UniverCity

THE COMMUNITY AT SIMON FRASER

Bringing Internet-Based GIS to the Burnaby Mountain Development

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Contents

Abstract

In recent years, the increasing popularity of the Internet has evolved to be an integral part of our society. In addition, it has brought some fundamental changes in the field of Geographic Information Systems (GIS). The powerful technology of the Internet enables GIS to access, process, and disseminate spatial information to a much wider audience than is possible with traditional GIS. In this project, rather than performing spatial analyses on the Burnaby Mountain Community Corporation (BMCC), we will create an online mapping application, using ESRI's ArcIMS development platform, that is directed towards the general public so *they* can perform the spatial analyses and independently explore the future community. A major function of this project is to provide a viewshed analysis capability and other online GIS functions such as spatial queries, buffering and distance measurements. However, we have faced various challenges with this project. Our biggest challenge is to educate the public and enable them to successfully use our Internet GIS application as a tool for exploring future community developments on Burnaby Mountain.

Introduction

The Internet as a medium for providing GIS is relatively new and still in its early stages. The number of Internet GIS applications have increased rapidly in recent years as more people begin to realize the advantages of providing geographical information to a wider audience. We can also expect the technology for providing online GIS to improve and become more advanced over time. As more websites are created to deliver online GIS applications the need to address the successful delivery of GIS over the Internet is crucial.

The focus of our group project is to create an Internet GIS application that will showcase the Burnaby Mountain Community Project (BMCP) to the general public. The future developments on Burnaby Mountain will have a great impact on how the surrounding area will look. The advantages of creating an online GIS application is that it will be interactive and easily accessible in providing geographical information about the development. For this project we will create the application model using ESRI's Internet Map Server software, ArcIMS.

The main function of the ArcIMS site is to provide a viewshed analysis capability. For the scope of this project we selected a set of twenty-two viewpoints around Burnaby Mountain where the viewshed analysis could be performed. The viewpoints were picked for their strategic view of the surrounding area. The user of the application can look at the viewshed in two ways. One is to look at static images generated for each point. The second, more innovative and interactive method provided uses Quicktime Virtual Reality (QTVR) to look at the viewshed for each point. Besides having the viewshed analysis capability the application will have simple GIS functionality included as well so that the user can perform simple spatial analysis on the dataset.

By providing the GIS application over the Internet we must consider the wide range of our intended audience. Our application will be used by those with little or no previous experience or training in geographical analysis. The design of our Internet GIS application reflects its intended use by having a simple interface that is easy to use, and providing a set of useful geographical data layers. The main objective of this Internet GIS application is to provide an interesting and interactive method of informing and educating the public about the Burnaby Mountain development.

Background

Simon Fraser University's history started in 1963 when the city of Burnaby agreed to donate 1000 acres to vie for the university site. The university started small, opening with 2500 students in September 1965. In 1970 the city of Burnaby started to negotiate the return of some of the university's lands to create a park, which marked the beginning of the process towards an agreement in principle for developing a sustainable community. In 1995, the Burnaby Mountain Community Corporation was formed to increase the community by using the 160 acres within the ring road at Simon Fraser University. Their overarching goal is to build private homes, businesses, parks, and an elementary school as a way to encourage social diversity, and a sustainable community of over 4500 people. A second objective is to create an Endowment Fund and other sources of revenue to support a wide range of University purposes including new student housing.

The university received permission to build the community when it traded 773 acres outside of the ring road for the rights to expand within the ring road. The first phase will take approximately 7 to 10 years to complete, and will include the development of the east section of SFU which is focused on building privately owned high density housing. Townhomes, apartments, condominiums and cooperatives ranging in height from 2 to 10 stories will be built to accommodate homeowners and tenants. The south neighborhood, as seen in our website, will not be developed for at least 7 years. The final community will see 1800 residences in a self-sustained community, which will accommodate faculty, staff and students, in addition to any other people who wish to live at the university. To reduce automotive traffic, transportation will be emphasized with bike trails, walkways, and public transit. In approximately 15 years, the final phase will be complete and the face of the university will have changed from the present "commuter campus" to an accomplished sustainable community.

Project Goals

Overview

The ultimate goal of this project is the creation of an online GIS application. The application will:

- Provide a map of the current SFU campus buildings, roads, parking lots and fields;
- Show the proposed locations of new buildings associated with the Burnaby Mountain development;
- Provide viewshed analysis, both in the traditional sense of displaying a map of "what areas are visible from a given point,' and by displaying 360º views of what can actually be seen from that point
- Allow the user to perform simple GIS operations, such as measuring distances, identifying attributes and buffering

Throughout the semester, as the project took form, the initial goals were shaped by limitations we encountered and the progress we made. This particular project is not designed to heavily emphasize spatial analysis, but rather it is designed to serve as a source of public information and insight into the development of the Simon Fraser Community.

Creating a Burnaby Mountain GIS Map

The primary goal of this project was to compile many different datasets and integrate them together into a comprehensive geodatabase. Using all of the data we received from previous projects and from the Burnaby Mountain Community Corporation, we worked on the creation of one larger dataset that would allow us to produce value added accurate information for everyone to use. This information could be especially practical for academic, business or public purposes. The ArcIMS software package is the medium used to create our interactive GIS website. This mapping software allowed us to further expand our goals by not only displaying a two-dimensional static image of the current campus and proposed developments, but to provide interactivity and basic GIS capabilities such as spatial queries, buffering and spatial overlays.

Viewshed Capabilities

Creating a viewshed analysis was a larger component of our project. The surface features that can be seen from a specified location define a viewshed. According to the original project instructions, the viewshed component was open to a few different approaches. First approach, the creation of a dynamic viewshed that regenerates after every click, presented too much work within the allotted time and was very demanding computationally. The second method we would have liked to have attempted was the usage of actual proposed building heights supplied by the BMCC, in order to provide examples of how some of the community will look like in 3D, superimposed over the current campus layout. This would have been a feasible task but the AutoCAD data we were provided with did not contain building height information. The plan to create a viewshed analysis was therefore modified due to these limitations. Although the viewshed had to be structured by some of these constraints listed above, it still remained a key component of our project. This new community will bring many changes to the existing campus and will have an impact on numerous surrounding communities; therefore our viewshed analysis is an essential part in informing the public about future developments.

GIS Capabilities

Another important objective of the project was to provide the end-user with some GIS capabilities through their web browser. There are many Internet mapping applications currently present on the World Wide Web such as, MapQuest, Yahoo Maps, Map Blast…etc, but only few of them allow for true GIS functionality. Our objective is to provide the end-user with the opportunity to perform operations such as spatial queries, buffering and spatial overlays. Modifying the map by removing or adding layers or changing the color scheme are also useful functions that will be provided in our final application. Requiring only a web browser and some basic Java applets, the end-user is able to harness the capabilities of GIS analysis without prior GIS experience or special software at the client end.

Showcasing Internet-Based GIS

Finally, our project will act as a powerful demonstration of the capabilities and advantages of this revolutionary new approach to Internet mapping and GIS. Using ArcIMS software, we will produce this interactive GIS application and illustrate how the issues of interactivity, customization and user friendliness can be dealt with by this new medium. With our final result we would like to provide a much more dynamic application, in contrast to a static map display, presented by numerous online mapping websites. (esri.com)

Data Collection

Our data was collected from different sources and in different formats. Data that was used included ArcView shapefiles of two different development arrangements, AutoCAD drawings of current and proposed structures, orthophotos of current SFU structures, campus maps, source photos for viewshed analysis, and some field work using a hand held GPS.

- The SFU Dataset was originally provided by SFU Facilities Management in AutoCAD .dwg format. This dataset was used in a previous Geography 452 project, where it was converted into ArcView shapefile format. The data was given to us in shapefile format, but needed a lot of work in terms of georeferencing and projection, which posed a problem when we tried to overlay data from other sources. Redigitizing some of the polygons was necessary to accommodate for missing, partially completed, and duplicated polygons. This dataset, depicted in Figure 1, included buildings, roads and fields.

- Orthophotos of the SFU area were also provided by Facilities Management.

- Two different proposed development arrangements were given to us: the ArcView shapefile, and in the data above. These proposed developments were created by the Hotson Bakker Architects and IBI Group.

- AutoCAD drawings of current buildings, roads, fields, parking lots, as well as proposed buildings, roads, trees, fields, etc. were supplied to us by the Ramsey Worden and Hunter Laird architects. These .dwg files were edited, reprojected, and converted into ArcView shapefiles used in our final layout.

- Campus maps were obtained from SFU Campus Security and were used for reference when redigitizing buildings to maintain accuracy of in terms of location and identification. Building names were also attained from the printed SFU campus map.

- Over 300 digital photographs were collected for the viewshed sites. They were later stitched together for the Quick Time Virtual Reality 360º display. This data collection required a day of fieldwork. Group members went to twenty-two selected points around the campus and collected images with a digital camera. Approximately 12-16 images

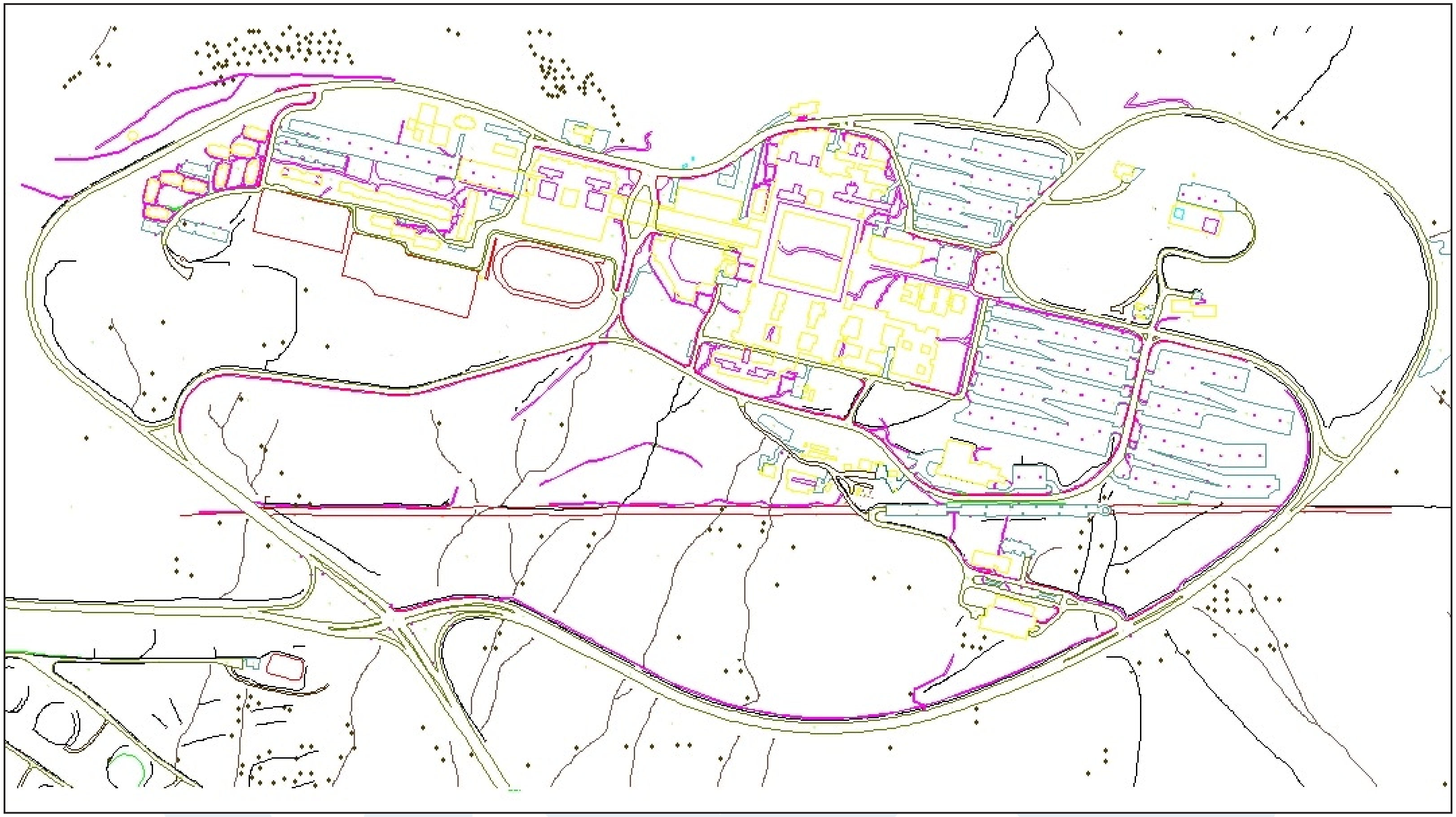


Figure 1: AutoCAD linework provided by SFU Facilities Management.

were acquired at each site to produce a 360º panoramic view of each location in QTVR. We used a 40-50% overlap to be certain all images could be stitched together. A handheld Global Positioning System made by Garmin (model GPS 12) was used to record positional location for each site. Latitude and longitude coordinates, along with elevation were recorded electronically so it could be used in the attribute table of each location. Although positional accuracy is dithered approximately 10 meters by the United States government, it offers the GIS user a good point of reference if other co-ordinates will be used.

Data Manipulation

Projection/Transformation of the Datasets

The datasets we were given were not projected and needed to be given a projection. The dataset was taken from AutoCAD files and there was a problem with the correct georefencing of the datasets to the airphotos. We used the airphotos of Burnaby Mountain to verify that the datasets were correctly geo-referenced. When we displayed the datasets and the airphotos together, we found that the datasets were about shifted approximately two kilometers away from the airphotos. Figure 2 illustrates this problem. To fix this, ArcInfo was used to translate the dataset from its current position to a new position which aligned correctly with the airphotos. ArcInfo has a command called TRANSFORM which changes coverage co-ordinates using an affine, similarity or projective transformation based on a set of control points (tics). We used the similarity option which would translate the coverage coordinates without skewing the data. The requirement for the TRANSFORM is that we need to create an output coverage with the corrected tic points. The TRANSFORM function will use these tic points as the parameters for the transformation equation which translates the dataset to the new location.

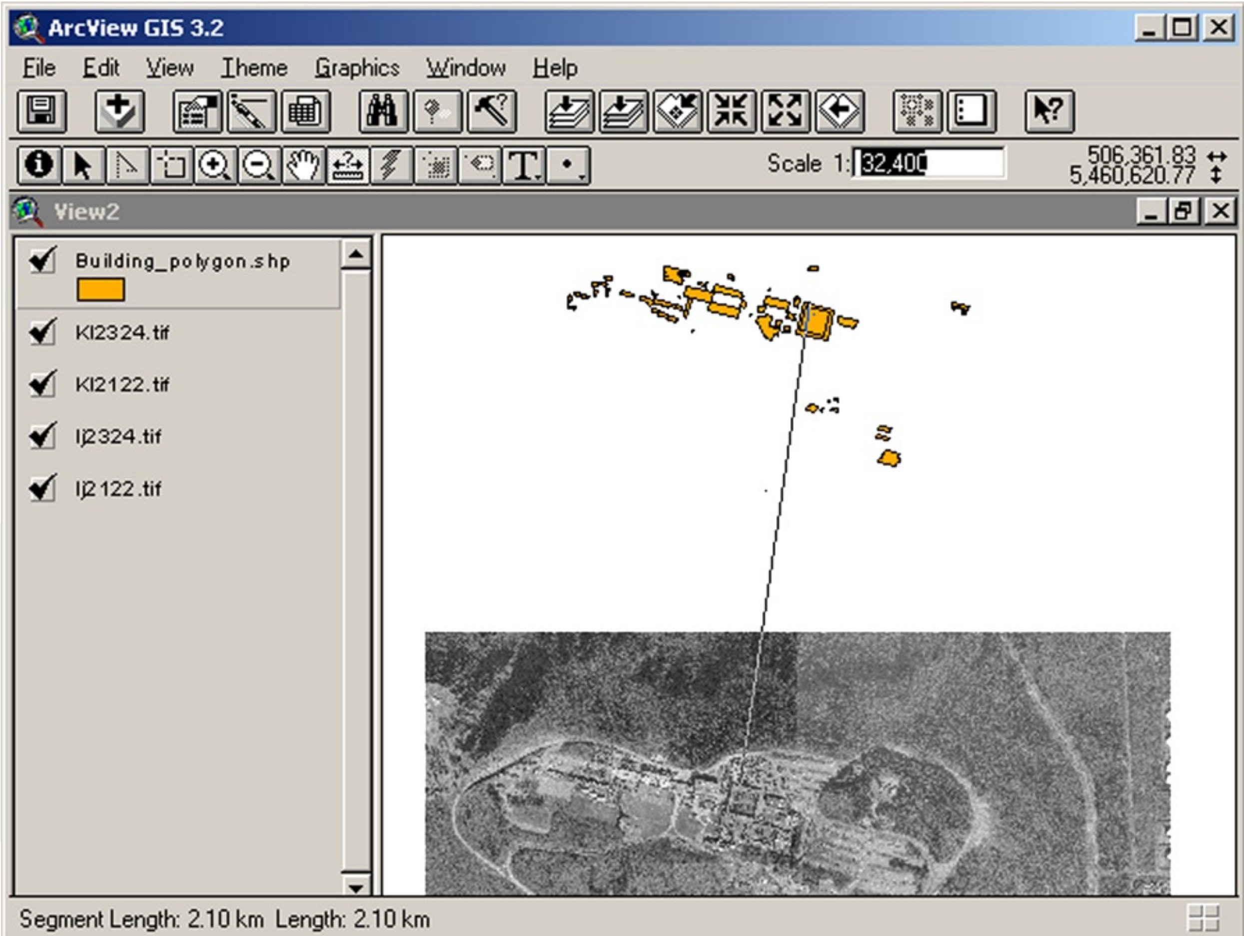


Figure 2: The AutoCAD data provided to us by SFU Facilities Management was offset from the (correctly georeferenced) orthophotos by more than two kilometers.

The projection of the dataset was a simple task. Since the shapefiles were not projected (projection was specified as Geographic) we needed to project the data into UTM coordinates. The ArcInfo command PROJECT was used to project the data. Before projecting, the shapefiles were exported to ArcInfo coverages using ArcCatalog. We could only do the projection on dataset if it was in coverage format. We needed to create a projection file that would transform the input projection (Geographic) to the output projection (UTM). That projeciton file, geog2utm.prj, is shown below:

```
/**** geog2utm.prj *****/
Input
Projection Geographic
Units DD
Datum NAD83
Parameters
Output
Projection UTM
Units Meters
Datum NAD83
Zone 10
Parameters
End
```

Redigitizing of SFU Buildings and Other Layers

We discovered that for some of the datasets it would be more efficient to redigitize the data over again. One of the datasets that had problems was the SFU buildings layer. This layer did not have separate polygons for many of the buildings and also were missing a few buildings. We also had to digitize a new layer called “fields” which combined all the playing fields on campus as well as the AQ pond. For the campus roads we decided to create two layers, one for the larger public roads and the other for the smaller restricted-access roads. We used ArcEdit for all the digitizing work. To redigitize the linework we needed to use the linework from the original AutoCad dataset.

Creating the Static Viewshed Images in ArcView

Besides the viewshed analysis using QTVR, we wanted to include static viewshed image for each viewpoint to show the visible surrounding areas. The static viewshed images give the user a map of the areas that are visible from the specific ground viewpoint. We only created viewshed images for the ground viewpoints and not the ones that were taken on the buildings since we do not know the exact elevation of these points. ArcView has an extension called 3D Analyst that allows a viewshed to be created from a single point or many points. ArcView allows a viewshed to be created from one point or many points. We only wanted to create a viewshed for a single ground viewpoint therefore we had to create a shapefiles for each one. ArcEdit was used to extract the viewpoints from the master viewpoint coverage

and put them into individual coverages. These coverages were then exported back into shapefiles to be used in ArcView.

One preliminary step to do is to create a TIN surface from a layer with elevation points. We used the contour line shapefile to create the TIN surface. The TIN acts as the elevation surface from which the viewshed is determined. We now have a TIN surface (Figure 3) as well as the shapefiles for each individual ground viewpoint. The viewshed image was created by simply selecting both the TIN surface and any one of the shapefiles (containing a single viewpoint). One thing we noticed was that viewshed created using the default one meter offset from ground level does not show a lot of visible areas. We tried using a two meter offset and this shows slightly more visible areas as expected. The two meter offset was favoured over the one meter offset.

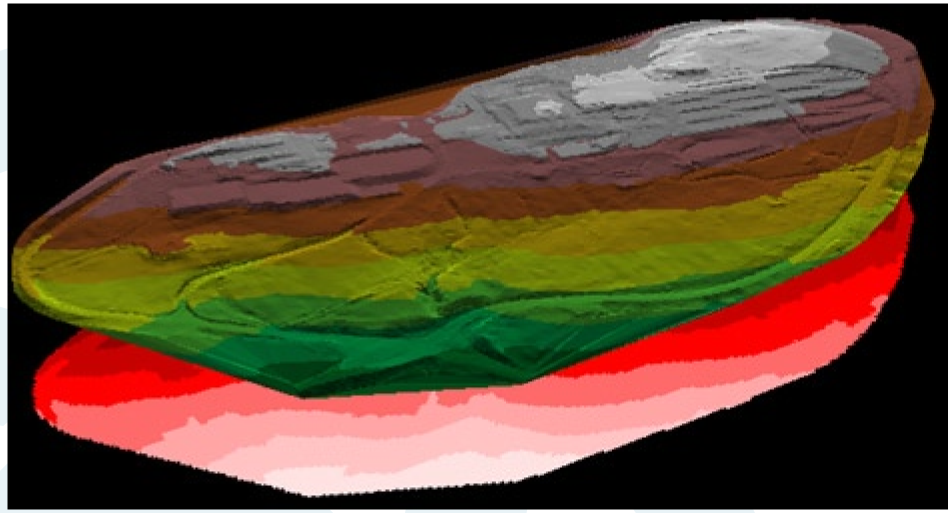


Figure 3: A TIN surface model of the SFU campus.

Figure 4: Viewshed map for point C.

Application Development (Methodology)

Creating the Basic Application Environment

Bringing GIS to the Internet is not as simple as generating some images, writing some HTML code and uploading it to a server. The web, as we know it, is not well-suited to the level of dynamic environment required. The web is, primarily, a static environment. To overcome this limitation, a separate environment, working in parallel with the web, is required. This environment is ESRI's ArcIMS.

ArcIMS is an Internet Mapping Server. IMS allows existing GIS data to be published interactively on the web. According to ESRI, "IMS also does something that no other Web-based mapping solution [MapQuest, Yahoo! Maps, etc.] can: it enables true distribution of GIS applications on the Web" (http://www.esri.com/software/Internetmaps/ims.html). ArcIMS operates in a distributed computing environment; a client (the end-user at their home or office computer) requests information from an Internet or Intranet server. The server then processes the request and sends the information back to the client viewer.

ArcIMS allow the integration and presentation of data from multiple sources. Locally stored shapefiles, coverages and ArcSDE layers can be combined with web-located data for localized query and analysis. The resulting presentation can be used as-is, in its default state, or can be highly customized and tailored to the individual project's needs.

ArcIMS integrates all the tools required to define, design, host and manage the site. This suite of tools is discussed in detail below.

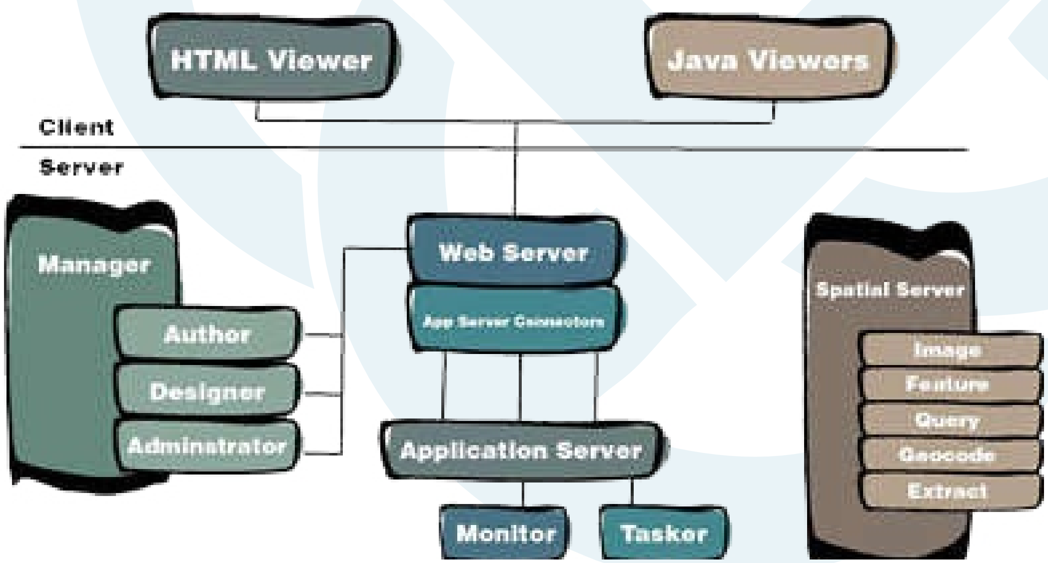


Figure 5: The ArcIMS structure.

ArcIMS

ArcIMS, and its various components, was the main application used in the creation of the application site. The term “components” is used as ArcIMS is more of a suite of programs that work with one another rather than one standalone application. Although these programs, Author, Designer and Administrator are all available as standalone Windows (and UNIX) applications, one program, ArcIMS Manager, brings them all together in one web-based interface. Manager also allows remote site management. Our application site was created using the tools provided in ArcIMS Manager, but it could easily have been designed using the tools independently of one another.

The first step in authoring a map and publishing it on the Internet is creating a MapService. “A MapService allows the content of a map configuration file to be published on the Internet and sets the framework for the web site’s functionality.” (ESRI, Using ArcIMS 3.1, 39). These configuration files, or .axl files, are structured text files, written in ArcXML, that “define content for MapServices and is used for requests and responses between clients… and servers.” (ESRI, 149). MapService configuration files are set up in ArcIMS Author.

Author’s interface is somewhat similar to that of ArcView GIS (Figure 6). Author allows for data (in ArcView shapfile, ArcInfo coverage or ArcSDE layer format) to be added. Like ArcView, Author sports a legend containing entries for each layer added. Right-clicking on each layer presents a menu full of options, including a Layer Properties option. The properties dialog box allows the user to change the name of the layer, set legend (colour, shading, stoke pitch, etc.) and label (font, size, positioning, style, etc.) options and change scale range settings. Author also allows the user to configure scale bar settings (screen and map units).

Author also allows the user to add MapTips to any layers present in the MapService. A MapTip is a text box that appears when the user hovers the mouse pointer over a feature on the map. Our application makes extensive use of MapTips; when a user hovers the mouse pointer over a University building on the map, for example, a MapTip appears that displays the name and abbreviation of that building (i.e. “Academic Quadrangle (AQ)”). One field per layer can be defined as that layer’s MapTip. This created a problem for our application. The building layer, for example, has separate fields for the building name and the building abbreviation; we used the concatenate function in Excel to create a MapTip field that

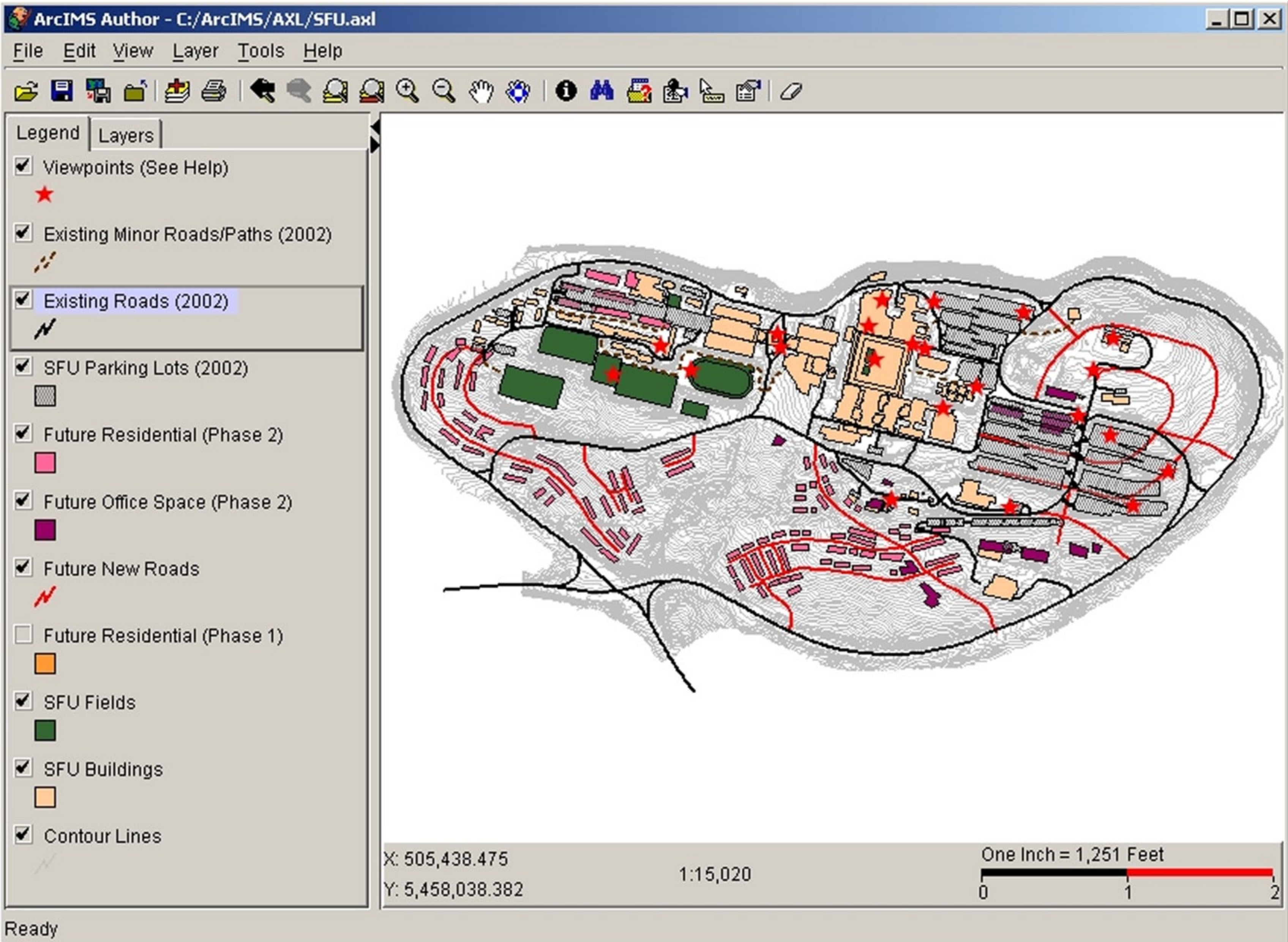


Figure 6: The ArcIMS Author interface bears strong resemblance to ArcView.

combines the required two fields. Creating the MapTip for the viewpoint layer required concatenating four separate fields along with several text strings.

Once the data is imported and all customizations have been completed, the settings are saved to an .axl file. The output of the MapService configuration file for our application, sfu.axl, is provided in Appendix C. This .axl file can be edited in a text editor for further configuration, if required. For example, we edited sfu.axl in order to change the colours of the proposed building layers after the original file had been created in Author.

The final step in creating the application is designing the website. This is accomplished in ArcIMS Designer, a wizard-based program that sets the parameters for the look and feel of the website. Designer allows the site administrator to set the following parameters:

- Adding a MapService (the file created in Author);
- Choosing between the HTML and Java Viewers (see below);
- Choosing the site template (see below);
- Choosing colours;
- Setting the map scale and extent;
- Choosing what layers are or are not visible;
- Defining the overview map, if used (we did not use an overview map);
- Setting scale bar options;
- Choosing what tools are provided to the user;
- Setting MapTips;
- Setting the final location (directory) for the website.

The two most important decisions that need to be made while using Designer are a) what viewer to use (HTML or Java) and b) what template to use (HTML, Java Standard or Java Custom).

The Viewer screen in designer offers the administrator up to two choices of viewers: HTML Viewer and Java Viewer. The HTML Viewer, a simple, server-side interface that offers limited functionality, is only available if the chosen MapService consists of one Image MapService. If this is not the case, the HTML Viewer option will appear grayed out and the only choice available will be the Java Viewer. The Java Viewer allows for more functionality, live streaming of data, and more customization. Using the Java Viewer necessitates the end user to download and install extra software to their PC – a Java runtime environment, or JRE, and the ArcIMS viewer software are both required for complete and proper functionality. Our application uses the Java Viewer.

After choosing the viewer, the administrator has to choose what template to base their site design on. If the site uses the HTML Viewer, the only choice given is the HTML template. If the site, like ours, uses the Java Viewer, there are two possible choices: Java Standard and Java Custom. The standard template includes all possible tools, a toolbar across the top of the screen, and does not allow for customization. The custom template offers a toolbar along the left side of the page, a choice of which tools are provided to the user, and full customization of the site using HTML and JavaScript. The UniverCity application uses the custom template. Most of the site has been changed from its stock state; these customizations are elsewhere in this report.

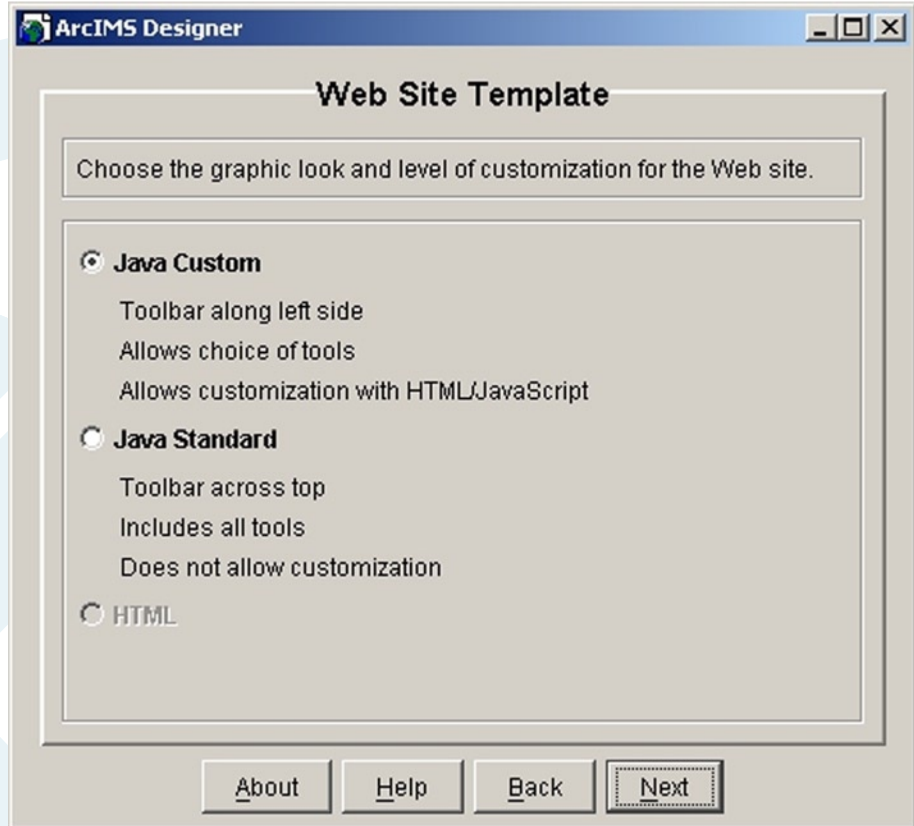


Figure 7: Author's template selection dialog box. Note that the HTML option is greyed-out, as there is no Image MapService available.

After all choices have been made, Designer writes the necessary files to the specified directories and the site is ready for use or further customization.

The final ArcIMS application is ArcIMS Administrator. Administrator offers many of the same features as the administration section of Manager, but in a standalone application. Administrator (and Manager) offers the following functionality:

- Starting and stopping MapServices;
- Opening and refreshing a site (for making changes to the legend, for example);
- Creating a new MapService;
- Saving the site configuration;

- Deleting a MapService;
- Managing Virtual Servers and folders.

ArcView GIS

ArcView GIS is a desktop GIS application developed by ESRI. ArcView was used to manipulate and prepare the data for our application. We used it to:

- Add attribute data to the basic shapfiles, such as building name, viewpoint elevation, etc.
- Remove extraneous data, such as spurious polygons.
- Create the TIN models and viewshed maps, using the 3D Analyst module.

ArcInfo Workstation & ArcEdit

ArcInfo is the comprehensive GIS that allows us to do numerous geoprocessing work like projecting and transforming our dataset. ArcEdit is the sub environment in ArcInfo which allows us to do the editing and digitizing of the ArcInfo coverages.

ArcCatalog

This ArcGIS application allows us to convert the dataset format between ArcInfo coverages and ArcView shapefiles and vice versa. The application works functions like a "Windows Explorer" for GIS data; it allows the user to manage their data.

Microsoft Excel

Microsoft Excel was used to make a variety of modifications to the dataset. It was used to add fields to shapefiles, convert the case of the URLs in viewpoints.dbf from uppercase to lowercase, create the MAPTIP fields (using the concatenate function to combine several fields into a new single field).

FileMaker Pro

FileMaker Pro is a relational database program. While adding attributes to the SFU Buildings layer, the .dfb file was damaged. There were more entries in the attribute table than in the shapefile index. Rather than start entering attributes all over again, we took a backup copy of the shapefile (with empty

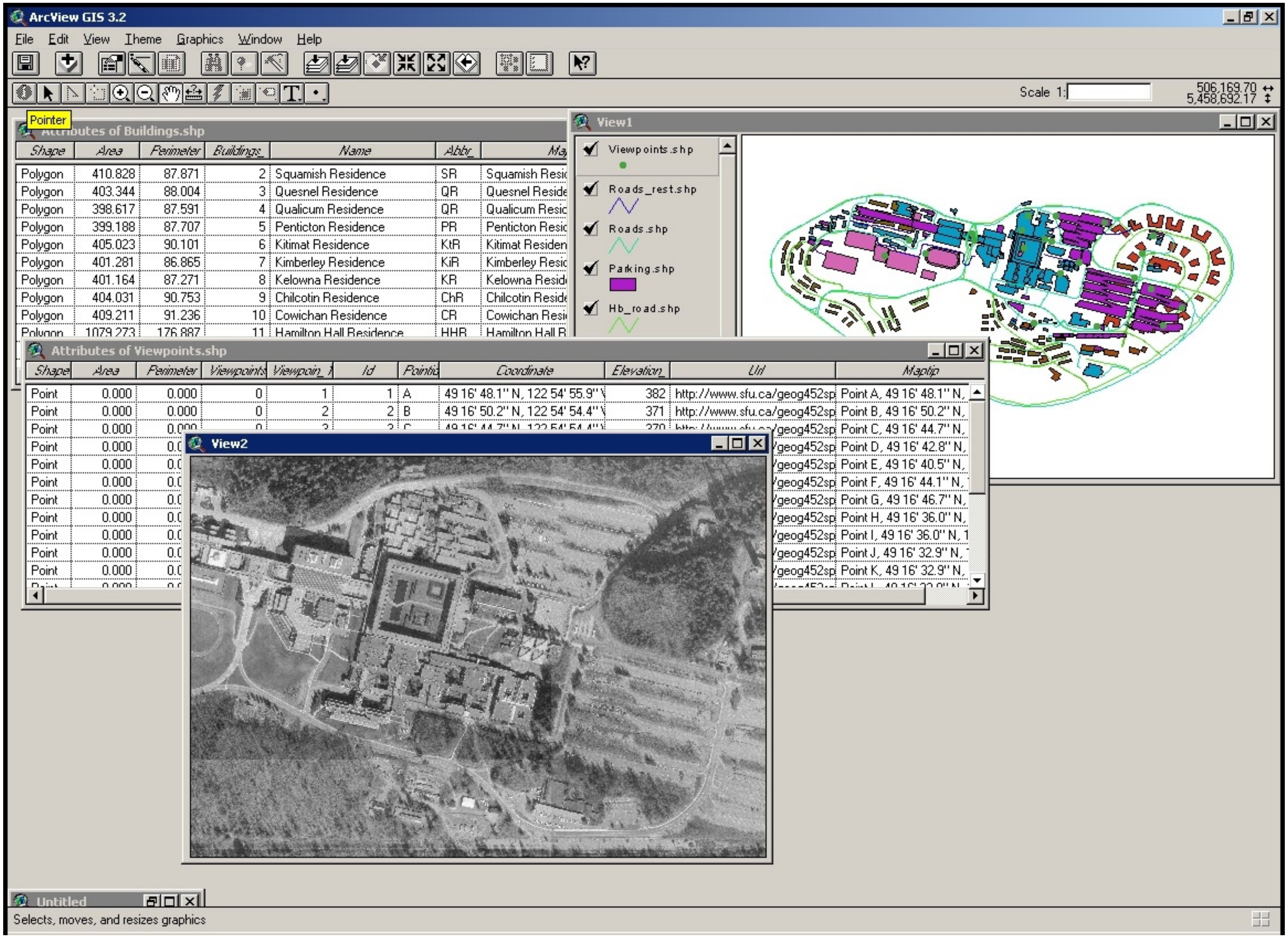


Figure 8: ArcView was used for multiple tasks, including adding attribute data.

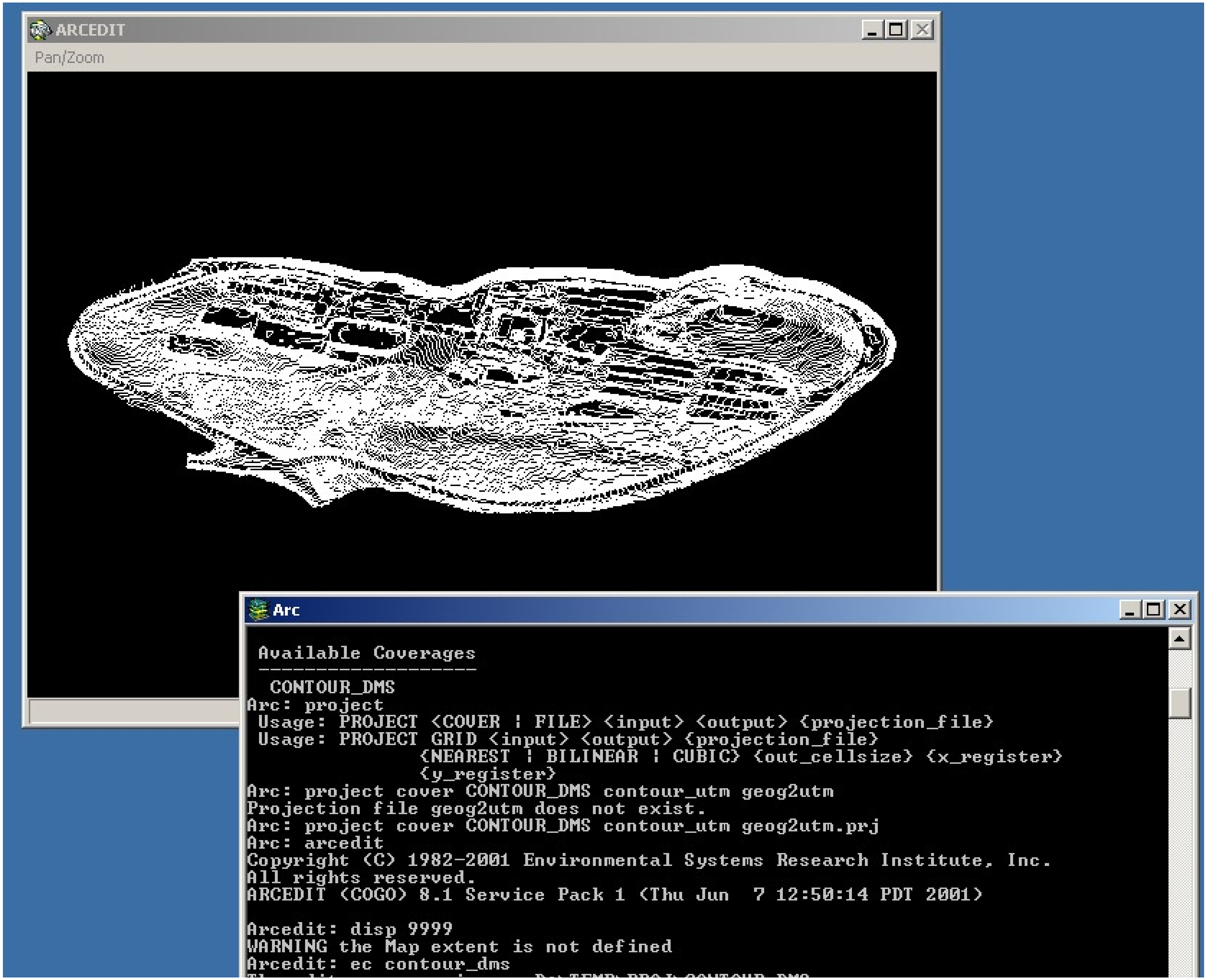


Figure 9: Projecting the countour line dataset in ArcEdit.

NAME and ABBR fields), imported it into FileMaker, linked it to the damaged copy, and using the polygon ID field as a key, we pulled the NAME and ABBR fields from the damaged file to the new, clean copy. The database was exported to a tab-delimited text file. That file was then opened in Excel and saved as a dBase IV (.dbf) file. ArcView was properly able to open the final .dbf file.

VR Worx

VR Worx was used to create the 360º panoramic views that accompany the application site. These views use a technology called QuickTime Virtual Reality, or QTVR. A QTVR panorama is a series of still images that are "stitched" together to create a single long image of a given scene. That image is then "wrapped" around to create a 360º circle. When viewed, the QTVR movie gives the effect of standing in one place and turning one's body in a complete circle.

We used a Kodak DC3400 digital camera to capture between 10 and 21 images for each of our viewpoints. With the camera mounted on a tripod, we simply took a series of pictures around the tripod's rotational axis, trying to achieve approximately 50% overlap in each image. In all, we ended up with approximately 315 images.

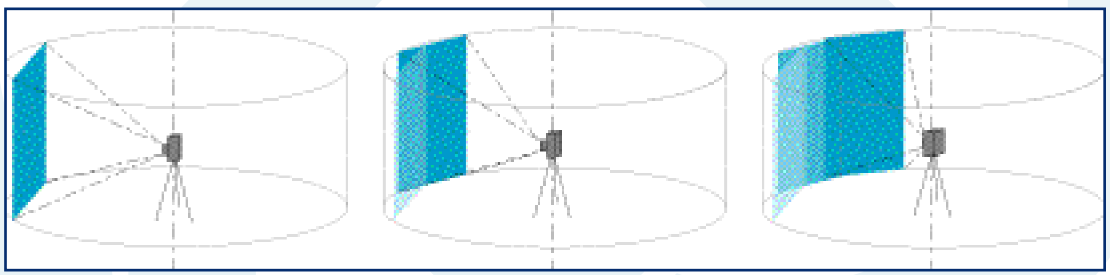


Figure 10: A QuickTime VR Panorama is created by taking a series of still images (with approximately 50% overlap) around a point.

Once the images had been downloaded and captured, we used VR Worx to create the panoramas. A template was created that had presets for the focal length of the camera's lens, angle of view and overlap. The program took the images from each viewpoint, stitched them together to form the panoramic image, blended them together and compressed and created the final movie file. The resulting files range in size from 350 kb to 1.5 MB in size.

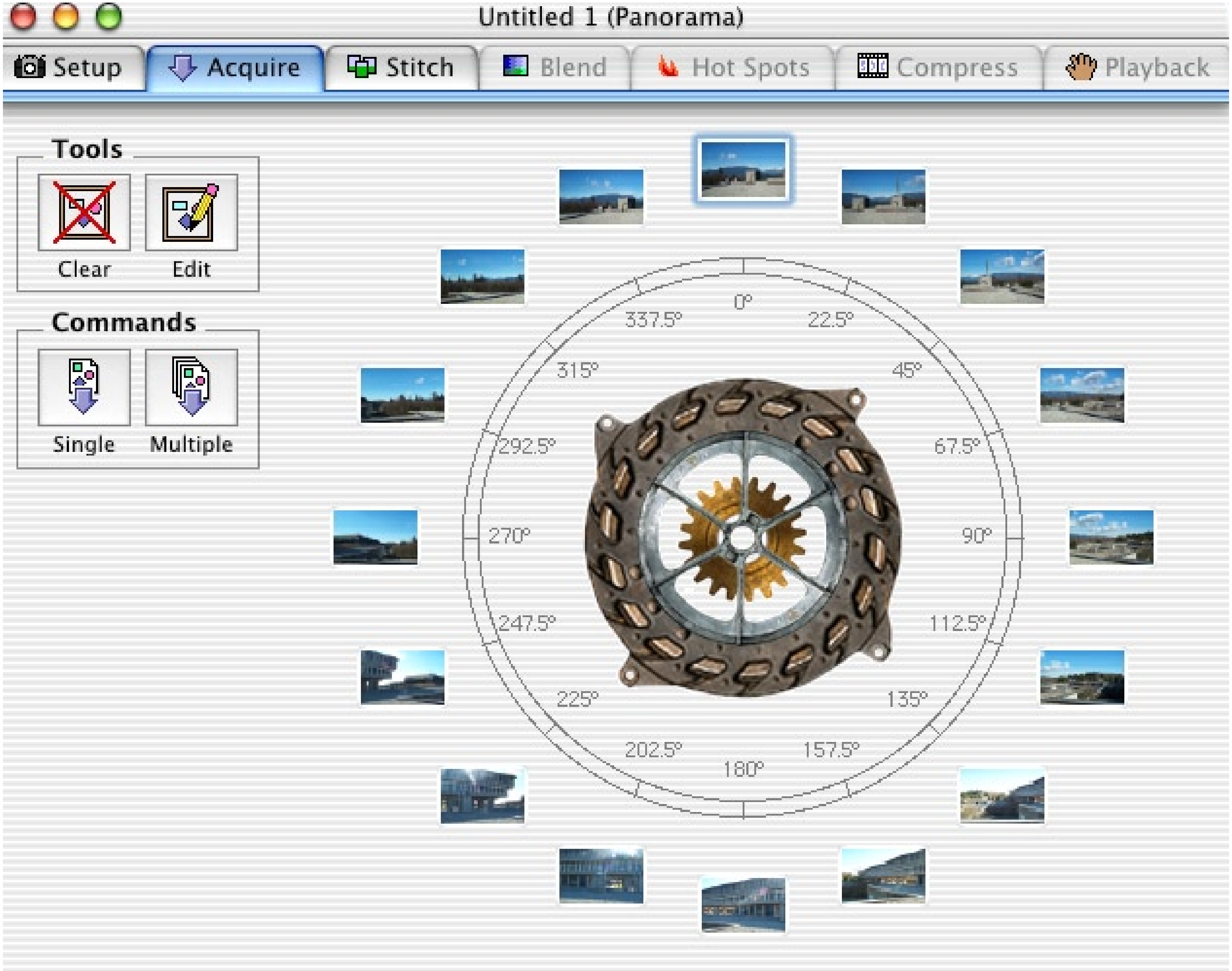


Figure 11: The VR Worx interface. The program takes a series of still images, stitches and wraps them to create a 360° panorama.

Miscellaneous Software

Other software used for the application site included: Adobe GoLive, Adobe Illustrator, Adobe Photoshop, BBEdit and Macromedia Freehand. Adobe InDesign 2 was used to crate the layout for this document.

Final Results

UniverCity: Bringing Internet-based GIS to the Burnaby Mountain Development

The ultimate goal of this project has been the creation of a user-friendly, Internet-based GIS showcasing the upcoming development of Burnaby Mountain.

An interactive Internet GIS website for the Burnaby Mountain Community Project (BMCP) has been created showing both the current and the future of Simon Fraser University and Burnaby Mountain. It is located at http://mapserver.geog.sfu.ca/Website/BMCC. Present SFU structures on our website include parking lots, playing fields, residences, roads and campus buildings. Proposed future structures such as residences, office space and roads are also included on our website. Other features added for enhanced interactivity include viewpoints, contour lines and digital orthophotos (aerial photography).

Map exploration tools for both spatial and non-spatial analysis, or just for viewing pleasure are included on the website. The following are a summary of the functions (as buttons) included on our website (ESRI Website, 2002):

MapTips

MapTips are small text boxes that appear when the user hovers the mouse pointer over an object. The text displayed varies depending on that feature the user is viewing, but includes elevation (for the contour line layer), feature name (for the building, field and parking lot layers) and coordinate information (included

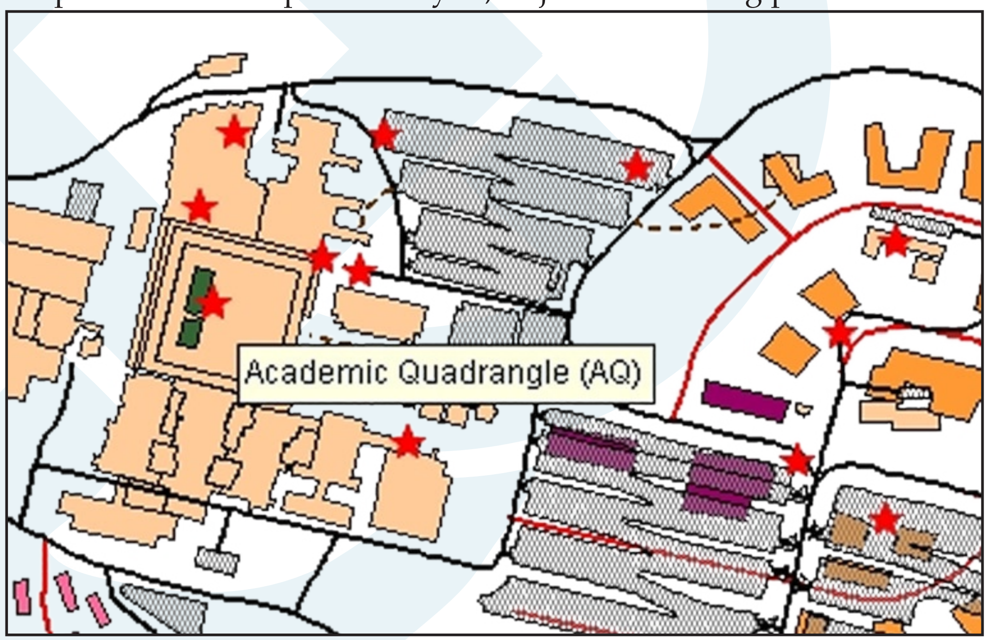


Figure 12: A MapTip. The text displayed varies depending on the feature the user has selected.

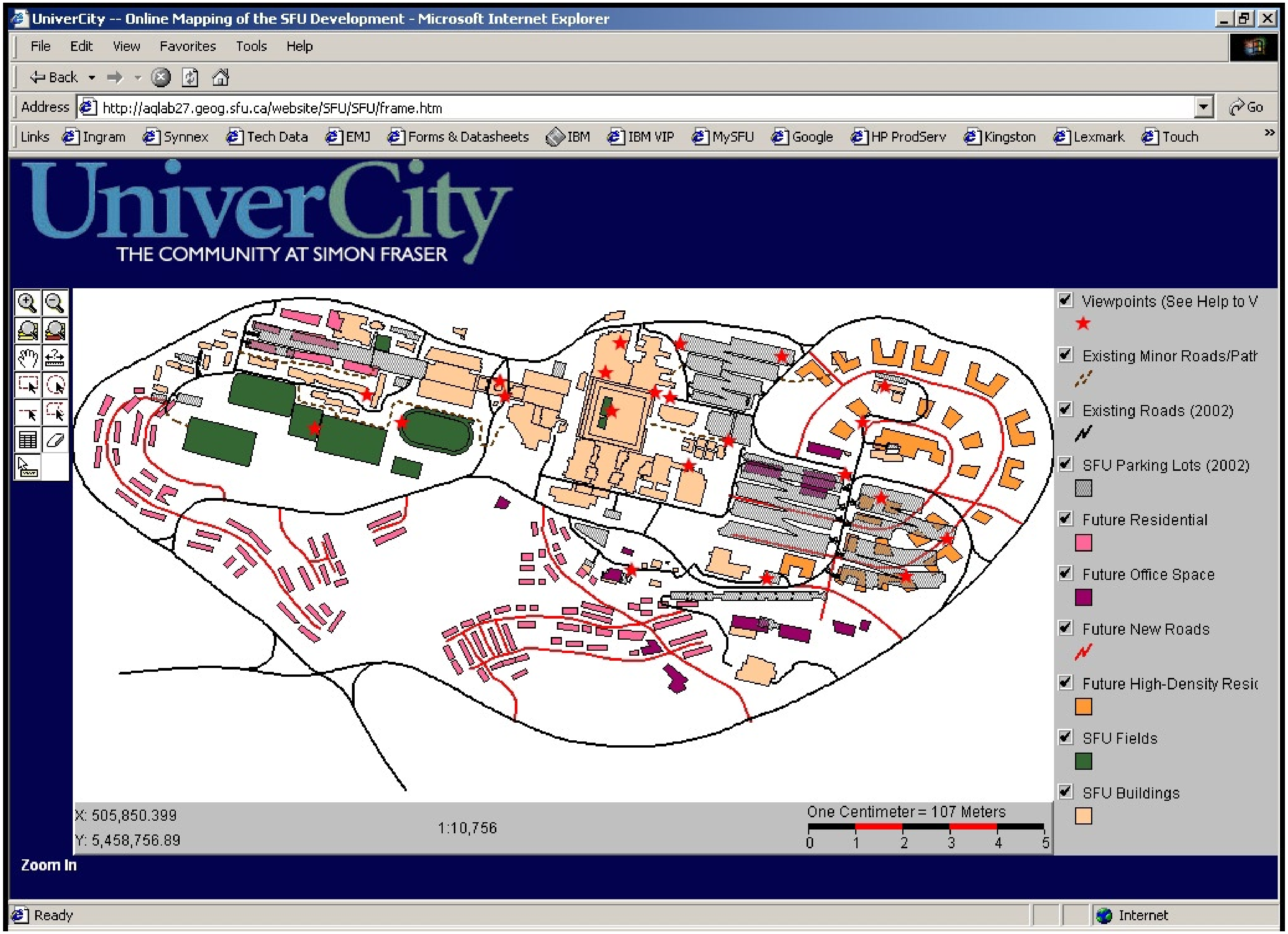
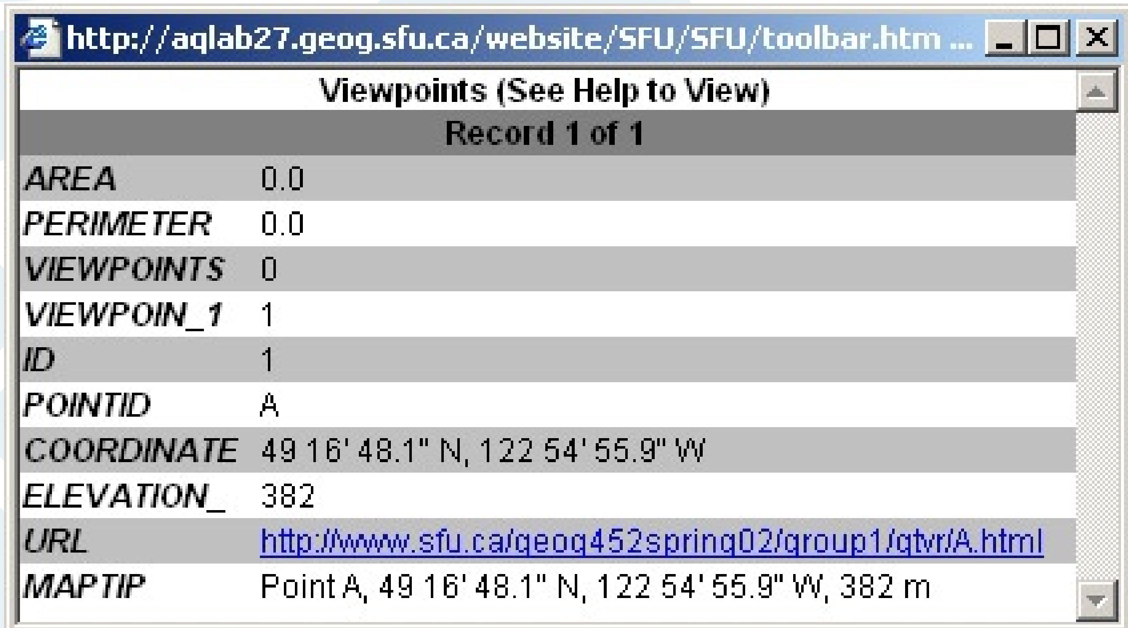


Figure 13: The final result -- UniverCity. Note that the site is undergoing constant modification, and may appear different than pictured here.

in the viewpoint layer). MapTips are a user-friendly approach to providing attribute data to novice users, as it only involves moving a mouse; no additional clicking and/or selecting is required.

Select features and view attributes

Four methods of selecting a feature(s) are included in the application. The user can draw a circle or rectangle around a feature, select a line feature or construct an irregular polygon selection. Once the feature(s) has/have been selected, the user can click on the Attribute button to view attribute table(s). The Clear All Selection button allows users to erase the selection set for all layers in the Web site.



http://aqlab27.geog.sfu.ca/website/SFU/SFU/toolbar.htm ...

Viewpoints (See Help to View)	
Record 1 of 1	
AREA	0.0
PERIMETER	0.0
VIEWPOINTS	0
VIEWPOIN_1	1
ID	1
POINTID	A
COORDINATE	49 16' 48.1" N, 122 54' 55.9" W
ELEVATION_	382
URL	http://www.sfu.ca/geog452spring02/group1/qtvr/A.html
MAPTIP	Point A, 49 16' 48.1" N, 122 54' 55.9" W, 382 m

Figure 14: The attribute table for Point A. Clicking on the blue link will take the user to the viewpoint page associated with the point.

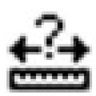
Obtain viewshed information

Using the method described above for selecting features, the user is able to see a viewshed analysis for twenty-two points around the SFU campus. The process requires three steps:

1. Select one or more viewpoints, using any of the feature selection tools (see above).
2. Click the Attribute button.
3. Click the hyperlink in the URL field for each viewpoint. The viewshed movie file (and 2D map, if applicable) will open in a new browser window.

Zooming and panning 

The zooming and panning buttons provide tools for navigating the map. Navigation includes zooming into and out of the map and panning, or sliding, the map in any direction. This way, users can investigate map details, view scale dependent features and labels, and focus on their area of interest.

Measuring 

The Measure button allows users of the website to quickly determine the distance between two points or along a route by digitizing a path directly on the map. Both the current segment length and the total length of the path are reported as the user digitizes the measurement. The measure units are based

on the scale bar's scale units; our application is set for metric units (screen units = centimeters, map units = kilometers).

Buffering Features

Creating buffer zones around features is an important part of spatial analysis. Questions such as "How many buildings are within 200 feet of Westmall Complex?" are easily solved through buffering.

Issues

As with any major undertaking, we faced several issues along the way. Some of these were minor, while others had the potential to significantly disrupt the project's outcome. Some are simply factors that needed to be taken into account during the construction of the application. These issues are described below, in no particular order.

System Requirements

As stated above, the application uses the ArcIMS Java Viewer. As such, it has unique system requirements for the end user. It requires two downloads – the JRE, and the IMS Viewer. Although they only have to be downloaded and installed once, it does add an extra step for the end user.

The Java Viewer is a "streaming" viewer. Instead of sending a static image in response to a request, as the HTML Viewer does, it maintains an open connection between client and server, with data constantly flowing back and forth. It is this stream that allows functionality such as live zooming, without the need for the user to click an "Update Map" button. This functionality comes at a price, however. It requires the user to have a relatively fast computer, and a broadband (DSL, cable, LAN, etc.) connection to the Internet.

One of the most limiting system requirements is that of supported operating systems and web browsers. At the time of this writing, only Microsoft Internet Explorer 5 (and above) running on Windows (9x, ME, NT or 2000) is supported. Netscape is not supported, as it does not allow the running of Java2 applications, necessary for the Java Viewer to function. This lack of interoperability means that users of Macintosh, Linux and other operating systems are incapable of viewing the site. In the spirit of interoperability and open standards, we sincerely hope that ESRI rectifies this situation soon.

Inadequate, Incomplete and/or Incorrect Data

When we began the project, we received a dataset from Jasper Stoodley. A previous Geography 452 group used this set, also for a project on the Burnaby Mountain development (their project site can be found at http://www.sfu.ca/geog452spring00/project2/). The dataset included the SFU buildings, roads and fields as well as the proposed development buildings.

Figure 16: The result of attempting to view the application on anything other than a PC running Microsoft Windows and Microsoft Internet Explorer. In this case, the system is a PowerMac G4 running Mac OS X 10.1.3

As we began working with the data, however, we realized that it was inadequate for our purposes. The previous group had obviously not intended their data to be used for analytical purposes. The most obvious evidence of this is demonstrated in Figure 17. The campus buildings had been digitized in one large block, not as discrete entities. As such, when we tried to select the Classroom Complex, the entire campus was selected. After weighing our options, we took the steps outlined above in Data Manipuation and created new coverages for the entire campus. This data then needed to be reprojected in order for it to be usable.

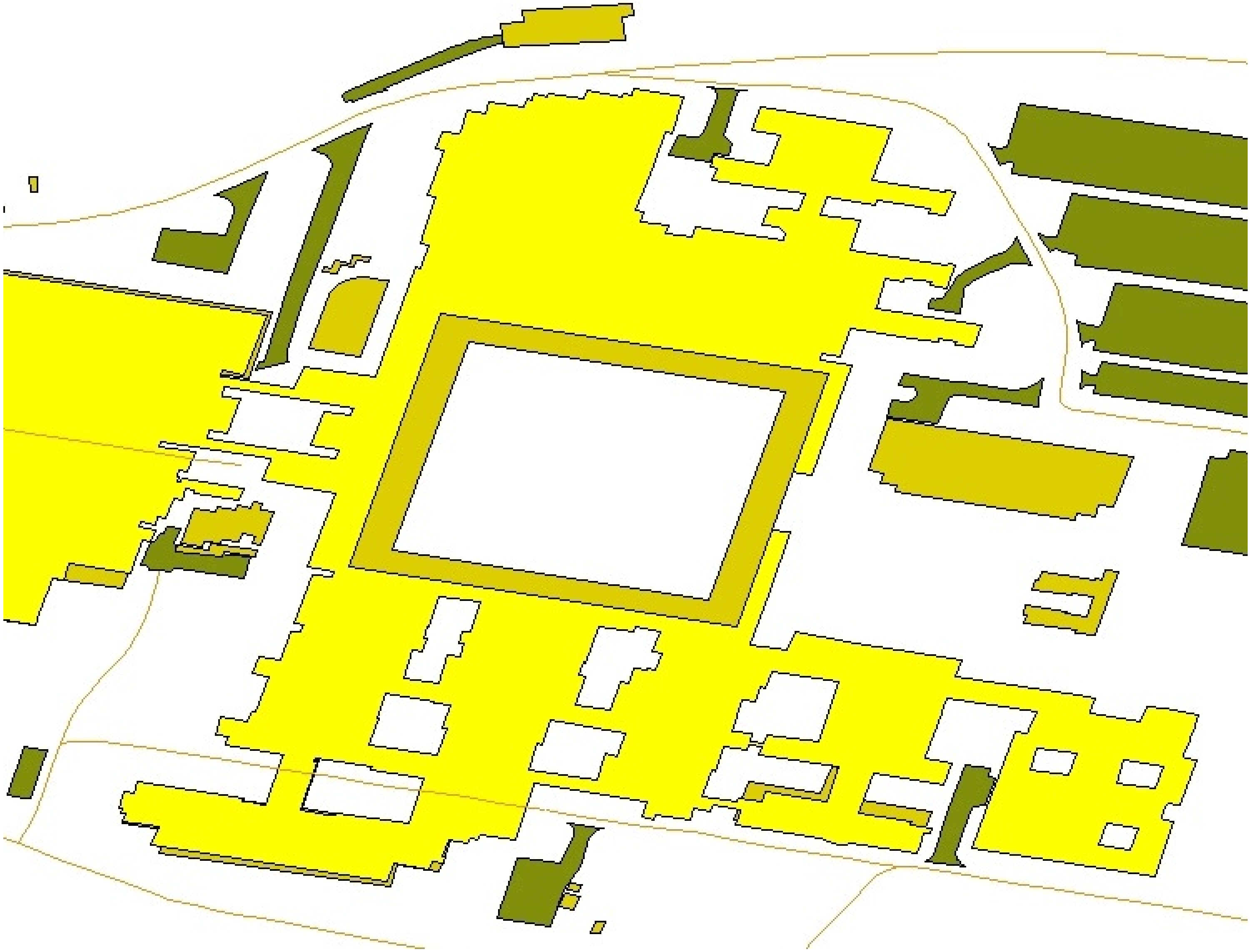


Figure 17: Poor digitizing of the original data provided to us resulted in multiple buildings being selected when we attempted to select only the Classroom Complex. We elected to redigitize the data rather than attempt to repair it.

Missing Photos in the Panorama Sets

After downloading the images captured for the viewpoint panoramas, it became evident that a few of the viewpoints were missing images. These were either damaged while being captured or not captured at all. The result is two or three interesting panoramas, as evidenced below.

Figure 18: Due to a missing photo in this set, the Academic Quadrangle has been transformed into the Adademic Trapezoid.

Security

Overall, our Java Viewer-based Internet application website is secure. Java provides a security framework, known as a "sandbox," to establish an intelligent security system that consists of three major: the Java language, the Java complier and verifierand security managers in the Java runtime environment (JRE). If the verifier cannot confirm that the Java complier produced the code being loaded, the code will not be loaded and executed. On the browser side, the user is secure in that the Java "sandbox" does not allow the applet(s) to modify the local file structure (i.e. no file writing, etc.). Thus, no viruses

can corrupt the local memory or system.

However, Java applets are not error or problem free in terms of security. This conservative system imposes some restrictions on what can be achieved by using the applets in the development of Internet

GIS. For instance, applets are prevented from accessing machines on the network other than the computer from which the applets were originally loaded. This can potentially lead to serious problems in development the Internet GIS application as a distributed system. Furthermore, because applets do not allow users to write on their local systems, data cannot be written nor saved to the user's local machine (Peng, 1998).

In the future, as overall Internet security improves, Internet GIS will become more secure and more flexible.

Quality of Data

Problems regarding the quality of data and the depth of our Internet GIS application have been compounded by uncertainty (for example, we were not able to obtain the heights of newly proposed buildings) and by time constraints (under three months allotted to complete the project). More sophisticated viewshed analysis would have been performed if there were data about the SFU building heights.

Arbitrary Selection of Viewpoints

In reality, just about any point on campus could be chosen as a viewpoint for our project; however, these points were chosen based upon judgment on where key places would the intended audience would be interested of knowing its viewshed. This can potential introduce bias and criticism to where what other viewpoints on campus could have been included or not.

Conclusion

The Internet and GIS

The integration of GIS with the Internet is an inevitable, rapidly growing trend into the future. It is important for the GIS community to monitor and define the course of this development. In addition, the Internet's ability to reach a wider audience will have important impacts on GIS users, developers, and institutions. For GIS users, Internet GIS also provides an efficient pool to conduct GIS analysis (i.e. buffering) over the web. For GIS developers, Internet GIS provides a new challenge and opportunity to broaden their market share (i.e. ESRI's ArcIMS software over its competitors). For institutions (i.e. SFU), Internet GIS will facilitate integration and coordination of different departments and functions within an organization as well as among organizations (BMCC) because spatial data in different departments are now easily accessible and sharable.

Interactive mapping is only the first step in the development of Internet GIS; Future developments will inevitably focus on interactive GIS analysis. Internet GIS also provides an opportunity to extend GIS technology and geospatial-information to a much broader user group - the general public (Peng, 1998).

Did We Meet Our Goals?

To recap, the goal of this project was to create an Internet-based GIS website featuring the Burnaby Mountain Community Project. This website was to have enabled the user to perform basic GIS operations such as measuring distances, viewing attribute data and buffering features. The application was also to provide a viewshed capability. After nearly three months of work, the question begs to be asked – was this goal met?

The answer lies in our application website, UniverCity. Available at http://mapserver.geog.sfu.ca/Website/BMCC, we believe that this site fulfils the stated goals for this project. The site provides the user with a online map of the current SFU campus as well as the proposed development. The site offers buffering, distance measuring and attribute querying, satisfying the GIS requirement. Lastly, it offers two types of viewshed analysis: a traditional, map-based depiction of all areas that can be seen from a given point, as well as an innovative, QuickTime Virtual Reality-based interactive viewshed, in which the user can immerse him/herself in a photorealistic view.

While we were not able to incorporate our every desire into the project (one wish, for example, was to be able to click on **any** point, not just a set of arbitrarily selected points, and obtain a viewshed – this proved to be nearly impossible given the constraints of time, computational power and experience), we firmly believe that we have met our goals and have provided the Burnaby Mountain community with a valuable resource.

What Did We Learn?

This project was, as is any well-devised assignment, a valuable learning experience for all group members. We started as complete neophytes in the realm of online GIS, but were expected to create a publicly accessible application in less than thirteen weeks. Our first few group meetings were spent huddled around SIS-27, with nothing more than the assignment outline and five blank stares. We soon completed ESRI's Virtual Campus online ArcIMS course and started tinkering away, creating test websites. We became experts in data manipulation, projection and repair and proficient at bringing GIS to the web. We all became project managers, in a sense; we had to take into account varying concerns, such as the extent of the GIS capabilities available to the user and the system requirements of the website.

More importantly, we learned a great deal about what it takes to bring a project such as this to fruition. Internet-based GIS is a constantly evolving arena. As much information came from other users in ESRI's online forums than it did from journal articles and ESRI's ArcIMS documentation. Creating this application has given each of us a toehold into this fascinating realm.

Looking Towards The Future

So, how relevant can our project be over long term ? What if building plans change, or attribute information comes available for the data we have? The advantage of our project is that it can be updated to enhance its functionality, and poses no obvious problem. However, an issue arises with who will continue site maintenance because once this project is finished we will not likely update, improve, or build the site. It would benefit the BMCC if it would take ownership but part of the responsibility would be to understand GIS and the ArcIMS software. The future of the site is yet unknown. Perhaps it would be wise to remove the site after 2 years if no-one updates pictures of the development. However, for the present time it offers an accurate venue for all people connected to the World Wide Web who can interactively view the present state of the campus, and who can anticipate change coming to SFU.

Appendix A: Glossary

Applet
A program written in Java and designed to be executed from within another application such as a web browser. (ESRI, 147)

ArcIMS
ESRI software that allows Internet mapping and distributed GIS solutions. The administrative framework lets users author map configuration files, publish MapServices, design web pages and administer ArcIMS Spatial Servers. (ESRI, 147)

ArcIMS Administrator
The ArcIMS component that allows users to manage MapServices, Servers, Virtual Servers and Folders. (ESRI, 147)

ArcIMS Author
The ArcIMS component that allows users to organize data into a map configuration file that can be used to create a MapService. A map configuration file specifies the map content: which data layers will be displayed and how they will look (colours, symbols, labels, etc.). (ESRI, 148)

ArcIMS Designer
The ArcIMS component that guides users in designing web pages based on at least one MapService and one of the ArcIMS viewers. Users choose from a variety of options including toolbar functions, scale bar properties and visible layer settings. (ESRI, 148)

ArcIMS Manager
ArcIMS Manager is a suite of web pages that guides you through the process of authoring map configuration files, publishing MapServices, designing web pages and administering sites. Manager combines the three independent ArcIMS Manager Applications -- Author, Designer and Administrator -- into one wizard-driven framework. manager resides on the web server computer and can be accessed

remotely. (ESRI, 148)

ArcIMS Viewers

The three ArcIMS Viewers -- HTML, Java Custom and Java Standard -- use a web site template to provide the functionality and graphic look used on your website. The Java Viewers require a onetime web download and are only compatible with web browsers that support Java 2 plug-in functionality. (ESRI, 148)

ArcXML

The Arc Extensible Markup Language (ArcXML) file format provides a structured method for communication between all ArcIMS components. ArcXML defines content for MapServices and is used for requests and responses between clients, the business logic tier and servers. (ESRI, 149)

Client

A computer and/or application that allows Internet users to communicate with a server. (ESRI, 149)

Client-Server Relationship

A common form of distributed system in which software is split between server tasks and client tasks. A client sends requests to a server, according to some protocol, asking for information or action, and the server responds. (dictionary.com)

Feature MapService

A Feature MapService uses the ArcIMS Spatial Server's feature streaming capabilities, The server bundles data and streams it to the requesting client. Since more of the processing is done in the Java applet, request are sent to an ArcIMS Spatial Server only when additional data [are] needed. (ESRI, 149)

HTML

Hypertext Markup Language. The coding language used to make hypertext documents for use on the web. HTML structures text inside tags that describe its content. For example, any text inside a set of <bold> </bold> tags will appear **bold**.

HTML Viewer

One of the ArcIMS Viewers that uses a single Image MapService. The HTML Viewer does not require a

Java plug-in. (ESRI, 150)

Image MapService
Image MapServices use the Spatial Server image rendering capabilities. When a request is received, a map is generated on the server, and the response is sent back as a JPEG, PNG or GIF image. A new map image is generated each time a client requests new information. (ESRI, 150)

IMS
Internet Map Server. (ESRI, 150)

Interoperability
The ability of software and hardware on multiple machines from multiple vendors to communicate.

Java
An object-oriented programming language developed by Sun Microsystems. Java provides a complete foundation for building and deploying cross-platform, enterprise applications. (ESRI, 151)

Java Viewer
ArcIMS Viewers that use a Java2 applet. The Java Viewers can be used with Feature or Image MapServices. They allow client-side drawing and editing and require a Java plug-in. (ESRI, 151)

JavaScript
A scripting language to enable web authors to design interactive sites. Although it shares many of the features and structures of the full Java language, it was developed independently. JavaScript can interact with HTML source code, enabling web authors to add dynamic content to their sites. (ESRI, 151)

Map Configuration File
Provides data layer content and symbology that the MapService registers to the ArcIMS Spatial Server and web server for processing. (ESRI, 151)

MapTip
A small text box that appears when the user hovers their mouse pointer over an object on the map.

MapTips display a specified field from the data layer.

MapService
A MapService allows the content of a map configuration file to be published on the Internet. (ESRI, 151)

Plug-in
Small software applications that extend the functionality of a web browser. (ESRI, 151)

QuickTime Virtual Reality (QTVR)
QTVR is a photorealistic cross-platform virtual reality technology that makes it possible to explore places as if you were really there. It takes a series of still images, captures around the axis of a point and stitches them together into one seamless panorama that the user can navigate with their mouse. It gives the effect of standing at a single point and rotating one's body around that point.

Shapefile
A shapefile is a simple, nontopological format for storing the geometric location and attribute information of geographic features. (ESRI, 153)

Tic
Registration or geographic control points for a coverage representing known locations on the Earth's surface. Tics allow all coverage features to be recorded in a common coordinate system (e.g., Universal Transverse Mercator [UTM] meters or State Plane feet). Tics are used to register map sheets when they are mounted on a digitizer and to transform the coordinates of a coverage (e.g., from digitizer units [inches] to UTM meters). (Arc Help)

Triangulated Irregular Network (TIN)
Triangulated irregular network. A surface representation derived from irregularly spaced sample points and breakline features. The TIN data set includes topological relationships between points and their neighboring triangles. Each sample point has an x,y coordinate and a surface, or z-value. These points are connected by edges to form a set of non-overlapping triangles used to represent the surface. TINs are also called irregular triangular mesh or irregular triangular surface model. (Arc Help)

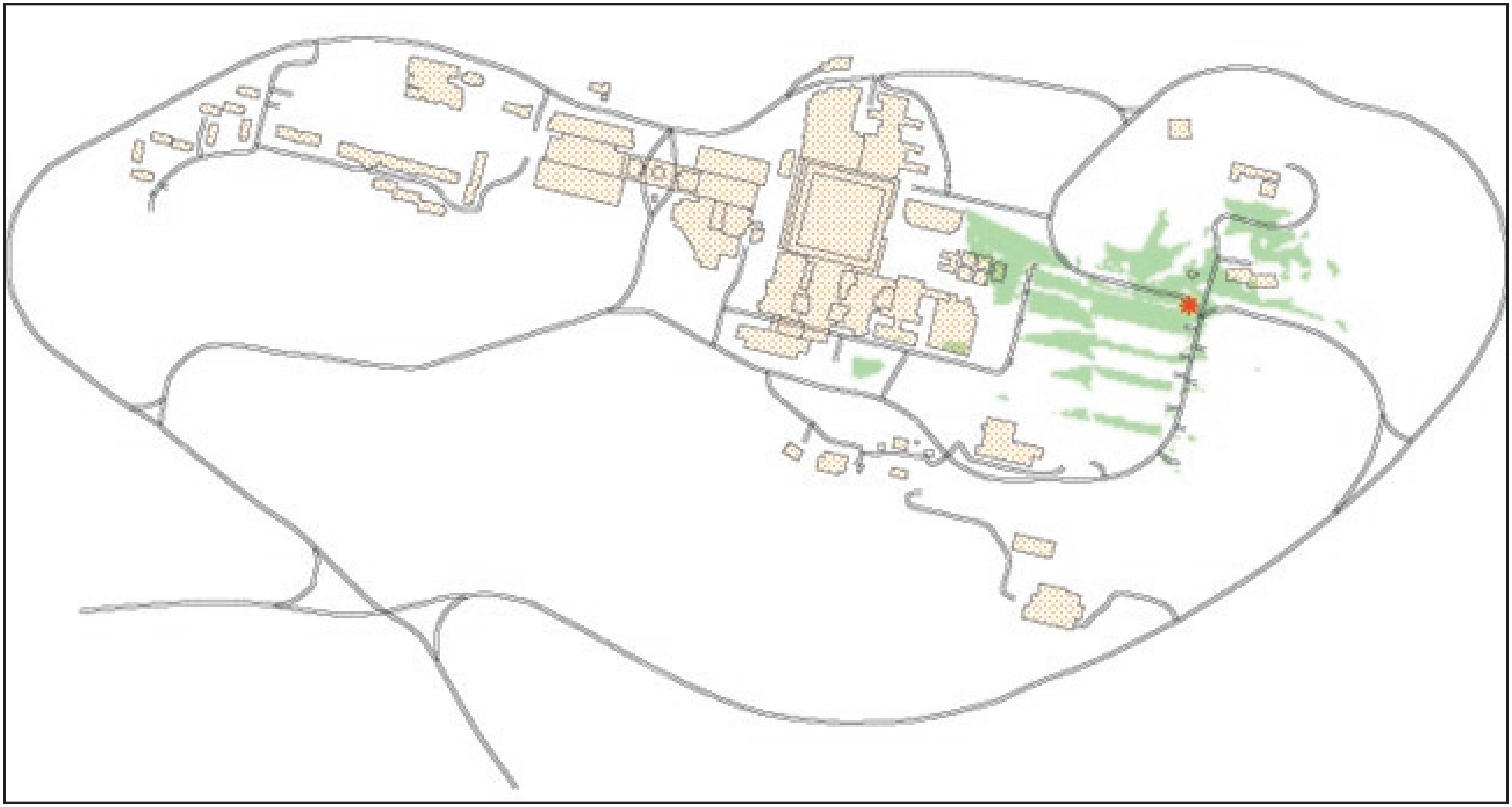
Viewshed
All the points that can be seen from a given point.

Appendix B: Viewshed Maps

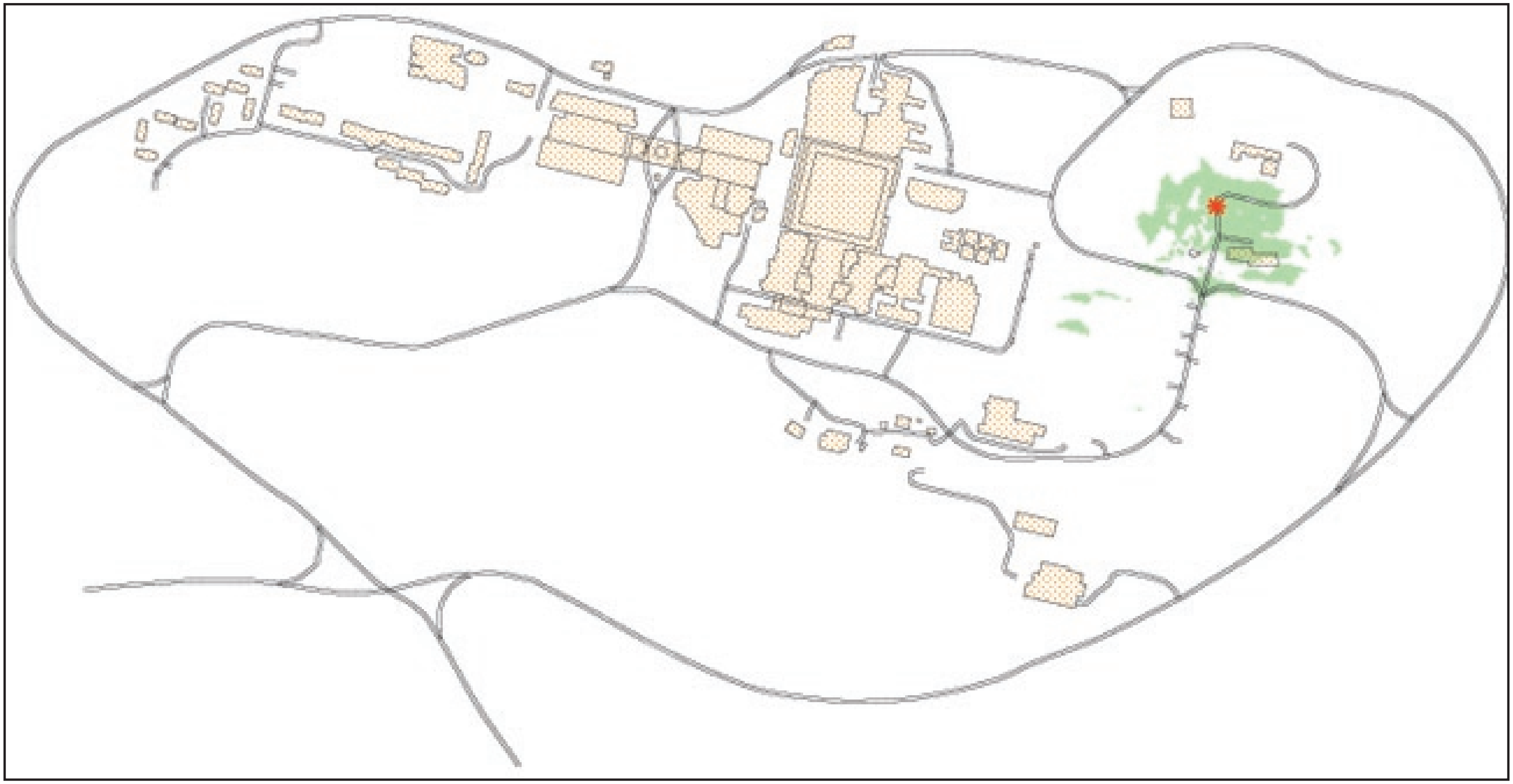
The following 14 images are the static viewshed maps generated by 3D Analyst for all viewpoints that originate on the ground.

Point C

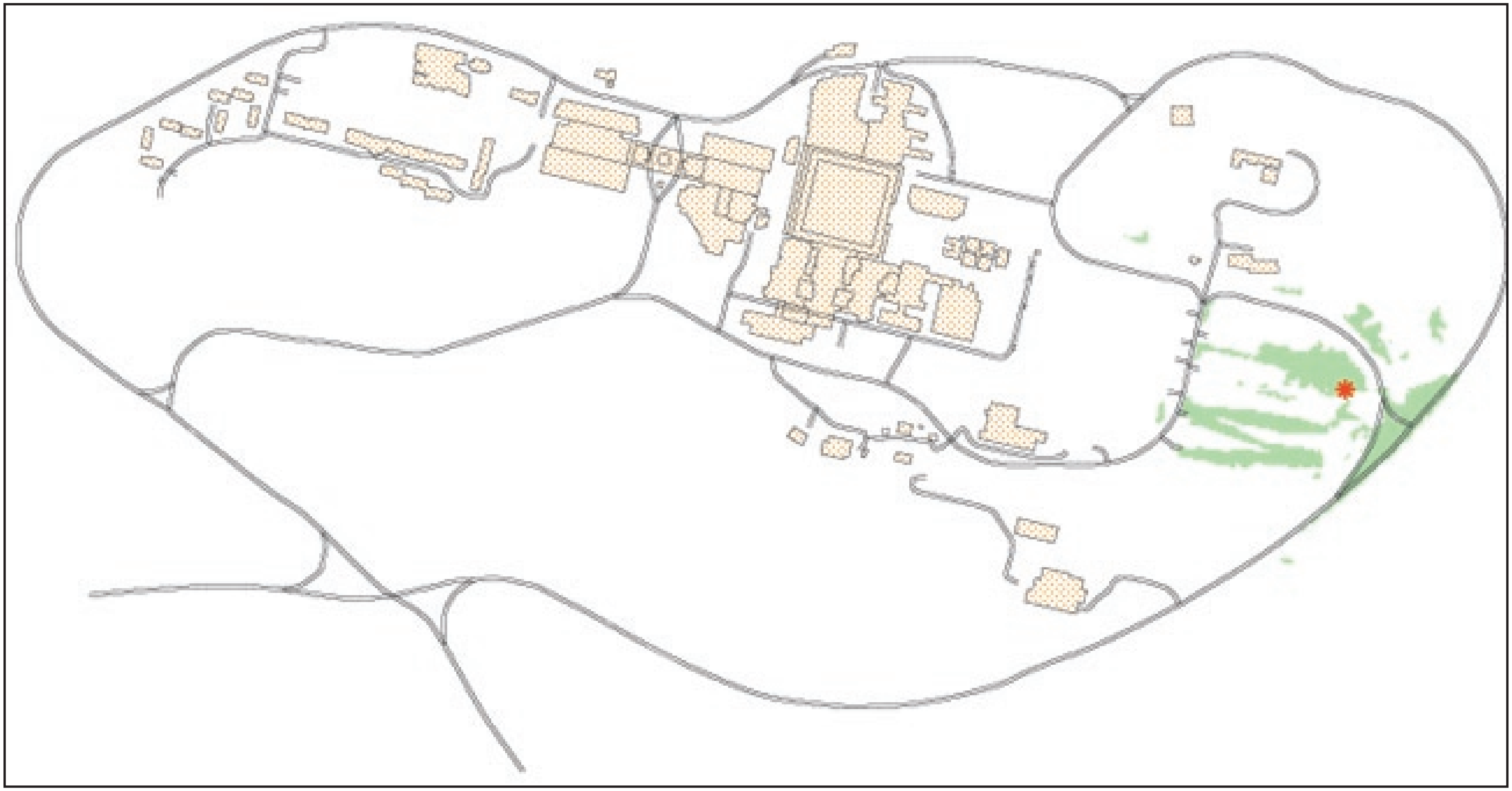
Point D



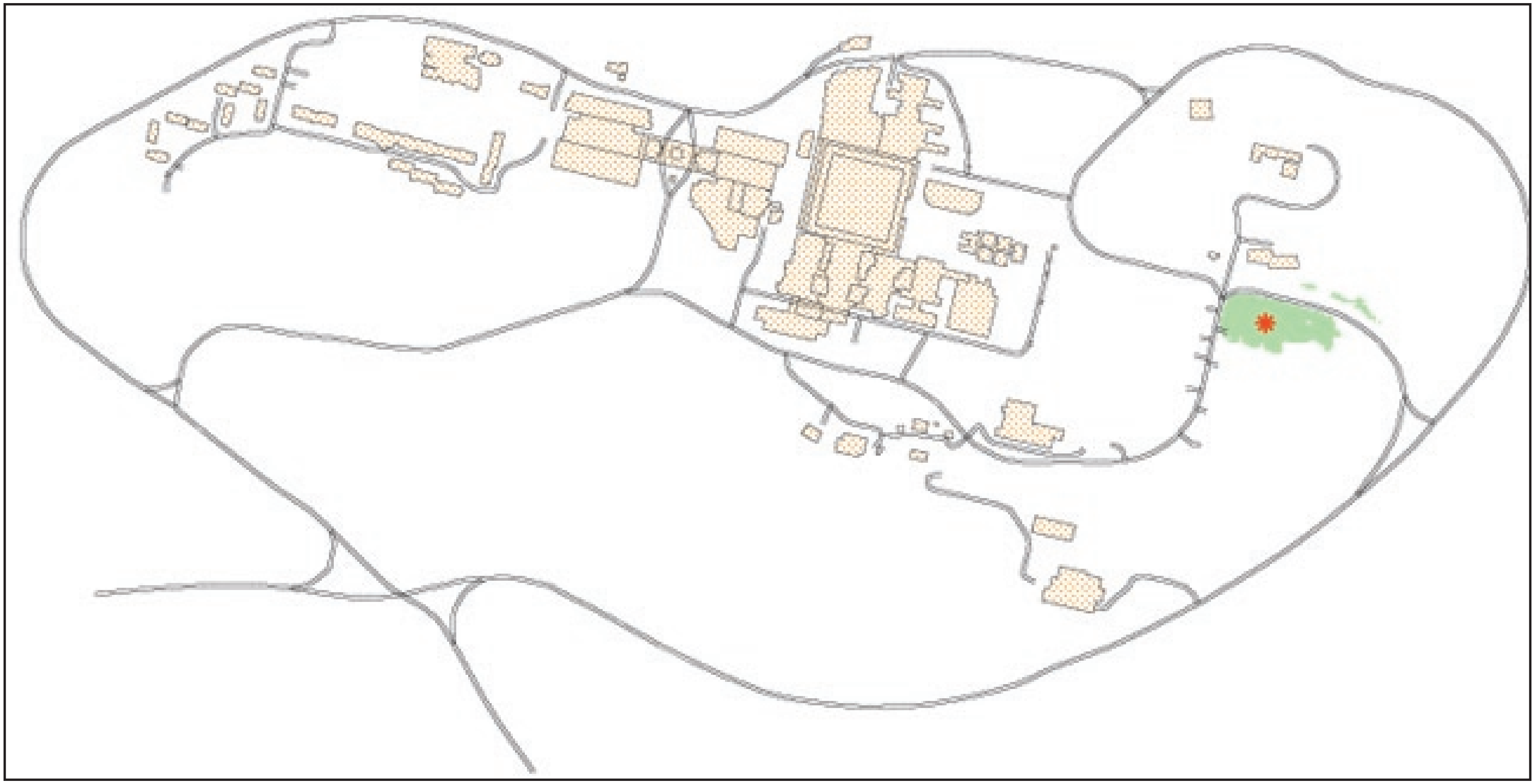
Point E



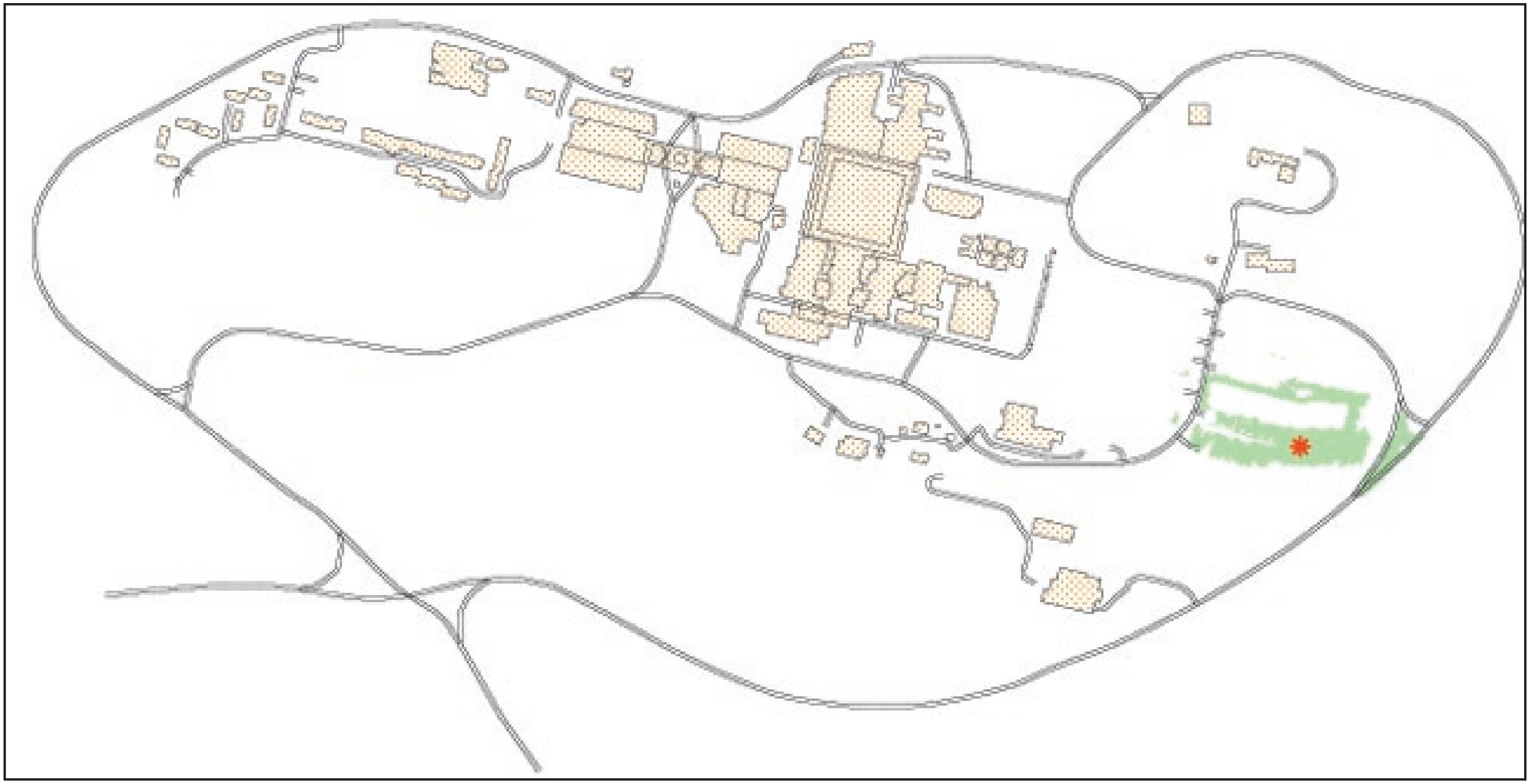
Point F



Point H



Point I



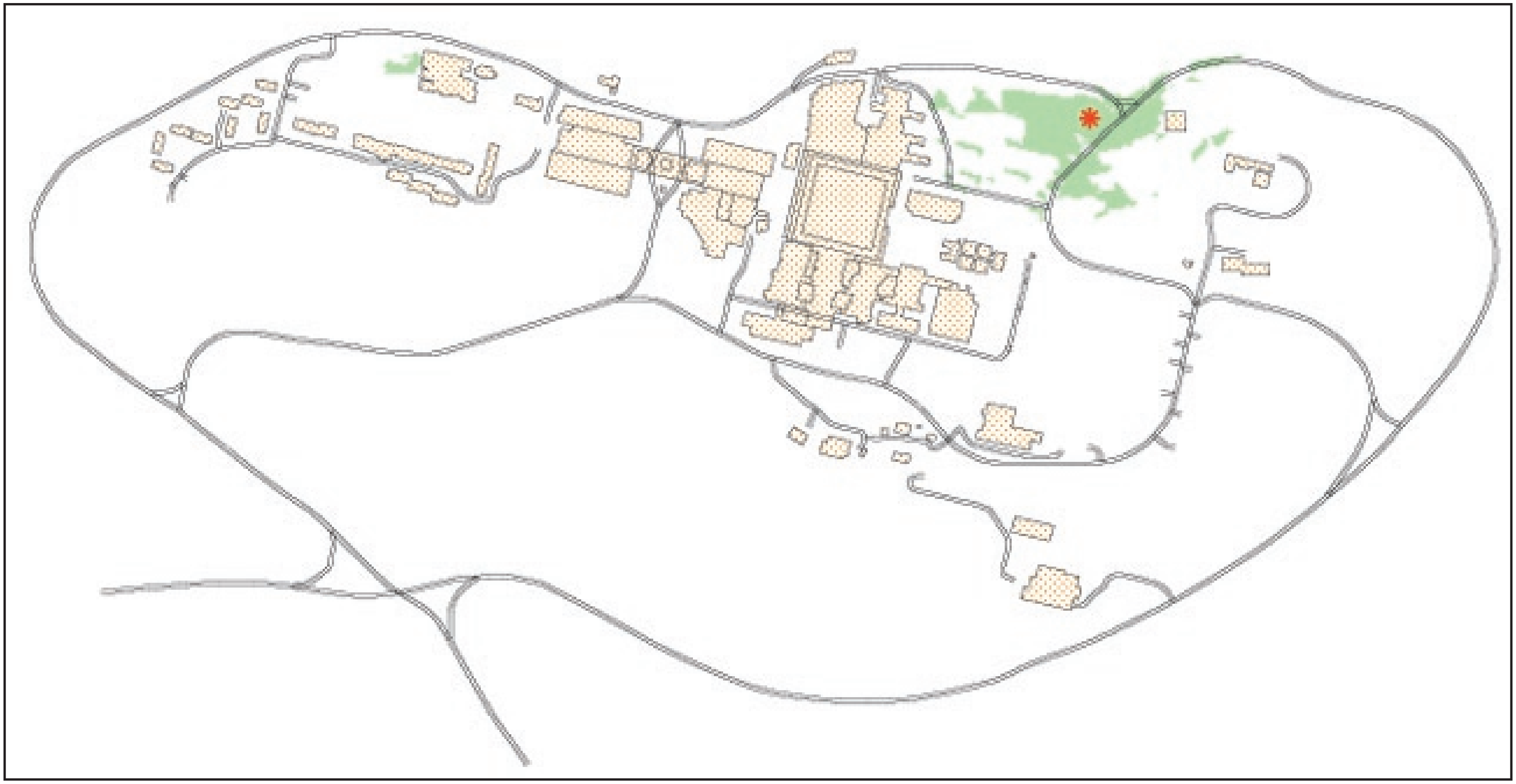
Point J

Point K

Point L

Point M

Point N



Point 0

Point P

Point Q

Appendix C: Map Configuration File

The following code is the sfu.axl map configuration file. This file sets up the parameters for the UniverCity web site, including layer name, visability, colour and symbology options. This file was current as of 2315 PST 18 March 2002.

```
<?xml version=”1.0” encoding=”UTF-8”?>

<ARCXML version=”1.1”>
  <CONFIG>
    <MAP>
      <PROPERTIES>
   <ENVELOPE minx=”504823.0625” miny=”5457610.5” maxx=”507071.25” maxy=”5458736.5” name=”Initial_
Extent” />
   <MAPUNITS units=”meters” />
      </PROPERTIES>
      <WORKSPACES>

<!--     <IMAGESERVERWORKSPACE name=”mapper_ws-0” url=”http://mapserver.geog.sfu.ca/servlet/com.e
sri.esrimap.Esrimap” service=”SFU_image” /> -->

      <IMAGEWORKSPACE directory=”C:\ArcIMS\Datasets\BMCC” name=”jai_ws-8” />
   <FEATURESERVERWORKSPACE name=”ifs_ws-0” url=”http://aqlab27.geog.sfu.ca/servlet/com.esri.esrim
ap.Esrimap” service=”SFU” />
      </WORKSPACES>

     <!-- <LAYER type=”image” name=”kl2324.tif” visible=”false” id=”0”>
   <DATASET name=”kl2324.tif” type=”image” workspace=”mapper_ws-0” />
      </LAYER>
      <LAYER type=”image” name=”kl2122.tif” visible=”false” id=”1”>
   <DATASET name=”kl2122.tif” type=”image” workspace=”mapper_ws-0” />
      </LAYER>
      <LAYER type=”image” name=”ij2324.tif” visible=”false” id=”2”>
   <DATASET name=”ij2324.tif” type=”image” workspace=”mapper_ws-0” />
      </LAYER>
      <LAYER type=”image” name=”ij2122.tif” visible=”false” id=”3”>
   <DATASET name=”ij2122.tif” type=”image” workspace=”mapper_ws-0” />
      </LAYER>
-->
    <LAYER type=”image” name=”Northeast Airphoto” visible=”false” id=”0”>
```

```
<DATASET name=”kl2324.tif” type=”image” workspace=”jai_ws-8” />
   </LAYER>
   <LAYER type=”image” name=”Southeast Airphoto” visible=”false” id=”1”>
<DATASET name=”kl2122.tif” type=”image” workspace=”jai_ws-8” />
   </LAYER>
   <LAYER type=”image” name=”Northwest Airphoto” visible=”false” id=”2”>
<DATASET name=”ij2324.tif” type=”image” workspace=”jai_ws-8” />
   </LAYER>
   <LAYER type=”image” name=”Southwest Airphoto” visible=”false” id=”3”>
<DATASET name=”ij2122.tif” type=”image” workspace=”jai_ws-8” />
   </LAYER>

   <LAYER type=”featureclass” name=”Contour Lines” visible=”false” id=”10”>
<DATASET name=”10” type=”line” workspace=”ifs_ws-0” />
   </LAYER>
   <LAYER type=”featureclass” name=”SFU Buildings” visible=”true” id=”0”>
<DATASET name=”0” type=”polygon” workspace=”ifs_ws-0” />
   </LAYER>
   <LAYER type=”featureclass” name=”SFU Fields” visible=”true” id=”1”>
<DATASET name=”1” type=”polygon” workspace=”ifs_ws-0” />
   </LAYER>
   <LAYER type=”featureclass” name=”Future High-Density Residential” visible=”false” id=”2”>
<DATASET name=”2” type=”polygon” workspace=”ifs_ws-0” />
   </LAYER>
   <LAYER type=”featureclass” name=”Future New Roads” visible=”false” id=”3”>
<DATASET name=”3” type=”line” workspace=”ifs_ws-0” />
   </LAYER>
   <LAYER type=”featureclass” name=”Future Office Space” visible=”false” id=”4”>
<DATASET name=”4” type=”polygon” workspace=”ifs_ws-0” />
   </LAYER>
   <LAYER type=”featureclass” name=”Future Residential” visible=”false” id=”5”>
<DATASET name=”5” type=”polygon” workspace=”ifs_ws-0” />
   </LAYER>
   <LAYER type=”featureclass” name=”SFU Parking Lots (2002)” visible=”true” id=”6”>
<DATASET name=”6” type=”polygon” workspace=”ifs_ws-0” />
   </LAYER>
   <LAYER type=”featureclass” name=”Existing Roads (2002)” visible=”true” id=”7”>
<DATASET name=”7” type=”line” workspace=”ifs_ws-0” />
   </LAYER>
   <LAYER type=”featureclass” name=”Existing Minor Roads/Paths (2002)” visible=”true” id=”8”>
<DATASET name=”8” type=”line” workspace=”ifs_ws-0” />
   </LAYER>
   <LAYER type=”featureclass” name=”Viewpoints (See Help to View)” visible=”true” id=”9”>
```


```
    <DATASET name="9" type="point" workspace="ifs_ws-0" />
       </LAYER>

     </MAP>
   </CONFIG>
 </ARCXML>
```

Appendix D: Websites of Interest

Apple QuickTime VR
http://www.apple.com/quicktime/qtvr

Burnaby Mountain Community Project
http://www.sfu.ca/bmcp

ESRI
http://www.esri.com

ESRI Viewshed ArcInfo8 Demo
http://maps.esri.com/viewshed

GIS Analysis of the Burnaby Mountain Community Project
http://www.sfu.ca/geog452spring00/project2

SFU Mapserver
http://mapserver.geog.sfu.ca/mapserver.htm

References
Apple Computer, Inc. 2002. Apple - Quicktime - QuickTime VR Authoring (http://www.apple.com/quicktime/qtvr)

Burnaby Mountain Community Corporation. 2001. East Neighbourhood Plan.

dictionary.com

Foresman, Timothy W. 1999. Spatial Analysis and Mapping on the Internet. Journal of Public Health Management and Practice 5 (4): 57-64.

Hardie, Andrew. 1998. Present state of Web GIS. Cartography 27 (2): 11-26.

Peng, Z-R. (1998). "An assessment framework for the development of Internet GIS". Environment and planning B: Planning and Design 1999 (21): 117-132.

ESRI. 2002. ArcIMS (http://www.esri.com/software/arcims/index.html)

ESRI. Unknown date. ArcInfo Help System (online help).

ESRI. 2002. ArcXML Programmer's Online Reference Guide (http://arconline.esri.com/arconline/documentation/ims_/WebHelp/ArcXMLGuide.htm?PID=6)

ESRI. 2000. Customizing ArcIMS - Java Viewer.

ESRI. 2002. ESRI Forums: ArcIMS Product Discussion Conference (http://forums.esri.com/forums.asp?c=64)

ESRI. 2000. Using ArcIMS.