WebRIT: An EPA Enterprise Tool for Web-Based Locational Data Improvement

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RTI, under a contract with the U.S. Environmental Protection Agency (EPA), has developed a combined ArcIMS and Oracle Spatial application called the Web-Based Reach Indexing Tool (WebRIT). WebRIT is used to create, validate, and update National Hydrography Dataset (NHD) reach indexes, latitude/longitude (lat/lon) coordinates, and other locational data related to EPA and other agencies' environmental program data. This paper describes the WebRIT's integrated use of ArcIMS, ArcSDE, Oracle Spatial, and Oracle in the EPA's environment to provide tools that cross program databases and provide a common framework for general locational data improvements with a Web-based mapping interface. Two specific components will be discussed, including a database-driven interface that provides custom tools, layers, and map extents based on database-stored user preferences, and the development of a generic zoom-by-geography tool that is also database driven.

Background

WebRIT for the Watershed Assessment, Tracking, and Environmental ResultS (WATERS) database is an Internet mapping tool that allows users to submit and update locational data for a wide variety of environmental programs. To help users identify locations, WebRIT provides point-and-click tools and displays data from various EPA environmental programs, including U.S. Geological Survey (USGS) topographical maps and aerial photos, and the NHD. By assisting users in georeferencing their environmental program data to the NHD, the WebRIT greatly enhances EPA's ability to evaluate the success of programs and to target optimal environmental protection strategies. WebRIT also provides a mechanism for updating source locational data already in national databases at EPA.

Currently, WebRIT allows users to submit locational information for the following EPA programs: Beaches Environmental Assessment and Coastal Health (BEACH) Act, the Nonpoint Source Grant Reporting and Tracking System (GRTS) program, Combined Sewer Overflows (CSO), Clean Water Needs Survey (CWNS), Drinking Water Intakes (DWI), Electronic Notice of Intent (eNOI), the Permit Application Software System (PASS), the Permit Compliance System (PCS), Special Appropriations Act Projects (SAAP), the Water Quality Standards (WQS) program, and USGS's National Water Information System (NWIS) program. In future versions, the WebRIT will be available for other program data, such as data from the STOrage and RETrieval (STORET) database, 303(d) impaired water listings, and other water quality monitoring stations.

The NHD (http://nhd.usgs.gov/) is a nationally consistent spatial data set of U.S. surface waters that contains information for several types of surface water features, including streams, lakes, reservoirs, canals, and dams. It is the result of cooperative efforts between EPA and the USGS. Every surface water feature in NHD is represented by an unique identifier (reach code). The

benefit of georeferencing environmental program data to NHD is that the information becomes anchored to the reach code, a nationally consistent identifier. This provides a framework for integrating many national surface water and environmental program databases. The NHD currently provides the framework for EPA's WATERS data integration effort (http://www.epa.gov/waters).

The WebRIT assigns Entity IDs or attributes to user-selected portions of the NHD through the creation of "events" that are stored in a central EPA database. These events represent the location of an attribute (such as the streams affected by a nonpoint source grant) along NHD stream reaches. Event records are stored in a table that contains the NHD reach code (unique stream reach address), position(s) along the NHD reach, and a unique identifier that links to the program database (such as the identifier for a specific impaired water). The user creates these events when using the WebRIT. The WebRIT allows the user to create three types of event layers: points, lines, and polygons. The WebRIT also provides methods for automated NHD indexing (event creation). The events created through the WebRIT interface are stored in a central EPA database where they can be later reviewed, modified, and approved. After approval, the events stored in the WebRIT database are transferred to the NHD Reach Address Database (RAD) (http://www.epa.gov/waters/about/rad.html), where they can be viewed through other EPA tools (http://www.epa.gov/waters/tools/).

The WebRIT also allows some programs to update their source locational data. The source locational data are usually point data and are the source lat/lon coordinates stored in a national database. Source locational data does not need to be linked to the NHD. For example, WebRIT allows PCS users to update the source lat/lon data stored in Envirofacts. The user can change the location of a source data point by deleting the original point and creating a new one. The updated locational data can then be sent back to the Envirofacts database on a periodic basis. Therefore, users of the WebRIT can update their source data and verify the data's location while they are also georeferencing their data to the NHD. Currently, WebRIT provides tools to update source points and will allow for the updating of source lines and polygons in future versions.

The WebRIT contains many datasets from both EPA and USGS. Some of the datasets include NHD, Digital Raster Graphics (DRGs), Digital Orthophoto Quadrangles (DOQs), detailed streets, county boundaries, and zip codes. The WebRIT not only allows users to create NHD events, but also has the ability to print out topographic maps and aerial photographs with user-defined points displayed on top. The user can also add annotation (an identifier and description) associated with each of these user-defined points. In addition, the WebRIT provides users the ability to capture lat/lon coordinates, many spatial and attribute selection options, and Federal Geographic Data Committee (FGDC)- compliant metadata associated with the event data created. Future versions of the WebRIT will also provide the ability to update existing environmental program data that have already been submitted to EPA, as well as the ability to submit spatial data to the EPA that is not associated with the NHD.

This paper discusses the WebRIT's database-driven interface that provides custom tools, layers, and map extents based on database-stored user preferences, and the development of a generic zoom-by -geography tool that is also database driven. For additional Internet information on georeferencing, go to http://www.epa.gov/owow/monitoring/georef/. For additional Internet information on WebRIT, go to http://www.epa.gov/waters/webrit/. For additional Internet information on NHD, go to http://nhd.usgs.gov/.

WebRIT Design

The WebRIT utilizes a distributed application architecture that breaks the application into smaller logical parts to handle presentation functions, business logic, and database functionality. This approach is a popular choice for Internet application development because it makes the code easier to write, easier to maintain, and easier to reuse.

Physically, the application can be broken into three tiers. The three tiers are the interface tier, the middle tier, and the database tier. The interface tier is comprised of the client's browser and the code that is run inside of it, including HTML, DHTML, and JavaScript. The middle tier represents the Web server, server side code, and server extensions, including Active Server Pages (ASP), Custom ActiveX Dynamic Link Libraries (DLLs), ActiveX Data Objects (ADO), Oracle Objects for OLE (OO4O), Servlets, and ArcIMS. The database tier includes the database, Oracle, Oracle PL/SQL stored procedures, and the database extensions, including Oracle Spatial and the Environmental Systems Research Institute's (ESRI's) Spatial Data Engine (SDE). The database tier contains both spatial and nonspatial tables. Figure 1 depicts the physical layout of the WebRIT architecture.

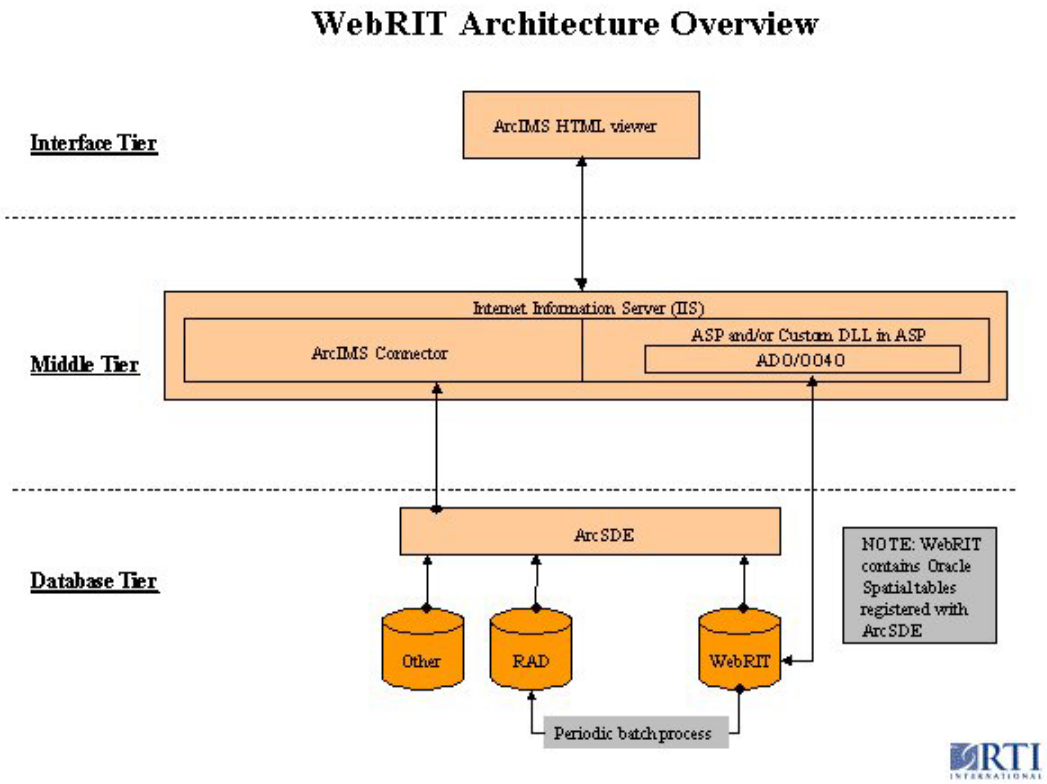

Figure 1. WebRIT Architecture Overview

The WebRIT makes extensive use of procedures stored in the database. Using stored procedures moves the application's business logic closer to the database to increase efficiency and also to take advantage of PL/SQL and Oracle Spatial SQL calls. In addition, the stored procedures can be easily bundled into future Web services, providing some WebRIT functionality without the

existing interface or middle tiers. Therefore, consumers of WebRIT services can create their own interface and middle tiers.

The WebRIT application is based on the ArcIMS HTML viewer model utilizing only HTML, DHTML, JavaScript, and frames in the client's browser. Frames are used to organize the interface features into groups. The primary frames are the toolbar, table of contents, map window, and information window. The use of frames makes the code more modular and thus easier to maintain and enhance without complete rewrites. In addition, the use of frames improves performance because the entire application content does not need to be refreshed with every user interaction. Figure 2 shows an example of the interface of the WebRIT application for an EPA BEACH Program user.

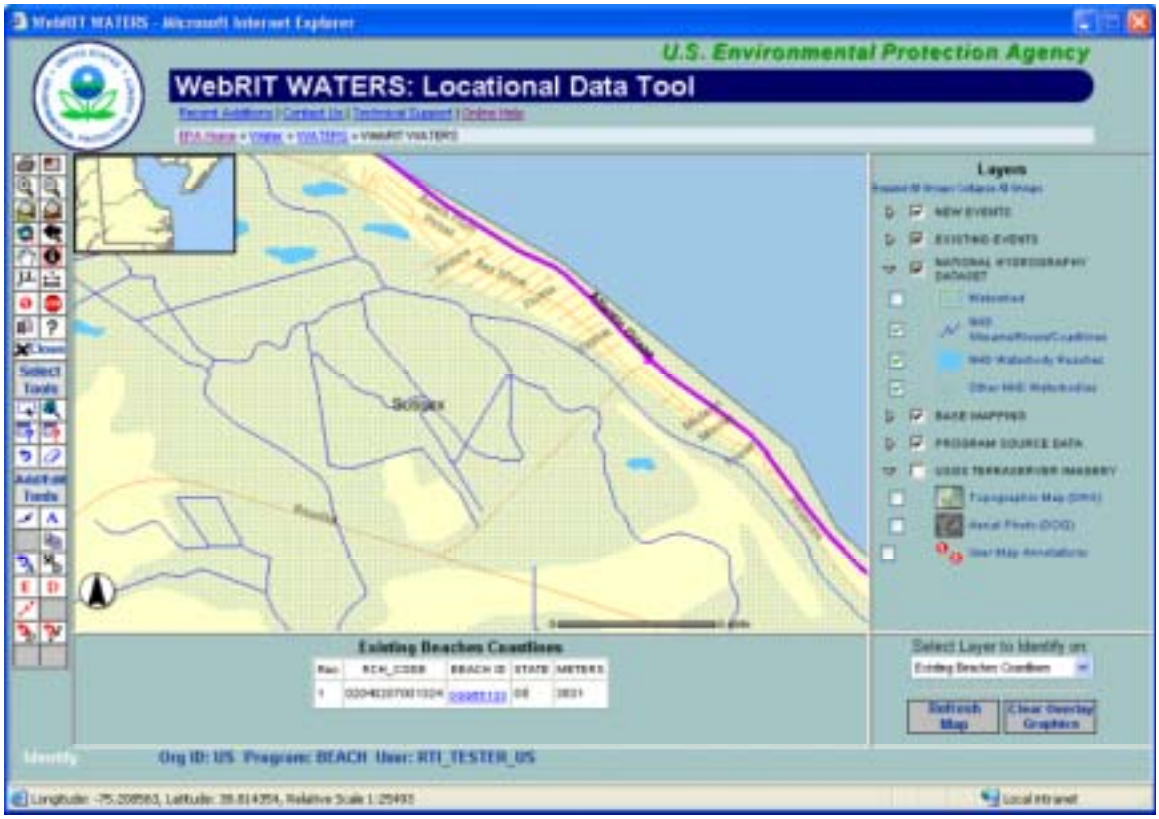

Figure 2. WebRIT Interface for EPA's BEACH Program

Database Driven Interface

One of the primary WebRIT requirements is that the interface and data displayed need to be different for different users. Multiple EPA programs use the WebRIT to enter spatial data and submit the data to EPA. However, each of these EPA programs have different needs, and therefore require the interface to be slightly different. To accommodate this requirement, the WebRIT design uses the database to drive the interface.

Using the WebRIT database, the application provides a user the ability to customize the toolbar and layers list; customize the values in data frames, including drop-down choices and pre-populated data fields; identify report output (e.g., which fields to display and field heading

aliases); and the type of data the user can see, zoom to, edit, and copy. The WebRIT database contains several tables and views with specific information about each EPA program's interface preferences and program-specific data. The WebRIT determines these preferences based on the EPA program, organization (e.g. state, EPA headquarters, EPA region), and access level the user is logged into as in the WebRIT.

Each EPA program can supply interface preferences related to the toolbar and the layers list. The tables and views related to the toolbar contain information on whether a tool is available for each EPA program. Using the database, the application can also provide custom functionality for certain tools, depending on which EPA program is using the application. An example of this type of database-driven feature is explained in more detail in the "Zoom by Geography Tool" section of this paper. The tables and views related to the layers list contain information about whether a layer is available in the application at all, and if so, if it is visible by default for each EPA program. For example, Figure 3 shows that in the database we can limit the inclusion of the "CopyEvent" tool to update users in the BEACH, DWI, GRTS, SAAP, TESTING, and WQS EPA programs.

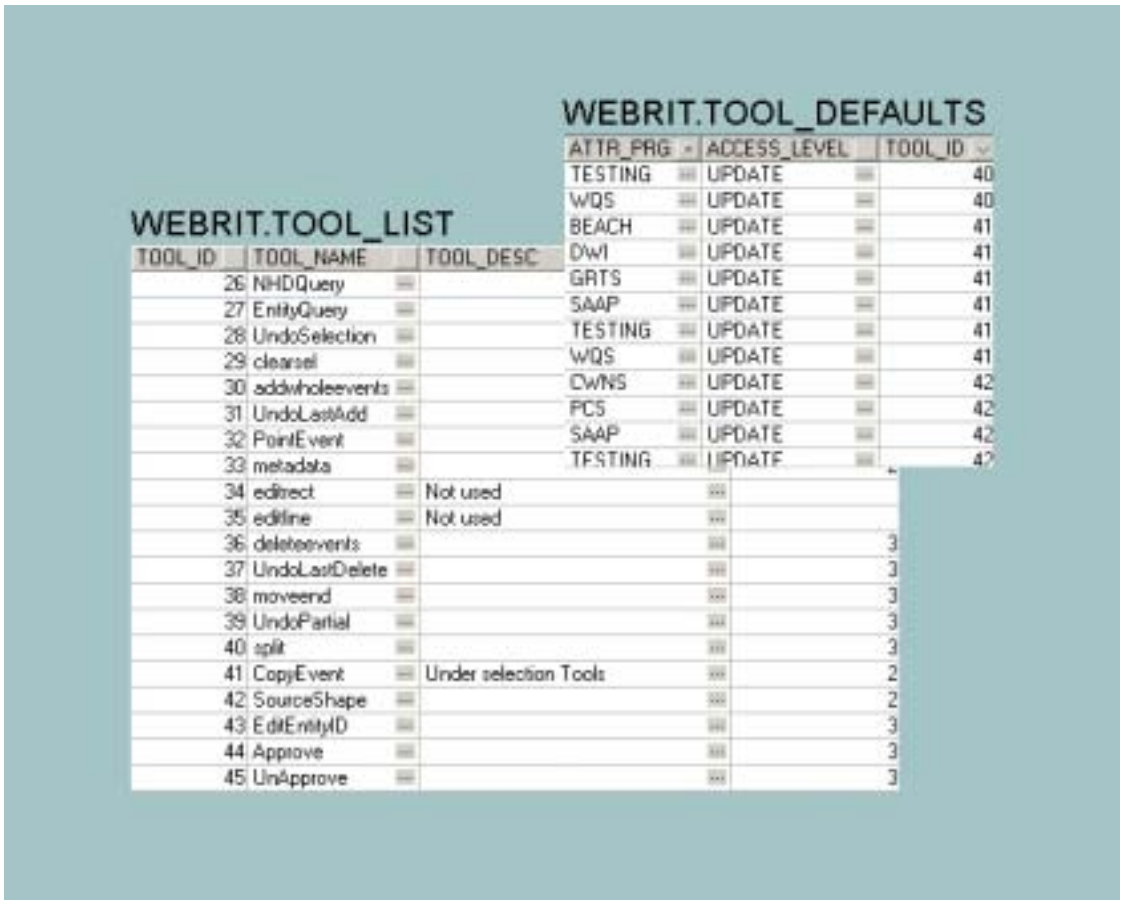

Figure 3. WebRIT Tools List and Program Defaults

Figure 4 contrasts the application's database-driven interface for a BEACH user with "update" rights (background) with the interface for a PASS user with "review only" rights (foreground); notice that the toolbar and the table of contents are different for each user.

Figure 4. Interface Comparison

Using the database, the user is also able to display certain portions of data layers and to symbolize the layers differently, depending on the EPA program and organization the user is logged into as in the application. This is done by applying query filters to the spatial layers each time they are requested. The query filters are stored in the database and linked to the EPA program that the user is logged in as in the WebRIT.

In addition, the WebRIT design allows each EPA program to provide custom information regarding metadata and ID selection. The WebRIT provides tools for users to enter Federal Geographic Data Committee (FGDC)-compliant metadata, and each program can provide default values for the fields that the user enters during this metadata creation process. In many cases, an EPA program is able to default all or at least the majority of the metadata fields; therefore, a user only has to enter minimal metadata, thus reducing the metadata collection burden. The WebRIT also provides forms for the user to choose an ID to be associated with the spatial data created. The WebRIT uses tables and views in the database to contain information, such as which database, table, or field names are used to create a unique "pick list" of IDs for each EPA program. The tables and views provide information such as the field heading to be used in the ID pick list form in the application interface.

The WebRIT also uses the database to determine which fields are used in the results of an "Identify" request for a specific EPA program. Each EPA program may want to show different fields for an Identify result on certain layers, because some layers in the application are specific to that EPA program. The database also allows for the assignment of field aliases to be displayed as field headings in the Identify reports for certain layers in the application.

Using this database-driven approach, the interface can be written in a generic fashion and still provide a custom interface for each user. The code written for the WebRIT interface queries the database to glean the logic of how to build the interface, rather than hard-coding that logic into the application's interface itself. A primary benefit to a database-driven interface is that it can simplify the application for users that require only basic functionality. This approach also reduces the workload for the user by easily defaulting data for their particular program. Another advantage is that if an EPA program decides to change something about their interface, such as remove a tool from the toolbar, then only a table in the database needs to be updated to modify the interface. This approach also reduces the cost of adding additional EPA programs to the WebRIT.

Zoom by Geography Tool

A new tool was developed for the WebRIT called the Zoom by Geography tool. The purpose of this tool is to allow users a quick and easy way to zoom to an area of interest. The interface for the tool wraps multiple types of zoom functionality, including standard ArcIMS spatial queries, Oracle attribute queries, and Oracle Spatial queries. The interface for the tool is brought up in a pop-up window and is organized by tabs. The complete set of possible zoom tabs for an EPA program using the WebRIT currently includes State, Zip Code, County, City, Latitude/Longitude, EntityID, and Annotations.

The Zoom by Geography tool has many advantages over the default zoom capability included in the standard ArcIMS browser interface. The new zoom functionality is tightly integrated with the Oracle database to enable complicated spatial and attribute queries. The tool combines Oracle queries and views with traditional ArcIMS queries and Oracle Spatial queries. The Oracle views can group results across multiple GIS layers, in addition to joining with multiple attribute tables. The Entity ID zoom is a good example of this process and is described in greater detail below.

In addition to complex combined queries of GIS layers, the tool also enables users to zoom to annotations that are drawn on the application's acetate layer. In the WebRIT, annotations are stored in the database as a simple attribute table containing lat/lon coordinates. The tool allows users to browse and zoom to annotation records stored in the database.

The Zoom by Geography tool's interface is database driven in the same way as the application's GIS layers and toolbar. When an EPA program decides to use the WebRIT, they will first determine which layers and tools are required for their users. This information is stored in the application's program preferences database tables. The Zoom by Geography tool reads the program preferences table to determine which zoom tabs should be available. Layers and tools that are not required by a program are removed from the interface, and the corresponding zoom tabs are also removed.

In addition, the tool uses the ArcIMS ActiveX connector to make custom query requests. The ActiveX connector is a convenient way to add new functionality to existing HTML-based ArcIMS Web sites. Using the ActiveX connector in ASP pages can enable the integration of

results from a database-stored procedure with traditional ArcIMS requests, all on the server side of the application. Using the ActiveX connector greatly reduces the number of trips required between client and server and also reduces the complexity of the client side JavaScript code.

An example of a more complex query that is included in the tool is the Zoom to Entity ID function. An Entity ID is the program's unique identifier for the spatial data the user creates with the WebRIT. The Entity ID links to an external program database, which contains more detailed attribute information about that data. An Entity ID can represent a point, line, or polygon feature. The Zoom to Entity ID query involves multiple steps by the user, as well as multiple input parameters. The input parameters result in queries on program-specific views in the database. These views span GIS layers of different spatial types, including points, lines, and polygons. The results of these queries are reported back to the user, where they can choose a single record that will result in an Oracle Spatial procedure call to locate the feature, return the bounding box, and return the bounding box or buffer geometry (points).

For Zoom to Entity ID, the user will first click the Zoom by Geography tool and will be presented with a pop-up window containing tab-separated zoom functions (Figure 5)

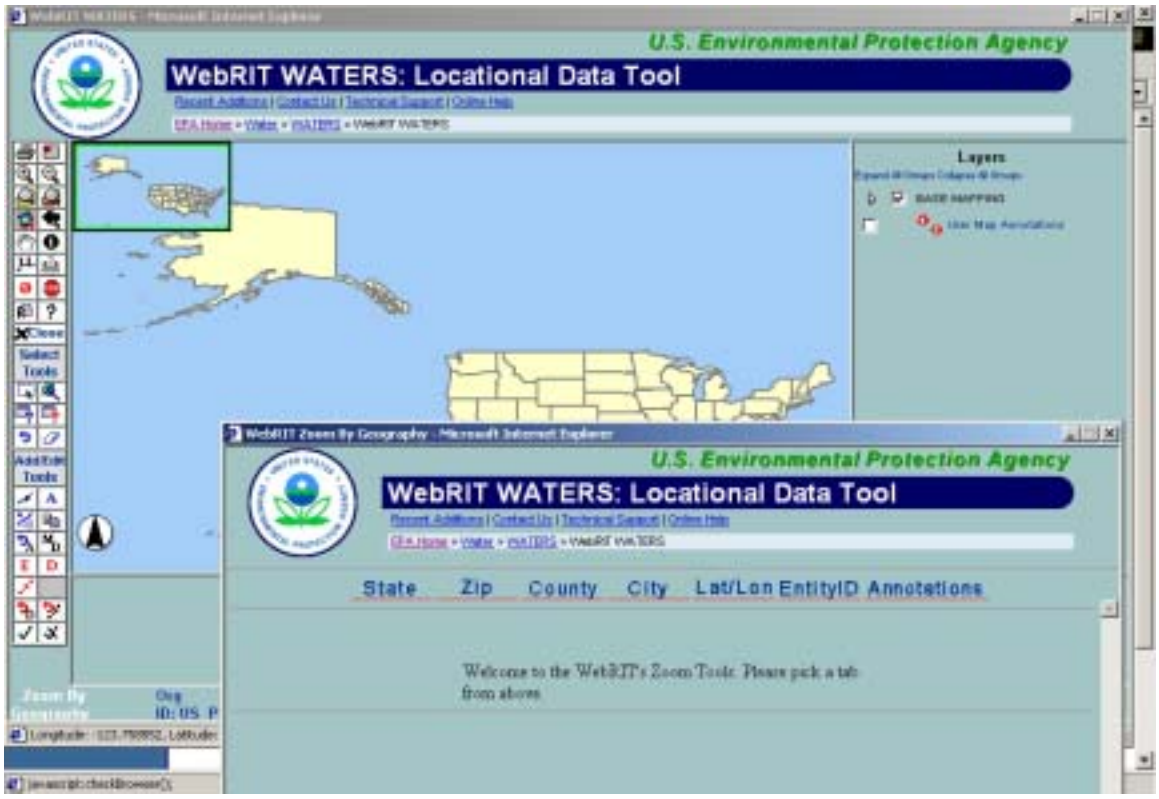

Figure 5. Zoom by Geography Tool tabs

In this case, the user will choose the Entity ID tab and be presented with two drop-down lists (Figure 6). The first drop-down contains a list of possible EPA programs from which the user is allowed to select Entity IDs. The list of possible EPA programs comes from a view stored in the database. The view contains all of the programs to which the user has access. The second drop-down contains a list of organizations that have entered data for the selected program. The organization list also comes from a view stored in the database. In the WebRIT, all EPA

programs' data are stored in combined tables, rather than one for each program. Using database-stored views allows the application to control access to certain programs records, depending on the account that has logged into the application.

Figure 6. Zoom by Geography Tool - Entity ID tab

After choosing an EPA program and an organization, the Zoom to Entity ID tool will query a third view from the Oracle database that combines matching records across multiple spatial types using the input parameters of the EPA program and organization entered. The table that is returned contains the complete list of Entity IDs for the program and organization combination, as well as a field that indicates each record's spatial data type. Additional fields are returned in the query, but are not displayed in the table, including the ArcIMS AXL IDs. In Figure 7 for the Delaware TESTING program, three Entity IDs were found in the two separate GIS layers for draft lines and draft polygons.

Figure 7. Zoom by Geography Tool - Entity ID tab - results

When the user selects the Entity ID record of interest, an ArcXML query request is built and sent using the Entity ID and the AXL ID for the record. The ArcXML request is sent using the ActiveX connector in a hidden ASP page that allows the Zoom tool to work independently from the rest of the WebRIT client code. The ArcXML tabular results are presented to the user, who can then choose to zoom to the feature(s) or go back and change their query by clicking the Entity ID tab again. (Figure 8)

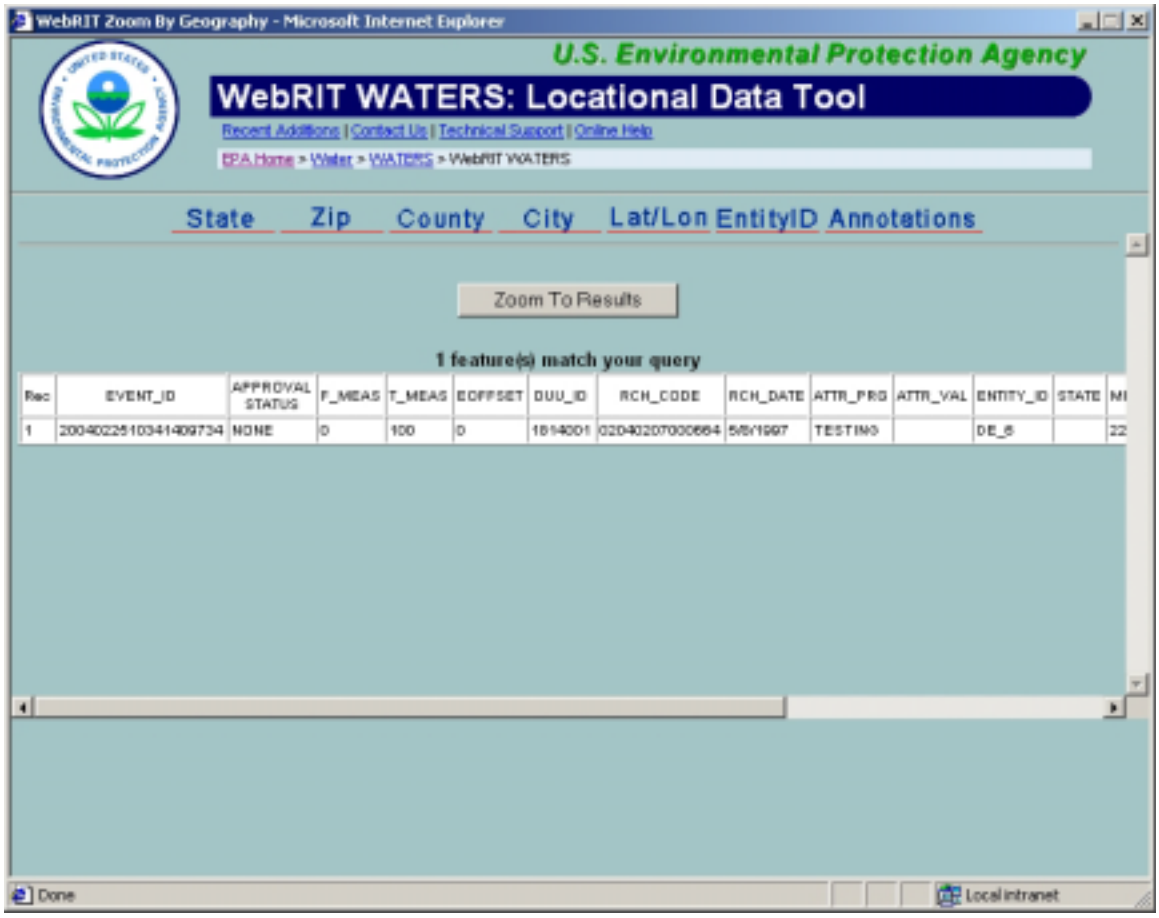

Figure 8. Zoom by Geography Tool - Entity ID tab - results

The results for an Entity ID query may return multiple records because it is not a unique key. In the example in Figure 8, only a single record is returned. When the user hits the Zoom To Results button, the Zoom by Geography pop-up window is closed and the main application map window is zoomed to a buffered envelope for the features. (Figure 9)

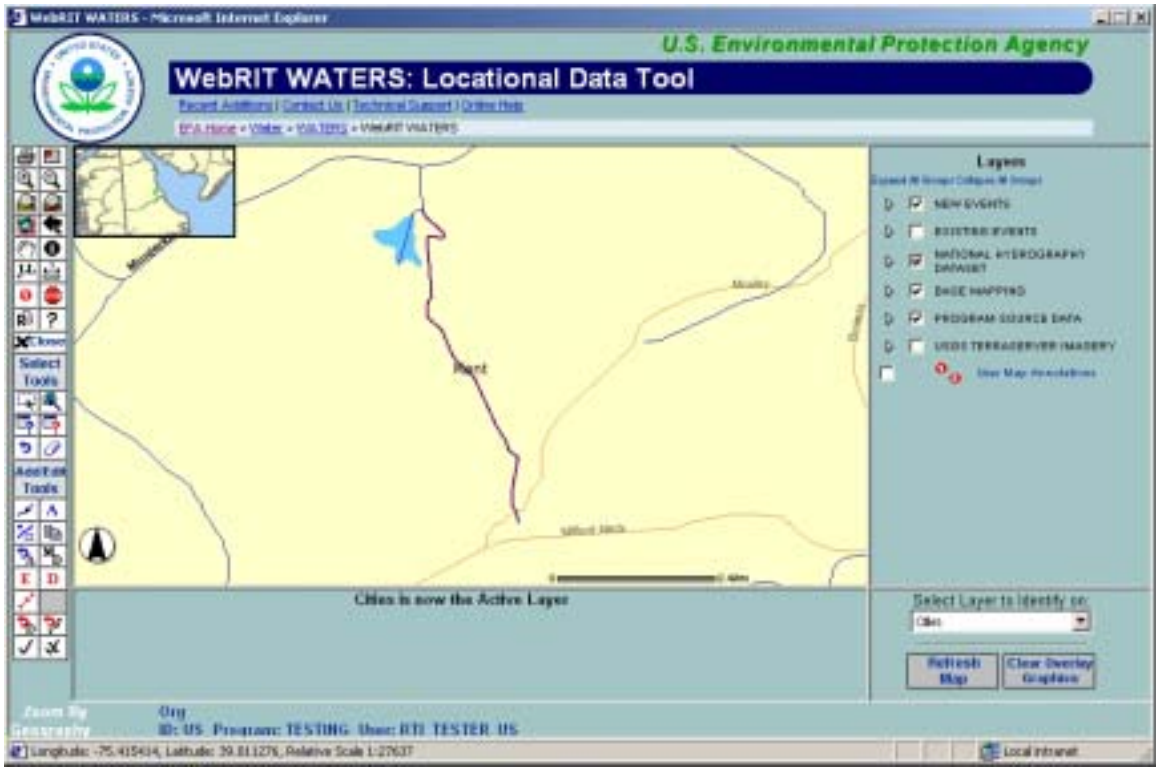

Figure 9. Zoom by Geography Tool - Entity ID tab - map zoom

Alternatively, if the results returned from the ArcIMS request represent a single point feature with no envelope, the Zoom to Entity ID code will call an Oracle Spatial stored procedure to buffer the point by a user-entered radius and will return the buffer geometry, as well as the buffered geometry's envelope. The buffered geometry can be used on the acetate layer to highlight the feature. (Figures 10 and 11)

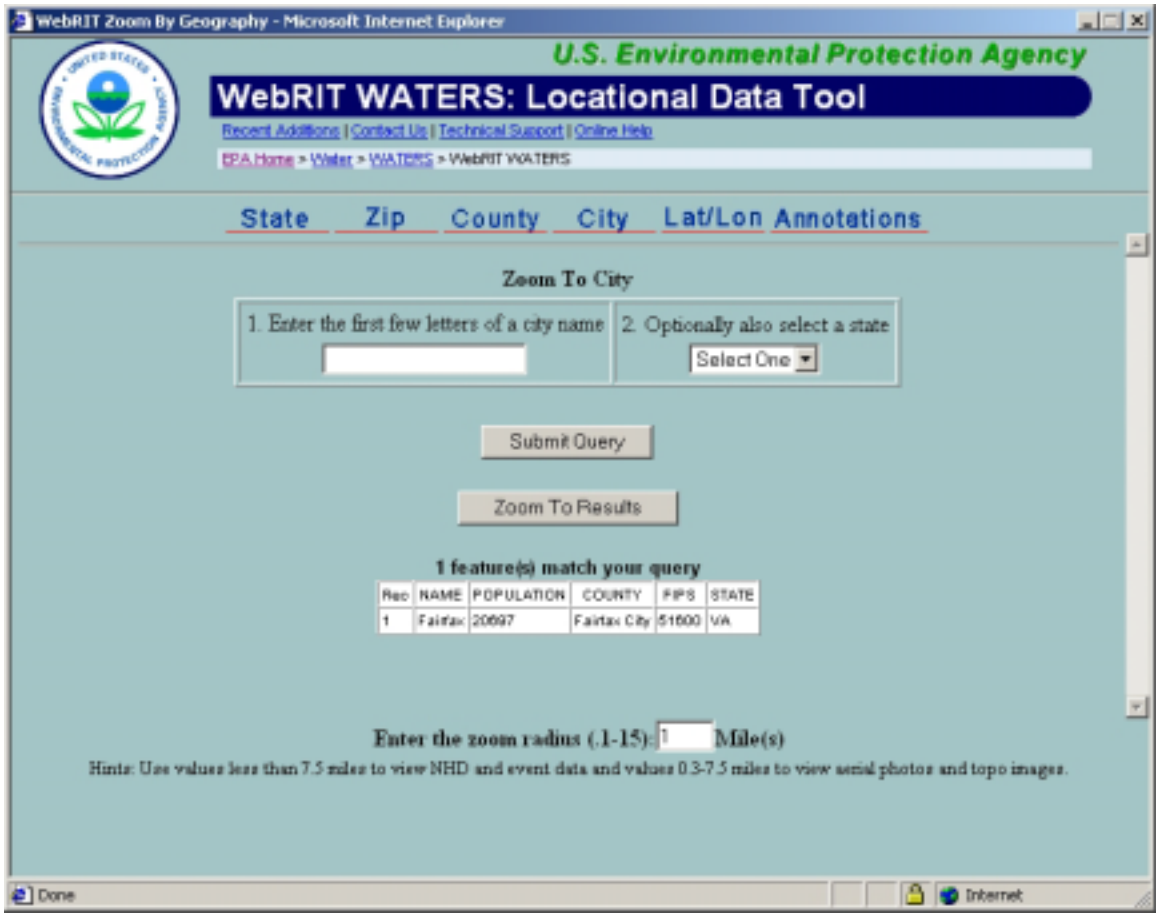

Figure 10. Zoom by Geography Tool - City tab

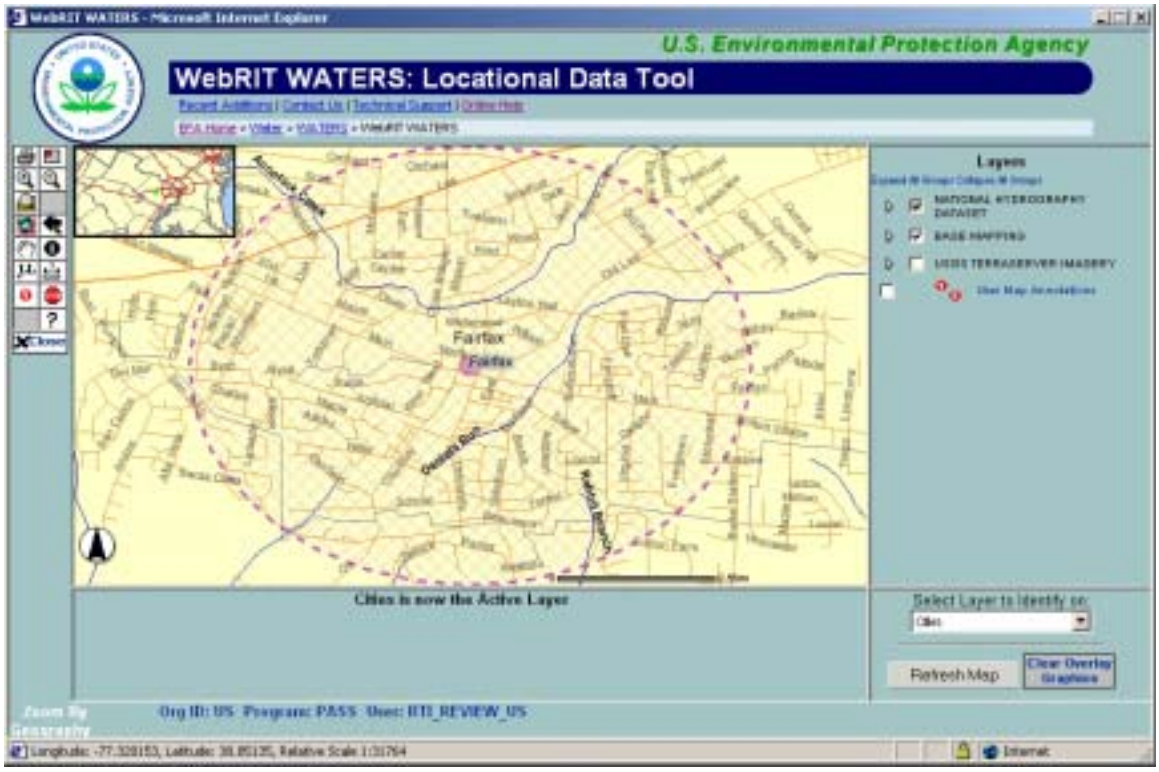

Figure 11. Zoom by Geography Tool - City tab - map zoom with buffer

Future Plans

Enhancements to the current WebRIT are planned. Future versions of the WebRIT will likely add a Zoom to Watershed tab to the Zoom by Geography tool. It will also allow users to enter query filters to limit the number of items returned in drop-down lists and tables; allow a user to open the application via URL using any of the zoom options from the Zoom by Geography tool; allow for additional EPA programs to be added; and will likely feature more custom EPA program tools. In addition, the WebRIT may store ArcXML request fragments in the database. A benefit to storing ArcXML request fragments in the database is that they can be easily changed with out having to modify and redeploy the front-end code. More of the WebRIT components may be made available as Web services to the user community in the future. The WebRIT will also continue to consume any other relevant Web services that are made available and appropriate to the application.

Conclusions

The WebRIT application is currently being used by a growing number of EPA programs to submit spatial data to EPA. The database-driven design of the application provides the flexibility to create a tailored application for a diverse set of users. This design allows EPA to easily add additional EPA programs to the WebRIT at a minimal cost.

The new Zoom by Geography tool allows users to quickly navigate the application and locate their area of interest. The tool allows for more complicated queries that combine the use of ArcIMS and the Oracle database.

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