

# Howard County Bureau of Highways Web-enabled Snowplow Tracking System



## Background

Howard County's Bureau of Highways is responsible for plowing 950 miles of Howard County "owned" roads. These roads are divided into three operational zones. During a snow event it is of paramount importance for the Bureau of Highway to maintain high efficiency and balance the snowplow progress among three zones. To balance the truck force, the Bureau of Highway needs to know the completion percentage of each zone as well as the progress of each individual truck. To maintain high efficiency, replacement trucks need to be dispatched whenever an operator is having mechanical problems. In addition, the Bureau of Highway needs to make snow treatment decisions based on road conditions and the elapsed time since the roads were last treated.

Prior to the implementation of the existing snowplow system, in the 1996 snow blizzard the Bureau of Highways encountered major difficulty. The difficulty results from a lack of access to real-time accurate information on the vehicle's location and the road conditions. It has become apparent that an effective way of solving these problems and efficiently managing the snowplow fleet is to develop an Automated Vehicle Location (AVL) tracking system. AVL uses the latest in Global Positioning System (GPS) satellite technology combined with wireless communications and software to deliver real-time computer maps with vehicle locations and road conditions. (See figure 1)

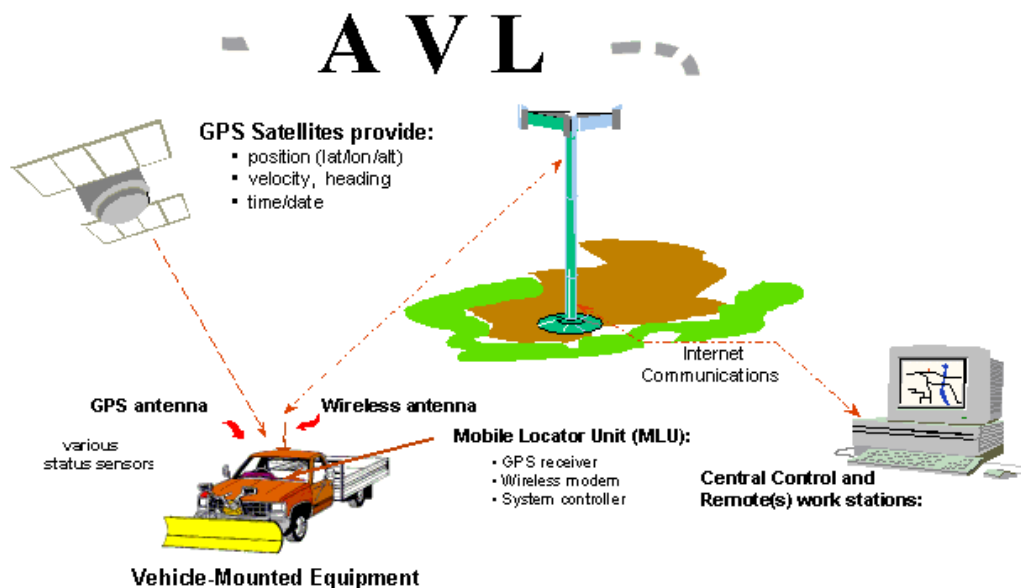


Figure 1 - AVL Overview

**Implementation** The goal of this project was to develop a snowplow tracking system to not only improve the Bureau of Highway's snowplow productivity, but also to improve the citizen's trust in government because of the service improvement. Soon after the system was functioning on Intranet, the County realized its potential and made the decision to expand the Internet component for greater accessibility. Using the Internet, residents and travelers can refer to the county WEB site to see which roads have been salted and plowed. The snowplow maps, which are updated every 15

minutes during storms, show both the road treatment conditions and the locations of snowplows.

In connection with the implementation of the Howard County Snowplow website, the Bureau of Highways is proposing additional analytical and reporting functions to enhance the system efficiency. The proposed capabilities will allow the County to balance the snow operation manpower among snow zones based on actual reports. It will allow the Bureau of Highways to more effectively utilize the location data being tracked. The potential result would be optimized use of existing vehicles and/or reduced number of snowplow equipment. The proposed tasks present significant snowplow efficiency improvement complementing the County's existing investments on snowplow tracking. These additions will enhance the analytical functionality already provided by the existing system currently in place.

**Cost** Last year, the hardware was installed on 83 snowplow trucks, with the information made available to supervisors in the highways bureau and to the public at <http://www.co.ho.md.us/snowpage.html>. As the first county in Maryland to implement the system, the Bureau of Highway is tracking its cost hoping to justify the \$400,000+ system cost by efficiency improvement. Each plow truck costs over \$100,000 initially and some \$40,000 (labor & maintenance) to operate. The county Bureau of Highways currently spends an average of \$350,000 each winter to clear snow from roads. If the system can reduce the number of trucks by one, the cost can be recovered in less than three years.

The county's road-cleaning expenses have ranged from \$60,000 to \$1.2 million per year over the past 15 years. The system will cost roughly \$10,000 a year to maintain. Although the Snowplow Tracking System investment is substantial, the Bureau of Highways have gained enough productivity increases and other benefits to more than offset the costs. Consequently, we are planning to install devices in the county's trash pickup trucks and street sweepers. The county's ultimate goal is to have the tracking system operational in every truck. This process may take some time because units are to be purchased only as funding becomes available.

**Intended Enhancement** To take advantage of the available equipment and devices, the Bureau of Highways is also now working with its service provider to expand the existing system. Plans call for developing a voice recognition data collection system. This system will to allow a mobile user to collect all the attributes within county's road right-of-way through CDPD data network and remotely update the database in a real-time basis.

### ***System Configuration***

To make the entire snow removal process visible for the public, the Map servers are hosted by the County, and the public access server is hosted by a co-location provider.

The image files created by the map servers were sent through the County's firewall in a 15-minute of interval to public server. (See figure 2)

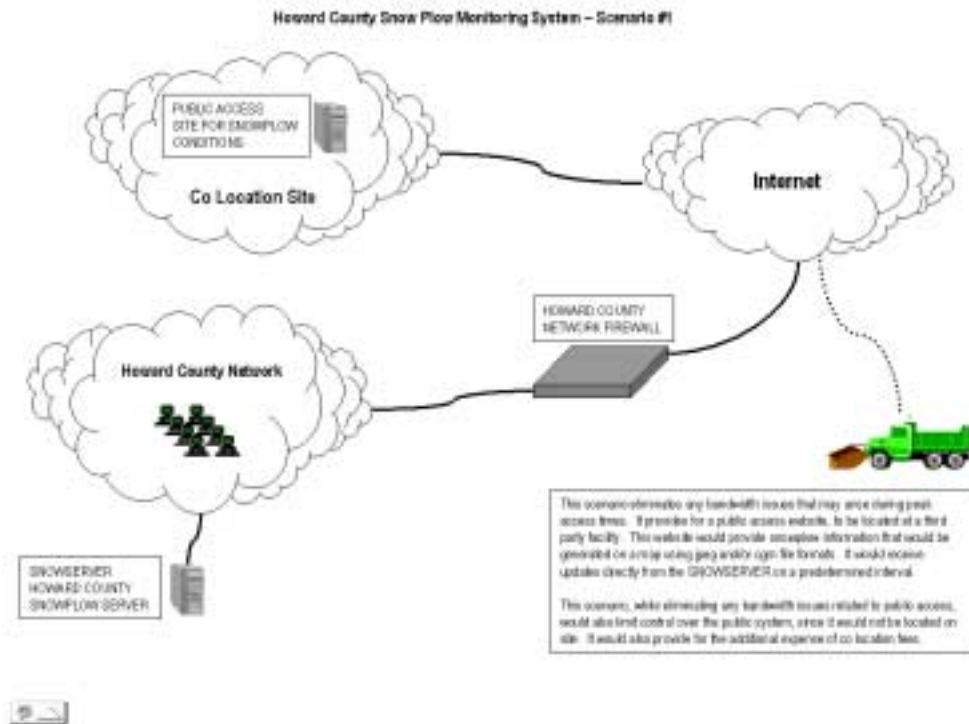


Figure 2 – Web configuration

### ***Basic Functionality***

Beyond the obvious function of displaying vehicle locations on a map, certain functionality was a requirement for the successful completion of the project. This functionality includes Statistical Tracking, Vehicle Location, Vehicle Logging/Playback, Inclusion/Exclusion Zone Definition, Vehicle Symbology Configuration, Incorporation of other datasets, and Web Site Capture.

Statistical tracking functionality includes the ability to capture variables such as speed, direction/vector, geographic location (X, Y coordinate), and the time of day. Also included in this functionality is the ability to summarize all of the aforementioned variables into a database on a per vehicle basis at time intervals of day, week or month.

Vehicle location is the foundation of the project and therefore the most important. Additional functionality is available that will allow users to locate a specific vehicle on-the screen based on the vehicle identification number, selection from the legend, or querying by the street name or other known location.

An important part of the project is the ability to replay plow location information from a log file. Vehicle location data including speed, direction, time, and location can be

captured in a daily log file for temporal analysis. The log file is then made available for display through the vehicle identification number and time frame.

In addition, it was necessary to allow an administrator the ability to assign vehicles to groups. These groups can be established based on geographic location or some other logical relationship. In order to establish the groups it is necessary to develop inclusion and exclusion zones, if they were not currently available. Once these zones are developed, vehicles can be activated/de-activated based on the inclusion/exclusion zones to which they belong. For example, if *Zone A* has been designated as an Exclusion Zone for *Vehicle A*, *Vehicle A* will not be visible when it is inside of that particular zone.

Vehicle Symbology definition is a necessary function for administrators and users. This functionality is available through the Administrative form and the Tracking form. All values that have been configured by the administrator will override any values the typical user attempts to configure. Vehicle symbology can also be configured to change based on information received from the vehicle's wireless modem. Other display functionality includes display of vehicle trails and directional arrows. Directional arrows allow the rotation of a vehicle symbol at the active angle of travel as it relates to North.

The client/server application also allows the user to incorporate other datasets and data Layers. The allowed formats include the following: ADC Raster Maps or Digital Ortho-Photography, GeoMedia Access Databases, ESRI shapefiles, and Oracle Spatial Data

### ***Hardware/Software***

Each plow is fitted with a Sierra Wireless Dart 300 modem and mobile data terminal. The wireless modem allows wide area network (WAN) connection with the "Snowplow" server through Verizon's network. The mobile data terminal was equipped with a GPS receiver that receives location data from a system of satellites, depending upon availability. The Dart 300 modem receives its geographic location data from GPS satellites, this data is then sent via the wireless modem to the "Snowplow" servers. The "Snowplow" servers then performs Inverted Differential Correction<sup>1</sup> and other data manipulation functions and places the plow location on the client application's mapping interface.

The client/server application consists three servers, the first server is to write and compute the incoming vehicles coordination to a SQL database. The second server is to retrieve the computed data from the first server and generate the maps. The third server is to populate the maps to a co-location provider for the display of status of the currently deployed vehicles and snow removal progress. All three pieces work in concert to achieve the resulting Snowplow Tracking Client/Server software and plowed roads status via the web.

The client/server application is comprised of an Administrative Program and a Client Program. The server application receives data from the wireless modem, processes the data and sends it to the client application. The server application also contains the administrative program described below. The client application is where the actual

vehicles are displayed on a map. The client application will be used most by everyday users. The web application uses the client/server application as a foundation and displays a thematic map of road conditions.

### ***Server Application***

The administrative program (See figure 3) allows a user, with the appropriate rights, to access functionality that is not available to the average user. This functionality includes map query, history archive, and overall system configurations. The administrative program allows the administrator to enable/disable logging and edit other system specific configurations. .

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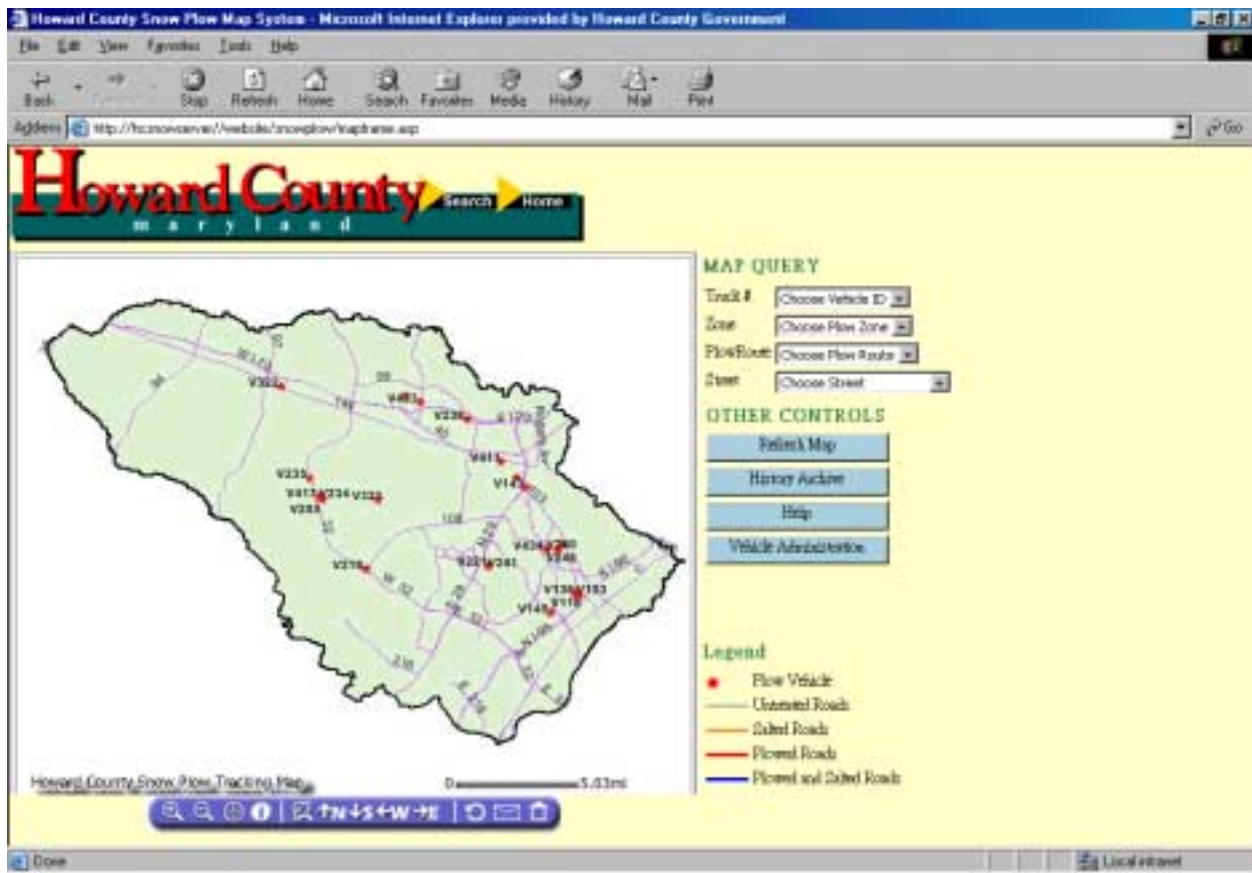


Figure 3 - Vehicle Administration

## Web Application

The County's map is partitioned to 5X5 matrix. A starting screen that is linked with the County WEB will be designed. The user can click on the interested grid to view the locations of snow trucks and the progress of snow removal.

The system will automatically archive the history data in half hour intervals during an event. (See figure 4) The title of each map contains the date and time it was created and is included in the hyperlink. The history archive can be used after a storm has occurred to redisplay the status of road conditions over time for analysis purposes.

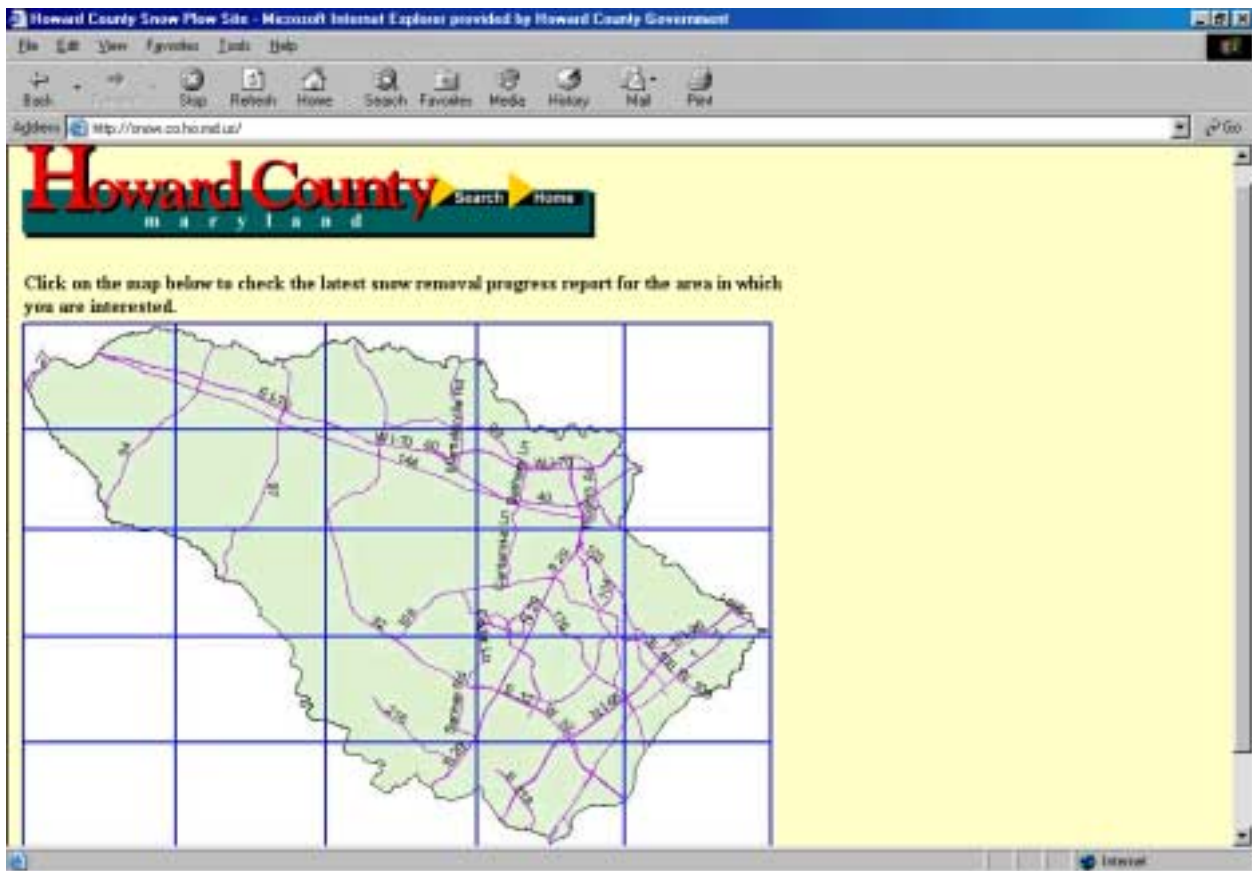


Figure 4 – 5x5 Matrix Grid Howard County Map

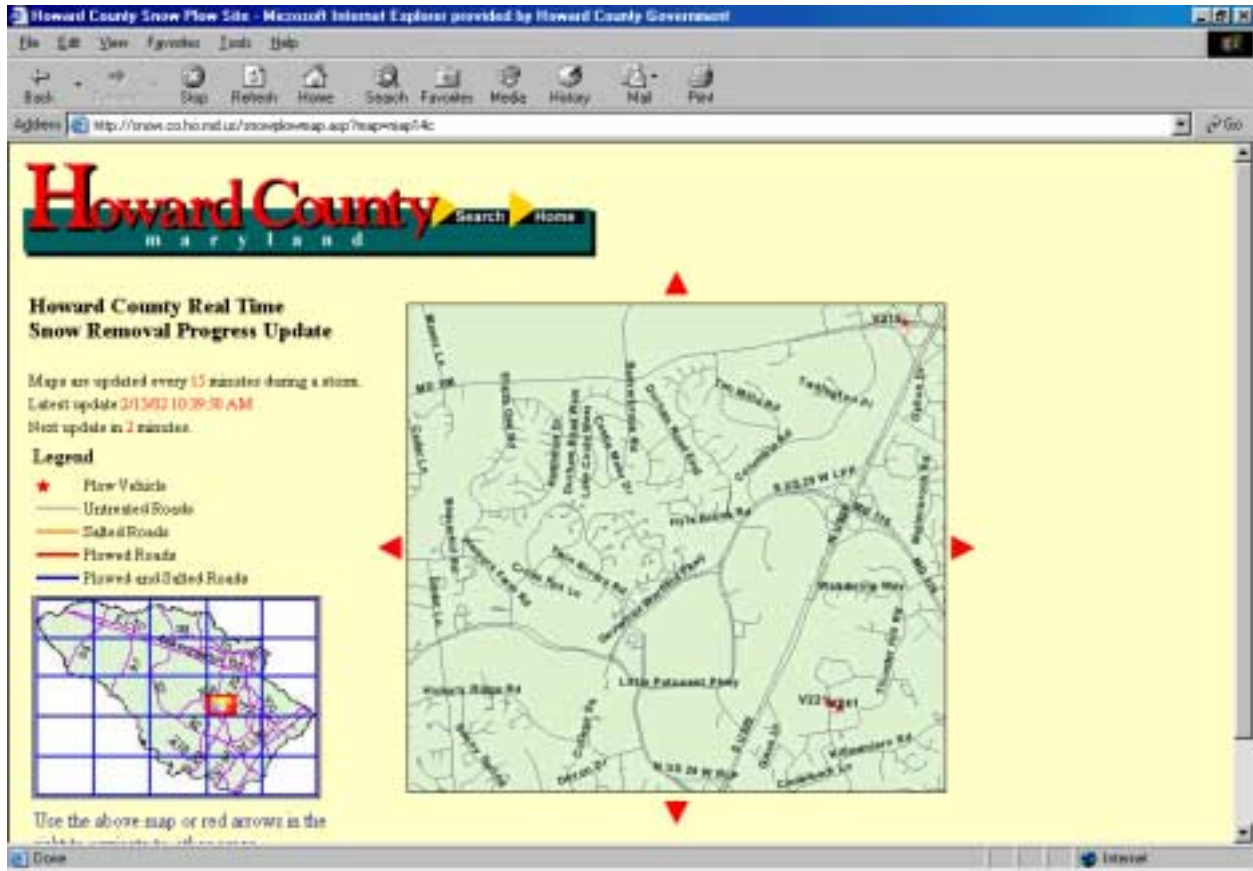


Figure 5 – Howard County Real Time Snow Removal Progress Update Map

The system will automatically archive the history data in a half hours interval during an event. (See figure 6) The title of each map contains the date and time it was created and is included in the hyperlink. The history archived can be used after a storm has occurred to redisplay the status of road conditions over time for analysis purposes.

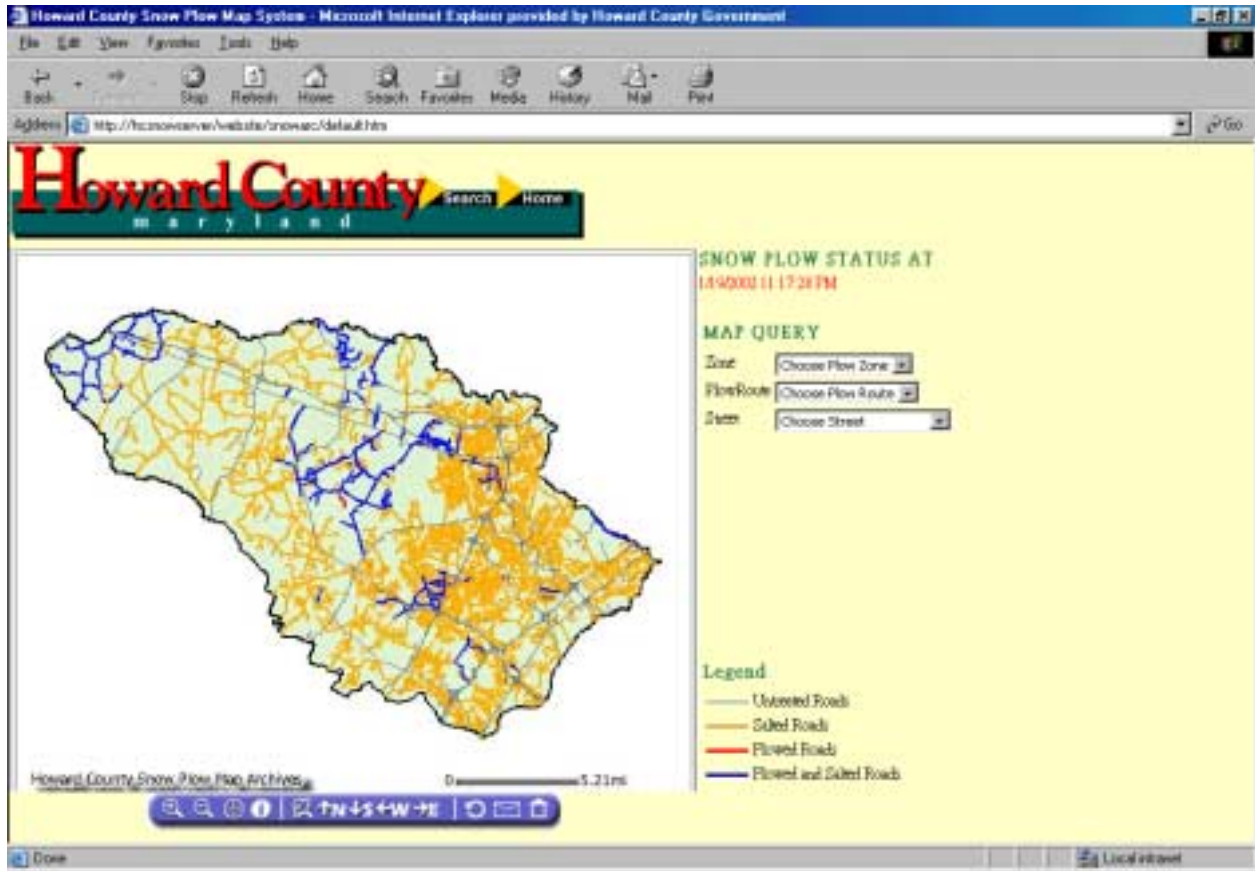


Figure 6 - History Archive Example



## *Manufacture References*

Howard County Bureau of Highways contracted **Enterprise Information Solutions** ([www.enterinfo.com](http://www.enterinfo.com)) to implement the AVL project and countywide projects. The online GIS software is ESRI ArcIMS and ArcSDE from **ESRI Corporation** ([www.esri.com](http://www.esri.com)) and runs on **Dell Computer Corporation** ([www.dell.com](http://www.dell.com)) servers. For the AVL project, the county used Dart 300 CDPD modems from **Sierra Wireless** ([www.sierrawireless.com](http://www.sierrawireless.com)) and mobile data terminal from **AVL Information Systems, Inc.** ([www.avlinfosys.com](http://www.avlinfosys.com)). Howard County CDPD transmission travels across the **Verizon Wireless** ([www.verizon.com](http://www.verizon.com)) mobile network and **Howard County ISSO** firewall (<http://www.co.ho.md.us/>).