

Abstract

Web mapping is becoming an important part of distributing spatial data over the Internet. Many disciplines have already begun to incorporate web maps into their studies. This paper looks at the technology behind web mapping and ways that it can be used in urban planning. Web maps have brought a dynamic way for the public to view map data and have brought the ability for users to customize maps. The technology makes use of Web Mapping Services (WMS) and open source software that allow the sharing of map data across the Internet. For urban planning, many cities have begun to use web maps to deliver information to the public on municipal development and zoning plans. However, there's much more that can be done. This paper looks at features of web mapping that have not yet been applied to urban planning. It also looks at two case studies to illustrate real-life examples of web maps and urban planning. It suggests more study into other features of web mapping and urban planning.

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1 Introduction

Web mapping is an emerging field in cartography and geography and geographers are beginning to discover its potential. Web mapping technology continues to develop with easy functionality for the public such as locating addresses, showing directions, and even three-dimensional views of the world.

Web maps are becoming widely used throughout the Internet. Many sites provide their spatial information using web maps. Web maps seem to have endless uses for showing geographic data, from providing the location of restaurants and other businesses in a certain area, to showing an interactive map of a university campus, or showing the entire world in three dimensions on a computer.

In the many fields of geography, web maps are being used to display geographers' findings. For example, to inform the public of the results of their work, physical geographers are using these maps. At Environment Canada's PlantWatch, the department is using web maps to show where certain species of plants are located and when the plants are in bloom. This helps determine changes in our environment (Canadian Nature Foundation & EMAN, 2006, What is PlantWatch?).

Urban planners are also beginning to use web mapping to get information out to the public. Until recently, most planners provided this information as static images instead of interactive maps. Any static maps (paper, text or graphic file maps) only provide basic features. However, web maps can provide more elements of urban planning to the public than previously available. This paper will look at the benefits of combining concepts in urban planning with the technology of web maps.

2 Progress of Cartography

2.1 Cartography before the Digital Age

Before the digital age, maps were created by hand. The information on the map was directly drawn on paper. Each symbol or line had to be measured by hand. Once the map was complete, it could not be changed. If any changes were required, the map had to be redrawn from scratch. Also, any information about the map had to be written on the map. There was no access to databases of information related to the map.

Throughout history, new methods have been created to help speed up the map making process. Before the printing press, each map had to be hand drawn and so distribution of the map was limited. New tools helped to create more accurate maps and more detailed information. New methods were found so that maps could be produced faster but still in limited quantities.

With the invention of the printing press, more maps could be produced from an original. When a map was created, or recreated, it could be quickly and easily reproduced and then distributed to a much larger audience. With more advancements in printing, even larger numbers of maps could be produced quickly and cheaply from a single source (Fitzgerald, 2002). However, to make changes to the original map, the cartographer usually had to start from scratch and print the map all over again.

2.2 Digital Maps

The invention of computers revolutionized the cartographic process. Computers offered the ability to make changes to the map whenever it was needed without starting over. The original map did not have to be recreated since it would be an electronic form and could be altered at any time.

Digital maps began as simple programs that assisted in the creation of hard copy maps. The features in these early programs were simple but limited. They provided basic symbols and text to create the maps. However, one difference from previous map production was the ability to make changes to a map even after it had already been created. A digital map could be changed and reproduced as many times as was needed.

As digital map technology progressed, so did the features available in the mapping software. Additional tools, such as calculators and editors, were added to the mapping applications which made it easier and faster to create maps. In recent years, even more features have been added to these applications, such as projection tools.

Despite all the advantages early digital maps provided, the end result was still a static map for the user. The map was designed based on the cartographer who created it and users did not have the choice to create their own customized map that satisfied their own requirements.

In addition, once any changes were made to the map, it had to be reprinted and redistributed to the user. This process took time and the map could quickly be out of date. If changes had to be made, it was costly as old copies had to be replaced and there was waste in the disposal of map inventory.

2.3 Geographic Information Systems

Geographic Information Systems (GIS) is a computer based system designed to input, store, manipulate and output geographically referenced data. (Natural Resources Canada Glossary of Remote Sensing Terms:

http://www.ccrs.nrcan.gc.ca/glossary/index_e.php?id=1430). GIS requires both a map (i.e. spatial data) and attribute data for the map. This became much easier once digital maps were introduced. Digital maps allowed certain attributes to be accessed behind the map features. With GIS, databases of information can be stored within the map file.

Web mapping is a branch of GIS so much of the features available in GIS are available for web mapping. Zooming functions, querying capabilities for databases, and calculating tools are just some of the GIS tools available in web mapping. With more development, web maps will be able to have all the features that GIS applications have.

3 Web Map Technology

There are two types of web maps available on the Internet: static maps and interactive maps. Static maps are usually images which the user cannot change. These maps can be updated fairly easily, but the uploading of the changes is not immediate. This paper will only look at the technology and possibilities of interactive web maps.

Interactive web mapping technology combines the accessibility of digital maps and GIS with the ability to interact with the map product. Web maps can be updated and distributed to the user in seconds at any time. The user can customize these maps for their own requirements using the web map technology. Printing these maps is entirely the user's choice and is no longer required of the map publisher. With web maps, the user is not required to know how the map was created. Customizing of the map should be simple and not require the user to have any prior knowledge on how the map was created.

The creator of the map on the other hand, must know the technology used for web mapping. There are several varieties of web mapping software available. Each has its own functions and ways of compiling the final version of the map on the Internet. Despite all the ways in which these applications distribute the maps, there are still fundamental procedures that they must follow.

Development of a web map requires that creators have the necessary equipment. These include a computer and appropriate software plus an Internet connection. Depending on the detail and content of the web map, a faster computer or connection might be required. These maps also require a web server, a web mapping server, and mapping data. One additional requirement that is important but not essential is mapping

metadata. The metadata provides information for the user and for any queries made on the web map (Mitchell, 2005, 11).

3.1 Web Server

Since all web sites require a web server, web maps require them as well. A web server is a computer or software program which takes in a request from the user and sends it to the web map service (WMS) which will be discussed later in this paper. The WMS then sends the requested information back to the web server and then the web server sends this information in image form to the web browser that requested the information originally (Mitchell, 2005, 11).

As with web map servers, there are different software applications available for the implementation of a web server. However, for the example web map application described in this paper, the Apache web service was used during its creation (the application could eventually be transferred to another web service) (Mitchell, 2005, 11).

3.2 Web Map Servers

A majority of web maps require a web map server. A web map server differs from a web server in that it distributes all the map information required for producing an image on the Internet. This information can be in vector or raster form initially, however the image produced for the web page will be in a raster image format (ex: gif, jpeg, etc.).

The web map service (WMS) can access map data from a local computer or from another web service. If the map data is stored on a local computer, the data can be in many different formats, such as a shapefile. If the original data is in vector format, then

there can be zooming capabilities on the final product of the web map. When accessing information from a local file, the creator of the web map has to update the information.

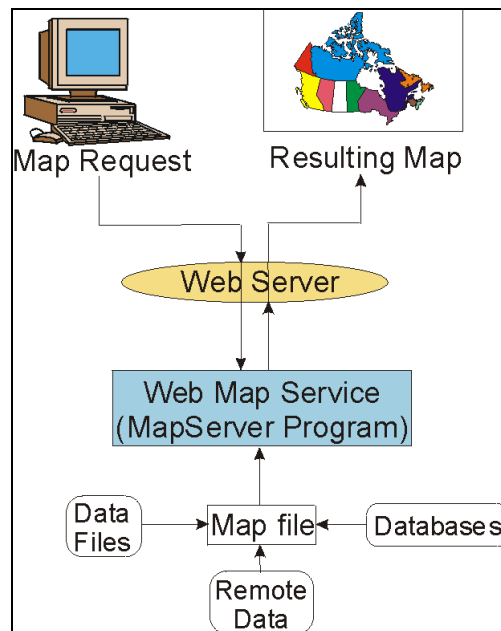


Figure 1 Basic setup of a web map program.

Source: Adapted from diagram by Tyler Mitchell

Usually information is accessed using a local computer when the data is only available as a local file and not on any other web map server on the Internet.

Using a local source or file, maintenance of the map data would have to be done by the creator of the web map. However, map data can also be accessed from another web map server which provides the advantage of automatic updating of a user's map if required, when the server is accessed. This allows for a more dynamic map and requires much less maintenance. Mitchell (2005) gives an example of a hurricane map provided by the government. Since the map is constantly changing, it is best to access the data through a WMS instead of maintaining it locally (Mitchell, 2005, 213).

Any map format can be used for a web map as long as the application used to create the web map supports the format. Both vector and raster maps can be used in web maps. Vector maps are those that represent spatial features by explicitly recording their geospatial co-ordinates and their attributes using points, lines and polygons (National Resources Canada, (2005), Vector Data). Raster maps are those that have a matrix of measurements ordered by layers, columns and rows with each cell in the matrix being implicitly addressable by its co-ordinates (Natural Resource Canada, 2005, Raster Data). However, similar to other GIS software, vector maps work better when using zoom features in a web map.

The requested information passed from the web server is called a service instance. The service instance specifies which map server to access and what type of data should be passed back to the web browser. The WMS service instance has three common operations: GetCapabilities, GetMap, and GetFeatureInfo. The GetCapabilities request returns an extensible markup language (XML) document with service functionality metadata and layer information. The GetMap request returns the map as an image based on the data contained within a map file (which will be explained below). The GetFeatureInfo request performs point-based query on the map, which is specified as x y coordinates in the request, and returns the information as a web page (Kralidis, 2005, slides 18-34). Here is an example of a web map server instance: http://localhost/cgi-bin/mapserv.exe?map=/ms4w/apps/ms_ogc_workshop/service/config.map&version=1.1.1&service=WMS&request=GetCapabilities.

There are many other services available for the development of web maps. The Web Feature Service (WFS) is one but it only uses vector map data. Unlike WMS that returns the map as an image only, WFS returns feature data as well, such as geographic coordinate data. However, only vector data is used for WFS servers. There are several other services available to web map developers with the only difference being the content that is returned from the server (Mitchell, 2005, 215).

The Queensway Expansion example in the web map application, described later in this paper, uses files from a local source. The map retrieves the information from shapefiles located on a hard drive. Shapefiles store non-topological and attribute information in a spatial data format. There is one WMS layer which has been added to the map to show an example of how a WMS service instance can be used. However, this layer has no true function for the map. The layer is called “Route / Road (L)” and is taken from the Centre for Topographic Information Sherbrooke map server.

There are also several different applications which make it easier to use a web map server. However, the MapServer software is used for the Queensway application. MapServer uses a mapfile which has all the information required to portray the map onto the web page. The mapfile stores the location of the data, whether it is locally or from another WMS, and gives the information to the MapServer in a specified image format, such as gif or jpeg.

3.3 Map File

A map file is the brain of a web map application. Map files store all the map data required for the application. Map files can come in different formats, such as an

extensible markup language (XML) document or a MapServer Mapfile format (*.map). This paper will focus on the MapServer map file since it was used to create the sample application provided.

All the information about the map is stored in the mapfile. The basics of a map are stored in this file such as the scale, projection, extent, layers, units, and the legend. All basic information for the web map is also stored within the mapfile, such as the name of the website and any metadata. A keymap can also be defined within the mapfile (McKenna, 2005, Mapfile Reference).

The mapfile also specifies the directory location of any local data required on the map. As mentioned above, it also stores the WMS connection if any data is required from an outside source. A mapfile can also specify what website should load when the mapfile is accessed and the specific behaviour it will follow (McKenna, 2005, Mapfile Reference: 17. Web).

All layer information is stored within the mapfile. This includes the name, the projection, the type, the metadata, and the datasource of each layer. Different classifications of the layers can be used for each layer within a mapfile. The name, the colour scheme, and the symbol style are some of the features that are stored for the different classes of a layer. Finally, querying data for each layer is also stored within the file (McKenna, 2006, Mapfile Reference: 7. Layer).

XML Context documents work in similar ways as mapfiles. They are both open source, meaning they can be changed by anyone at any time, and they both hold almost the same information. However, the difference between the two files is the programming language. Mapfiles use a language created by MapServer while XML Context files use a

modified form of the HyperText Markup Language (HTML). Out of the two formats, XML Context files are more interoperable since many applications can access them. The XML Context Specification was created by the Open Geospatial Consortium (OGC) (Jerome Sonnet, 2005).

Another major difference between the two file formats is that XML Context documents do not have the ability to use any local data, such as shapefiles. However, an XML Context file can access the contents of a mapfile by going through a WMS server.

All web maps use a map file in some form or another. It provides all the data the map server needs to project a map image on a screen.

3.4 Open Source Technology

In the past with GIS and Internet sites, there have been concerns about interoperability. Some file formats that work in one location or application do not work in another. Also, anybody who wanted to make changes to a certain application cannot since there is no access to the code. This has led to the development of open source technology. Open source is the concept that the user has free access to the coding behind a file or application with no licence restrictions (Open Source Initiative, 1997).

Open source technology is important for web mapping. Although some applications do not provide open source, many are implementing open source versions. One organization that is leading the open source technology in web mapping is the Open Geospatial Consortium (OGC) which provides a universal means for web map designers so there is integration between different mapping applications (OGC About, <http://www.opengeospatial.org/about/>). In other words, it provides a way to use someone

else's geospatial data and vice versa. A Canadian organization that is based on OGC is the Canadian Geospatial Data Infrastructure (CGDI). CGDI provides geographic information to Canadians free of charge (CGDI, 2005). The information can be imported into any web map.

3.5 Development Applications

A web map service, a web server, and a mapfile are the basics needed to create a web mapping application. Combining these three features with an application like MapServer is required to create a basic web map. All that is needed is an HTML document which uses these features.

However, using the basics can be quite complicated, especially for a new developer of a web map application. To assist in the creation of a web map, many different development softwares have been created. Some can be purchased and some are available free from the Internet as open-source technology.

3.6 Sample Web Map Application

The purpose of the sample application is to show how a real-life case study can be implemented into a web map application. The application shows how an urban plan can be used in a web map. This section will go through the general details behind the sample application.

The web map for this project was created using the Chameleon development software. Chameleon is an open source technology which aids in the creation of a web map application. Chameleon is based on the MapServer technology described above.

This development software provides all the tools required to create a working web map. Each of the tools displayed on the screen are provided by Chameleon, which calls them widgets (DM Solutions Group, N.d., Chameleon).

All the map information portrayed on the screen is from a mapfile. Chameleon accesses the mapfile and sends it to the web page using the map server and displays the information using the widgets (DM Solutions Group, N.d., Chameleon). The layers, the map, the extent, the scale, and the units are all taken from the mapfile. The keymap and button images are taken from image files located on the hard drive.

For each function on the screen, Chameleon has a different widget to perform these functions. Chameleon provides widgets for the zoom buttons, the pan buttons, and querying options.

The basis behind a Chameleon web map application is an HTML file. All the widgets are stored within this HTML file as well as any other visual information on the website. The information is stored in the HTML language format.

4 Web Mapping and Urban Planning

There are many benefits web mapping has to offer for urban planning. Some urban planners use web maps to provide information across the Internet, but there are other capabilities that have not yet been utilized.

Most urban planning maps found on the Internet are not interactive. The maps are usually an image which the user cannot manipulate. However, even many Internet urban planning maps that are interactive do not use the full potential of the web mapping technology. This section explains how web maps can be used generally for urban planning issues and provides current examples of urban planning issues in the City of Ottawa.

In the context of urban planning, the word planning is defined as “...a process which alters the development of another process, or alters a situation, in order to achieve the goals of the planner or those who the planner represents.” (Khan, 2004, Introduction to Urban Planning). So, urban planning makes changes to a prior plan or situation for future goals.

There are several steps required when creating an urban plan. These steps are: investigate and identify the problem, develop problem statement, establish goals and objectives, establish criteria (and standards) for design and evaluation, design alternative actions, collect relevant data, analyse alternatives, evaluate alternatives in terms of effectiveness & costs, choice, and implementation (of some parts of the Plan). Once these steps are completed, planners start again until a viable plan can be implemented. This process is called the systems analysis approach and is now the basic framework of urban

planning. (Khan, 2004, Planning Urban System and Components). This paper will look at some of the elements of this cycle and how they can be used in a web map application.

4.1 Existing Urban Planning Web Maps

Combining urban planning maps with web maps is a fairly new concept.

However, many web maps have been created by municipalities that want more interaction for their citizens interested in their urban plans. Many governments have created web maps that display the current planning initiatives and future ones as well. On many urban planning web maps, municipalities have chosen to show the zoning laws within their jurisdiction. Other features may also be included in these web maps, such as flood plain data, landmarks, aerial photos, and subdivision plans.

This section of this paper will look at some of the existing urban planning web maps found on the Internet. It will also look at some other web maps that are still the leaders in web map technology, although not dealing with urban planning.

The methodology used to search for these web maps is simple. Since there are so many urban planning web maps on the Internet, to narrow the search, I went on the Internet using the term “zoning web maps” in a Google search. Looking at the first few pages of results, I chose the web maps which offered different features from the earlier web maps found in my search. This helped provide a larger number of urban planning web map tools found across the Internet. However, the only drawback is that the search did not get every unique tool available. All of these maps provide the simple web map tools such as zoom options, querying features, panning options, printing options, etc.

4.1.1 Austin, Texas

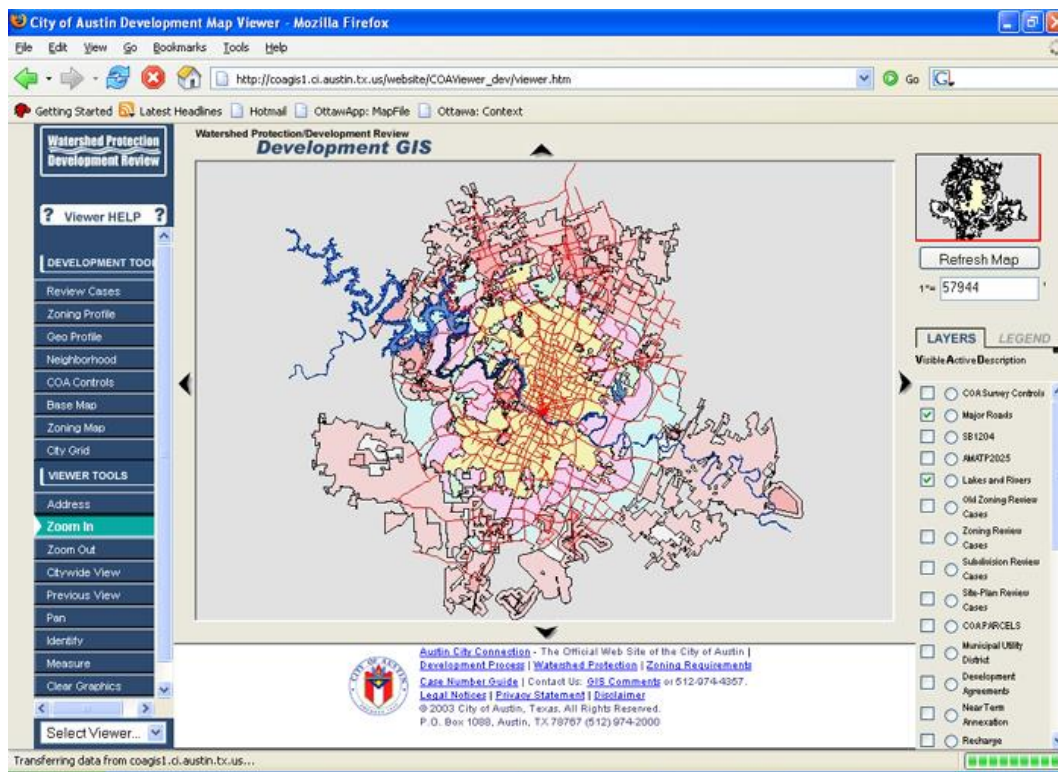


Figure 2 Screen capture of the City of Austin web map.

Source: City of Austin web site

The first web map which offered several tools for urban planning is the Watershed Protection/Development Review map found at the official website of the City of Austin, Texas (site: http://coagis1.ci.austin.tx.us/website/COAViewer_dev/viewer.htm). This map uses many tools that are widely used and a few that are unique. The site includes zoning data, aerial photos of the city, watersheds data, flood plains, and other basic layers such as major roads, rivers and lakes. The site also includes map layers unique to the site such as zoning review cases, subdivision review cases, annexations of municipalities within the region, aquifer recharge zones, development agreements, neighbourhood associations, and university neighbourhoods.

The map also uses several tools for querying and interacting with the website. It utilizes an identify tool which allows the user to query a database attached to each map layer. The map also includes an address locator, a case review query tool which the user can use to review past development cases, city grid query tool which allows the user to zoom into a specific grid on the map, and profile tools for the zones, statistics, and neighbourhoods of the city.

4.1.2 Burnsville, Minnesota

The second web map to offer features found in urban planning is at the City of Burnsville, Minnesota website (site: <http://s98200.co.dakota.mn.us/website/bvzoning/viewer.htm>). Although this map does not have many features, there are some worth mentioning. The map provides information on zoning bylaws and a 100-year flood plain boundary. It also provides some unique map layers such as condominium locations and planned unit development.

4.1.3 Snohomish County, Washington

Another example of a web map that provides zoning and flood plain information is the Snohomish County Interactive Permit / Zoning Map (site: <http://gis.co.snohomish.wa.us/maps/permits/index.htm>).

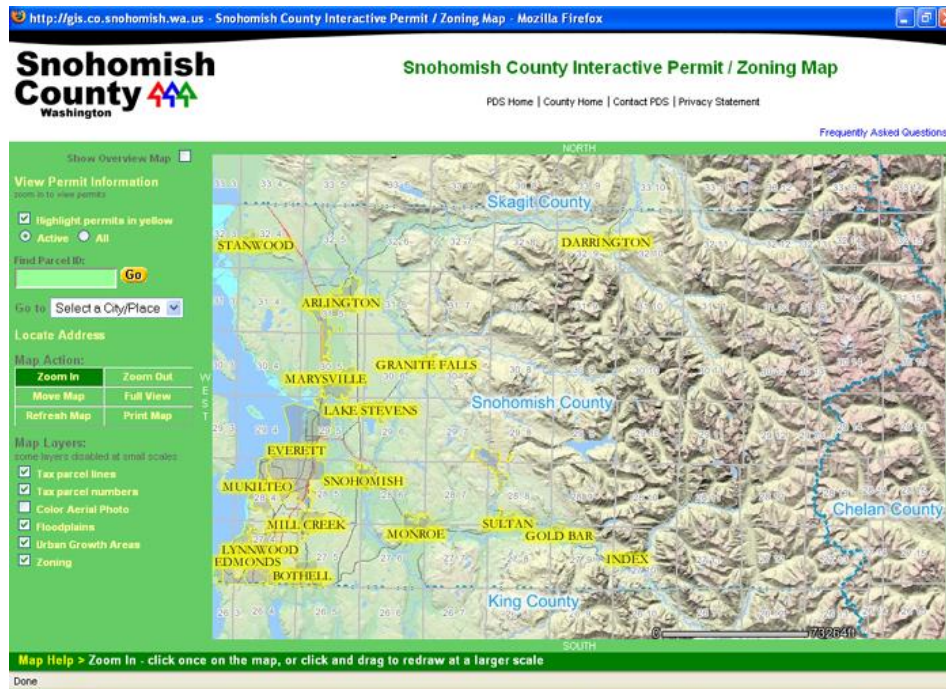


Figure 3 Screen capture of the Snohomish County web map.

Source: Snohomish County web site.

This map provides many of the layers and features found on the other web maps such as zoning, flood plains, aerial photos, and address locator. The Snohomish map also offers map layers and features not found in the other web maps such as tax parcel lines and numbers, permit information, and urban growth areas.

4.1.4 Vancouver, British Columbia

Many Canadian cities have begun using web maps to deliver data on their urban plans. The City of Vancouver includes layers and features on their web map site (site: <http://www.city.vancouver.bc.ca/vanmap/>). The municipality's web map provides information not only on current planning initiatives, but also on future projects which the city will undertake.

The Vancouver site offers a great deal of layers for people wishing to know more about the city. It provides many different infrastructure maps such as for the sewer and water systems, city projects, road projects, subdivision locations, and zoning districts. The map also provides some recreational information such as public art locations and tourist sites. It includes several images as well such as satellite images and orthophotographs. Orthophotographs are derived from a conventional perspective photograph by simple or differential rectification so that the image displacements caused by camera tilt and relief of terrain are removed (National Resources Canada, (2005), Orthophoto). It also has an important map layer which shows where truck routes are located. This would be beneficial for anybody choosing to move to Vancouver since a majority of people do not want to live next to a truck route. The concept of using web maps for people who are moving will be broadened later on in this paper.

4.1.5 Google Web Maps

The development of web maps is progressing rapidly. Extensive features are being developed for many web maps found on the Internet. Google is one web map developer leading this technology with many features not found elsewhere on the web. The company is continuing to expand its features.

The Google web map allows the user to find a location based on an address or a business and get directions to that location from a destination specified by the user. What makes this feature unique is that any location can be found around the world. Google also provides satellite imagery for almost every location on Earth. Other features

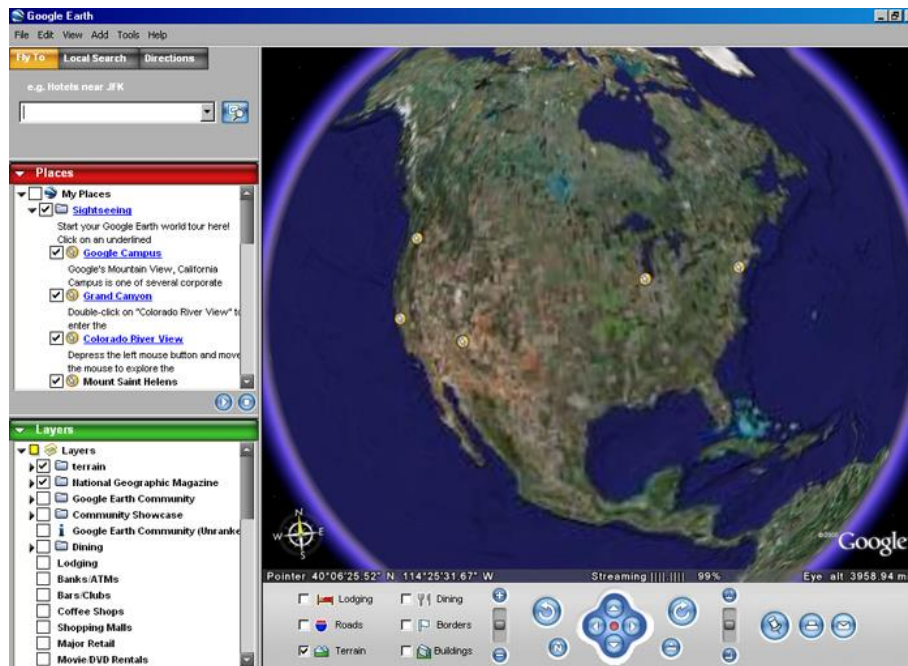


Figure 4 Screen capture of the Google Earth application.

Source: Captured from the application by author.

include the ability for any user to add a Google map to their own personal website as well as having a default location when the user loads up a Google map. There are also several features that Google is currently developing. One is the ability to remove certain roads from the directions which Google produces for the user. (Google, 2005).

However, Google also provides many other features not found elsewhere on the Internet. It has developed an application, Google Earth, which views the world in three dimensions. The user can pan the Earth not only on the x and y axis, but also on the z-axis. The user can zoom into an area, rotate the world, and see the area from a ground view perspective in 3-D. It displays the information based on the satellite images. However, this is an application and although it is available to download over the Internet and requires an Internet connection to use it, it is not a web map in the “traditional” sense. It is not available directly on a website but uses software that must be downloaded.

The program accesses the Internet to receive the current map data. Google Earth uses a file format similar to XML called Keyhole Markup Language (KML) (Google, 2006).

4.2 Web Maps for Personal Use

When creating a web map, it is important to know who the main audience will be. In the case of urban planning, this is usually the general public who are interested in or want to know more about a planning issue. It is important to understand what the audience wants so the web map will be useful.

People who want to know more about a planning issue can usually be identified under one of two categories: those who live in the affected area and those who will be moving to the city. For people who live in any of the affected areas, it is important to provide as much information as possible on what impacts the plan will have on them, what the benefits and costs will be to them, and why the plan will be implemented. As for people who are moving to the area, it is important to show what is already there and what will be there based on future development plans. These people can then decide where they will want to move based on the information provided on the web map.

4.3 Land Use Planning

Land use planning controls the selection of location for certain land uses. For example, in most land use plans, industrial facilities are not located near residential areas. In some cases, commercial zones are also separated from residential areas. However, joined commercial and residential zoned areas, known as mixed-use land uses, are becoming the preferred choice for planners.

When a person moves to a new location, they want to know what is available to them in that area. In general, people usually want to be close enough to basic services, such as police, fire, etc. However, depending on the type of person moving into the new area, the choice of other necessities might differ. For example, if it is a family moving into the area, they might look at the size of the residential lots, the proximity to schools, the available recreational facilities, and the shopping centres in the area. If the person moving into the area is single, the availability of shops, apartments, restaurants, and recreational facilities might be the most important.

Municipalities through zoning laws control locations for these services and facilities. Zoning laws specify where certain facilities can and cannot go. Usually there is a pattern in which family services are zoned together and the other services are grouped as well. For example, areas zoned for higher density structures, such as apartments, will also be located near zoning for restaurants, shops, etc. Areas zoned for lower-density structures, like housing subdivisions, will be located near land zoned for shopping centres, institutions such as schools, and parkland, etc.

There are also certain infrastructures that are zoned away from the general public. For families and single people, neither would want to live near an industrial facility, a garbage dump, or a major highway. The zoning laws help to separate these facilities away from residential areas.

One important point of urban planning is that it plans out what needs to be done in the short-term, mid-term, and long-term periods. Most plans look ahead up to about twenty years from the time they are developed. Usually this means that before anything is built on a site, the zoning for that site has been in the plans for years. If the public has

access to the zoning laws, then they can plan for where they want to live not only by what is currently there, but also by what is planned for the future. An example of an area zoned for future development is provided in the sample web map application.

However, zoning information is not always easily available for the general public. Some municipalities provide specific zoning documents through their libraries. Others only provide this information through special requests. Most people who are moving into a new location do not bother to request the zoning documents or have access to library facilities in the area. This is where web mapping could be used to help residents and new arrivals.

A web map can provide an interactive way for the public to see a municipality's zoning bylaws. With the interactive map, users can decide what area they want to live based on the information on the site concerning the available services in the area, the zoning bylaws and amendments, and any other information regarding future development in the area. The web map can also provide the means for the municipality's residents to submit comments to planners in the municipality.

One tool that can be useful for anyone looking for information about a certain location is a calculating tool. This tool provides the user with the ability to figure out where certain facilities and services are located in proximity to the preferred location of the user. For example, if a family chooses to move into an area and they want to know where the schools are located, they would enter in a preferred walking distance and pinpoint a school within that distance. This feature can also be used for anyone who wants facilities within a certain distance of their choice of residence. In addition, it can help users identify facilities they would not want to live near.

The zoning bylaw maps provide the public with a similar tool. They can find out if there are plans to place schools within walking distance, or whether industries are planned too close to where they live. They can also find out if there are future plans to build any major roads nearby. Information can be provided to them on the noise impact of the road, for example, so users can find a place away from the road where the noise impact would be insignificant.

Another major factor that determines where people will move is the proximity to their work. People choose to live within walking, biking, bussing, or driving distance of their work. The choice of these modes would depend on the user's priorities. The public can use the web map to locate where they live and see if it is close enough to where they work.

4.4 Transportation Planning

Another important consideration of urban planning is transportation.

Transportation planning determines where roads and other modes of transportation will be placed. It also helps to determine the transportation patterns of the city and what modifications need to be done to the road network in the future. Using the patterns, the planners can then decide what mode of transportation, such as automobiles, buses, or trains, should be used and where they should be placed (Khan, 2004, Transportation Planning).

Different calculations are used when creating these plans. Trip generation information is calculated to determine where most people travel. This information then helps to establish the traffic volume on the city roads. The calculations also help to

determine how many riders a certain mode of transportation will carry. For example, if a city is planning to build a light-rail system, these calculations can help determine how many people would actually use the system (Levy, 2003, 198-201).

For the public, transportation is extremely important to their day-to-day lives. In order to get to any other location in the city, the public must use a mode of transportation. The most important transportation consideration for the public is the commute to their work. When choosing a place to live, many people want to know what is the quickest way to their work and how long it will take them to get there. They may also want to find out about future transportation expansion for their preferred area to see whether the planned expansion would satisfy their requirements. Web maps can provide this function for the user.

In GIS, the concept of finding the easiest and quickest way to get from point A to point B is called network analysis. A network analyser calculates the easiest route based on the distances specified on the map and calculates the quickest route based on the speed limits included on the map (ESRI, 2005). The network analyser can also be used in a web map, provided the distance and speed limits are included in the map data. Users can enter where they live and the web map returns the best route to take to get from their home to work. Other information can also be included in this calculation, such as traffic congestion. Also, the user's preferred mode of transportation can be factored in to determine the best route. If the user wishes to drive, then the web map can plan a route preferable for driving. If the user wishes to take a bus, then the map can return a result based on the city bus routes, and so on. For this option to work, bus, train, and bicycle path maps need to be included in the web map.

This network information can also be useful for the planners as well. In this case, users can submit their network information using the web map. The planner then accesses this information and uses it in the trip generation calculations. This may not provide an accurate account of traffic volume on different streets, but it gives a rough estimate of which modes people use, where they are coming from and where they are going.

Location tools are also useful in transportation planning. Most modes of transportation create a significant amount of noise. Being close to highways, railways, or airports is usually undesirable for city residents. There is usually information on the noise level of these three modes in transportation plans and the noise level data can be included in a web map as a layer which shows the farthest distance which the sound will reach for each of the modes. This way the user can decide where the noise impact is the least.

4.5 Multiple Objective/Multiple Criteria Decision Making

Multiple objective and multiple criteria decision-making is a concept in GIS where different criteria for a specific objective, or objectives, are weighed based on a ranking system. The criteria are ranked based on a scale from 1/9 to 9 (from less important to most important). These ranked criteria are then put into a matrix. Consistency ratios are then used to evaluate the given criteria to see which one is most important. The final result will be the best answer for that objective based on the weighed criteria (Eastman, 1995, 542).

As mentioned above, the public will usually choose the place to live based on the proximity to services and facilities. In the web map, using this concept in GIS, the user can have the choice to weigh certain criteria on the map, such as schools, shops,

recreational facilities, etc. The user weighs these criteria based on the level of importance to the user. The web map then calculates the best location based on the inputs of the user. This way, the web map can help the user on the choice of where to live.

4.6 Public Consultation

During the system analysis mentioned at the beginning of this section, urban planners require public consultation to get feedback for the plans and to get people involved in the decision-making process. Web maps can make this easier and more convenient. With a visual, interactive mapping application, the public can be better informed of the planning process and users have the ability to provide immediate feedback to the planners.

Public consultation always requires community meetings. These meetings provide a way for the public to hear the suggestions of the planners and voice their opinions of the plans. It is also a way for the planners to hear any concerns from the public and to take the concerns into consideration when modifying the plans.

But frequently, turnout at these meetings is low because of lack of awareness on the part of interested residents. The web map can provide a layer which shows where these meetings are being held. When the user clicks on the meeting location point, information pops up giving the address and time of the meeting. It can also give information on the specific issues that are to be discussed at the meeting. If the meeting occurred in the past, the query result can provide a link where people can find out what was discussed at the meeting or can still voice their opinions. Through web maps, the public can have quick and easy access to urban planning meeting information.

4.7 Case Studies

To better illustrate the two types of planning mentioned above, a prototype web map has been included with this project. In this web map are two case studies in Ottawa: one is an example of a transportation plan and the other a land use plan. The first case study is a current issue in Ottawa regarding the expansion of highway 417, the Queensway. The Queensway study provides an example of transportation plan. The second case study is on the KNL Development subdivision planned for northern Kanata. The KNL development offers an example of a land use plan.

4.7.1 Queensway Case Study

Currently, there are plans to expand Highway 417 (Queensway) through Ottawa. The extent of the project is from Highway 416 in the west to Anderson Road in the southeast. This expansion will see lanes added for both directions of the Queensway (Government of Ontario, 2006, Background).

The Queensway is the most used road in Ottawa. It is the feeder road into the city for commuters from the western, eastern, and southern suburbs. It is also the easiest way for outside travellers to get through Ottawa. Thus, the Queensway is heavily congested during the peak hours. Due to heavy growth in Ottawa's suburbs, the traffic volume on the Queensway has also increased over the last twenty years. The Ontario government believes that expanding the Queensway will help to relieve much of the congestion on the highway (Government of Ontario, 2006, Background).

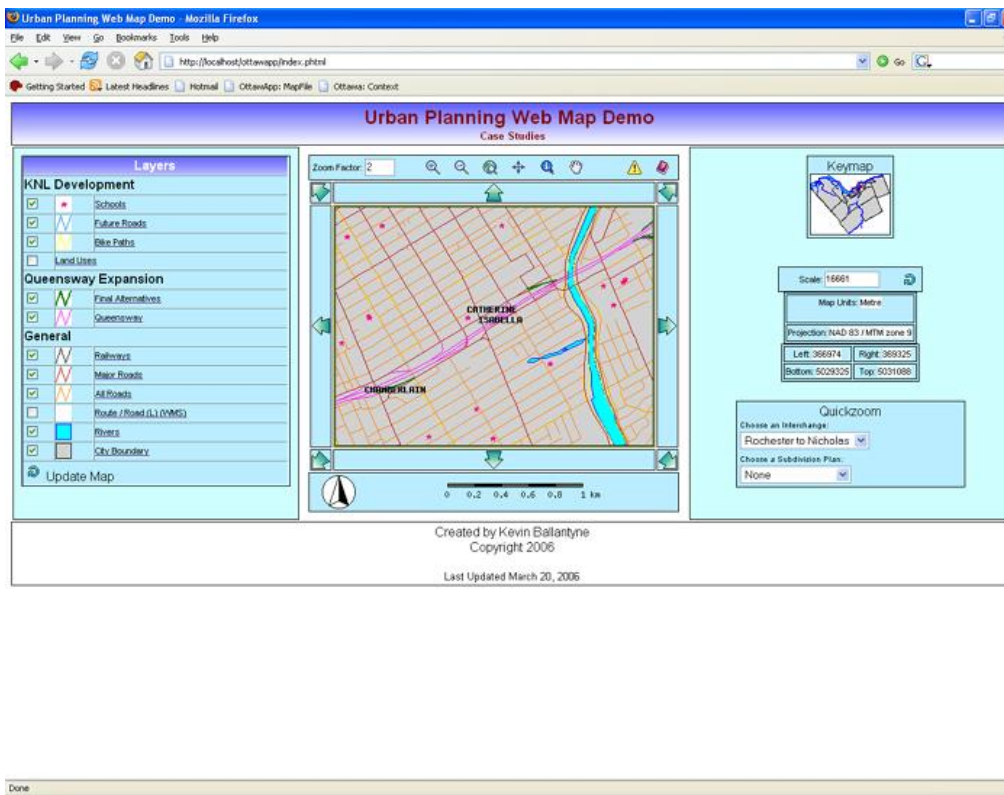


Figure 5 Screen capture of the urban planning web map demo for the Queensway expansion.

Source: The author

During the Queensway expansion study, the planners followed the system analysis approach mentioned above. They identified a problem and stated it: the congestion on the Queensway is the main problem in moving people across the city quickly and conveniently. The planners established goals and objectives, such as expanding it. They evaluated the situation and created designs. They created and analysed alternatives, and consulted with the public throughout the analysis process (Government of Ontario, 2006).

One of the key steps in the systems analysis cycle is the creation and analysis of alternatives. The analysis of alternatives looks at the cost and benefits of each alternative and provides an alternate course of action for the implementation of the plans. These

alternatives can help to save the project. For example, if the original plans turn out to be too costly, a more economic alternative could be implemented.

Public consultation is essential during the analysis of the plans and alternatives. The public can choose which alternatives they prefer or they can present alternatives of their own. However, the final decision rests with the planner. With web mapping, planners have an effective tool to make their alternatives available to the public.

In the plans for the expansion of the Queensway, the planners have included alternative ideas for specific sections in the study area. Due to much local concern, some of these alternatives have been implemented as part of the final plan. For example, the plans originally called for the inclusion of an exit lane in the Ottawa East area similar to Highway 401. However, this exit lane would have consumed large chunks of local and private property. Due to protests by a coalition against the expansion, the design of the exit lane was changed and an alternative was introduced: the construction of a retaining wall to build up the embankment creating space for the additional lane without taking more land.

In this case, web maps could have been created to inform the public of the alternatives but this was not done. Each alternative for the expansion could have been shown as map data on the Internet. Different layers could have been used to display these alternatives. Economic and impact (cost-benefit) data could have been included in a database so when the user (public) clicked on the map, information on the alternative would have been displayed including cost comparisons.

Most map data that is readily available to the public are the lists of modifications for the Queensway expansion. However, these maps are in no way dynamic and

interactive. All the available maps are images or documents. Many of these images could be transferred to a web map where the user can choose which modifications he or she would like to view and allow for comparison of the alternatives.

In the prototype web map application, some of the alternatives are shown based on data taken from the static maps available on the Queensway expansion website. For the web map, only the alternatives for the section between Rochester and Nicholas Streets are shown. This area is prone to a big expansion with the addition of an extra lane in each direction and significant modification to the interchanges. With more time and study, more map data could be added in the future.

Between these interchanges is the area where public concern is voiced the most as the expansion will have the greatest impact on this area. Many leaders in the affected communities have protested against the expansion of the Queensway. The project will affect these communities greatly both in traffic volume and consumption of the land next for Highway 417. These community leaders have provided alternatives of their own to the expansion, such as expanding rapid transit or placing a lower speed limit on the Queensway through the downtown core (Johnson, 2005).

As mentioned above, the public's voice is an integral part of the urban planning process. Public consultation is an extremely important part in developing an urban plan. As a result, the public should be more informed of where meetings will be held. For the Queensway expansion plans there were three public consultation meetings which helped the consultants get feedback. Some of the suggestions from the public were addressed and as a result, many of the alternatives proposed at the meetings were included in the final plans.

There are many other features that can be added to web map technology for urban planning. Some of these would require extra analysis not available in the plans in order to be included in a web map.

One such concept is traffic volume on local streets fed by the Queensway. With the Queensway expansion, several arterial and local streets will be greatly impacted. A web map could show where changes in traffic volume might occur on these streets. This would require information on the current traffic congestion on the Queensway as well as the current traffic volume on any of the feeder roads. The final map layer would require a simulation of the future traffic congestion on the Queensway and local streets based on projected increases in vehicular traffic. This final map would be beneficial to the public since it would give them some indication of which streets will be the most affected by the expansion.

As mentioned above, the public is usually concerned with the noise impact when dealing with the construction or expansion of a highway. Many residents along the Queensway are concerned about the noise impact the expansion will have on their neighbourhoods. The plans for the Queensway expansion include noise impact analysis maps and where sound barriers will be built. These maps could be added to the web map so the residents would know where the greatest noise impact will be.

During the construction of the highway, the public should be informed of the progress of the expansion. The public could be notified of the where and when construction will take place. This information could be included in a web map. The map could be updated as the construction progresses and could show where the greatest

impact would be for both motorists and people who live in the area due to the construction. It would also show what impact there would be to the natural surroundings due to the construction.

4.7.2 Kanata Lakes Development Case Study

Another urban planning issue that is of concern in Ottawa is the KNL Development Inc. development currently underway in Kanata. Since this will be a future subdivision plan, it is a good example of how web maps can be used for land use purposes.

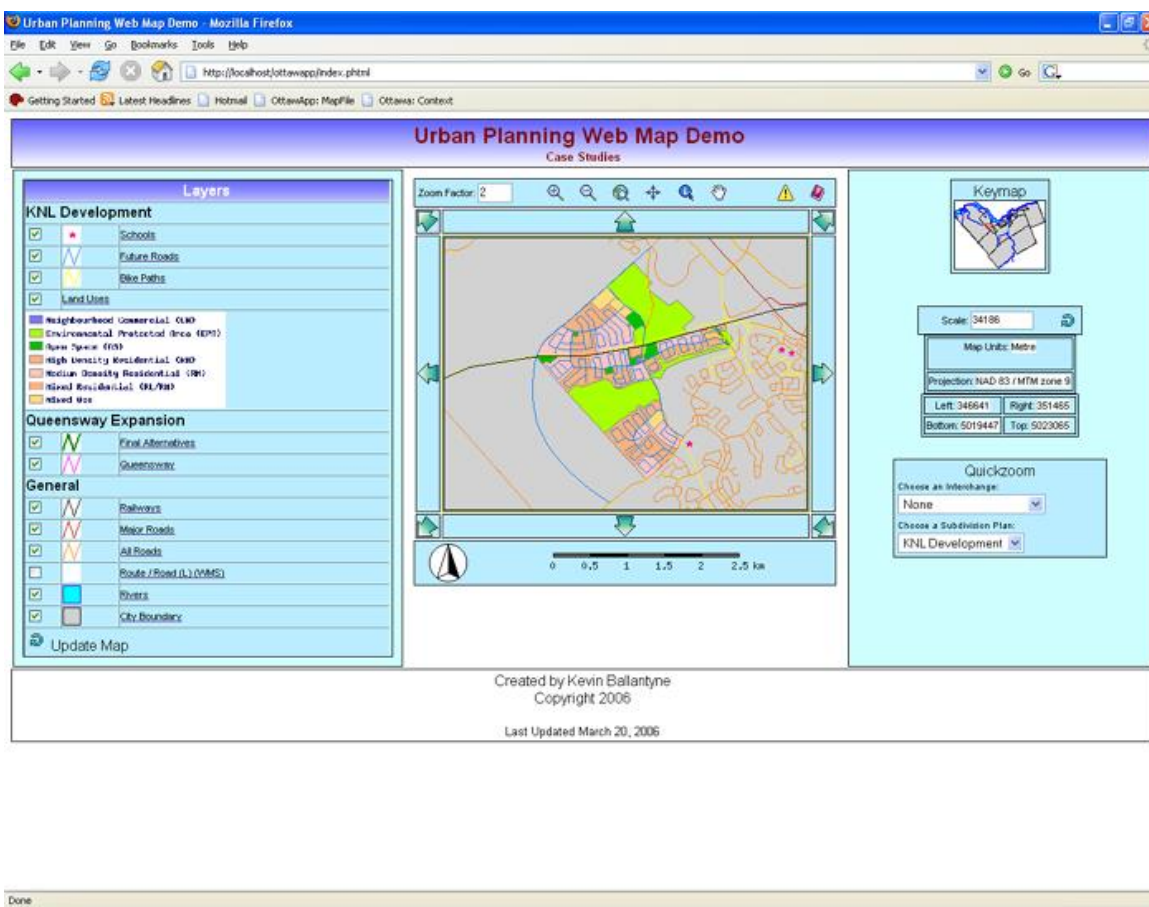


Figure 6 Screen capture of the web map demo program for the KNL development.

Source: The author.

The KNL Development project is a major issue for the people living in northern Kanata. The planned development will be located on sensitive environmental land. It will also be located in an area of an old forest and wetlands. Many of the residents in the area use the area for recreational purposes with its many walking trails. The City of Ottawa and the residents of Kanata Lakes and Beaverbrook have been fighting for several years to preserve as much of the environmental land as possible or to even try and stop the development all together (Reynolds, 2004).

Some of the information mentioned above about land use planning for web maps can be applied to the KNL Development case study. The first step in creating any layers for this map is determining who the audience is. In the case of the KNL Development project, the audience would most likely be people in the area looking at the issues related to the land, or people who plan to move into the area once it is developed.

In general, the suburbs usually have bigger lots and houses than in the inner city. Families who move into the area would be looking for lot sizes, school locations, recreational and open spaces, and shopping centres. The new development includes some of these features but lacks others such as schools or shopping centres.

On the sample web map provided (cemml.carleton.ca/ottawapp/), there are several different layers which have been added to show examples of how the information on services can be shown. The two basic layers are the future road network and the planned zoning bylaws. The bylaws determine where different housing densities, shopping areas, and recreational areas will be located. The map also includes a layer of current schools that are located nearby.

As mentioned above, there are several additional GIS features that could be added to the web map. A network analyst tool could be added which would determine how long it would take to get from the new development to downtown Ottawa or to determine how long it would take to get to the closest school. A feature which also can determine what is the closest school based on the given zoning layer or the layer of current schools.

5 Conclusion

Web maps are an important and emerging technology in the development of GIS and cartography. In the past, maps could not be changed once created. They could only hold the information which was displayed on them. With the development of digital technology, maps have become more widely available and provide much more information in an interactive way for users.

Web maps combine both the technological capabilities of GIS and the Internet. They provide Internet users with all the information and features found on original paper maps as well as the features found in a GIS application. All this technology is readily available both for the user and for any creators with the implementation of open source technology.

Many fields in geography have just begun to realize the potential that web maps have to offer to them. Urban planners, despite the number of current web maps available, are still not using web map technology to its full potential. Web maps can provide a means to deliver information not previously available to the public on land use plans and transportation plans. They can provide information on any type of plan as long as further study is done to determine how to implement those plans into a web map.

This paper has provided two Ottawa case studies to show how different issues can be applied to a web map application. The two case studies deal with land use and transportation planning. These case studies are universal and can be compared to any other city. The case studies help determine exactly what tools and features are needed to provide the particular information.

There are many other features that can be added to a web map for urban planning.
Further study needs to be conducted in order to determine what can be achieved.

Appendix A

Description of Layers in Demo Application

Layer Name	Description	Source	Filename
KNL Development			
Schools	Displays all the schools within the City of Ottawa.	City of Ottawa GIS Data. http://ottawa.ca/city_services/maps/atlas/general_use_CD_en.html	Schools.shp
Future Roads	Displays the future roads planned for the KNL Development subdivision.	Based on Schedule A2 to amendment no. XX to the Official Plan, Schedule B of the former City of Kanata. URL: http://www.flora.org/greenspace/projects/KNL/KNL_OPA-Zoning-POSD-ACS2004-DEV-APR-0054.html	new_roads.shp
Bike Paths	Current bike paths in the City of Ottawa. This layer shows the impact the development would have on recreational activities	City of Ottawa GIS Data.	Bike_paths.shp
Land Use	Land uses for the future development of the KNL Development.	Based on Schedule A2 to amendment no. XX to the Official Plan, Schedule B of the former City of Kanata. URL: http://www.flora.org/greenspace/projects/KNL/KNL_OPA-Zoning-POSD-ACS2004-DEV-APR-0054.html	zones.shp
Queensway Expansion			
Final Alternatives	All the alternative plans for the Queensway expansion. Since the map is only a demo, the alternatives are only shown for the interchanges between Rochester and Nicholas Streets.	Ottawa Queensway: Preliminary Design and Environmental Assessment Study Public Involvement Centre No. 2 Alternative Plans and Evaluation Results Technically Preferred Alternative (TPA) URL: http://www.mto.gov.on.ca/english/engineering/417ea/pic2/alt.s.htm	alternatives.shp
Queensway	Displays the Highway 417 (Queensway) right-of-way.	Adapted from City of Ottawa GIS Data.	h417.shp
General			

Railways	Displays the railways within the City of Ottawa.	City of Ottawa GIS Data.	Railways.shp
Major Roads	All the major roads in the City of Ottawa.	Adapted from City of Ottawa GIS Data.	major_roads.shp
All Roads	All roads in the City of Ottawa.	City of Ottawa GIS Data.	All_Roads.shp
Route / Road (L) (WMS)	A layer which shows all the roads. This layer is an example of how a map from another web map service can be used in the demo application.	Web Mapping Service (WMS) for Digital Topographic Data WMS Connection: http://wms.cits.rncan.gc.ca/cgi-bin/cubeserv.cgi?	none; taken from a WMS service
Rivers	All the major rivers in the City of Ottawa.	City of Ottawa GIS Data.	Rivers.shp
City Boundary	The current City of Ottawa boundary.	City of Ottawa GIS Data.	City_Boundary.shp

Bibliography

1. Canadian Geospatial Data Infrastructure (CGDI). (2005). *CGDI-endorsed Standards and Specifications*.
<<http://www.geoconnections.org/CGDI.cfm/fuseaction/developersCorner.endspecs/gcs.cfm>> [March 15, 2006].
2. Canadian Nature Federation and Environment Canada's Ecological Monitoring and Assessment Network (EMAN). (2006).
<<http://www.naturewatch.ca/english/plantwatch/>> [March 15, 2006].
3. Natural Resources Canada. (2005). *Glossary of remote sensing terms*.
<http://www.ccrs.nrcan.gc.ca/glossary/index_e.php> [April 5, 2006].
4. DM Solutions Group. (N.d.). *Chameleon*. <<http://chameleon.maptools.org/>> [March 15, 2006].
5. ESRI. (2005). *ArcView Network Analyst*.
<<http://www.esri.com/software/arcview/extensions/networkanalyst/>> [March 15, 2006].
6. Fitzgerald, Joseph H. (2002). *Map Printing Methods*.
<<http://www.broward.org/library/bienes/lii14009.htm>> [March 15, 2006].
7. Google. (2005). *Google Help Center: Features*.
<<http://local.google.ca/support/bin/answer.py?answer=24867&topic=1467>> [March 15, 2006].
8. Google. (2006). *Google Earth KML 2.0 Specification*.
<http://earth.google.com/kml/kml_intro.html> [April 2, 2006].
9. Government of Ontario. (2006). *Ottawa Queensway Preliminary Design and Environmental Assessment Study*.
<<http://www.mto.gov.on.ca/english/engineering/417ea/index.html>> [March 15, 2006].
10. Johnson, Pierre. (July 4, 2005). *Coalition Against Queensway Widening: Info on Alternatives*. <<http://www.ottawaeast.ca/QWalternatives.html>> [March 15, 2006].
11. Khan, A.M. (2004). *GEOG 4303 Course Notes: Urban Planning*. Carleton University.
12. Kralidis, Tom. (2005). *MapServer OGC Web Services Workshop: Powerpoint Presentation*. <http://devgeo.cciw.ca/ms_ogc_workshop/index.html> [March 15, 2006].
13. Levy, John M. (2003). *Contemporary Urban Planning*. Upper Saddle River, New Jersey: Prentice Hall.

14. McKenna, Jeff. (2005). *MapServer: Mapfile Reference*. <<http://mapserver.gis.umn.edu/docs/reference/mapfile>> [March 15, 2006].
15. McKenna, Jeff. (2005). *MapServer: Mapfile Reference: 17. Web*. <<http://mapserver.gis.umn.edu/docs/reference/mapfile/web>> [March 15, 2006].
16. McKenna, Jeff. (2006). *MapServer: Mapfile Reference: 7. Layer*. <<http://mapserver.gis.umn.edu/docs/reference/mapfile/layer>> [March 15, 2006].
17. Mitchell, Tyler. (2005). *Web Mapping Illustrated*. Sebastopol, CA: O'Reilly.
18. Open Geospatial Consortium, Inc. (2006). *Open Source Consortium: About Us*. <<http://www.opengeospatial.org/about/>> [March 15, 2006].
19. Open Source Initiative. (1997). *The Open Source Definition*. <<http://www.opensource.org/docs/definition.php>> [March 15, 2006].
20. Reynolds, Steve. (2004). *KNL Draft Plan*. <http://beaverbrook-kanata.ca/knl_draft_plan.htm> [March 15, 2006].
21. Sonnet, Jerome. (2005). Web Map Context Documents. *Open Geospatial Consortium Inc.: Reference #05-005*. <https://portal.opengeospatial.org/files/?artifact_id=8618> [March 15, 2006].