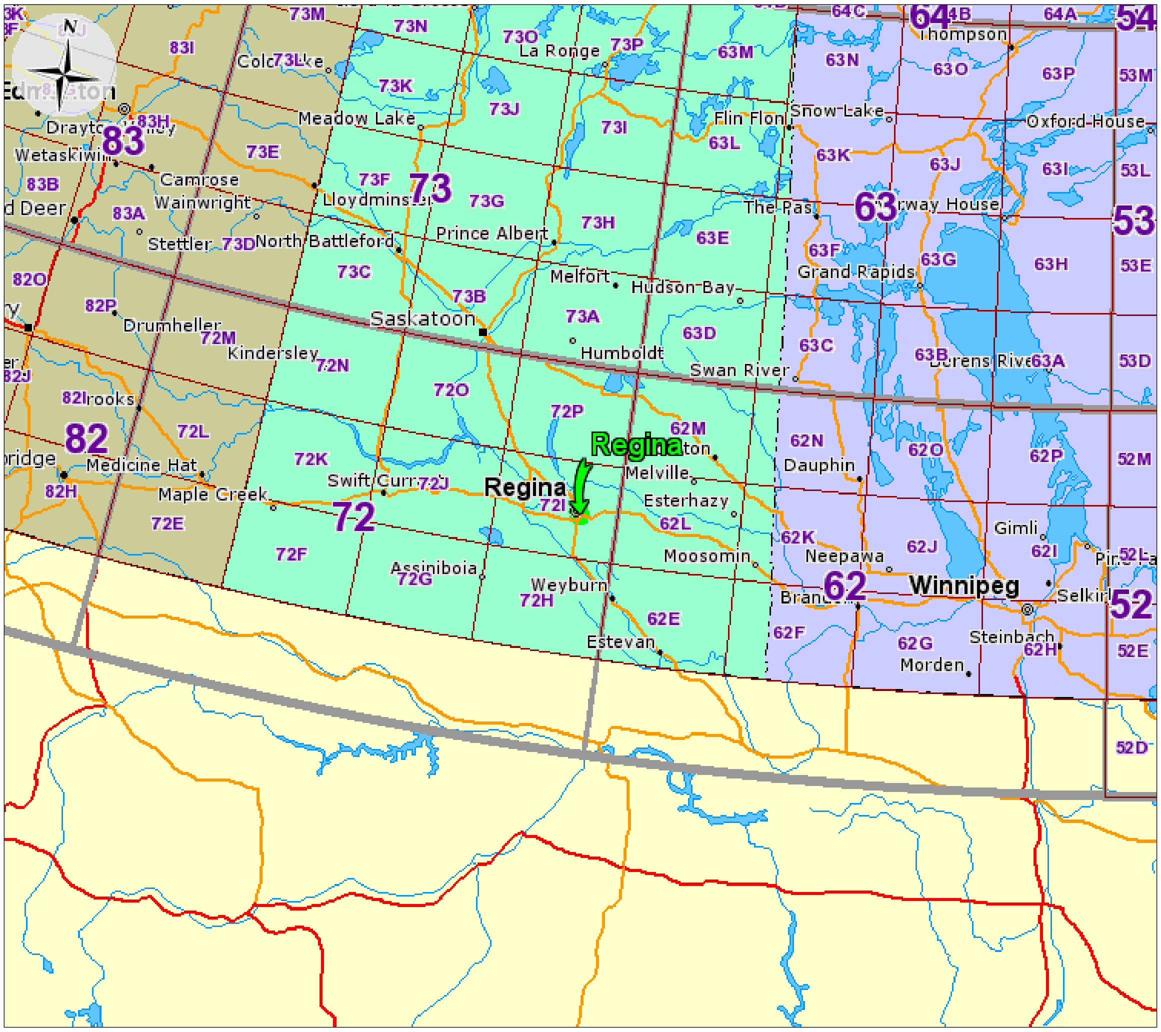
13. Consider the following map image from "The Atlas of Canada" (you may wish to view the map live at *http://atlas.nrcan.gc.ca*):

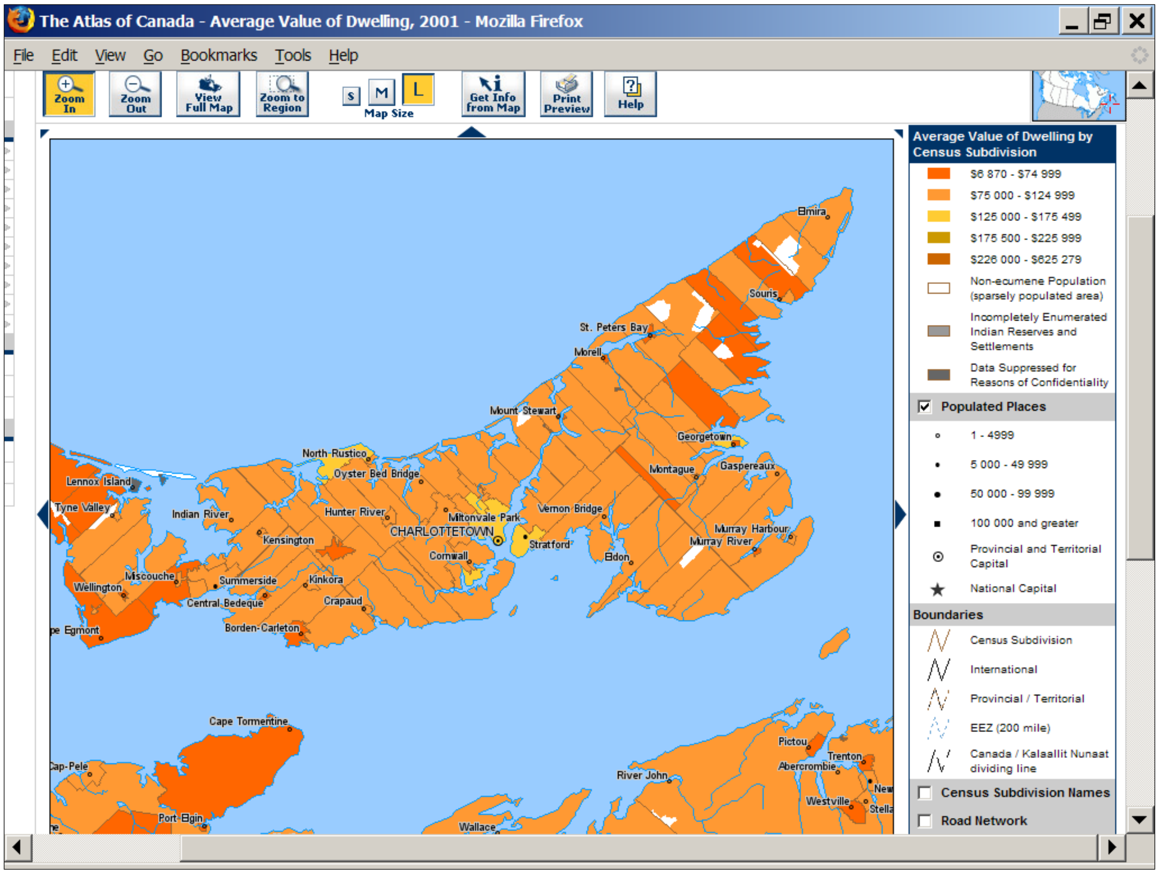


This is an example of a:

(1) topographic map.
(2) contour map.
(3) choropleth map.
(4) three-dimensional map.

Assignment 10 continues on next page

14. Consider the following map image from "The Atlas of Canada" (you may wish to view the map live at *http://atlas.nrcan.gc.ca*):

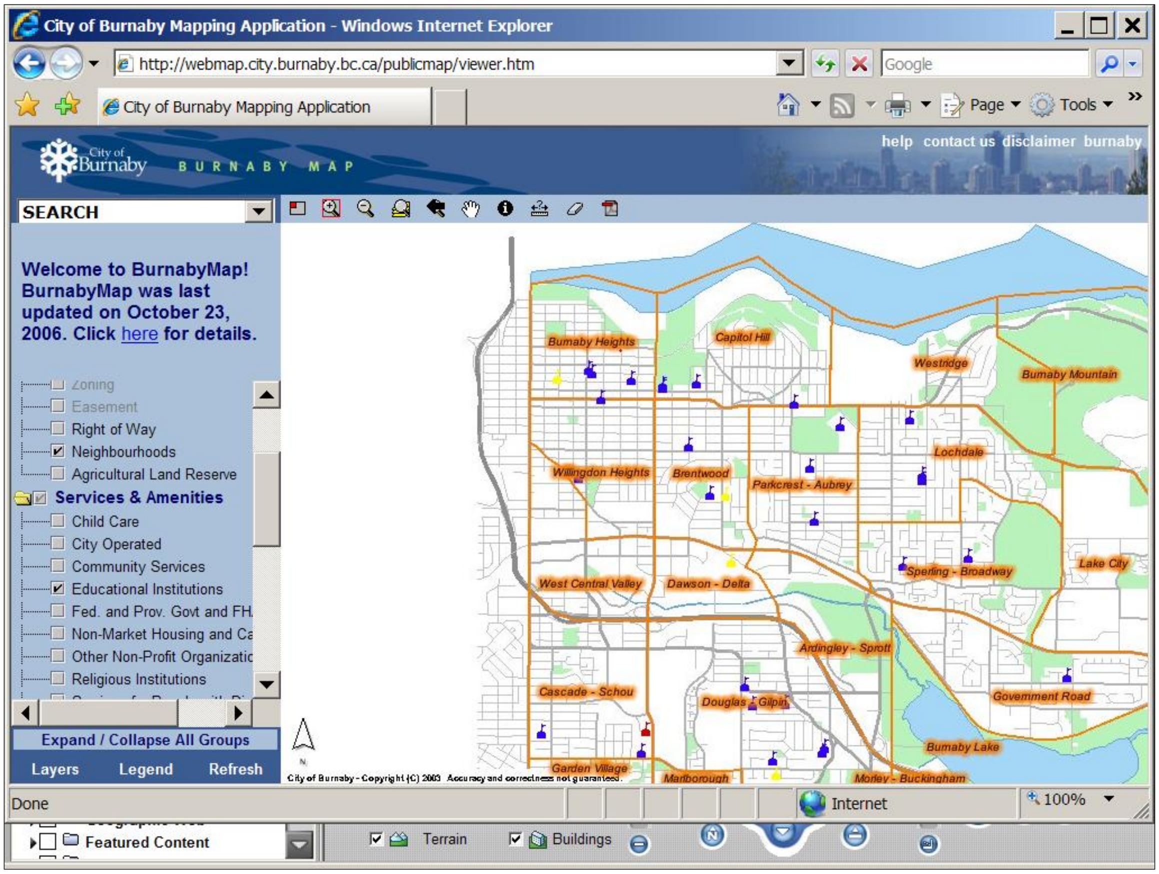


This map uses shading to illustrate average house values for PEI. This is an example of a:

(1) topographic map.
(2) contour map.
(3) choropleth map.
(4) three-dimensional map.

Assignment 10 continues on next page

15. Consider the following map image from "BurnabyMap" (you may wish to view the map live at *www.city.burnaby.bc.ca/burnabymap.html*):



This GIS allows multiple layers to be added for numerous attributes. The map above shows neighbourhoods and educational institutions. Which of the following statements is TRUE?

(1) A line buffer is used here to highlight the locational advantages of institutions by neighbourhood.
(2) Adding layers allows you to focus the GIS to help you with your specific research questions.
(3) This choropleth map isolates political influence and socioeconomic status.
(4) This map used 3-D to illustrate elevation and topography.

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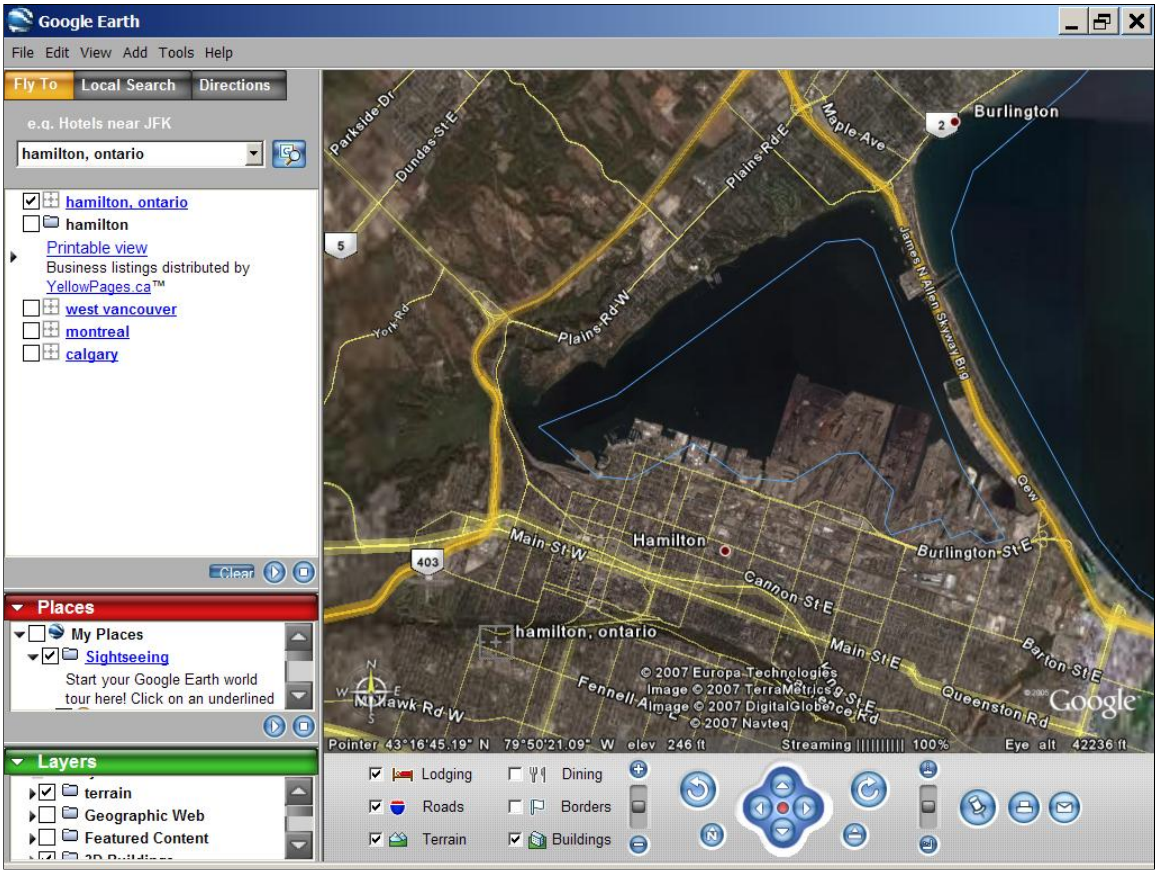
16. Consider the following map image from "Google Earth" for Hamilton, Ontario (you may wish to download the program and view the map live at *http://earth.google.com/):*



If you were completing an environmental impact analysis for a proposed industrial development, you might use this GIS to:

(1) create 3-D landscape images of important sites.
(2) add a layer showing optimal drive-times for shoppers.
(3) integrate with assessment data to verify appraisal ratios and census data to identify demographic information.
(4) do all of the above.

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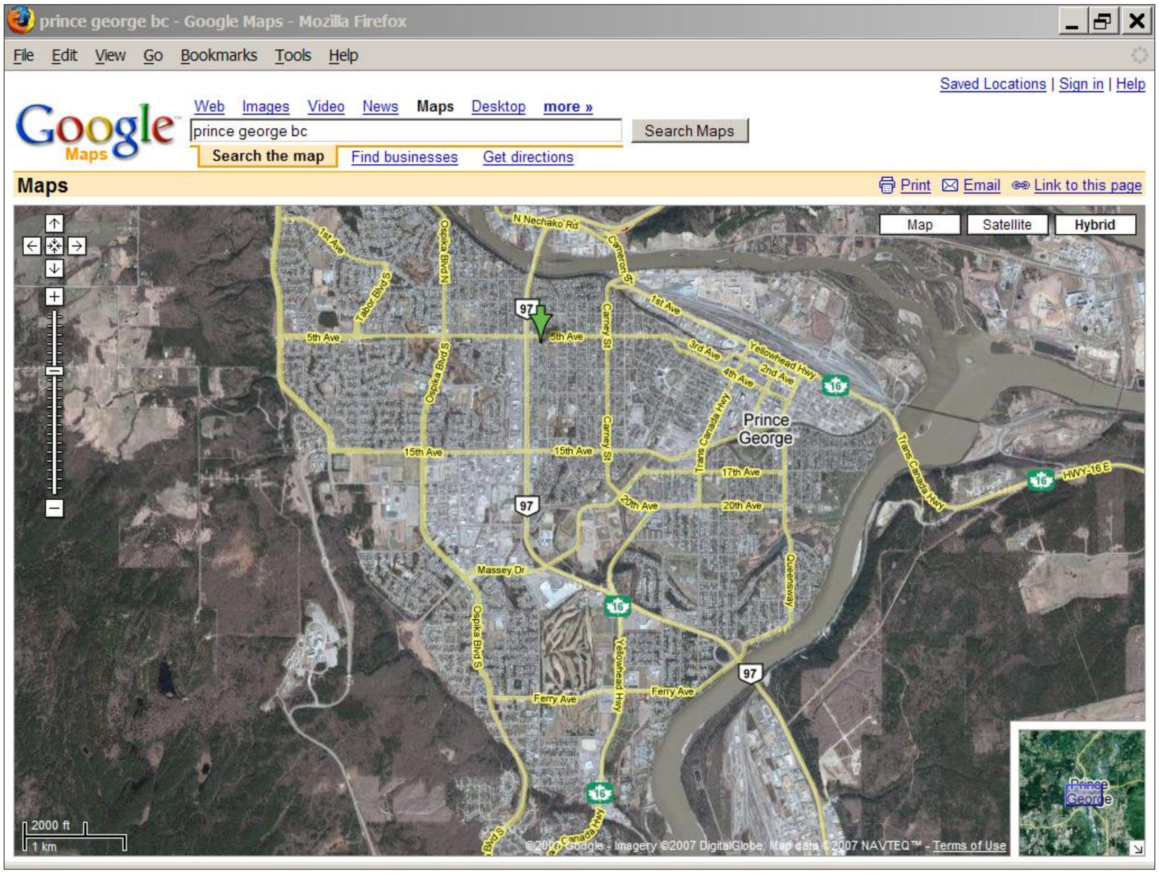
17. Consider the following map image from "Google Maps" for Prince George, BC (you may wish to visit the site and view the map live at *http://maps.google.com*):



If you were completing a market research report for a shopping centre in Prince George, you might use this GIS to:

(1) create road maps highlighting key competitors.
(2) create satellite maps highlighting site attributes of the shopping centre.
(3) search the city and region for related businesses.
(4) do all of the above.

18. Which of the following GIS features is LEAST likely to be used by an assessor?

(1) Ratio analysis.
(2) Sale verification.
(3) Real-time vehicle tracking.
(4) Permit analysis to highlight need for inspections.

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19. Which of the following explains how an appraiser might effectively use a GIS?

(1) Highlighting neighbourhood boundaries by overlaying property values, traffic volumes, and commercial uses.
(2) Isolating comparables by viewing a map of recent neighbourhood sales, highlighting property value and building age.
(3) Applying change detection software to identify reclaimed harbour land.
(4) All of the above.

20. An appraiser in Toronto is working with GIS software on her personal computer. She has downloaded location data from several web sources, but the software is unable to interpret the data format and she cannot build this data into the GIS. This is an example of a problem with:

(1) interoperability.
(2) overlay operations.
(3) inadequate isochrones.
(4) none of the above.

___ 20 Marks

Planning Ahead

Please note that Project 2 is due at the end of week 11, one week after the Assignment 10 due date. You should be well into the work required for this project now.

End of Assignment 10