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WebTRAGIS: Transportation Routing Analysis Geographic System User's Manual

Steven Peterson

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Computational Sciences and Engineering Division

WEBTRAGIS: TRANSPORTATION ROUTING AND ANALYSIS GEOGRAPHIC INFORMATION SYSTEM USER'S MANUAL

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ACRONYMS

AICW	Atlantic Intracoastal Waterways
BD	border
BNSF	Burlington Northern Santa Fe Railway
CFR	Code of Federal Regulations
CIWW	commercial inland
CN	Canadian National Railways
CPRS	Canadian Pacific Railway
CSXT	CSX Transportation
DOE	Department of Energy
DTED	Digital Terrain Elevation Data
EM	Office of Environmental Management
GICW	Gulf Intracoastal Waterways
GIS	geographic information system
GLK	Great Lakes
GTM	gross ton-miles
GUI	graphical user interface
HRCQ	highway route-controlled quantities
IWW	inland waterways
KCS	Kansas City Southern Railway
L/D	lock and dam
NIMA	National Imagery and Mapping Agency
NNSS	Nevada National Security Site
NP	nuclear plant
NS	Norfolk Southern Railway
NTAD	National Transportation Atlas Database
OCM	ocean-going commercial shipping lanes
ORNL	Oak Ridge National Laboratory
PCWW	Pacific Coast Waterways
TIGER	Topologically Integrated Geographic Encoding and Referencing
UP	Union Pacific Railroad
WebTRAGIS	Web-Based Transportation Routing Analysis Geographic Information System
WIPP	Waste Isolation Pilot Plant
XX	territorial waters

ABSTRACT

The Web-Based Transportation Routing Analysis Geographic Information System (WebTRAGIS) model is a geographic information system tool for modeling transportation routing. WebTRAGIS is deployed as a browser-based application interface, and the routing engine is located on a server at Oak Ridge National Laboratory (ORNL). WebTRAGIS offers users numerous options for route calculation using uniquely value-added network databases for highway, rail, and waterway infrastructures in the continental United States. The model also provides reporting information on population counts for all transportation segments using the LandScan USA population distribution data model.

1. INTRODUCTION

The Web-Based Transportation Routing Analysis Geographic Information System (WebTRAGIS) is a user-friendly, geographic information system (GIS)–based transportation routing and analysis computer model. Funding for the development of WebTRAGIS has been provided by the Department of Energy (DOE) Office of Environmental Management (EM). WebTRAGIS is a browser-based application, and the user interface is accessed through a web browser via a personal computer or other web-capable device. The WebTRAGIS routing engine and its large data files reside on a server maintained by Oak Ridge National Laboratory (ORNL). The model uses the web-based application as an interface for communication and data input between the user and the ORNL server. While WebTRAGIS is the primary user interface for accessing the TRAGIS routing engine[1], users may also take advantage of a specialized batch input process that allows multiple routes to be prepared by the user, submitted to ORNL, and then calculated at one time. The basic conceptual user interface architecture for WebTRAGIS is shown in Fig. 1.1.

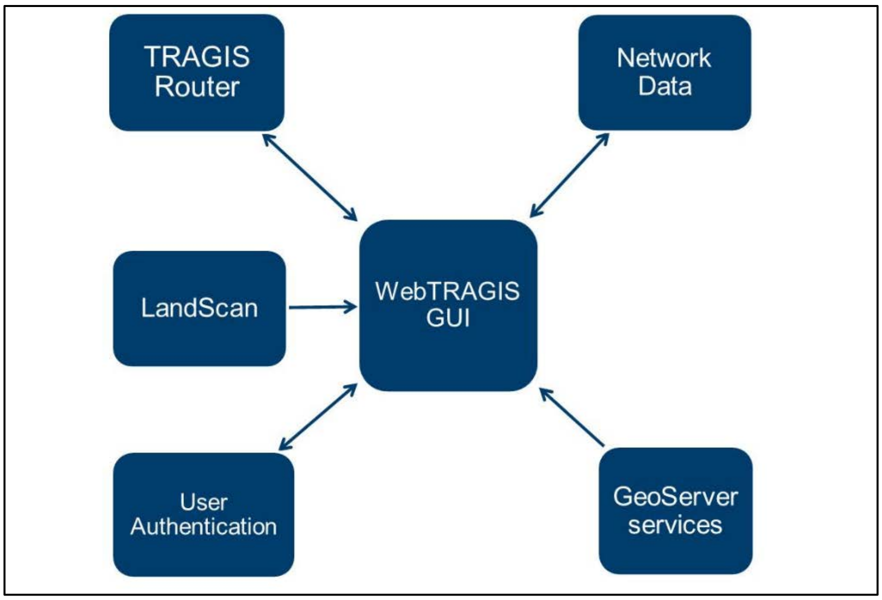


Fig. 1.1. Conceptual design of WebTRAGIS.

The lineage of the TRAGIS routing model can be traced back a quarter of a century to the development of two transportation routing models at ORNL in 1979: HIGHWAY (Johnson 1993a), which predicts truck transportation routes, and INTERLINE (Johnson 1993b), which predicts rail and waterway transportation routes. Both of these models were used for many years by the DOE community for a variety of routing needs. The subsequent development of TRAGIS dates to April 1994, when DOE-EM's Transportation Management Division (EM-261) held a meeting called the Baseline Requirements Assessment Session with transportation routing experts and users of the HIGHWAY and INTERLINE models. As a result of the session, the development of a new GIS routing model, TRAGIS, was initiated (Johnson and Michelhaugh, 2003).

[1] The terms "WebTRAGIS" and "TRAGIS" are often used interchangeably due to the close coupling of the two systems into a seamless platform. Strictly speaking, *TRAGIS* is the routing engine and associated databases used to generate routes, while *WebTRAGIS* is the graphical user interface (GUI) used to input route parameters and constraints into the TRAGIS routing system.

TRAGIS went through several stages in its early development. The initial version of the model operated on SUN™ UNIX® workstations. At that time, the Windows PC operating system could not easily handle the large geographic transportation networks in TRAGIS. The availability of TRAGIS only on UNIX 2 workstations severely limited the availability of TRAGIS to its user community, very few of whom had such computers. The next phase of TRAGIS development provided users a client-server web application dubbed WebTRAGIS, which vastly improved the accessibility of the model. In 2012, at the behest of DOE-EM, ORNL developed the current web browser user interface model of WebTRAGIS to interact with the TRAGIS routing engine. The current version takes advantage of updates in web browser capabilities and data service technologies to provide a more flexible set of user access options.

WebTRAGIS was developed to be accessible over the internet with an easy-to-use browser interface capable of being accessed by most web browser applications, including Internet Explorer, Chrome, Firefox, Opera, and Safari[2]. Mobile users may also access WebTRAGIS using the Android platform[3] by selecting an appropriate Android web browser such as Firefox or Chrome. The user interface of the current version is deployed as a browser-based application , whereas the routing engine with its large data files reside on a server maintained by ORNL. Access to the user interface is handled by a single-factor authorization security protocol through which users register for an account and subsequently log in with their approved password. The WebTRAGIS browser interface serves as the user's point of contact and data input vehicle to the routing engine. The browser application was developed using several open-source technology platforms, including JavaScript for the application interface, OpenLayers for the spatial data visualization, RESTful for the web services, Red Hat Linux for the server operations, and PostgreSQL/PostGIS for user and data management.

The TRAGIS routing engine, written in C++, resides on the server and receives the route parameters from users accessing the WebTRAGIS application. On the server, the routing parameter inputs are passed to the routing engine, used to calculate a route, and then generate output listings as a series of summary reports. The summary output files, including a visual depiction of the route, are then are transmitted over the internet to the user interface. Users may then save, delete, and download route information as necessary from within the WebTRAGIS user interface.

WebTRAGIS provides users access to highway, rail, and waterway routing networks. WebTRAGIS networks provide users routes with a high degree of geographic detail. In particular, the rail and waterway networks have been thoroughly updated using high resolution satellite and aerial imagery. As a result, these updated networks display an "on entity" representation of the actual physical networks.

The current highway network is currently a 1:100,000 scale network representing the major highways and roadways of the continental United States based on US Geological Survey (USGS) Digital Line Graphs and the US Census Bureau Topologically Integrated Geographic Encoding and Referencing (TIGER) system. These networks allow for a more accurate representation of actual transportation network characteristics and neighboring populations for subsequent GIS analysis. The current TRAGIS railroad network was developed using the original ORNL 1:100,000 scale database, which was a modification of the US Department of Transportation's (DOT's) National Transportation Atlas Database (NTAD) network provided by the US Department of Transportation (DOT). The currently deployed waterways

[2] WebTRAGIS is currently tested in Internet Explorer, Edge, Firefox and Chrome. While it was initially developed and tested using Safari, updates are not currently tested in that browser. No user issues have been noted with Safari. WebTRAGIS also works with Opera, but like Safari, it is not tested for compatibility with WebTRAGIS updates.
[3] As noted for the Safari browser, WebTRAGIS has not been designed or tested for compatibility with iPhones or iPads. As a result, WebTRAGIS performance may be sub-optimal when using one of these devices.

network was developed from a highly detailed 1:100,000 scale waterways network obtained from the US Army Corps of Engineers.

An important aspect of WebTRAGIS is the need to continually review and update the routing networks. Infrastructure changes occur with new road construction, highway renumbering, rail abandonment, and changes of rail ownership. The routing networks used in WebTRAGIS undergo scheduled maintenance to ensure that the quality of the databases is as accurate as possible.

An important feature of WebTRAGIS is its consistent user interface for each of the transportation modes. The basic routing functions for each mode are similar whether the user is running rail, highway, or waterway routes. Some variations in the interface may occur, such as options selecting from multiple railroad companies for rail routing, or the type of waterway system to access. However, when a user learns routing basics for one transportation mode in WebTRAGIS, it is not difficult to generate routes using the same basic principles for other modes.

The WebTRAGIS interface allows route modes, origins, and destinations to be selected from a list of node names. After selecting the desired transportation mode, users then select origin and destination states and nodes. First, users select an origin state from a drop down menu. Once a state is selected, a list of node names for that state is available in a separate drop down menu. The user can scroll through this list and select a node. The user then repeats this process to select the destination state and node. In addition to nodes at city locations and within the network, WebTRAGIS databases contain hundreds of specific nodes for the locations of all commercial nuclear reactors, DOE sites, military installations, and other important nuclear-related sites of interest. This user's manual includes appendixes of selected facility locations for both the highway and rail routing networks.

After an origin and a destination are selected, the model is ready to calculate a route based on criteria established by option selections. A default set of criteria is active for each transportation mode in the model. After completing the route calculation, WebTRAGIS displays the route in the user interface. The user can also view a series of summary reports, which include information on the route in summary or detailed format, the route population, and information on critical infrastructure such as schools, hospitals, and daycare facilities located within 800 meters of the route. All of the information—except for critical infrastructure data—can be saved and downloaded by users. The download files include text files that can be input into the RADTRAN (Neuhauser and Kanipe, 2000) risk model.

WebTRAGIS provides users with mode-specific routing option settings that change various parameters used by the model for route calculations. Examples of some of the options include adjusting highway speeds, using preferred highway routes for radioactive materials, and using dedicated trains for rail routing. WebTRAGIS also provides functions to temporarily modify the routing networks. Users may select an option to block an entire state, blocking all nodes and links to it in the network, or use a bounding box to draw on the user interface map regions to be excluded from the route generation process. Users should be aware that if excessive areas are blocked, a route solution may not be possible.

Another available feature available in TRAGIS is information on Native American tribal lands along routes. This data is only possible with such detailed shape files of the routing networks along with similar detailed tribal land boundary files. Tribal land boundaries are overlaid with the highway and rail networks allowing the model to report the names and the route mileage within each reservation. Tribal lands can also be viewed in relation to routes using the WebTRAGIS mapping features.

The availability of high-resolution population data for transportation routes has always been one of the main features of the ORNL routing models. Currently, WebTRAGIS uses population figures determined by the LandScan USA population database that are based on American Community Survey intercensal data. This new population data provides more detailed population estimates than the previous client-server version of TRAGIS. The previous model provided population data on a 15 arc-second grid for the United States. The new version of LandScan provided in WebTRAGIS has population information at a 3 arc-second resolution[4].

This user's manual consists of five sections. Section 2 provides user access and account management instructions and a general overview of the TRAGIS model including the mapping features and data management functions. This section is very useful for users who have not worked with graphical user interface (GUI) programs or web browser applications. Specifics for highway, railway, and waterway features are discussed in Sections 3–5, respectively. Section 6 briefly discusses future development plans for the model.

[4] An arc-second is 1/60th of a minute of angular distance. An arc-minute is 1/60th of a degree of angular measurement. A degree corresponds to 1/360th of a revolution, or turn, of the earth, so an arc-second is 1/3600th of a degree. Thus, 3 arc-seconds corresponds, roughly, to approximately 90 meters.

2. GENERAL OVERVIEW OF WEBTRAGIS

WebTRAGIS was developed as a web browser-based application capable of being used on a variety of browser platforms, such as Internet Explorer, FireFox, Chrome, Opera, and Safari. WebTRAGIS can be accessed via its home page at https://webtragis.ornl.gov/tragis/app/login (Fig. 2.1). The following links are located on the lower portion of the home page:

- *Request an account* brings up the TRAGIS account request form.
- *Forgot my password* allows approved users to have a new system-generated password sent to their registered email address if they have forgotten their password, or need to reset their password.
- *Disclaimer* provides information that all users should read regarding use of federal computer systems.

When checked, the *Remember Me* function will remember users after they log in to WebTRAGIS, so if they close the WebTRAGIS browser window and then reopen WebTRAGIS, they will be taken directly to the main page. However, if you restart your PC the *Remember Me* function resets, so you will need to log in normally.

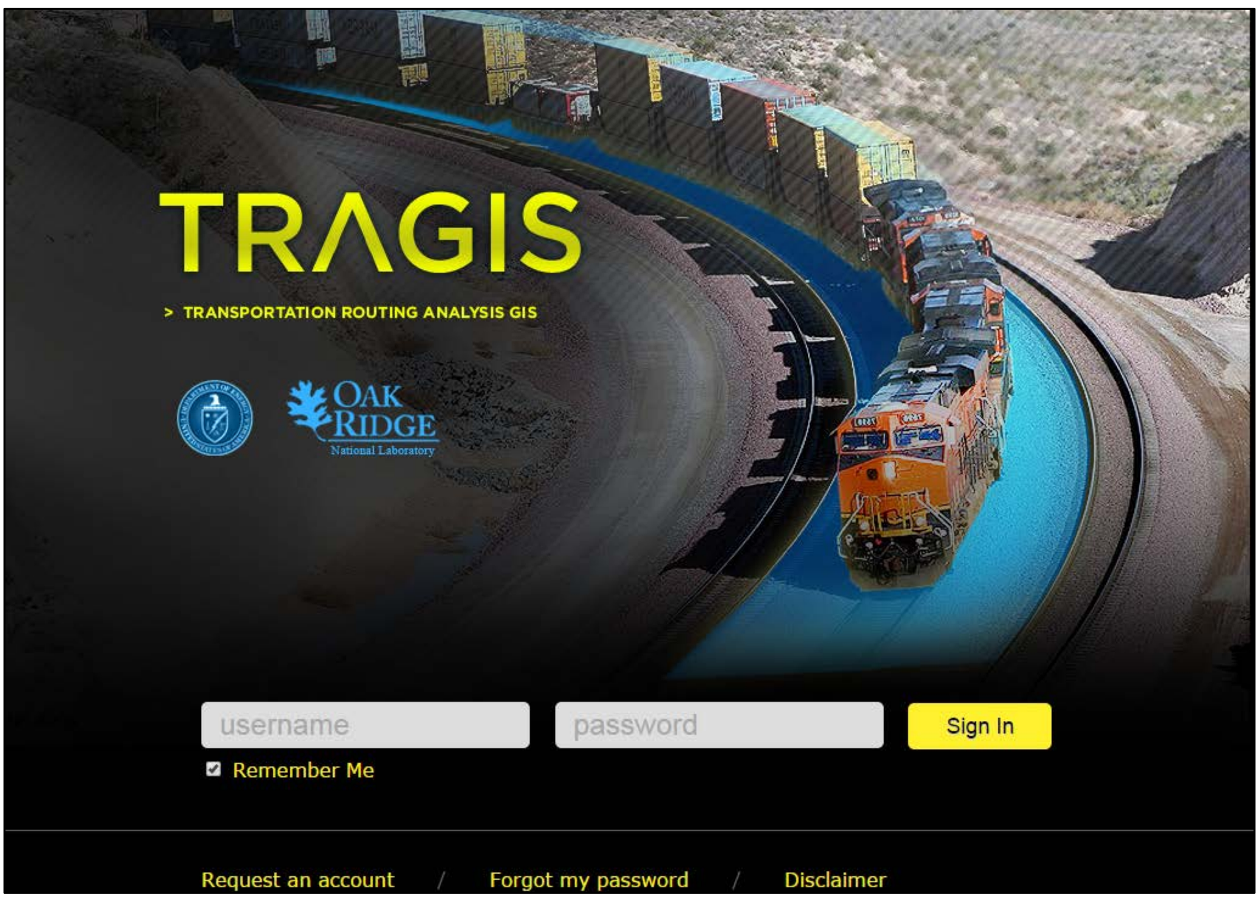


Fig. 2.1 WebTRAGIS home page.

2.1 REGISTERING AN ACCOUNT

The first step for new users is to register for TRAGIS by clicking on the *Request an account* link at the bottom of the home page (Fig. 2.1). The registration page contains the TRAGIS account request form (Fig. 2.2) and the terms of use (Fig. 2.3).

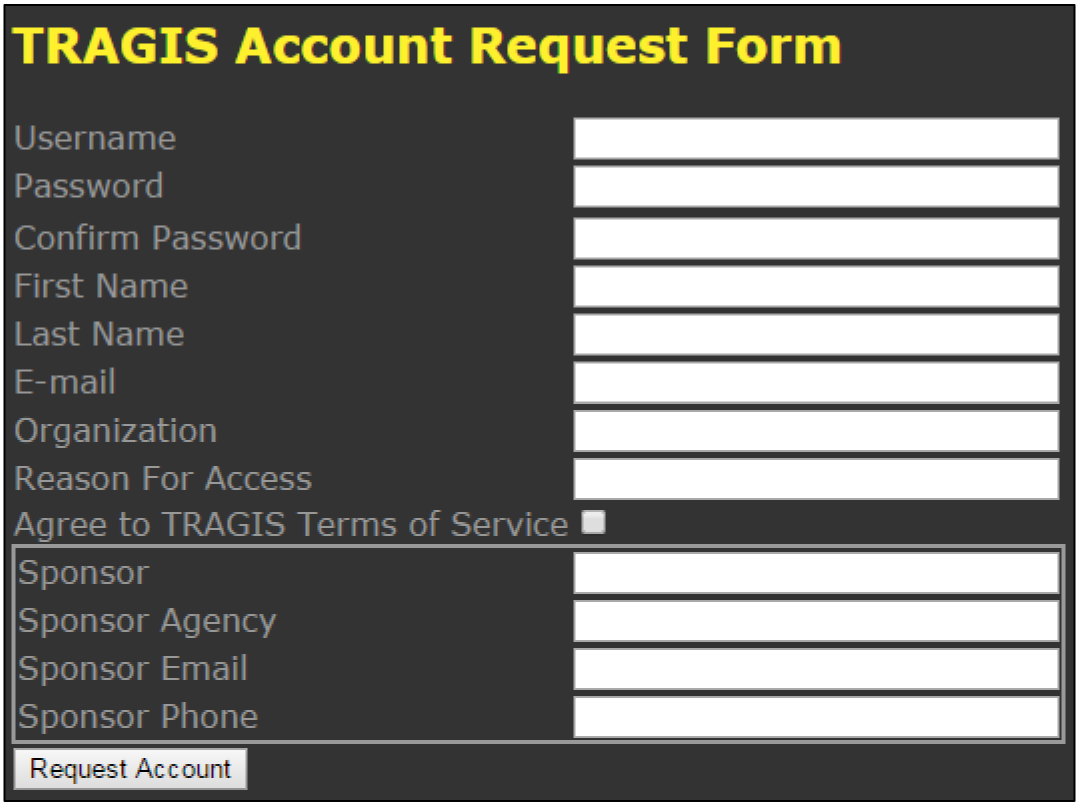


Fig. 2.2. WebTRAGIS account request form.

TRAGIS Terms of Service

The content, services, and functionality of the TRAGIS domain name (the "TRAGIS Website", "TRAGIS" or "Website") are administered by UT-Battelle, LLC, ("UT-Battelle) under the authority of its Prime Contract No. DE-AC05-00OR22725 with the U.S. Department of Energy (DOE).

Your use of the TRAGIS Website constitutes your agreement to be bound by all of the following terms and conditions. Please read them carefully before using the Website. If you do not agree to any of these Terms or conditions, you must not use the website.

Although we may attempt to notify you when major changes are made to these Terms of Service, you should periodically review the most up-to-date version (https://webtragis.ornl.gov). Oak Ridge National Laboratory may, in its sole discretion, modify or revise these Terms of Service and policies at any time, and you agree to be bound by such modifications or revisions. Nothing in this Agreement shall be deemed to confer any third-party rights or benefits.

TRAGIS Website

These Terms of Service apply to all users of the TRAGIS Website, including users who are also contributors of information and other materials on the Website. The TRAGIS Website includes all information, materials, and applications found on the TRAGIS Website.

TRAGIS Website Accounts

In order to access the Website, you will have been assigned an account. You may never use another account without permission from UT-Battelle.

Although UT-Battelle will not be liable for your losses caused by any unauthorized use of your account, you may be liable for the losses of UT-Battelle or others due to such unauthorized use.

Fig. 2.3. TRAGIS terms of service.

Figure 2.2 shows the fields that a new user needs to complete. Data must be entered in all fields, especially the reason for access. Currently, users are allowed to select a username and password. DOE requires WebTRAGIS passwords to be 18 characters in length. The password must include a mix of letters, capitalizations, numbers, and special characters; passwords must contain at least one numerical, one special character, and at least one capitalized and lower case letter. As with any computer password, the use of a common phrase or fixed set of numbers is not advisable.

Currently, the WebTRAGIS model is only approved for unrestricted use by federal employees using .gov or .mil email accounts. All other users—such as state government employees, federal contractors without .gov or .mil emails, or accounts for educational use—must be US citizens and obtain a federal government sponsor to have an account approved. Federal sponsors must be employed by the US government and in a position of project responsibility and oversee the activities of the non-federal user requesting an account. Educational account users should contact ORNL at TRAGISsupport@ornl.gov before submitting a request for access. ORNL and DOE have special provisions for approving limited-use academic accounts. Instructors should be prepared to submit a copy of either a course syllabus in which WebTRAGIS access will be used, or an approved research proposal, such as a thesis or dissertation proposal, that will benefit from having WebTRAGIS access. The use of WebTRAGIS for private, commercial use is prohibited.

After completing the user registration form, the system generates an email message to notify the WebTRAGIS project manager and developer that a new account is pending approval. After WebTRAGIS management reviews the registration and verifies the requester's status with a federal sponsor as needed, an email message is sent to the user notifying them whether their account is approved, rejected, or requires more information.

After being notified of registration approval, the new WebTRAGIS user can return to the WebTRAGIS home page, enter their username and password, and then select *Sign In*. Users will then be directed to the main page. When users log in to WebTRAGIS after receiving account approval, the main page screen will display the federal government disclaimer shown in Fig. 2.4. Users should familiarize themselves with the conditions and parameters outlined in the disclaimer before proceeding to the main page.

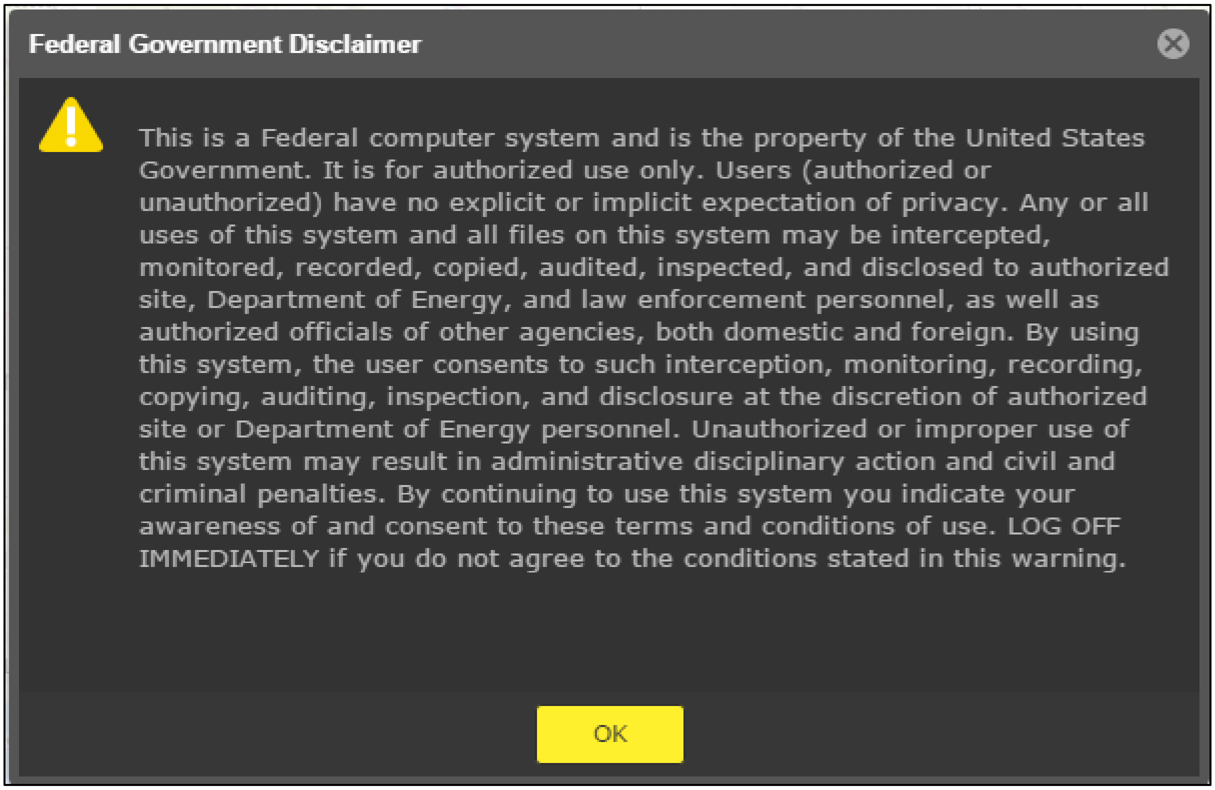


Fig. 2.4. Federal government disclaimer.

2.2 ACCESSING WEBTRAGIS AND THE MAP DISPLAY INTERFACE

Figure 2.5 shows the initial appearance of WebTRAGIS after the user has entered their username and password. WebTRAGIS is designed with a set of route and mapping options that can be accessed by clicking on the appropriate screen tab in the top left window, or using the map navigation toolbar at the top of the map display. By default, WebTRAGIS opens with the *Route Controls* tab and the map display set to the national map provided by Bing Road.

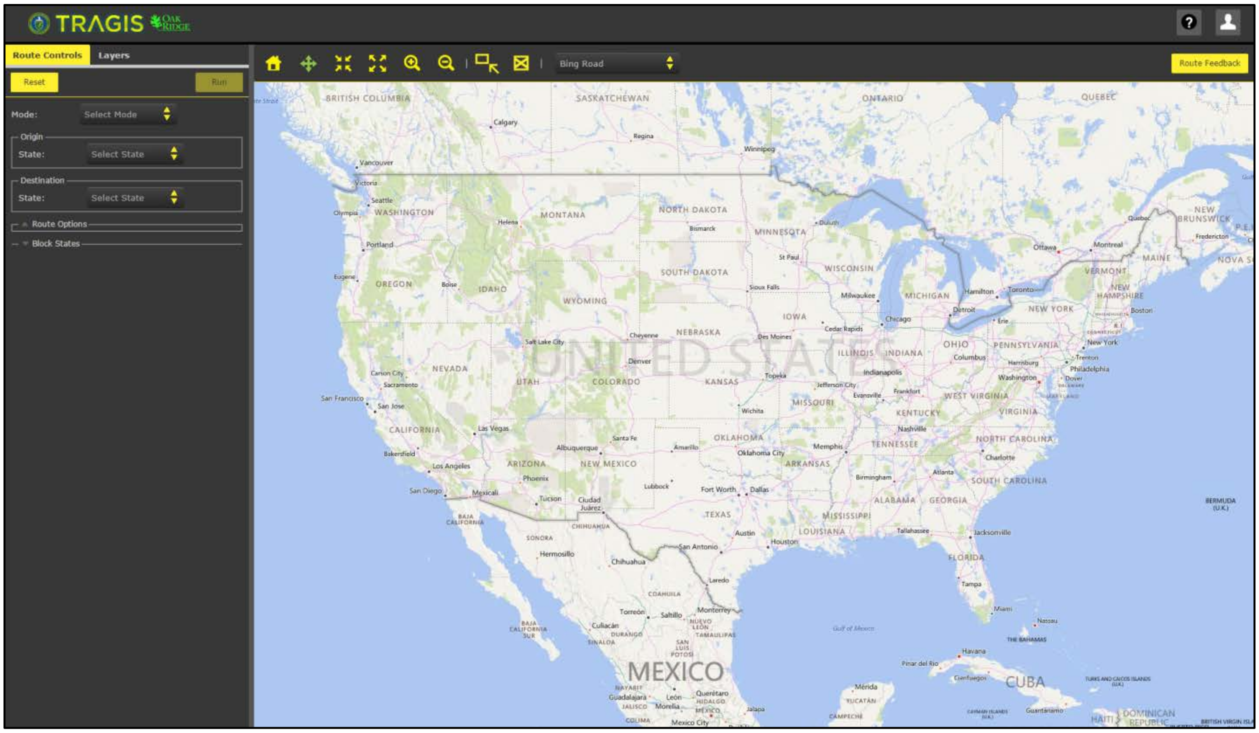


Fig. 2.5. WebTRAGIS main page and map interface.

2.2.1 Route Controls Tab

After successfully logging into WebTRAGIS, the *Route Controls* tab is the initial screen tab displayed in the navigation panel. The center of the screen displays a map interface (Fig. 2.6). Initially, the tab shows three route selection boxes, along with buttons to *Run* or *Reset* a route, and menus for *Route Options* and to *Block States*.

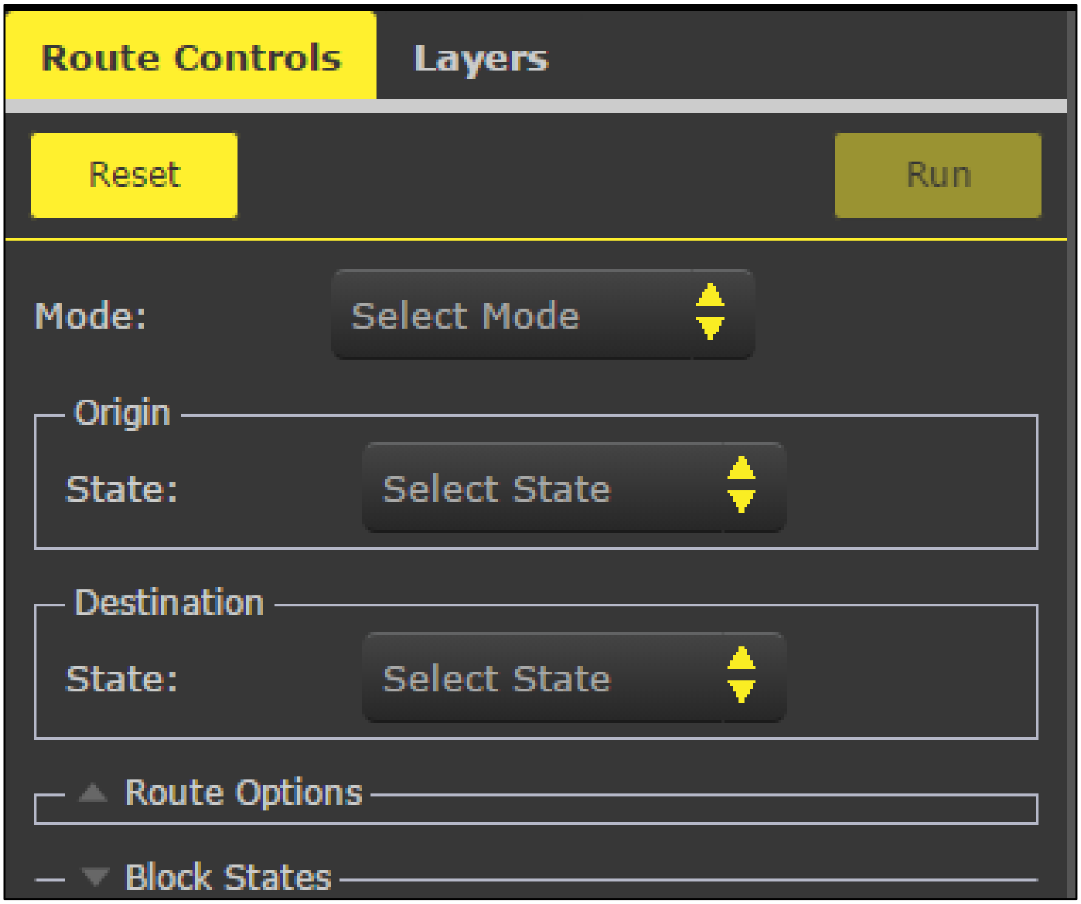


Fig. 2.6. Route controls menu.

Mode selection is the first selection tab. From the drop-down menu, users may select to run a highway, railroad, or waterway route. Once a mode is selected, different modal *Route Options* are displayed for selection. Modal routing and blocking options are discussed in more detail in Sections 3, 4, and 5.

2.2.2 Map Navigation and Blocking Toolbar

Figure 2.7 shows the map navigation and blocking toolbar. The toolbar provides users with several options for navigating around the map and two options involving blocking. These two types of options are separated by a graphic hyphen in the toolbar. The default map navigation setting is the pan option. Panning on the map is accomplished by placing the mouse cursor over the map display and then holding down the left mouse button. This action changes the cursor to resemble the pan tool icon. When the left mouse button is depressed, users may click on the screen and re-center the map display.

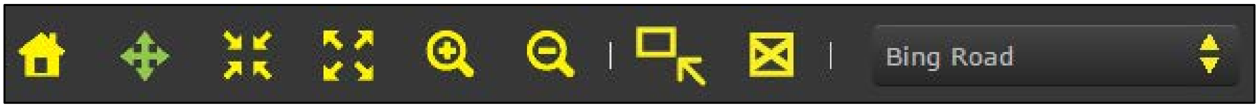


Fig. 2.7. Map navigation and blocking toolbar.

Users may also select four toolbar options that provide zoom-in and zoom-out capabilities. The two icons with arrows provide (from left to right) a fixed zoom-in and zoom-out of the current map display. The two icons resembling magnifying glasses allow users to define an area on the map by selecting the icon and then drawing a bounding box on the map display. This will then resize the map display accordingly.

The final two icons may be used in blocking operations when running routes. The bounding box, which looks like an arrow pointing to a box (shown in green in Fig. 2.8), allows users to exclude areas of the map from routes. Every network option within a bounding box will be removed from the possible solution set of links and nodes used to determine a route. Users may create several bounding boxes at the same time to block particular areas from being eligible for routing. An origin or destination within a bounding box cannot be selected, and blocking large areas or using multiple bounding boxes may prevent the program from determining a routing solution. To remove bounding boxes, simply click the "*X* within a box" in the toolbar. This action removes all bounding boxes displayed on the map.

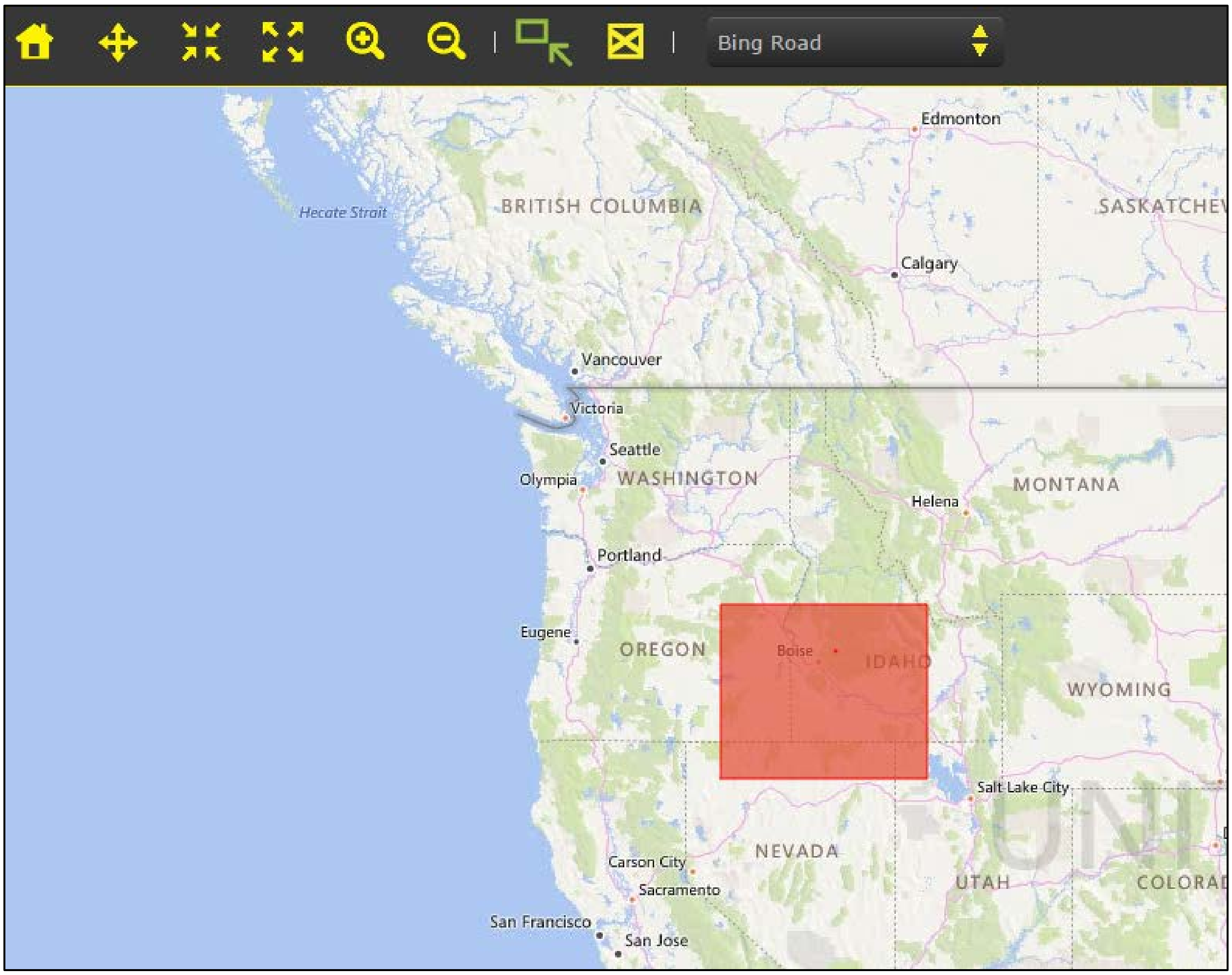


Fig. 2.8. Route blocking bounding box.

2.2.3 Layers Tab

The *Layers* tab provides several menu and display options (Fig. 2.9). These may be toggled on or off by checking the appropriate box under *Visible***.** Once a layer has been selected, it becomes visible on the map display. WebTRAGIS provides layer displays of tribal land and county boundaries; critical infrastructure features such as fire stations, hospitals, daycare centers, nursing homes, and schools; and LandScan population data from either the LandScan Global (30 arc-second resolution) or an ambient (day-night average) population derived from LandScan USA at a 3 arc-second resolution (~90 meter). WebTRAGIS also provides users with the option to display the different national networks for each mode. Finally, the *My Routes* section displays the routes run during the current session, as well as previous routes saved by the user. This feature is discussed in more detail in Sections 3,4, and 5.

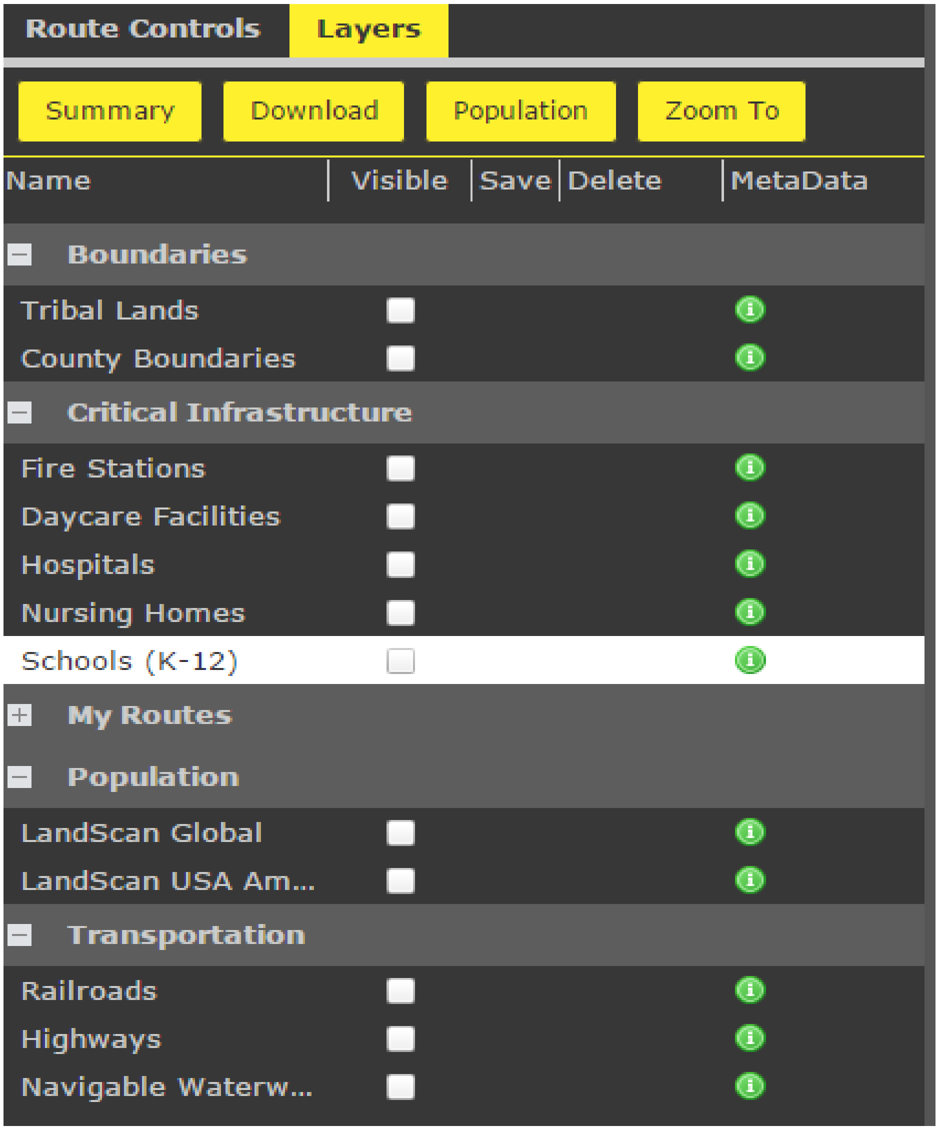


Fig. 2.9. WebTRAGIS layers menu.

An example of the different layers can be seen in Fig. 2.10, which displays the area around Kansas City. In this view, county boundaries have been highlighted in gray and tribal lands are noted in red polygons. The railroads layer is displayed in green, hospitals are indicated by the layer of blue dots. A rail route can also be noted as a purple line with orange nodes traversing through the Kansas City metropolitan area.

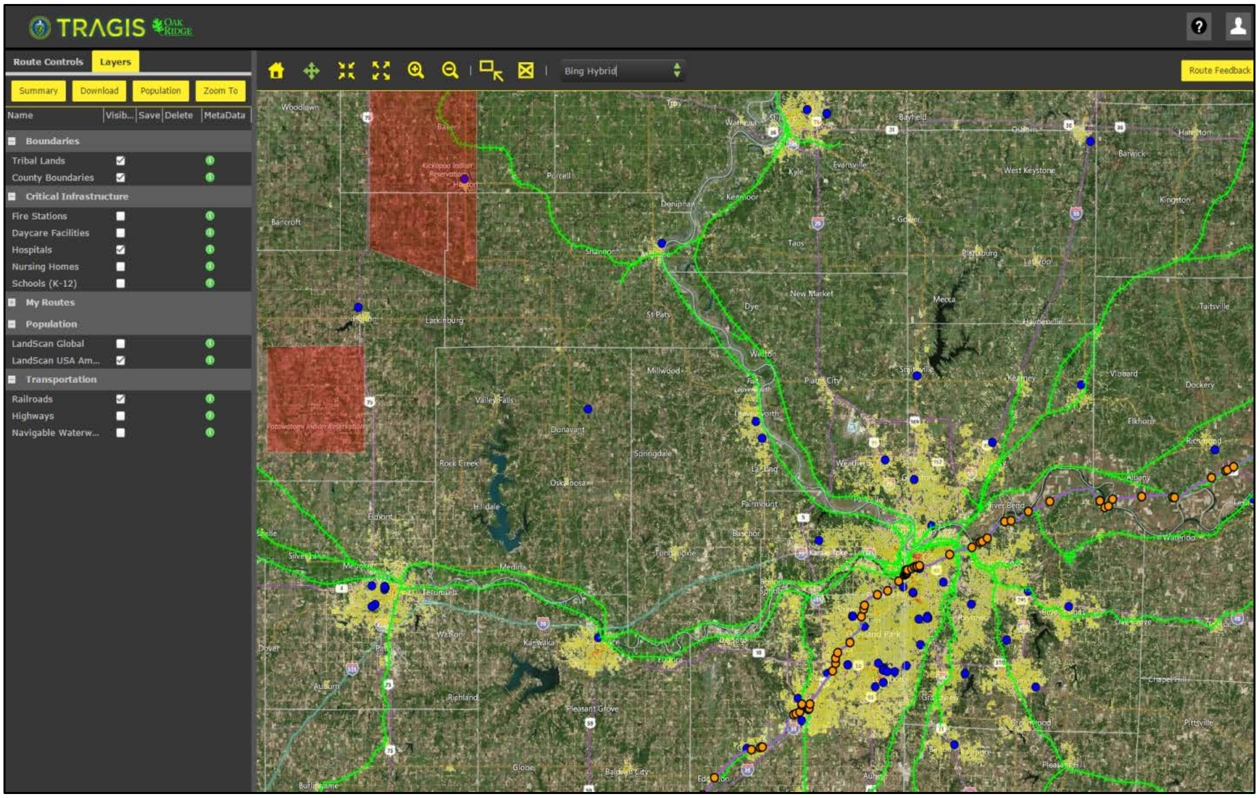


Fig. 2.10. WebTRAGIS layers display.

2.3 USER ACCOUNT MANAGEMENT, CONTACT, AND ROUTE FEEDBACK

Also located on the top right of the WebTRAGIS main page are the *Route Feedback*, *Contact*, and *User Account Management* options (Fig. 2.11).

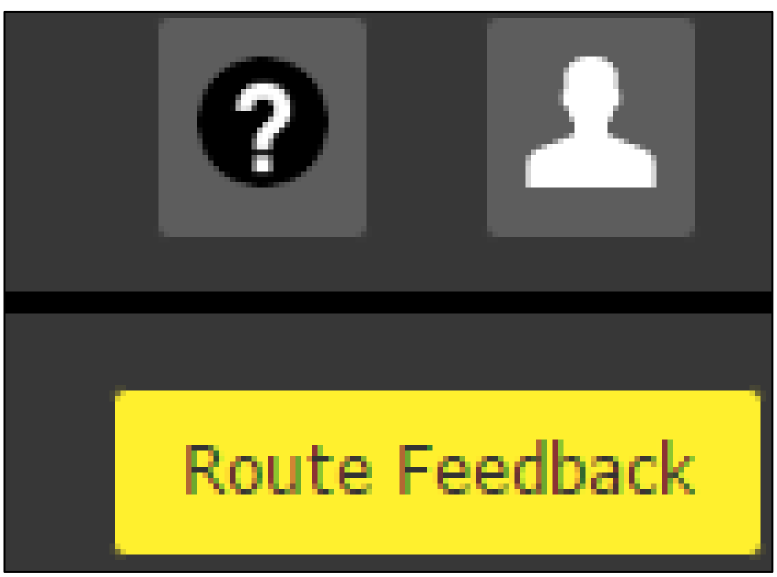


Fig. 2.11. Account management, contact, and route feedback menus

Selecting *Route Feedback* opens a menu that allows users to select a route from a list of previously generated routes. After a route has been selected, a message form opens in a new menu (Fig. 2.12). This allows users to communicate with WebTRAGIS administrators regarding any errors or corrections in the route output that need to be addressed. The *Feedback Form* can also be accessed by selecting the "*?*" icon in the toolbar.

Fig. 2.12. Feedback form.

The *User Account Management* menu can be accessed by selecting the profile icon. This opens up the *Account Settings* menu (Fig. 2.13).

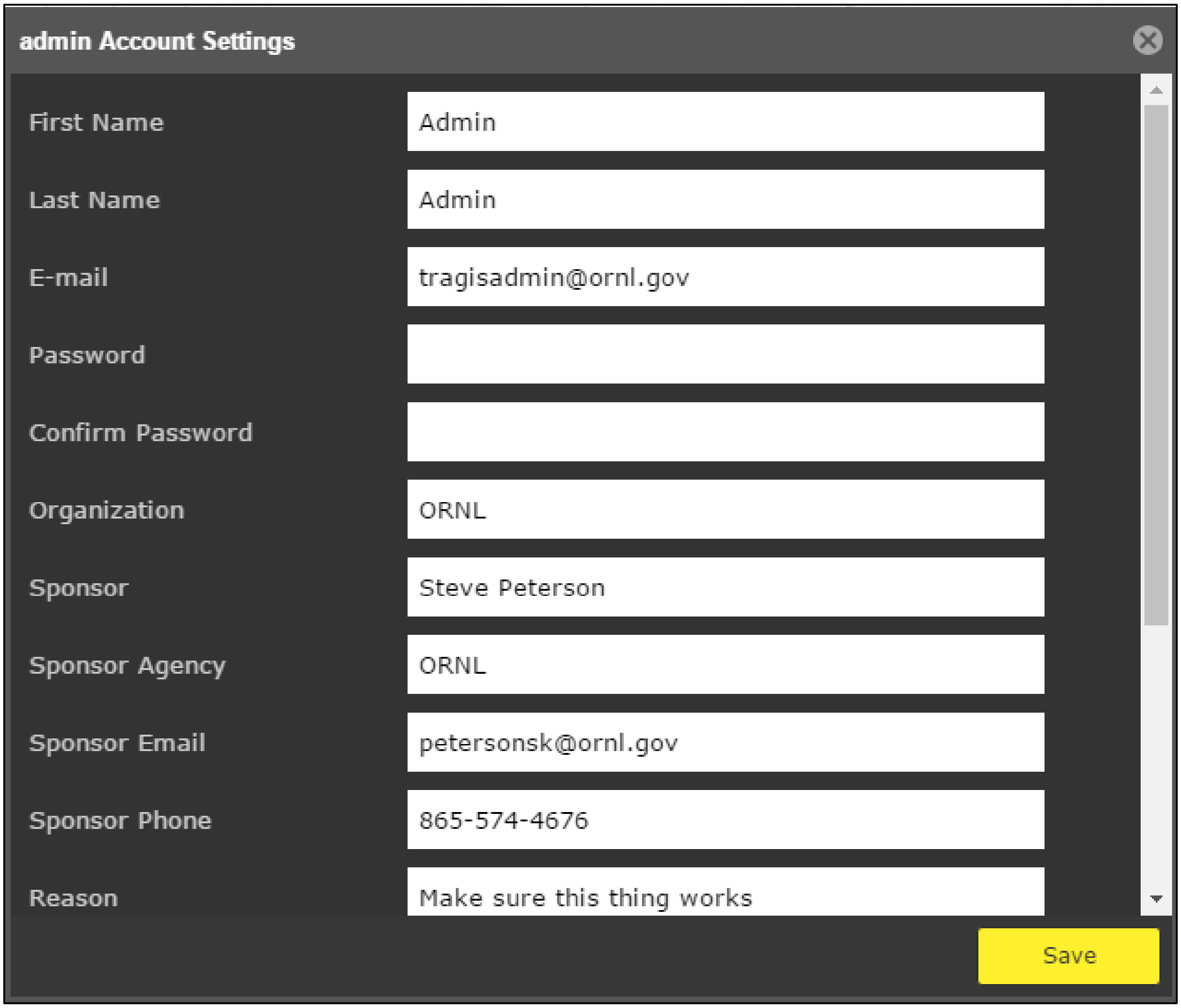


Fig. 2.13. User account settings menu.

In this menu users can enter a new password or update their organization and sponsor information as necessary. As noted previously, all user passwords must be 18 characters and conform to the WebTRAGIS password specifications. At present, users are required to change their passwords every 90 days. Users are sent several reminder emails to log in and update their password. This may be done by accessing the *Account Settings* menu, or by using the *Forgot My Password* option on the log-in page.

2.4 WEBTRAGIS POPULATION DATA

An important feature of the WebTRAGIS model is the ability to obtain detailed route-specific population density values and distances as well as population count data for calculated routes. The population data accessed by the TRAGIS routing engine is derived from the ORNL-developed LandScan USA 3 arc-second (~90 meter) grid cell population database and also the LandScan Global 30 arc-second (~1 km) grid cell data. Both datasets represent an ambient (average over 24 hours) population distribution and are developed from a combination of data sources, including 2010 US Census Bureau block group population, American Community Survey intercensal, data, Census TIGER road data, slope from the National Imagery and Mapping Agency's (NIMA) Digital Terrain Elevation Data (DTED), and land cover from the USGS National Land Cover Database. The data are modeled to best approximate the actual location of the resident population (Bhaduri et al., 2007).

An example of the LandScan USA 3 arc-second grid cell population can be seen in Fig. 2.14. The figure provides a rail network link in the Midland, Texas urban area.

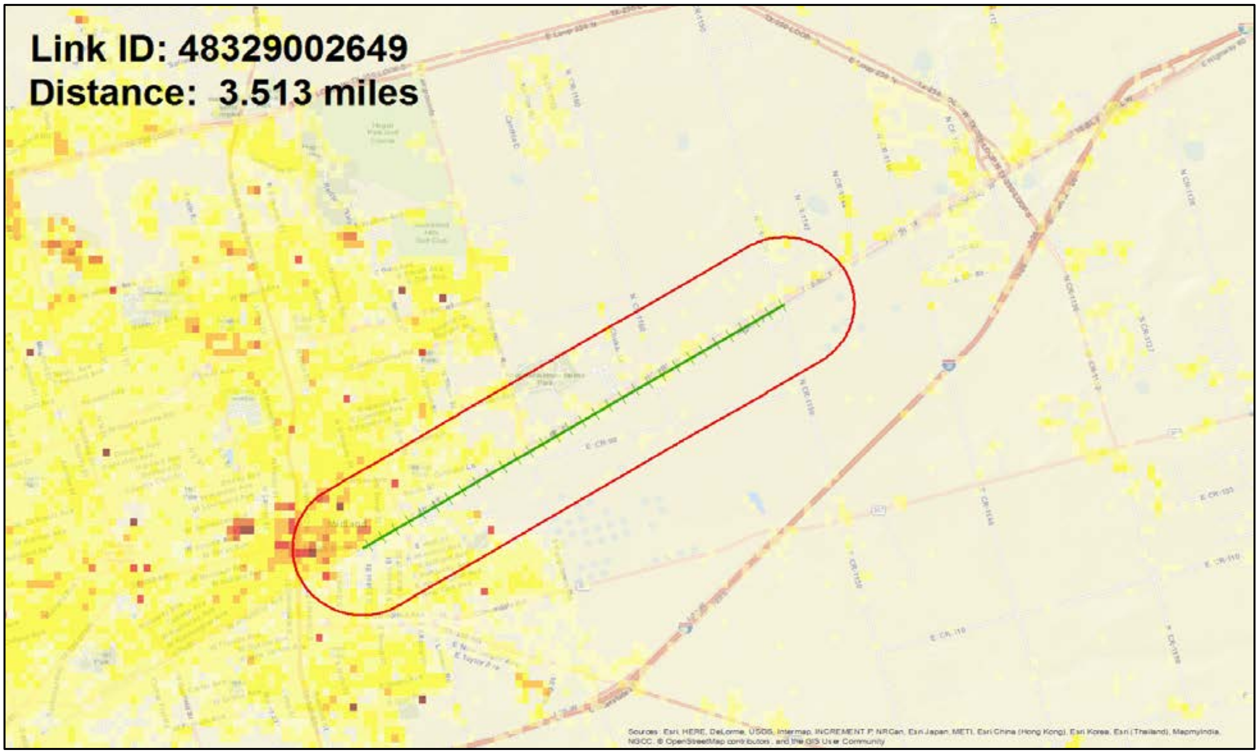


Fig. 2.14. LandScan USA sample.

In Fig. 2.14 each grid cell represents a specific number of people and is shaded from light yellow (very low population) to dark red (high population). LandScan data is normalized to the Census block group. This means that for a specific block group, the grid cells that comprise or cover the area represented by the block group have the total population of that block group. The geographic area of each grid cell is also known, and the population density of each cell is computed by dividing the population of a cell by the area of the cell.

WebTRAGIS derives population densities using an 800 meter buffer around each network link along the transportation route. Densities are reported in three categories[5]:

- Rural/low: below 139 people/mi^2
- Suburban/medium: between 139 and 3,326 people/mi^2
- Urban/high: above 3,326 people/mi^2

[5] Currently, WebTRAGIS only reports population density distances in terms of standard English units, i.e. miles and square miles. Future updates are expected to offer users the option to have WebTRAGIS report distance and population density values in metric units. Comparable metric densities are below 54 people/km^2, between 54 and 1284 people/km^2 and above 1284 people/km^2.

WebTRAGIS reports two different population densities or density distance calculations. The first reports densities and associated distances by link, while the second format is a summary by state available in the *Standard* and *Detailed Results* reports (see Section 3.5.2 below). To calculate the population density distances for each link, WebTRAGIS determines the link distance and the corresponding LandScan population grid cells that the link passes through. An 800 meter ellipse is then drawn around each center point as in Fig. 2.15. Any population grid cell with a center point lying within the 800 meter ellipse has the corresponding population count included in the gridded link population calculation. The link is then split up by grid cell and a center point for each link is determined (Fig. 2.16).

Figure 2.15 illustrates the population density methodology. In this example, a detail of the railroad network link from Midland, Texas seen in Fig. 2.14 is shown overlaid on the LandScan USA 3 arc-second population grid. The total link distance is 3.513 miles, and the center points for the gridded links reflect the population counts for each grid cell. The first link center point is highlighted and the link distance is calculated to be 0.0069 miles. WebTRAGIS then applies the 800-meter ellipse, and the total population is determined. Using the population count of 43 persons and the known area of the buffered area (0.78 mi^2), a population density of 55 persons/mi^2 is calculated. This results in the grid-link segment being classified as rural. WebTRAGIS then places the 0.0069 mile distance into the rural density class and proceeds to the next cell until population densities are completed for the entire link (Fig. 2.16). A more complete discussion of the population calculations, reporting options, and the types of population reporting in the summary outputs is included in Appendix D.

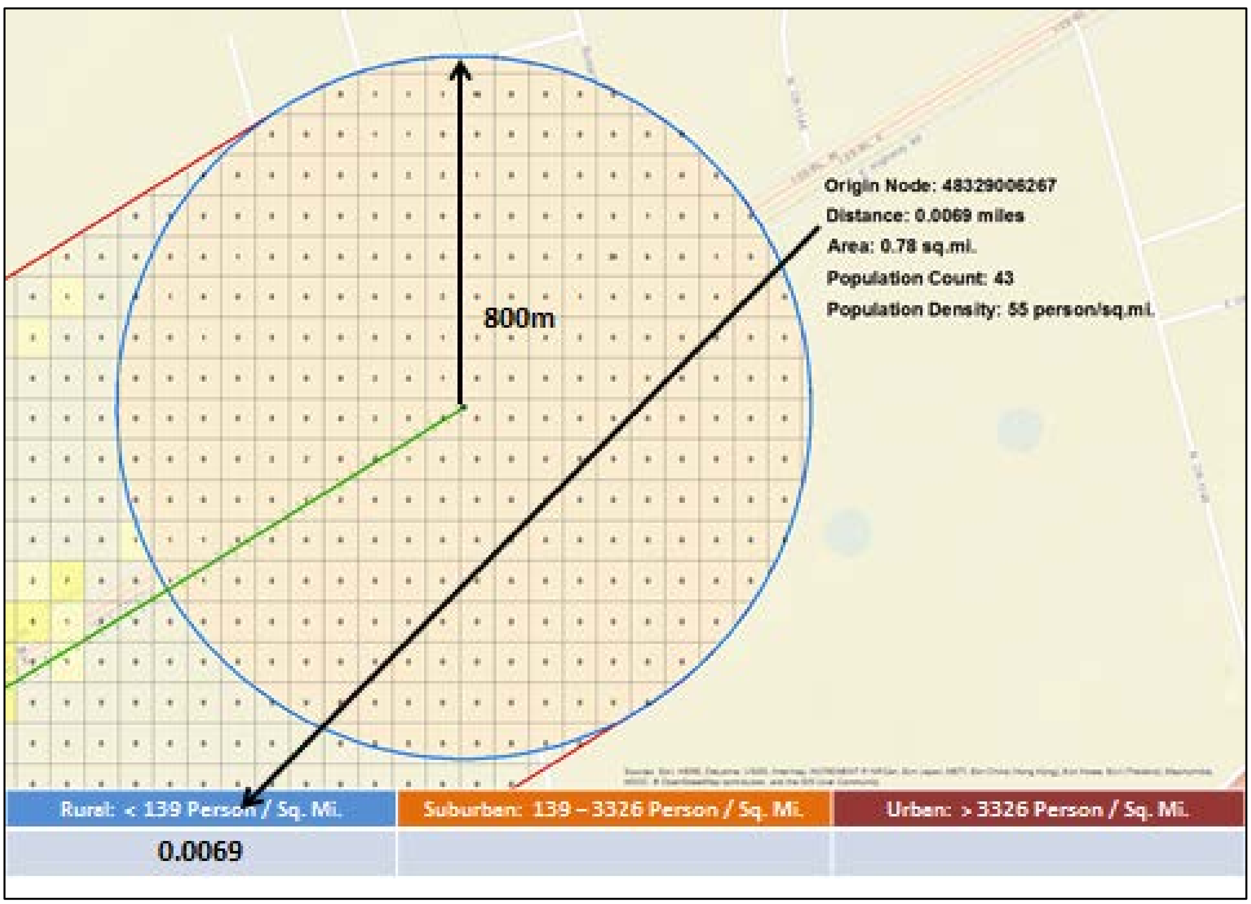


Fig. 2.15. Population density calculation detail

In Fig. 2.16, the entire link has now been classified, and the appropriate link distances assigned to each population category. As a result, the entire link is now broken down into the various density classes using the highly detailed 3 arc-second population grid. This provides users a much finer resolution population dataset than was available in previous versions of WebTRAGIS using population data at 15 arc-second resolution derived from LandScan.

WebTRAGIS provides the population data in several different formats for users to choose from. First, when users select the *Summary* button from the *Layers* menu, a series of reports are generated (detailed in the following section) and displayed below the map interface. In the *Standard* and *Detailed Results* tabs, a summary of the population densities by state is provided at the bottom of each listing. In the *Route Details* tab, the population density distances for each category are listed, while the *Route Population* tab provides the actual population count found within the800 meter buffer for each route link. Also, if users decide to save and download a route file, the output contains a state summary file suitable for use as an input into population risk calculation programs such as RADTRAN[6].

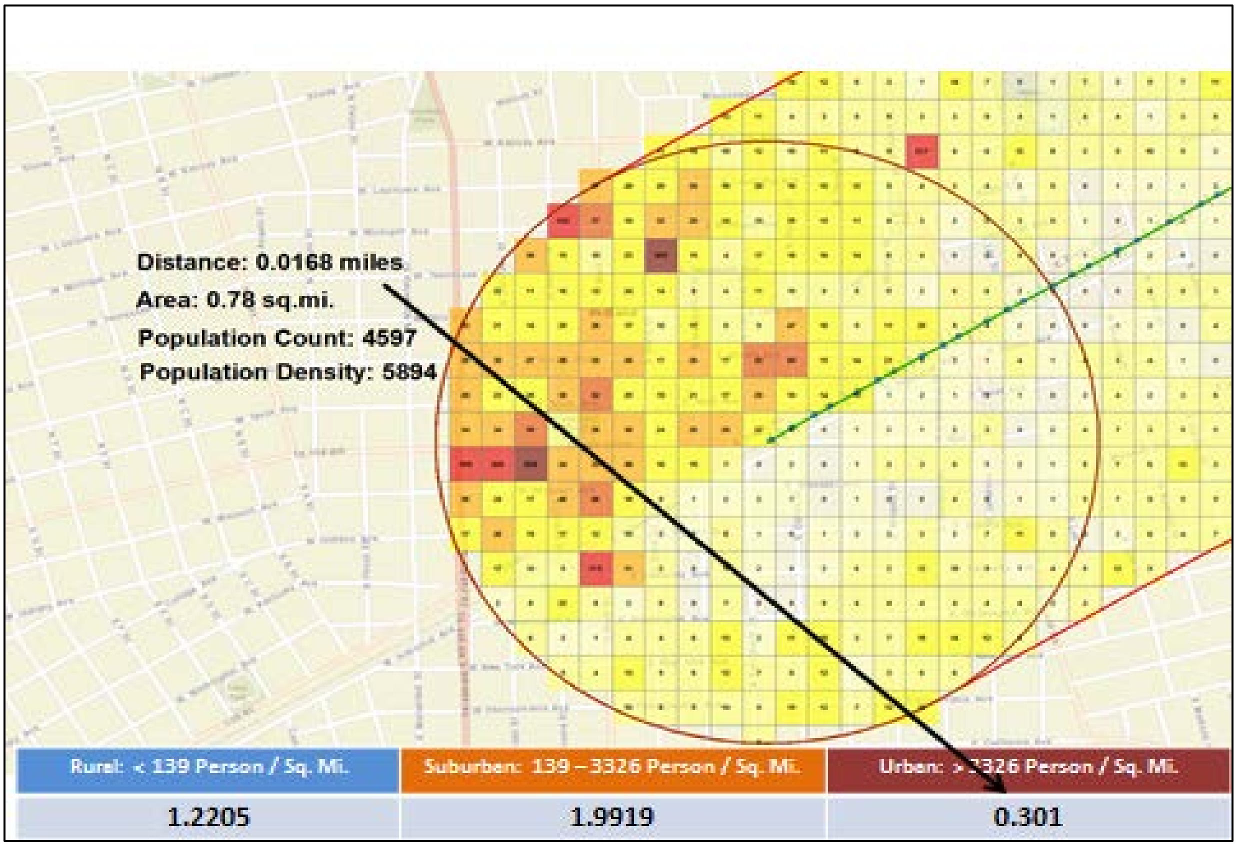


Figure 2.16 WebTRAGIS population density by link

[6] It should be noted that users will not be able to "reverse engineer" population counts from the population density values reported in the Route Details screen. WebTRAGIS does provide an average density value for each density category, but the density calculation methodology effectively recounts population for each gridded link segment. As a result, the same population cell may be counted several times in calculating densities as 800 meter buffer ellipse passes over the link depending upon the link distance and link curvature. Thus, the link distances by density classification will correspond to the link distance, but the average densities will not yield a similar result with the link population counts. See Appendix D for more information.

Figures 2.17 and 2.18 are provided as an illustration of the differences in population detail provided by the 3 arc-second data versus the older 15 arc-second data. Figure 2.17 shows the derived 15 arc-second population data for an area in central Kansas City, Missouri, including the railroad network. Various highways are also shown on this map. Figure 2.18 shows the same area with the 3 arc-second population data. As can be readily observed, the 3 arc-second data provides much better population resolution and a more accurate means for assessing population risk. The aggregation level of the 15 arc-second data overstates the actual distribution of population leading to higher estimates of population density than are warranted by the actual population count distributions.

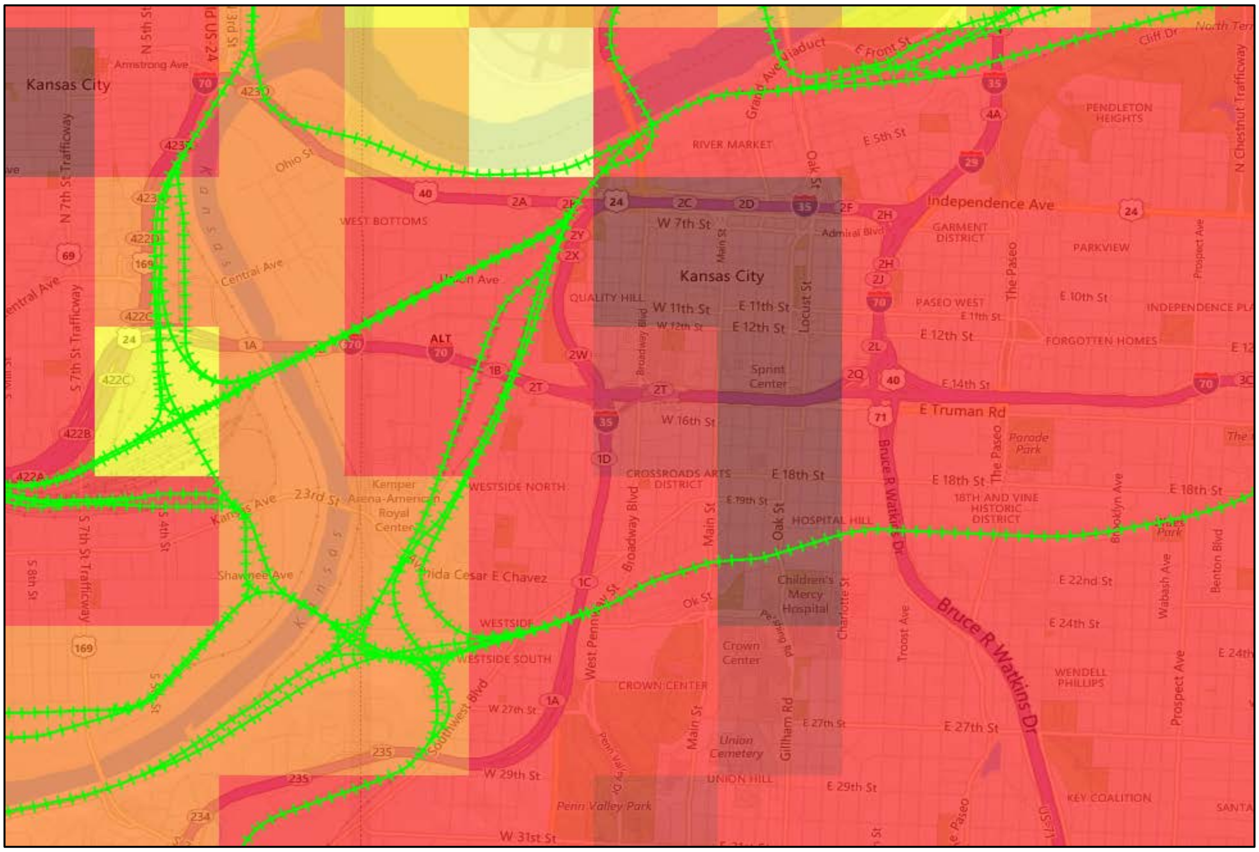


Fig. 2.17. Kansas City 15 arc-second population.

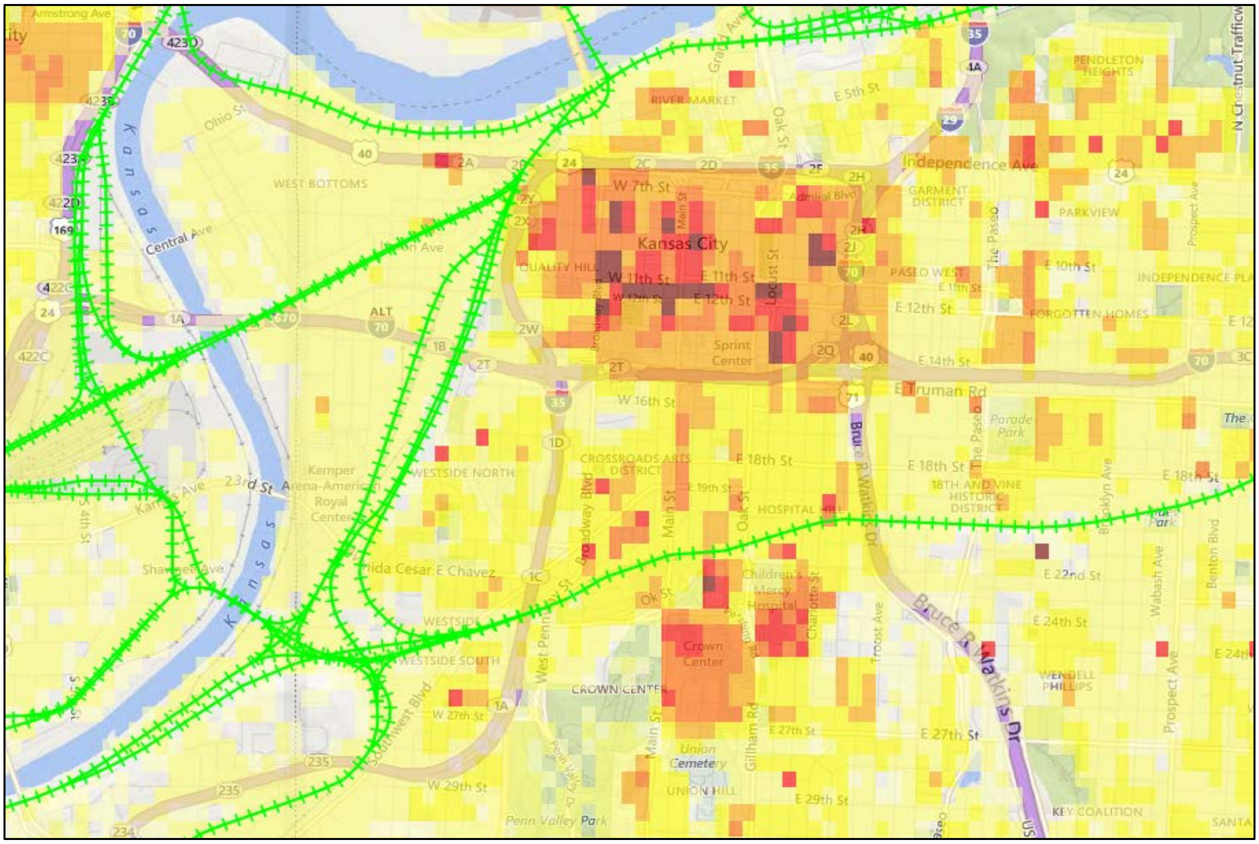


Fig. 2.18. Kansas City 3 arc-second population.

3. ROUTING IN WEBTRAGIS

Routing in WebTRAGIS is designed to be as intuitive and simple as possible for users to implement. To generate a simple route, a user only needs to determine an origin and a destination, and WebTRAGIS will calculate the route. In some cases, such as rail, the user may need to specify a particular rail carrier; however, the basic simplicity of route generation remains. As a result, the same basic routing method is applicable to all of the modes. What follows are details on some of the specific routing parameters and constraints users may apply to the different modes when generating routes and then a discussion of the route output, which is identical for each mode.

3.1 ROUTING BASICS

Routing in WebTRAGIS depends on the particular mode of shipment selected by the user. Each mode has a specific network with mode-specific characteristics, and mode-specific route constraint options. These are selectable from the *Route Controls* menu (Fig. 2.6). When a user clicks on the *Select Mode* button, a drop down menu displays the three WebTRAGIS modes: highway, railroad, and waterway. When the user selects a specific mode, the *Origin* and *Destination* menus are loaded with the different network nodes and the different *Route Options* specific to each mode are activated.

Route generation is based upon the mathematical methodology known as “shortest path”; although, the actual routing algorithm is modified to handle interconnected networks as well as to account for specific attributes of the various modes expressed as impedances. These impedances modify the distance parameters in the shortest path algorithm so that the objective function for each of the modes is not strictly shortest path, but one of impedance minimization. While impedance is a function of distance, it also incorporates dynamic attributes such as transfers between rail networks which involve the time spent changing crews, inspections, and refueling. As a result, impedance captures friction in the transportation system. By minimizing impedance, the TRAGIS routing engine seeks to minimize not only distance, but also the friction from occurrences such as transfers between railroads.

3.1.1 Route Blocking

As noted in Section 2.2.2, WebTRAGIS users may use a bounding box to block certain locations from the potential route solution set. Applying a bounding box excludes any network features (both nodes and links) from the possible route solution set. Under the *Route Controls* menu users may also select to block entire states from the route solution sets using the *Block States* drop down menu (Fig. 3.1). Selecting a state excludes all of the applicable network nodes and links from inclusion in the route solution. More than one state can be selected to block; however, origin and destination states cannot be blocked. Users should be aware that the more states that are selected for blocking and/or large numbers of blocks by bounding box decreases that the possibility of determining a routing solution.

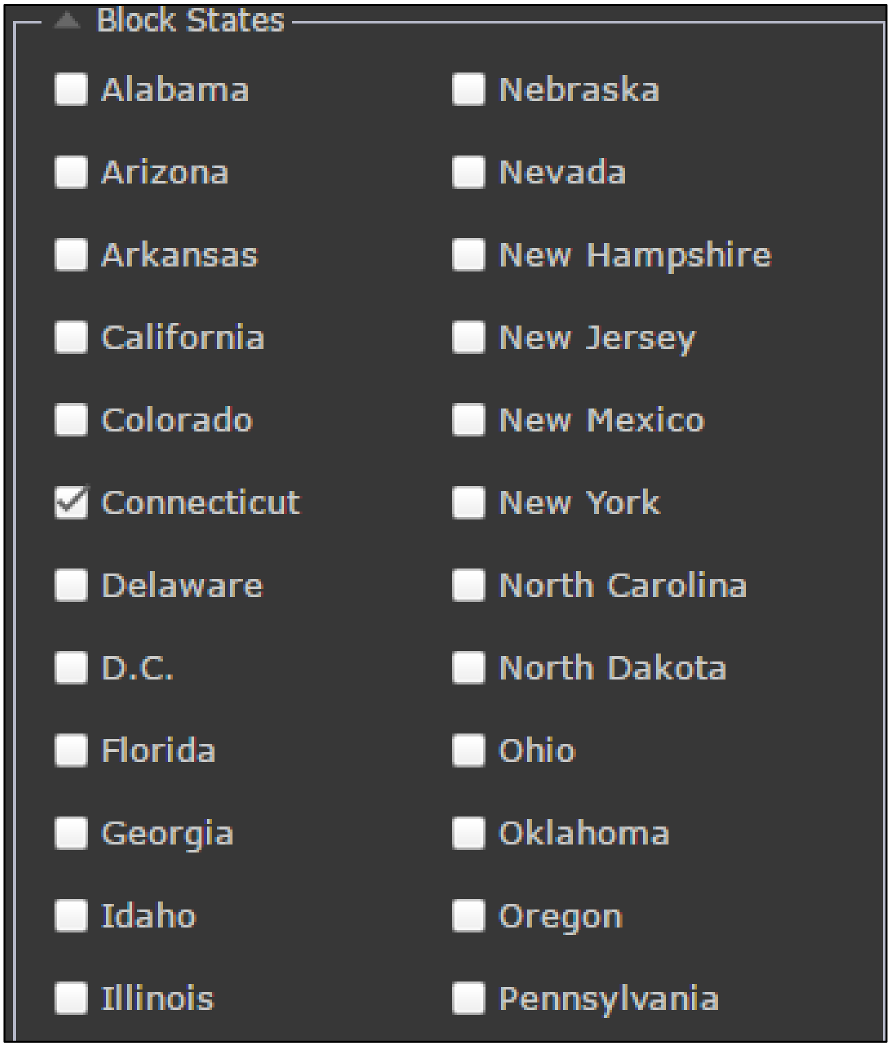


Fig. 3.1. Blocking states in the route controls menu.

3.2 HIGHWAY ROUTING

The WebTRAGIS routing model can calculate a number of different types of highway routes. By default, the model calculates commercial highway routes, but by selecting different options, the model can determine routes that meet the US DOT regulations for shipments of highway route-controlled quantities (HRCQ) of radioactive material, non-HRCQ hazardous materials, and routes for shipments to the Waste Isolation Pilot Plant (WIPP).

As shown in Equation (1), TRAGIS employs the following objective function for determining the impedance, L, over a route with i segments:

$$L = Min\sum_i \left(\alpha D_i + \beta T_i\right), \tag{1}$$

where

L = total impedance of a route;
α = distance bias;

D_i = distance of segment *i*, miles;
β = time bias; and
T_i = time required to travel along segment *i*, minutes.

Setting the values of the distance and time biases defines a particular routing criterion. For example, under the commercial route setting, α and β are defined as 0.3 and 0.7, respectively.

3.2.1 WebTRAGIS Highway Network

The WebTRAGIS highway network has been developed from a 1:100,000 scale road network derived from USGS digital line graphs and Census TIGER data. The network represents slightly over 237,000 miles and includes all US Interstate highways, most US highways except those that closely parallel Interstate highways, most major state highways, and other local roads (both county and city) connecting to various specific sites of interest. Currently there are over 21,000 highway segments (links) and almost 15,000 intersections (nodes). Included in the network are all commercial nuclear power plants, DOE sites, commercial airports (designated by their location identification code), and military airports (also designated by their location identification code). Appendix A provides a list of node names for selected facilities in the WebTRAGIS highway network. A GIS distance measuring technique using an equidistant projection calculates the distance (in both miles and kilometers) of each link in the highway network. Other attributes in the highway network include the speed limit, toll designation, commercial truck restrictions, roads within urbanized areas over 100,000 people, preferred route designation for HRCQ shipments, and nonradioactive hazardous material route restrictions.

3.2.2 Highway Naming Conventions

WebTRAGIS uses a unique set of naming conventions for the node and link components of the highway network. The following sections detail those conventions.

3.2.2.1 Highway link naming conventions

The naming convention for links in the WebTRAGIS highway network uses up to five characters. The first character is a letter designating whether the highway is classified as an Interstate, US highway, state highway, turnpike, county, or local road. The second through the fifth characters represent the route number of the highway. For roads that do not have numbers, a short abbreviation of the road name is used. Names of toll roads and toll bridges include the $ and # signs, respectively, as the fifth character in the highway name. Examples of this convention are as follows:

- Interstate highways: I40, I35W, I470$ (toll road), I278# (toll bridge)
- US highways: U1, U31, U412
- State highways: S9, S62, S162, S3132
- Turnpikes not part of the Interstate System: TBGP (Blue Grass Parkway in Kentucky), TFLT$ (Florida Turnpike toll road)
- County roads: C2, C10, C300E
- Local roads: LOCAL

Each link may also have up to three different highway numbers assigned to it, representing cases where multiple highways traverse the same segment of a road. Examples include I90/I94 in Wisconsin, U14/U16/U20 in Wyoming, and S22/S33 in Idaho. Normally, mixtures of different classes of roads are not included together, such as a US highway running concurrent with an Interstate highway. The reason for not mixing the different classes is to reduce the length of the standard route listing output. In the route listing, only the first two road names are provided.

3.2.2.2 Highway node naming conventions

Highway node names follow a standard naming convention consisting of three parts—a city name, a directional modifier, and a pair of intersection descriptors. The city name of the node is generally the city or town nearest the intersection. The directional modifier describes the direction that the node is in relation to the center or downtown portion of the city (i.e., N for north, S for south, SE for southeast, etc.) Intersection descriptors normally identify the two primary highways that meet or cross at the node location. On most Interstate highway nodes, the Interstate number along with the exit number comprises the intersection descriptors. A node where two Interstate highways meet will have both Interstate highway numbers as the intersection descriptors.

Some nodes do not follow the standard naming convention. One situation is a node named for a facility, such as an airport, nuclear plant (NP), or DOE site rather than a specific city. Usually such facilities will not include a directional modifier or intersection description in the full name. The other situation is state border nodes. State border nodes are placed in a unique state designation with the abbreviation “BD” for border. The names of the state border nodes are constructed from the state abbreviations, the highway network link name, and a location descriptor. The first four characters are the two state abbreviations of the bordering states, with the lower alphabetic state appearing first. The first four characters of the highway designation of the road crossing the state border follow the state abbreviations. The final eight characters of a state border node name consist of the city name or location taken from the closest adjacent nodes in either state, appearing in the same order as the state abbreviation order.

Figure 3.2 shows a portion of the highway network in the vicinity of Memphis, Tennessee. This figure helps illustrate the link and node naming conventions. In this example, roads are color-coded by the type of highway: Interstate highways are blue, US highways are red, state highways are green, and local roads are orange. Black circles indicate nodes. The nodes in Tennessee and at the state border are all identified by their name.

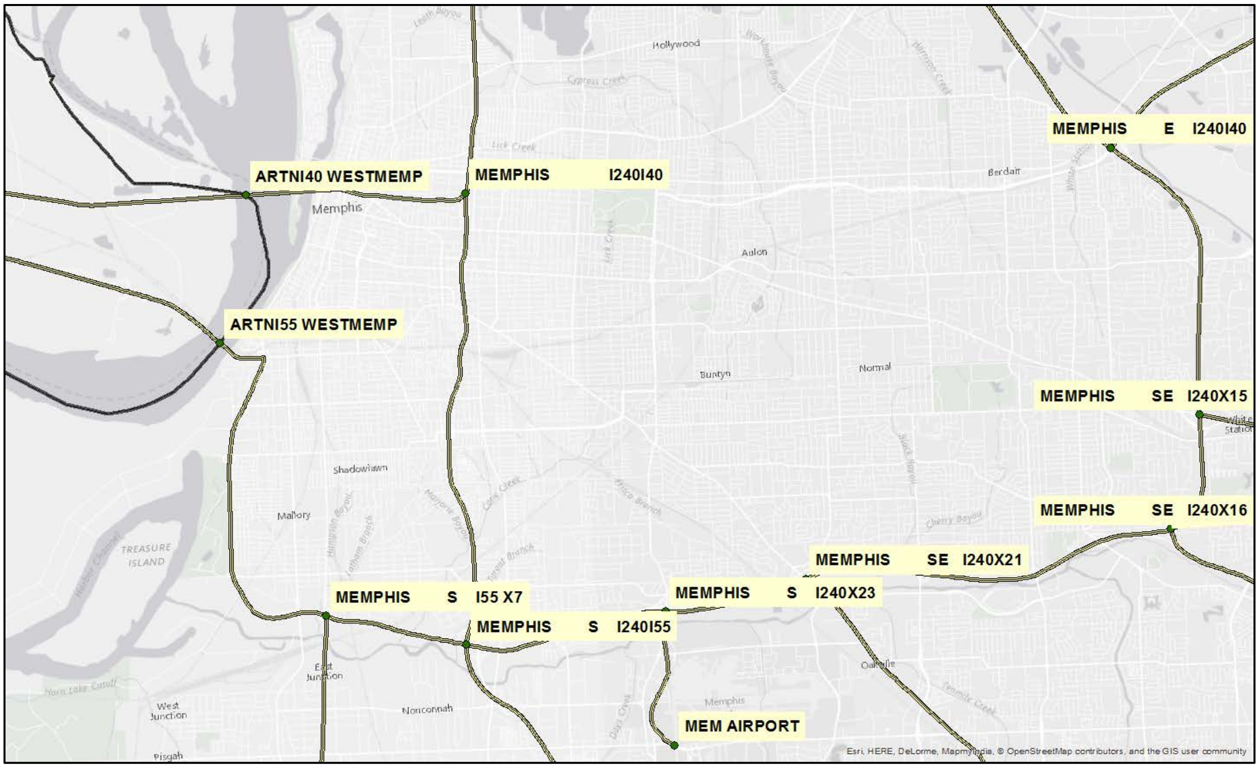


Fig. 3.2. Highway link and node naming example.

It should be noted that all but three nodes in Fig. 3.2 are named Memphis. All of the Memphis nodes have directional modifiers (the sole exception is the node located nearest to downtown Memphis). The directional modifier indicates the direction the node is from the downtown area of the city. The Memphis International Airport is labeled "MEM Airport"; MEM is the three character US Airport Code for that airport. Two border nodes between Arkansas and Tennessee west of Memphis—ARTNI40 WestMemp and ARTNI55 WestMemp—provide an example of the border node naming convention.

The WebTRAGIS highway network includes locations for over 900 airports that have scheduled passenger service, military airports, or airports that have had DOE air freight shipments. Airports are identified by their three- or four-character standardized location identifier code. Other locations such as DOE facilities and commercial nuclear power plants may not have a directional modifier or intersection descriptors as part of the node name.

3.2.2.3 Highway routing constraints and modifiers

The default highway routing menu is shown in Fig. 3.3. Under the WebTRAGIS default, routing is set to *Commercial HAZMAT*. Here the *HAZMAT* box is checked, and WebTRAGIS will follow the applicable routing criteria for general hazardous materials shipping in the United States as specified in National Hazardous Materials Route Registry. This option specifies those highways that are designated for hazardous materials transportation as well as those roadways that have been restricted from carrying hazardous materials shipments.

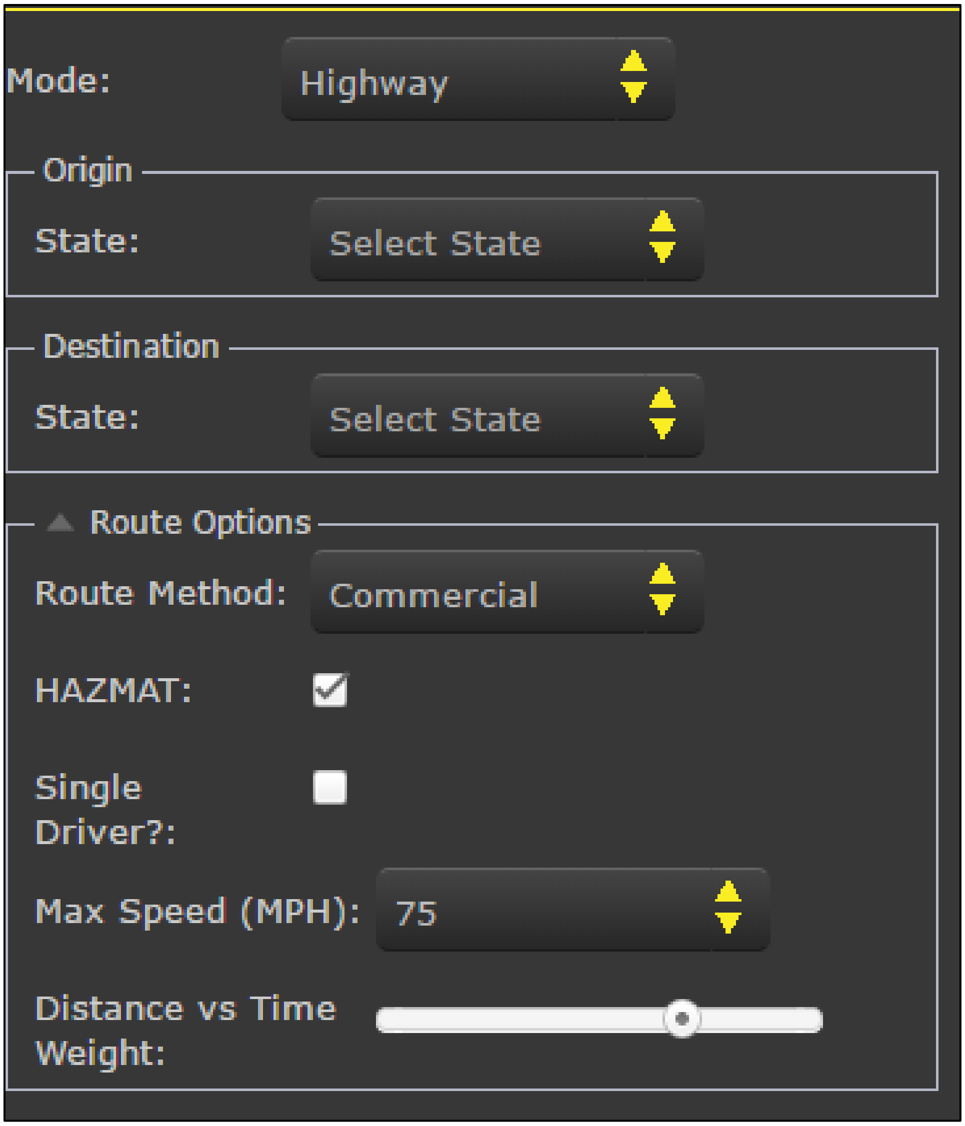


Fig. 3.3. Highway routing menu.

Commercial, Quickest/Shortest, HRCQ, HAZMAT, WIPP, and NNSS Routing

WebTRAGIS allows users to apply other routing constraints in addition to the default settings. By unselecting *HAZMAT*, highway routes generated by WebTRAGIS will be purely commercial and use any link in the highways network. The routing model in Equation (1) is used with values set by default to $\alpha = 0.3$ and $\beta = 0.7$ as seen on the *Distance vs Time Weight* bar in Fig. 3.3. Setting $\alpha = 0.0$ and $\beta = 1.0$, the most rapid route will be estimated (giving the entire weight to time). This is the setting for the *Quickest* route type. When $\alpha = 1.0$ and $\beta = 0.0$, the shortest possible route will be calculated (giving the entire weight to distance). This is the setting for the *Shortest* route type. WebTRAGIS implements a slider bar under *Advanced Route Options* (Fig. 3.4) that allows the user to adjust the weighting of the α and β parameters. By moving the slider bar to the left, the routes are biased toward $\alpha = 1.0$ (shortest), and moving the bar towards the right biases routes toward $\beta = 1.0$ (quickest).

When HRCQ of radioactive materials, other HAZMAT shipments, routes designated for WIPP in New Mexico, or for DOE shipments of radioactive materials to the Nevada National Security Site (NNSS) are selected from the *Route Method* drop down menu, WebTRAGIS follows the applicable DOT routing regulations in the Code of Federal Regulations (CFR; 49 CFR 397.101) and the National Hazardous Materials Route Registry. WIPP routes follow the same criteria as those of HRCQ, but include state-designated routing options to be given preference in routing where possible. Similarly, NNSS routes follow standard HRCQ routing procedures but also factor in the use of specific roadways designated by the states of Nevada and California for the shipment of radioactive materials to the Nevada National Security Site.

DOT regulations state that HRCQ shipments shall operate only over preferred routes, which primarily follow Interstate System highways, Interstate System bypasses or beltways around a city, and state designated preferred routes. State routing agencies may designate preferred routes as an alternative to, or in addition to, one or more interstates. In making this determination, the state must show the alternative preferred route is as safe as the Interstate route it is replacing and must register all such designated preferred routes with DOT. The WebTRAGIS highway network includes the designated preferred routes and state-designated routes for HRCQ shipments. Routes are to be selected that reduce time in transit over the preferred route segment of the trip.

The DOT routing requirements require that the shortest route between the pickup location to the nearest preferred route entry location and the shortest distance route to the destination from the nearest preferred route exit location be used. All of these requirements are incorporated in the HRCQ route type. The impedance equation for calculating a HRCQ route is shown in Equation (2):

$$L = Min \sum_i (\alpha D_i + \beta T_i)\gamma \tag{2}$$

where

L = total impedance of a route;
α = distance bias, with
  α = 0.0 if preferred route,
  α = 1.0 if nonpreferred route;
D_i = distance of segment i, miles;
β = time bias, with
  β = 1.0 if preferred route,
  β = 0.0 if nonpreferred route;
T_i = time required to travel along segment i, minutes;
γ = nonpreferred route multiplier, with
  γ = 1.0 if preferred route,
  γ = 30.0 if nonpreferred route.

The HRCQ, WIPP, and NNSS route types calculate the quickest route over preferred roads and a penalized shortest route over nonpreferred roads. This routing penalty is the purpose of the nonpreferred route multiplier. The default value of the nonpreferred route multiplier (γ) has been determined empirically and ensures that the calculated route will conform to DOT regulations. When using the NNSS routing option, WebTRAGIS users will need to account for particular black-out dates designated by the state of California that prohibit the use of CA-127. A warning message will appear with the black-out dates when NNSS routes are selected, and the same warning will appear on the route output listings.

Modifying number of drivers and maximum speed

Two other options that users may modify are the number of drivers and the maximum allowable speed a truck may travel on a route. These options do not alter the constraints determining the route path, but do affect the route output regarding the travel time estimates and expected stops along a route. In some cases, altering the maximum speed will result in an alternate route being selected.

The WebTRAGIS highway network has the allowable speed limit for each roadway segment as an attribute. WebTRAGIS calculates an estimated travel time using the link distances and the maximum road speed limit (i.e., travel time is estimated as a free flow over the links without a congestion penalty). However, by selecting the *Max Speed (MPH)* drop down menu, users may impose a maximum speed on the network links. Adjusting this value may affect the route calculation; the maximum speed is also used to determine shipment duration and arrival time, which are identified on the route listing. While the default maximum speed is 75 mph, users may select from maximum speeds down to 40 mph. By selecting a maximum speed, WebTRAGIS will use the selected maximum speed on all network links that have posted speed limits in excess of the chosen maximum speed. For example, if a maximum speed of 50 mph is selected, any links that have a posted speed limit in excess of 50 mph will be treated as if the speed limit was 50 mph. As a result, the estimated driving time is adjusted.

Another option that affects the driving time is the option to choose a *Single Driver*. The default in WebTRAGIS is for each shipment to have two drivers. By choosing either one or two drivers, users are able to invoke different route travel time and stop calculations based on the Federal Motor Carrier Safety Administration hours of service regulations. The driving options in WebTRAGIS include:

- For one driver, the maximum driving time is 10 hours. For every 5 hours of driving time, the driver must take a 30 minute rest. After 10 hours, the driver must take 8 hours to sleep.
- For two drivers, there is no maximum driving time. For every 4 hours of driving time, one driver takes a 30 minute rest. There is no sleep time stop for two drivers.

3.3 RAILWAY ROUTING

The WebTRAGIS routing model calculates rail routes that simulate the routing practices of the railroad companies in the United States. The basic concept of determining rail routes is to calculate the shortest path based on travel distance biased by traffic density in terms of gross ton-miles (GTM). With highway routing, time and distance are primary factors. The highest speed roads are limited access and highway routes generally following such roads. With rail routing, traffic stays on the main lines which have the highest traffic density, the highest class of track, and the most sophisticated signaling systems. Another difference between highway and rail routing is ownership. Trucking companies can operate over any highway within the national highway network. For railroads, the national rail network is actually an interconnected series of smaller networks owned and maintained by separate, mostly private, companies. These individual railroad companies can only move freight over lines they own or have permission to operate over. Further details regarding the operational characteristics of the US rail network and the WebTRAGIS rail network can be found in Sections 3.3.1 and 3.3.2, respectively.

Each segment of the rail-network database has a distance, in miles, and a variable signifying the traffic density. Using this information, the network is divided into the following six classes:

- A-mainline—more than 60 million GTM per year
- B-mainline—40 to 60 million GTM per year
- C-mainline—20 to 40 million GTM per year
- A-branchline—10 to 20 million GTM per year
- B-branchline—5 to 10 million GTM per year
- C-branchline—less than 5 million GTM per year

In addition to biasing the distance based on traffic density, the model also penalizes transfers from one rail carrier to another. Finally, the WebTRAGIS model also reduces the impedance values on the originating rail carrier. These features replicate the practice of actual rail routing, meaning the originating carrier will attempt to keep the shipment on its system for as much of the total route as possible.

3.3.1 Operational Characteristics of the US Railroad System

Any mathematical model designed to predict rail transportation routes must be capable of simulating the operation of the US railroad system. This system is composed of a large number of independent companies that compete economically while simultaneously cooperating through interchange agreements, trackage rights agreements, and haulage rights agreements, to move freight efficiently across the country. Each company typically owns its own network of rail lines. In some instances, a company may have operating rights on a rail line owned by another company, a concept referred to as “trackage rights.” Some railroads also operate with what are known as “haulage rights.” This allows a larger railroad to market the services and connections of a smaller railroad such that a rail customer can rely on the larger company for a single bill. Under haulage rights, the relationship is strictly for marketing and financial purposes; the two railroads continue to operate separately on their own track and interchanges. For more background information on railroad operations refer to *The Railroad: What It Is, What It Does* (Armstrong 1998).

The overall network is an aggregate of the interconnected track networks of hundreds of individual railroad systems. Private companies control virtually all railroads in the United States. Only a small amount of US rail mileage is publicly owned, and most of this is dedicated to passenger operation—specifically commuter service in major urban areas. Private ownership of rail lines places constraints on the movement of commodities. No single railroad company is able to serve all possible origins and destinations of any significant distance apart, so at least two railroad companies must be used for most shipments.

The ability of railroad companies to freely exchange equipment between their networks is one feature of the US rail system. Although any single company is limited to regional service, railroads cooperate by exchanging individual or blocks of freight cars moving to points beyond their individual service areas. These exchanges occur at designated transfer, or interchange, points where the lines of two or more companies meet. Sometimes interchange is handled by a third party, such as a terminal railroad. Interchanges are the bridges that connect the networks of the individual railroads thereby forming a national network.

Some locations are served by more than one railroad, and the shipper may choose which railroad will transport the shipment. This choice is based on a number of factors including cost, quality of service, and the railroad’s willingness to provide service. While the shipper is, in principle, free to specify the railroads to be used as well as the interchange points, most shippers generally negotiate with a single railroad company, and that railroad will arrange to have the shipment interchanged with the other carriers involved in completing the shipment.

There are three aspects of realistically simulating common railroad routing practices. The first is the route that traffic will take between points on a single railroad system. The routing algorithm is designed to preferentially route a shipment on the rail lines having the highest traffic volume. High volume mainline routes are preferred because they are generally well maintained because the railroad depends on these lines for a major portion of its revenue (i.e., hence the name “mainline”). In addition, routing along high-traffic lines usually replicates railroad operational practices.

The second aspect of rail routing is the selection of the sequence of railroads between the origin and destination. A delay is often involved in transferring a shipment from one railroad to another. While there are some run-through interchanges where the trains are not disassembled, the majority of interchanges require the incoming train to be disassembled and the cars to be sorted according to the receiving railroad. After the cars have been transferred to the receiving railroad's yard, they will be resorted according to destination and assembled into outgoing trains. To provide efficient service, the railroads try to reduce the time delays associated with interchanges by minimizing the number of interchanges in a route. This is accomplished in the WebTRAGIS model by imposing a numerical penalty for each interchange, which increases the apparent length of the route. Thus, when the model attempts to minimize the length of the route, it will also minimize the number of transfers to reduce the estimated time duration of a shipment.

The third aspect of routing on US railroads is the desire of each individual company to maximize its portion of the shipment's associated revenue. This normally results in the originating railroad transporting the shipment as far as possible on its system before transferring the shipment to another railroad. This feature is represented in the WebTRAGIS model by the originating railroad preference. In evaluating the length of the route, the model treats 1 mile of travel on the originating railroad as being "less" than 1 mile on other railroads. (See discussion in Section 4.6.1 on the originating railroad factor.) This numerical adjustment increases the originating railroad's portion of the route.

3.3.2 WebTRAGIS Railroad Network

The WebTRAGIS rail network has been extensively revised from the previous TRAGIS rail network. The older TRAGIS network was developed as a 1:100,000 scale rail network derived from the USGS digital line graphs. This network was revised by ORNL using high-resolution satellite imagery to improve the topological accuracy of the rail alignments and placement of nodes. The current WebTRAGIS rail network consists of over 94,000 links and over 35,000 nodes representing approximately 143,000 miles of mainline and branchline track. The network consists of all active rail lines in the United States with the exception of minor industrial spurs, yard tracks, and sidings. Nodes have been included in the network for nuclear reactors, rail accessible coal-fired power plants, DOE sites, and military bases with rail access. In some cases, other known industrial facilities such as port facilities, petroleum, ethanol and biodiesel refineries, and grain elevators are included as named nodes in the network. The rail network has been continuously updated and is revised on a regular schedule to reflect line abandonment, company mergers, short line spin-offs, and new rail construction. The updates and revisions have been done to make the network as topologically accurate as possible with the existing ground conditions. The previous version of TRAGIS included the proposed alignments for the construction of a new rail line to the Yucca Mountain repository site. Since DOE suspended its license application for the Yucca Mountain facility, the current version of WebTRAGIS does not include the proposed rail alignments.

Many WebTRAGIS users may not be very familiar with the rail network in the United States. There are currently over 500 different railroad companies operating in the country. Many of these railroads are very small and own or operate a small amount of track. Such railroads are known as "short lines." A few short lines have existed as small railroads since they were built, but most have been created over the past quarter century during the major consolidation that has occurred in the railroad industry. This consolidation has resulted in four major railroads based in the United States—Burlington Northern Santa Fe Railway (BNSF), CSX Transportation (CSXT), Norfolk Southern Railway (NS), and Union Pacific Railroad (UP). These four major railroads operate over more than 60 percent of the track in the country. Each of these rail systems operates over more than 20,000 miles of track. Between the many small short line railroads and the four large systems are a few mid-sized railroad companies, which include the Canadian National Railways (CN), Canadian Pacific Railway (CPRS), and Kansas City Southern Railway (KCS). (CN operates on over 6,700 miles of track and CPRS operates over 4,300 miles of track in the

United States. KCS operates on about 3,700 miles of track.) Nearly all the other railroads operate over less than 1,000 miles of track.

3.3.3 WebTRAGIS Railroad Routing Features

Rail routing in WebTRAGIS consists of two types: the standard train option or the dedicated train option. The rail routing options in WebTRAGIS are shown in Fig. 3.4.

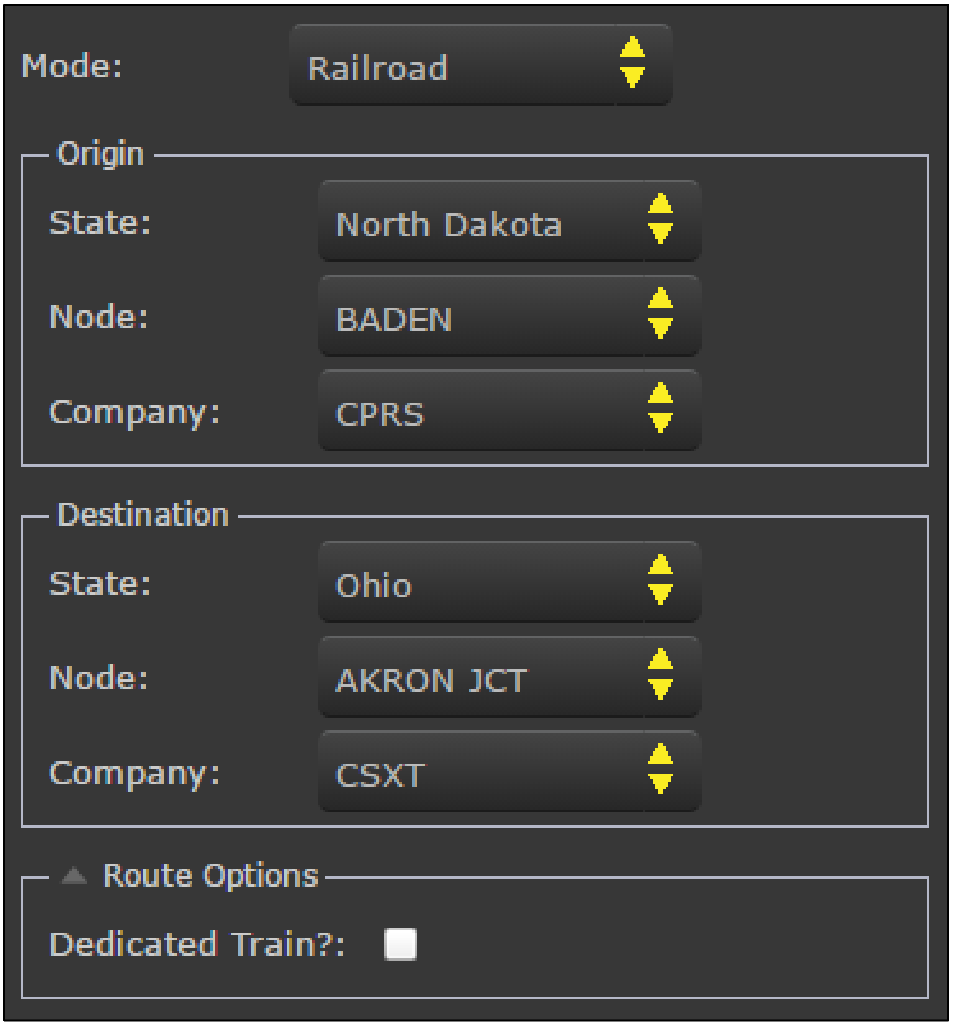


Fig. 3.4. WebTRAGIS rail routing options.

The WebTRAGIS default is for a standard train. In the context of rail routing, the standard train objective function is used to calculate impedance, *L*. This objective function is shown in Equation (3):

$$L = Min\left\{\sum_i (\sigma_i f_i d_i) + \sum_n (T_n)\right\}, \tag{3}$$

where

L = total impedance of a route;
σ_i = railroad factor for link *i*, with

σ_i = 0.8 for the originating railroad,
σ_i = 1.0 for all other railroads;
f_i = mainline classification factor for link *i*, with
f_i = 1.0 for A-mainline,
f_i = 1.2 for B-mainline,
f_i = 1.6 for C-mainline
f_i = 1.9 for A-branchline,
f_i = 4.0 for B-branchline,
f_i = 6.0 for C-branchline;
d_i = distance along link *i*, in miles;
T_n = transfer penalty factor at node *n*, with
T_n = 151.0 for a terminal transfer,
T_n = 300.0 for a primary transfer,
T_n = 400.0 for a minor transfer,
T_n = 1500.0 for a detour transfer.

With the commercial route type, the routing algorithm shown in Equation (3) preferentially routes a shipment along the A-, B-, and C-mainlines, and minimizes interchanges between railroad companies. In general, shipments utilize the branchlines only as a connection between the mainline network and the origin or destination. Frequently, several railroads will provide service at the same location. Selection of an originating railroad has an impact on the estimated route because the originating railroad will preferentially attempt to move the shipment on its own system before interchanging with another railroad to maximize its portion of the revenue. Because of the originating railroad factor, commercial rail routes are not necessarily symmetrically reversible. As a result, a different route may be determined if the origin and destination (thereby changing the originating railroad) are reversed.

The WebTRAGIS railroad network classifies the nodes by interchange type. The overwhelming majority of nodes in the network are only simple origin or destination locations, and interchange activity does not occur there. However, there are almost 1,600 nodes in the network where some type of interchange activity does take place. These nodes are classified as either terminal, primary, minor, or detour. Terminals have a transfer penalty of 151 units, and primary interchanges have a 300 unit penalty. Minor interchanges have penalties of 400 units, while detour locations—locations that are only used when other preferable interchange locations are unavailable—are given a penalty of 1,500 units. Under normal operating conditions, a detour interchange location will not be used.

3.3.3.1 Dedicated train route type

The dedicated train route type provides a variation on the standard train route type. With a dedicated train route, the originating railroad factor is not considered, and the transfer penalty factor is reduced by a factor of ten. Equation (4) is the impedance equation for calculating a dedicated train route:

$$L = Min\left\{\sum_i \left(f_i d_i\right) + \sum_n \left(\frac{T_n}{10}\right)\right\}, \tag{4}$$

where

L = total impedance of a route;
f_i = mainline classification factor for link *i*, with
f_i = 1.0 for A-mainline,
f_i = 1.2 for B-mainline,
f_i = 1.6 for C-mainline

f_i = 1.9 for A-branchline,
f_i = 4.0 for B-branchline,
f_i = 6.0 for C-branchline;
d_i = distance along link i, in miles;
T_n = transfer penalty factor at node n, with
T_n = 151.0 for a terminal transfer,
T_n = 300.0 for a primary transfer,
T_n = 400.0 for a minor transfer,
T_n = 1500.0 for a detour transfer.

The effect of the dedicated train route type is that rail routes become more symmetric and more "network neutral" as the ownership prerogatives of the standard routing model are minimized. As a result, more direct routes are chosen owing to the lower impact of transfer penalties between railroads. The dedicated train route type should only be used if a dedicated train is expected to be used for shipments. In some cases, this route type will generate the same route as the commercial train route type.

3.4 WATERWAY ROUTING

Waterway routing is the third transportation mode available in WebTRAGIS and is similar in many respects to the routing methodology used for rail shipments. The waterway database consists of both inland waterways, coastal waterways, and deep-water routes. Inland waterways include all navigable channels with a minimum depth of 6 feet. The coastal waterway and deep-water portions of the network consist of connections between ports on the Pacific Ocean, Gulf of Mexico, Atlantic Ocean, and Great Lakes regions as well as to US territories in the Pacific Ocean. The network does not have company ownership as in the rail network, but rather defines the network according to waterways types based on location and designation. Transfers between inland, coastal, and deep-water route types are treated as break-of-bulk points.

3.4.1 WebTRAGIS Waterway Network

The waterway network used in WebTRAGIS was developed using a detail national waterways model developed by the US Army Corps of Engineers. ORNL undertook a review of the network both to simplify the structure of the network and to improve the topological accuracy of the links. The simplification process involved reducing the number of nodes in the network from 19,000 to just over 4,000, and the number of links from over 21,000 to just over 4,600, which represents almost 160,000 miles of domestic and international waterways. Topological accuracy was improved by manually adjusting the link geographies using high-resolution satellite imagery. During this process the waterway systems in the network were classified as shallow draft inland waterways, designated "IWW," deeper draft commercial inland waterways as "CIWW." The various coastal waterways were given appropriate designations:"AICW" for the Atlantic Intracoastal Waterways, "GICW" for the Gulf, and "PCWW" for the Pacific Coast. Links in the Great Lakes were given the designation "GLK," and the ocean-going commercial shipping lanes were designated "OCM."

3.4.2 WebTRAGIS Waterway Node Naming Conventions

The WebTRAGIS waterway network has a straightforward set of node naming conventions. Nodes located outside immediate US territorial waters carry the state abbreviation "XX." Node names generally fall into five categories: port facilities, lock and dam locations, waterway junctions, facility locations, and state boundaries. In most cases, the node name is taken directly from the original US Army Corps of Engineers database. However, in some cases other naming conventions are used. Port facilities may have the name of the city, followed by a semicolon and the term "Port of" or a shortened version, depending upon the length of the city name. For example, in Virginia the port of Norfolk is called “Norfolk; Port of,” and the port of Newport News is called “Newport News; Port.” In those port locations where there are several port terminal facilities, each terminal may have its own name. For example, the Port of Wilmington, North Carolina, has three associated nodes: “Wilmington North,” “Wilmington North Wharves,” and “Wilmington Wharves.” Lock and dam locations use two nodes per lock—one node at either end of the actual lock barge channel. Lock and dam names use the abbreviation “L/D” along with either the name of the lock or the number of the facility and a directional attribute. Examples of these types of nodes include “ROBERT C. BYRD L/D NORTH,” which is the north entry to the lock and dam channel on the Ohio River in West Virginia, and “MISSISSIPPI RIVER L/D 21 SOUTH,” which is located at the south end of the barge channel on Lock and Dam 21 on the Mississippi.

Waterway junction node names usually include the names of the two bodies of water that meet at the node location. Examples of these node names include “KASKASKIA - MISSISSIPPI RIVER JCT” at the junction of the Kaskaskia and Mississippi Rivers downstream from Saint Louis, and “MOBILE BAY - GIW JCT” where the Gulf Intracoastal Waterway meets Mobile Bay in Alabama. Facility locations are also included in the waterway network. Nuclear power plants with barge facilities (either active or needing refurbishment) are included in the network with the designation “NP.” Some naval facilities are also included in the network. Examples of these nodes include “CALVERT CLIFFS NP” in Maryland and “NORFOLK NAVAL SHIPYARD” in Virginia. The final type of node names are state boundary locations. An example of such a location is “AR - MO BORDER,” which is along the Tennessee border on the Mississippi River at the Arkansas and Missouri state line.

3.4.3 WebTRAGIS Waterway Routing

The WebTRAGIS model calculates waterway routes by minimizing the total impedance between the origin and destination. The impedance is defined as a function of distance, type of waterway system used, and any transfers between waterway systems. The impedance equation is shown in Equation (5):

$$L = Min\left\{\sum_i \left(f_i d_i\right) + \sum_n T_n\right\} \tag{5}$$

where

L = total impedance of a route;
f_i = weighting factor for link i, with
- f_i = 1.0 for ocean commercial marine,
- f_i = 1.0 for commercial inland waterways,
- f_i = 1.2 for coastal waterways,
- f_i = 1.5 for Great Lakes, and
- f_i = 2.5 for shallow-draft inland waterways;

d_i = distance for link i, in miles;
T_n = transfer penalty factor at node n.

Figure 3.5 provides an example of the waterway routing options in WebTRAGIS.

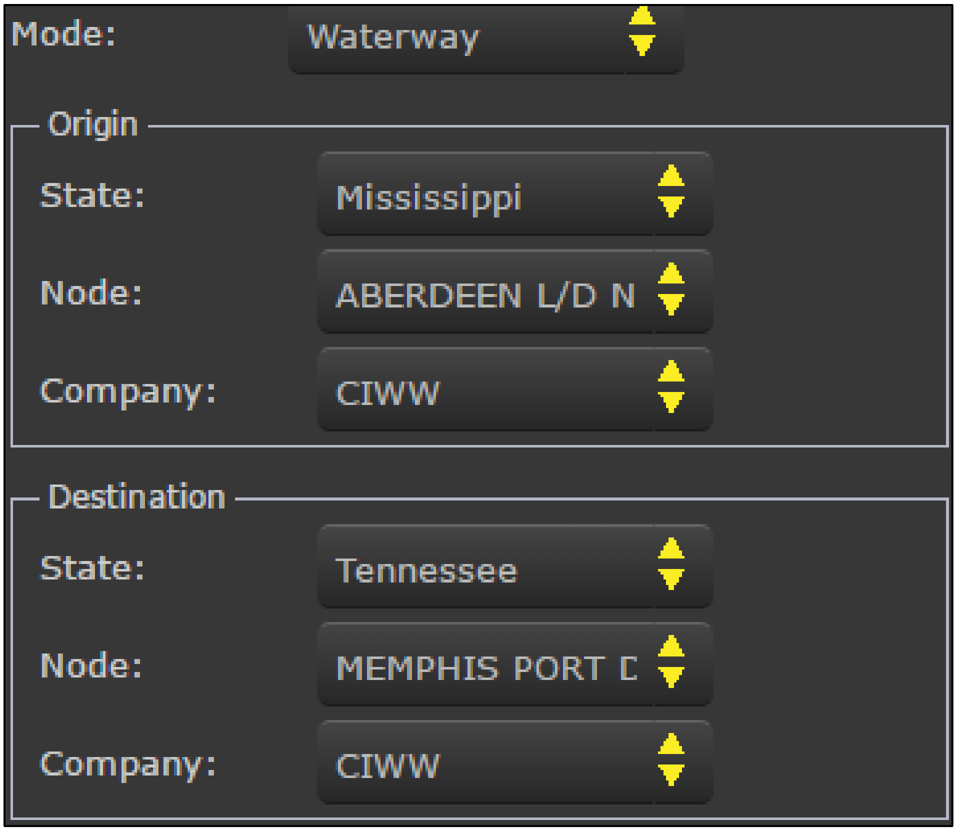


Fig. 3.5. WebTRAGIS waterways routing.

3.5 ROUTING OUTPUT

Routing output and reporting in WebTRAGIS is standardized across all three modes. After a route has been determined and the *Run* option selected, the screen will shift to the *Layers* menu and a map of the route will display with a system-generated route designation shown under *My Routes* in the *Layers* menu as can be seen in Fig. 3.6.

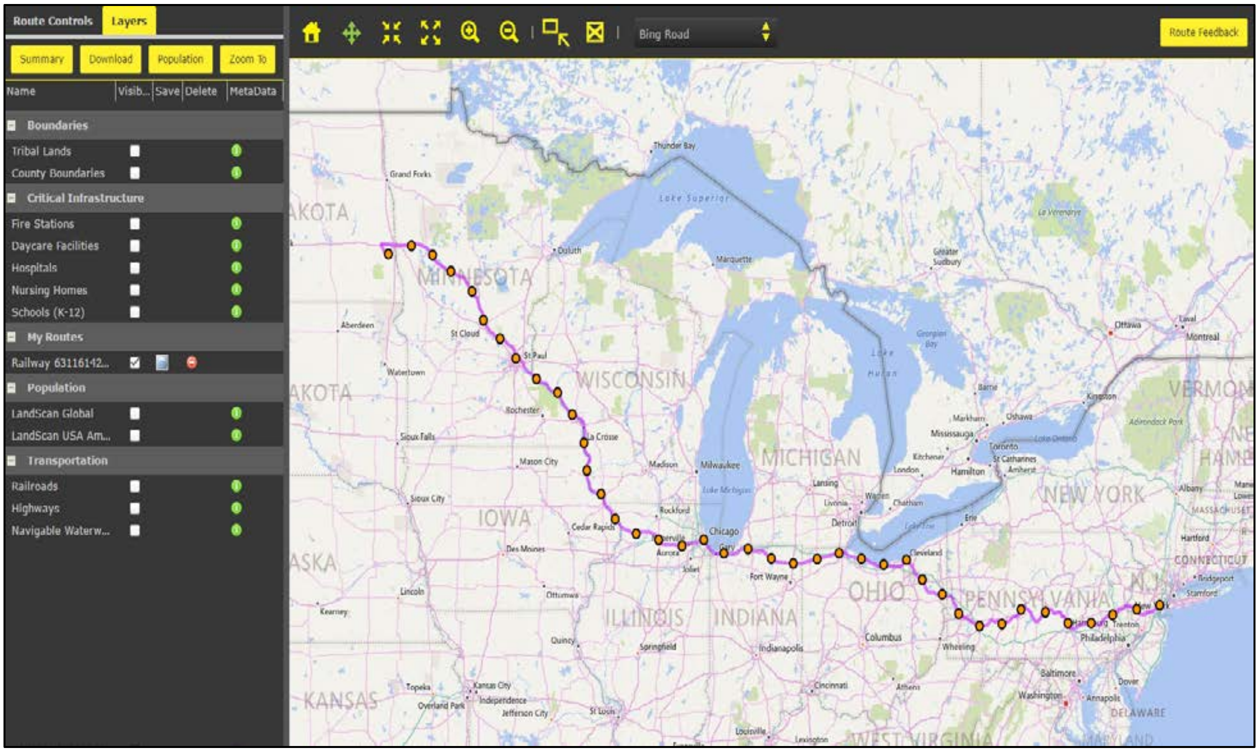


Fig. 3.6. WebTRAGIS layers with route display.

3.5.1 Route Map Display

The mapping capability in WebTRAGIS is one of the primary features of the model. The mapping capabilities of WebTRAGIS are a combination of OpenLayers, PostGIS, and web services capabilities. The map information and data display entirely via the internet.

Figure 3.5 shows the basic display of the *Route Map* screen in the *Layers* menu tab. This section will discuss the use of the variety of route display features available in WebTRAGIS not already covered in Section 2 above. These features include the *Route Summary* option, the *Route Population* option, saving routes in WebTRAGIS, and downloading route data.

Once a route has been run in WebTRAGIS, the active tab switches from *Route Controls* to *Layers*. The newly generated route becomes visible under the *My Routes* menu as can be seen in Fig. 3.7. Also, the capabilities of the *Summary*, *Download*, and *Population* tabs becomes available.

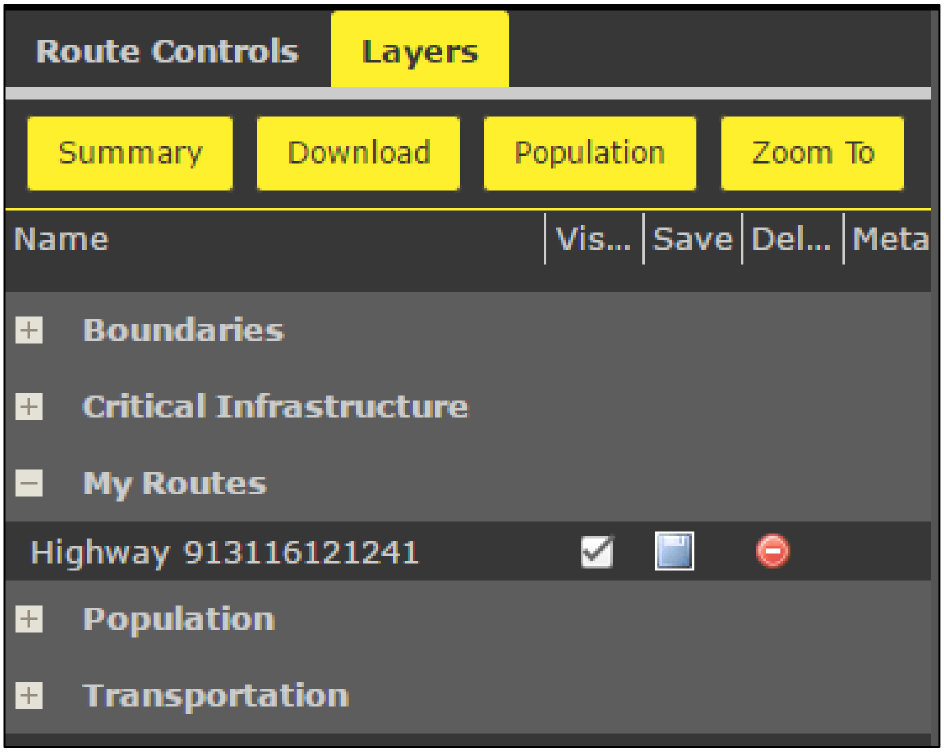


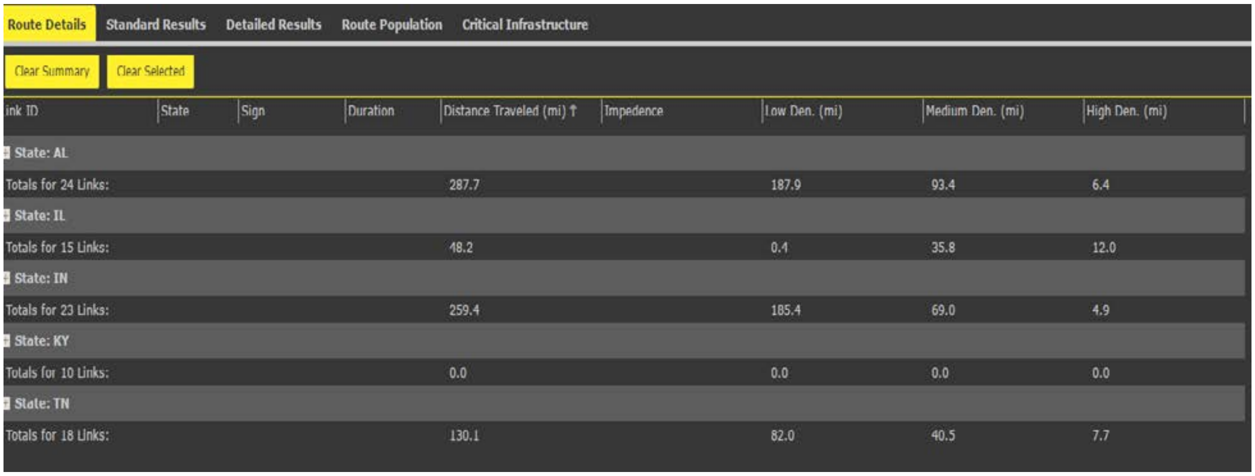
Fig. 3.7. New route display under My Routes

3.5.2 Route Summary Tabs and Saving Routes

After a route has been generated users may select the *Summary* tab and also save the route. This tab provides a series of reports describing the route and the constraints applied. There are four separate reports and associated output available in the Route Summary, which opens at the bottom of the GUI.

Users may choose to save a route by locating the route under *My Routes* and the selecting the blue save disk icon. This will invoke a new menu, *Route Name*, in which the user can enter a new route name. Once the name has been input, the route origin, destination, and constraint inputs are saved in the user's account. Saved routes will then be available the next time the user logs in to WebTRAGIS; by checking to display a saved route, WebTRAGIS reruns the route with the origin, destination, and constraints as saved. Since WebTRAGIS saves only the route input information and not the route output, subsequent changes to the modal network may generate different results. Users should be aware that such changes might result in different route solutions.

Within the summary output tabs, the first is the *Route Details* table. This table provided a link-by-link breakdown of the route by state. Each individual link of a route is separated by state and the link distance and the population density along the link is reported. The results can be summarized by state, which allows users to view a comprehensive summary of the route by state (Fig. 3.8). Users will note that summarizing the Route Details by state will yield the same results found in the state population density distances reported in the Standard and Detailed Results screens.



ink ID	State	Sign	Duration	Distance Traveled (mi)	Impedence	Low Den. (mi)	Medium Den. (mi)	High Den. (mi)
State: AL								
Totals for 24 Links:				287.7		187.9	93.4	6.4
State: IL								
Totals for 15 Links:				48.2		0.4	35.8	12.0
State: IN								
Totals for 23 Links:				259.4		185.4	69.0	4.9
State: KY								
Totals for 10 Links:				0.0		0.0	0.0	0.0
State: TN								
Totals for 18 Links:				130.1		82.0	40.5	7.7

Fig. 3.8. Route summary by state.

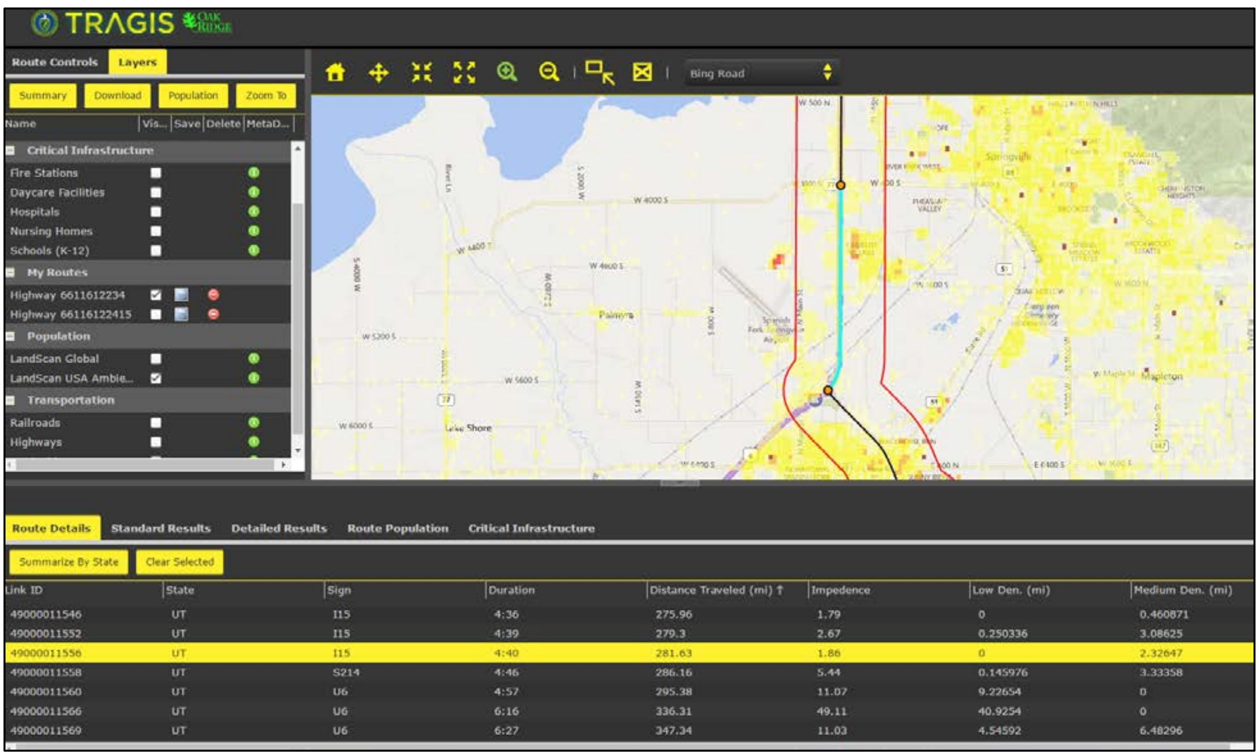


Fig. 3.9. Route details by link with display.

Once the *Route Details* are available, users may select an individual link from the list by double-clicking the *Link ID*. This will cause the map display to zoom in to the particular link, which will be highlighted in blue (Fig. 3.9). WebTRAGIS also displays the default 800 meter buffer around the route links in the map display. Population values and critical infrastructure elements listed in the *Route Summary* outputs are based on this buffer distance.

The second and third Route Summary tabs are the *Standard Results* and *Detailed Results* tabs. These files are the same as the original route output files generated in previous versions of TRAGIS. The reports are formatted text files providing an overview of the route inputs, route constraints, and a list of the locations the route has traversed from origin to destination. These files also provide a state level population density summary that can be used to input parameters into programs such as RADTRAN.

The *Route Population* tab provides a link-by-link population count for the entire route. By selecting a Link ID, the map display will zoom in to the particular link, which will be highlighted in blue, in the same manner as link selection in the *Route Details* tab (Fig. 3.10).

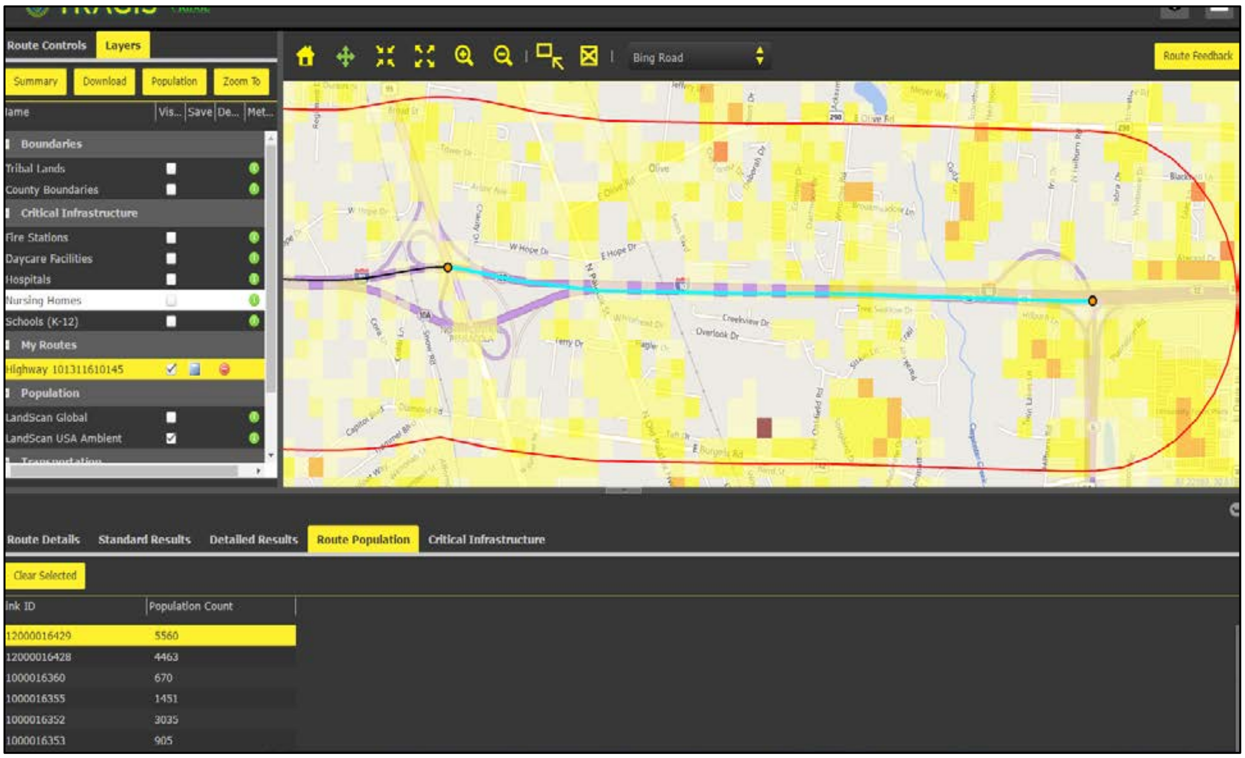


Fig. 3.10. Route population by link detail.

The final *Route Summary* tab is *Critical Infrastructure*. This tab provides a list of all of the features found in the critical infrastructure layers, which are located inside the 800 meter buffer along a route. The list proceeds from origin to destination and includes the name, address, city, and facility type (school, hospital, etc.) for each feature. Critical infrastructure information is provided in the *Route Summary*, but these features are not available as downloadable because of data use restrictions.

3.5.3 Route Population

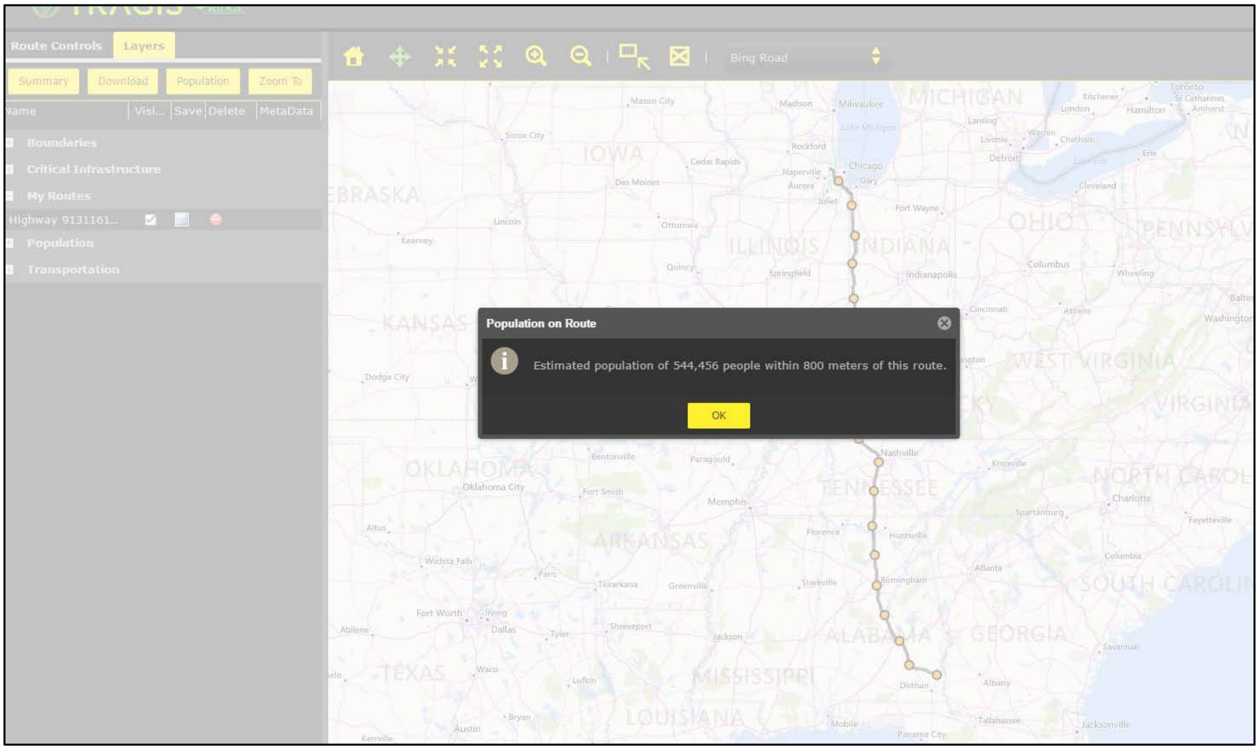


Fig. 3.11. Population on route.

Selecting the *Population* tab requests that WebTRAGIS calculate the entire population found within the 800-meter buffer of the route. The population count is then reported as can be seen in Fig. 3.11.

3.5.4 Route Download

The *Download* tab allows users to select a route to be downloaded. Once a route is selected, WebTRAGIS creates a zipfile containing several route output files. Users may then use these route output files in other programs, or as reference files, as needed. The download zipfile is sent to the same local machine address that has been set up by the user for internet file downloads, usually a file named “Downloads” that can be accessed through the local machine file tree. The file will be designated, “[Username]download.”

The download file contains several different files. There are two text files corresponding to the *Standard* and *Detailed Results* tabs found in the *Route Summary*. These files are formatted to be best viewed in a programs such as Word or WordPad. The zipfile also contains several Excel-compatible CSV files corresponding to the *Route Details* and *Population* tabs found in the *Summary* titled “RouteInfo” and “PopbyLink,” respectively. There is also a CSV file titled “RouteDensityByState” that may be used as input into population radiation dose risk models such as RADTRAN. Finally, for display purposes, the download includes a KML file for visualizing the route in programs such as Google Earth, and a set of shape files for use in standard GIS applications such as ArcMap or QGIS.

3.5.5 Zoom

This feature allows a user to select any previously generated routes that are in *My Routes*. Once selected, the Map Display will zoom to the feature extent to display the route.

3.6 INTERMODAL ROUTING

Currently, WebTRAGIS does not have an active intermodal routing feature that enables users to access all three modal networks in combination from origin to destination. While this feature is not active, code has been developed that does allow for intermodal routing to be implemented at some point in the future as user demands and program needs dictate.

At present, the largest impediment to implementation of active intermodal routing in WebTRAGIS is the lack of a definitive database of intermodal transfer locations. Since, WebTRAGIS is, first and foremost, a route planning tool for the shipment of radioactive materials, the scope for intermodal transfers needs to be focused on those locations that can accommodate transfers of radioactive materials between modes rather than a generic intermodal routing capability. At present, there are no established criteria for the safety, security, and physical operational characteristics for such facilities so that candidate transfer sites can be identified and assessed.

Since intermodal routing using WebTRAGIS relies upon the user to access two or more of the modal networks individually, please be aware that the assumptions of origin and destination locations of routes assumed to have an intermodal component may not accurately reflect the requisite site characteristics necessary to transfer radioactive materials. Any combination of routes that assume that intermodal transfers can or will occur at specific locations must be weighed against the uncertainty of as-yet-undetermined site characteristics that will satisfy the regulatory concerns of agencies as diverse as those within DOE, the Nuclear Regulatory Commission, and DOT. For an overview of the challenges of intermodal routing, please refer to Maheras et al. (2013).

4. FUTURE DEVELOPMENT

The WebTRAGIS application provides a major change in technology from the previous TRAGIS model developed at ORNL. WebTRAGIS offers a new and improved GUI and GIS features using entirely open source web services while still retaining the routing model capabilities of the previous TRAGIS program. As needed, ORNL will provide additional improvements to WebTRAGIS to improve the user experience and enhance the performance of the model.

If users have any comments and questions about suggested improvements to the WebTRAGIS model, please contact the author.

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APPENDIX A. SELECTED FACILITY LOCATIONS ON THE WEBTRAGIS HIGHWAY NETWORK

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The following list of facility locations provides the appropriate WebTRAGIS highway node name that should be used when designating an origin or destination point. Each location is either identified by a specific node name or the nearest appropriate node name that should be used for routing to that site.

Alabama

Anniston Army Depot	ANNISTON DEPOT
Bellefonte Nuclear Power Plant (never completed)	BELLEFONTE NP
Browns Ferry Nuclear Power Plant	BROWNS FERRY NP
Joseph M. Farley Nuclear Power Plant	FARLEY NP
Marshall Space Flight Center	MARSHALL SFC
Maxwell Air Force Base	MXF AIRPORT
Port of Mobile, Alabama State Docks	AL STATE DOCKS
Redstone Arsenal	REDSTONE ARSNL N I565S255

Arizona

Davis-Monthan Air Force Base	DMA AIRPORT
Luke Air Force Base	LUF AIRPORT
Palo Verde Nuclear Power Plant	PALO VERDE NP
University of Arizona	U OF ARIZONA
Yuma Proving Grounds	YUMA PRVNG GND

Arkansas

Arkansas Nuclear One Power Plant	ARKANSAS NP
Fort Chaffee	FORT CHAFFEE
Little Rock Air Force Base	LRF AIRPORT
Pine Bluff Arsenal	PINE BLUFF ARL

California

Beale Air Force Base	BAB AIRPORT
Concord Naval Weapons Station	CONCORD NWS
Diablo Canyon Nuclear Power Station	DIABLO CANYON NP
Edwards Air Force Base	EDW AIRPORT
Energy Technology Engineering Center	ETEC
General Electric Vallecitos Nuclear Center	GE VALLECITOS
General Atomics	GENERAL ATOMICS
Humboldt Bay Nuclear Power Plant	HUMBOLDT BAY NP
Laboratory for Energy-Related Health Research	LEHR
Lawrence Berkeley National Laboratory	L BERKELEY LAB
Lawrence Livermore National Laboratory (East Gate)	L LIVERMORE LB
Lawrence Livermore Site 300	L LIV LB S 300
March Air Reserve Base	RIV AIRPORT
Moffett Field Naval Air Station	NUQ AIRPORT
North Island Naval Air Station	NZY AIRPORT
Port of Long Beach	PORT OF LONG BEACH
Port of Los Angeles	PORT OF LA
Port of Oakland	PORT OF OAKLAND
Port of Richmond	PORT OF RICHMOND

Port of Sacramento	PORT OF SACMTO
Port of San Francisco	PORT OF SF
Port of Stockton	PORT OF STOCKTON
Rancho Seco Nuclear Power Plant	RANCHO SECO NP
Rocketdyne Propulsion and Power	ROCKETDYNE
San Diego Unified Port	PORT OF SAN DIEGO
San Onofre Nuclear Power Plant	SAN ONOFRE NP
Sandia National Labs-Livermore (West Gate)	SNL LIVERMORE
Sierra Army Depot	AHC AIRPORT
Sanford Linear Accelerator Center	STANFORD L AC
Travis Air Force Base	SUU AIRPORT
UCLA Lab of Nuclear Medicine & Rad. Biology	UCLA LNM&RB
University of California, Irvine	U OF C IRVINE
Vandenberg Air Force Base	VANDENBERG AFB
Colorado	
Denver Federal Center	DENVER FED CTR
Fort St Vrain Nuclear Power Plant	FT ST VRAIN NP
National Renewable Energy Laboratory	NREL
Rocky Flats Plant	ROCKY FLATS
Rust Geotech, Grand Junction Project Office	GRAND JCT PO
Connecticut	
Haddam Neck Nuclear Power Plant	HADDAM NECK NP
Knolls Atomic Power Laboratory, Windsor Site	KAPL-WINDSOR
Millstone Nuclear Power Plant	MILLSTONE NP
UNC Naval Products	UNC NAVAL
Yale University	YALE UNIV
Delaware	
Dover Air Force Base	DOVER AF BASE
Port of Wilmington	PORT OF WILMINGTON
District of Columbia	
DOE/HQ Forrestal Building	DOE FORRESTAL
Florida	
Canaveral Port Authority	PORT CANAVERAL
Cape Canaveral Air Force Station	C CANAVERAL AFS
Cecil Field Naval Air Station	CECIL FLD NAS
Crystal River Nuclear Power Plant	CRYSTAL RIVER NP
Eglin Air Force Base	VPS AIRPORT
Jacksonville Port Authority, Blount Island Terminal	JACKSONVL PORT
Kennedy Space Center	KENNEDY SP CTR
MacDill Air Force Base	MCF AIRPORT
NASA Vehicle Assembly Building	NASA V A BLDG
Patrick Air Force Base	COF AIRPORT
Port Everglades Authority	PORT EVERGLADES
Port of Miami	PORT OF MIAMI
St Lucie Nuclear Power Plant	ST LUCIE NP

Tampa Port Authority	PORT OF TAMPA
Turkey Point Nuclear Power Plant	TURKEY POINT NP
Tyndall Air Force Base	PAM AIRPORT
University of Florida	U OF FLORIDA

Georgia

Brunswick State Docks	BRUNSWICK ST DOCKS
Dobbins Air Reserve Base	MGE AIRPORT
Fort Benning	FORT BENNING
Georgia Institute of Technology	GEORGIA TECH
Edwin I. Hatch Nuclear Power Plant	HATCH NP
Kings Bay Naval Submarine Base	KINGS BAY NSB
Moody Air Force Base	VAD AIRPORT
Robins Air Force Base	WRB AIRPORT
Port of Savannah	SAVANNAH PORT
Vogtle Nuclear Power Plant	VOGTLE NP

Idaho

Argonne National Laboratory West	ARGONNE WEST
Idaho National Engineering & Environmental Lab	INEEL
Idaho State University	IDAHO ST UNIV
INEEL Chemical Plant	INEEL CHEM PLT
INEEL Radioactive Waste Management Center	RWMC
Mountain Home Air Force Base	MUO AIRPORT
Naval Reactors Site at INEEL	NAVAL REACTORS

Illinois

Allied Chemical	ALLIED CHEM
Argonne National Laboratory	ARGONNE NATL L
Braidwood Nuclear Power Plant	BRAIDWOOD NP
Byron Nuclear Power Plant	BYRON NP
Clinton Nuclear Power Plant	CLINTON NP
Dresden Nuclear Power Plant	DRESDEN NP
Fermi National Accelerator Laboratory	FERMI NATL LAB
General Electric Morris Operations	GE MORRIS OPRTNS
Illinois International Port, Chicago	IL INTL PORT
LaSalle Nuclear Power Plant	LA SALLE NP
Quad Cities Nuclear Power Plant	QUAD CITIES NP
Scott Air Force Base	BLV AIRPORT
University of Illinois	U OF ILLINOIS
Zion Nuclear Power Plant	ZION NP

Indiana

Newport Army Ammunition Plant	NEWPORT AM PLT
Purdue University	PURDUE UNIV

Iowa

Ames Laboratory	AMES LAB
Duane Arnold Nuclear Power Plant	ARNOLD NP
Iowa State University	IOWA ST UNIV

Kansas

McConnell Air Force Base	IAB AIRPORT
Kansas State University	KANSAS ST UNIV S
Wolf Creek Nuclear Power Plant	WOLF CREEK NP

Kentucky

Lexington-Blue Grass Army Depot	BLUE GRASS DPO
Paducah Gaseous Diffusion Plant	PADUCAH GDP

Louisiana

Barksdale Air Force Base	BAD AIRPORT
Greater Baton Rouge Port Commission	PORT ALLEN S I10 X153
Port of Lake Charles	PORT OF LK CHRL
Port of New Orleans	PORT OF NEW ORLEANS
River Bend Nuclear Power Plant	RIVER BEND NP
Waterford Nuclear Power Plant	WATERFORD NP

Maine

Maine Yankee Nuclear Power Plant	MAINE YANKEE NP
Port of Portland	PORTLAND PORT
Portsmouth, NH Naval Shipyard	PORTSMOUTH NAV

Maryland

Aberdeen Proving Grounds	ABERDEEN PRG G
Andrews Air Force Base	ADW AIRPORT
Calvert Cliffs Nuclear Power Plant	CALVERT CLIFFS NP
Dundalk Marine Terminal, Baltimore	DUNDALK PORT
DOE/HQ Germantown	DOE GERMANTOWN
Edgewood Arsenal	EDGEWOOD ARSNL
National Institute of Standards & Technology	NIST
National Naval Medical Center	NAVAL MED CNTR
University of Maryland	U OF MARYLAND

Massachusetts

Massachusetts Institute of Technology	MIT
Massachusetts Port Authority	MASSPORT
University of Lowell	UNIV OF LOWELL
University of Massachusetts	NORTHAMPTON NE I91 X19
Westover Air Reserve Base	CEF AIRPORT
Worcester Polytechnic Institute	WORCESTER POLY
Yankee-Rowe Nuclear Power Plant	YANKEE-ROWE NP

Michigan

Big Rock Point Nuclear Power Plant	BIG ROCK POINT NP
D. C. Cook Nuclear Power Plant	COOK NP
Detroit/Wayne County Port Authority	PORT OF DETROIT
Dow Chemical Plant	DOW CHEMICAL
Fermi Nuclear Power Plant	FERMI NP
Michigan State University	MICH ST UNIV

Palisades Nuclear Power Plant	PALISADES NP
University of Michigan	U OF MICHIGAN
Minnesota	
Monticello Nuclear Power Plant	MONTICELLO NP
Prairie Island Nuclear Power Plant	PRAIRIE ISLAND NP
Seaway Port Authority of Duluth	PORT OF DULUTH
University of Minnesota	U OF MINNESOTA
Mississippi	
Columbus Air Force Base	CBM AIRPORT
Grand Gulf Nuclear Power Plant	GRAND GULF NP
Keesler Air Force Base	BIX AIRPORT
National Space Technology Laboratories	NATL S T LAB
Port of Gulfport	PORT OF GULFPORT
Port of Pascagoula	PORT OF PASCAGOULA
Missouri	
Callaway Nuclear Power Plant	CALLAWAY NP
Honeywell Kansas City Plant	K C PLANT
University of Missouri	U OF MISSOURI
University of Missouri-Rolla	U OF MO-ROLLA
Whiteman Air Force Base	WHITEMAN AFB
Montana	
Malstrom Air Force Base	GFA AIRPORT
Nebraska	
Cooper Station Nuclear Power Plant	COOPER NP
Fort Calhoun Nuclear Power Plant	FORT CALHOUN NP
Offutt Air Force Base	OFF AIRPORT
U.S. Veterans Hospital, Omaha	VETERANS HOSP
Nevada	
EMAD Compound	NNSS EMAD
Nellis Air Force Base	LSV AIRPORT
Nevada Test Site	MERCURY
NNSS	NNSS L74 AIRPORT
Tonopah Test Range	TNX AIRPORT
Yucca Mountain Repository	NNSS YUCCA MOUNTAIN
New Hampshire	
Portsmouth Naval Shipyard	(see Maine)
Seabrook Nuclear Power Plant	SEABROOK NP
New Jersey	
Earle Naval Weapons Station	EARLE NWS
Hope Creek Nuclear Power Plant	HOPE CREEK NP
McGuire Air Force Base	WRI AIRPORT
Oyster Creek Nuclear Power Plant	OYSTER CREEK NP

Paulsboro Terminal	PORT OF PAULSBORO
Petty Island Terminal (Port of Philadelphia)	PETTY ISL TERM
Picatinny Arsenal	PICATINNY ARNL
Port of Elizabeth	PORT OF ELIZABETH
Port of Newark	PORT NEWARK
Princeton University Plasma Physics Laboratory	PRINCTN PLASMA
Salem Nuclear Power Plant	SALEM NP

New Mexico

Alternate Control Facility	ACF
Cannon Air Force Base	CVS AIRPORT
Holloman Air Force Base	HMN AIRPORT
Kirtland Air Force Base	HMN AIRPORT
Los Alamos National Laboratory	LOS ALAMOS N L
Lovelace Inhalation Toxicology Research Institute	LOVELACE ITRI
Sandia National Laboratories	SANDIA NATL LABS
University of New Mexico	U OF NEW MEXICO
Waste Isolation Pilot Plant	WIPP
White Sands Missile Range	WSD AIRPORT

New York

Brookhaven National Laboratory	BROOKHAVEN LAB
Cintichem	CINTICHEM NUCL
Cornell University	CORNELL UNIV
Environmental Measurement Laboratory (New York)	ENV MEAS LAB
James A. FitzPatrick Nuclear Power Plant	FITZPATRICK NP
Ginna Nuclear Power Plant	GINNA NP
Indian Point Nuclear Power Plant	INDIAN POINT NP
Knolls Atomic Power Laboratory-Kesselring Site	KAPL-KESSELRNG
Knolls Atomic Power Laboratory-Knolls Site	KAPL KNOLLS - SPRU
Manhattan College	MANHATTAN COL
Nine Mile Point Nuclear Power Plant	NINE MILE POINT NP
Port of Buffalo	PORT OF BUFFALO
Rensselaer Polytechnic Institute	RPI
SUNY Buffalo	SUNY BUFFALO
SPRU	KAPL KNOLLS - SPRU
West Valley Demonstration Project	WEST VALLEY RP

North Carolina

Brunswick Nuclear Power Plant	BRUNSWICK NP
General Electric Nuclear Energy Products	GE NUCLEAR
Shearon Harris Nuclear Power Plant	HARRIS NP
McGuire Nuclear Power Plant	MCGUIRE NP
North Carolina Port Authority	MOREHEAD CITY
North Carolina State University	NC STATE UNIV
Pope Air Force Base	POB AIRPORT
Port of Wilmington	PORT OF WILMINGTON
Seymour Johnson Air Force Base	GSB AIRPORT
Sunny Point Marine Terminal	SUNNY POINT TM

North Dakota	
Grand Forks Air Force Base	RDR AIRPORT
Minot Air Force Base	MINOT AFB
Ohio	
Battelle Memorial Institute	BATTELLE
Battelle West Jefferson Site	BATTELLE W-J
Cleveland-Cuyahoga County Port Authority	CLEVELAND PORT
Davis-Besse Nuclear Power Plant	DAVIS-BESSE NP
Fernald Environmental Management Project	FERNALD PLANT
Miamisburg Environmental Management Project	MOUND FACILITY
Ohio State University	OHIO STATE U
Perry Nuclear Power Plant	PERRY NP
Portsmouth Gaseous Diffusion Plant	PORTSMOUTH GDP
RMI Titanium Company	RMI PLANT
Toledo-Lucas County Port Authority	PORT OF TOLEDO
Wright-Patterson Air Force Base	FFO AIRPORT
Oklahoma	
Altus Air Force Base	LTS AIRPORT
Tinker Air Force Base	TIK AIRPORT
University of Oklahoma	U OF OKLAHOMA
Vance Air Force Base	END AIRPORT
Oregon	
Oregon State University	OREGON ST UNIV
Port of Portland	PORT OF PORTLAND
Reed College	REED COLLEGE
Trojan Nuclear Power Plant	TROJAN NP
Umatilla Army Depot	UMATILLA DEPOT
Pennsylvania	
Beaver Valley Nuclear Power Plant	BEAVER VALLEY NP
Bettis Atomic Power Laboratory	BETTIS APL
Limerick Nuclear Power Plant	LIMERICK NP
Peach Bottom Nuclear Power Plant	PEACH BOTTOM NP
Pennsylvania State University	PENN STATE
Pittsburgh Energy Technology Center	PETC
Pittsburgh Naval Reactors Office	BETTIS APL
Port of Chester (Eddystone)	PORT OF CHESTER
Port of Marcus Hook	PORT OF MARCUS HOOK
Port of Philadelphia	PHILADELPHIA PORT
Susquehanna Nuclear Power Plant	SUSQUEHANNA NP
Three Mile Island Nuclear Power Plant	THREE MILE IS NP
Rhode Island	
Rhode Island AEC	RHODE IS AEC
South Carolina	
Catawba Nuclear Power Plant	CATAWBA NP

Charleston Air Force Base	CHARLESTON AFB
Charleston Naval Base	CHARLESTON NAVAL BASE
Oconee Nuclear Power Plant	OCONEE NP
Port of Charleston (N. Charleston Terminal)	N CHARLTN TERM
Port of Charleston (Wando Terminal)	WANDO TERMINAL
H. B. Robinson Nuclear Power Plant	ROBINSON NP
Savannah River Site (3/700 Area)	SRS
Savannah River Site (MFFF Area)	SRS SITE F
Savannah River Site (OWPF Area)	SRS SITE S
Savannah River Site (RBOF Area)	SRS SITE H
Shaw Air Force Base	SSC AIRPORT
Summer Nuclear Power Plant	SUMMER NP
University of South Carolina	U OF S CAROLINA
Westinghouse Electric Nuclear Fuel (Columbia)	WEST NF FAB

South Dakota

Ellsworth Air Force Base	RCA AIRPORT

Tennessee

East Tennessee Technology Park (K-25 Site)	K-25
High Flux Isotope Reactor	HFIR
Nuclear Fuel Services	NFS ERWIN
Oak Ridge National Laboratory	ORNL
Oak Ridge Reservation	O R RSVTN SITE
Scientific Ecology Group (Oak Ridge)	SEG
Sequoyah Nuclear Power Plant	SEQUOYAH NP
Solid Waste Area Group 6 (Oak Ridge)	SWAG-6
Watts Bar Nuclear Power Plant	WATTS BAR NP
Y-12 Plant	Y-12

Texas

Camp Bullis	CAMP BULLIS
Comanche Peak Nuclear Power Plant	COMANCHE PEAK NP
Dyess Air Force Base	DYS AIRPORT
Kelly Air Force Base	SKF AIRPORT
Laughlin Air Force Base	DLF AIRPORT
LBJ Space Flight Center	LBJ SPACE CNTR
Mormon Plant	MORMON PLANT
Pantex Plant	PANTEX PLANT
Port of Beaumont	PORT OF BEAUMONT
Port of Corpus Christi	PORT OF CORPUS CHR
Port of Freeport	PORT OF FREEPORT
Port of Galveston	PORT OF GALVSTN
Port of Houston	PORT OF HOUSTON
Port of Port Arthur	PORT ARTHUR PT
Port of Texas City	PORT OF TEXAS CITY
Randolph Air Force Base	RANDOLPH AFB
South Texas Nuclear Power Plant	SOUTH TEXAS NP
Texas A&M University	TEXAS A&M UNIV
University of Texas	U OF TEXAS

Utah

Dugway Proving Grounds	DUGWAY PVG GND
Envirocare	CLIVE
Safety-Kleen Grayback Mountain Facility	GRAYBACK FCLTY
Tooele Army Depot	TOOELE DEPOT
University of Utah	U OF UTAH

Vermont

Vermont Yankee Nuclear Power Plant	VERMONT YANKEE NP

Virginia

ARECO Facility	FOREST
Babcock & Wilcox, Lynchburg	B&W FUEL PLANT
Langley Air Force Base	LFI AIRPORT
Newport News Marine Terminal	N N MARINE TERM
Norfolk International Terminal	NORFOLK INTL TM
Norfolk Naval Air Station	NGU AIRPORT
Norfolk Naval Base	NORFOLK NAVAL BASE
North Anna Nuclear Power Plant	NORTH ANNA NP
Port of Richmond	VA DEEPWTR TERM
Portsmouth Marine Terminal	PM MARINE TERM
Portsmouth Naval Shipyard	PM NAVAL SHPYRD
Surry Nuclear Power Plant	SURRY NP
University of Virginia	U OF VIRGINIA
Yorktown Naval Weapons Station	YORKTOWN NWS

Washington

Bangor Undersea Warfare Engineering Station Annex	BANGOR UWESA
Columbia Nuclear Power Plant	COLUMBIA NP
Fairchild Air Force Base	SKA AIRPORT
Hanford Site (Westinghouse Hanford, Pacific NW Lab)	HANFORD
McCord Air Force Base	TCM AIRPORT
Port of Keyport	KEYPORT
Port of Seattle	PORT OF SEATTLE
Port of Tacoma	PORT OF TACOMA
Puget Sound Naval Shipyard (Bremerton)	PS NAVAL SHPYD
University of Washington	U OF WASHINGTON
Washington State University	WASHINGTON ST

West Virginia

Morgantown Energy Technology Center	METC

Wisconsin

Kewaunee Nuclear Power Plant	KEWAUNEE NP
LaCrosse Nuclear Power Plant	LA CROSSE NP
Point Beach Nuclear Power Plant	POINT BEACH NP
University of Wisconsin	U OF WISCONSIN

Wyoming

Francis E. Warren Air Force Base	F E WARREN AFB

APPENDIX B. WebTRAGIS RAILROAD NETWORK ABBREVIATION

APPENDIX B. WEBTRAGIS RAILROAD NETWORK ABBREVIATION

This appendix provides a tabular list of the abbreviations in the WebTRAGIS Railroad Network. The first column provides the Standard Carrier Alpha Code (SCAC) for the 796 railroads included in the network. The second column provides the railroad name, and the third column identifies the corporate owner if the railroad is part of a larger railroad or holding company. For example, the ABWR is the abbreviation for the Alabama Warrior Railway. This short line railroad is owned by Watco, a railroad holding company.

SCAC	Railroad	Ownership
AA	Ann Arbor Railroad	Watco
AB	Akron Barberton Cluster Railway	WE
ABR	Athens Line	
ABS	Alabama Southern Railroad	Watco
ABWR	Alabama Warrior Railway	Watco
ACEX	Altamont Commuter Express	
ACJR	Ashtabula Carson & Jefferson Railroad	
ACWR	Aberdeen Carolina & Western Railway	
ADA	AD&A Railroad	
ADBF	Adrian & Blissfield Railroad	Adrian & Blissfield
ADIX	Adirondack Scenic	
AERC	Albany & Eastern Railroad	Willamette Valley
AFR	Amador Foothills Railroad	
AGR	Alabama & Gulf Coast Railway	Genessee & Wyoming
AIKR	Aiken Railway Company	Western Carolina Railway Service
AKDN	Acadiana Railway	
AKMD	Arkansas Midland Railroad	Genessee & Wyoming
ALAB	Alabama Railroad	Pioneer Railcorp
ALLN	Allentown and Auburn Railroad	
ALM	Arkansas Louisiana & Missouri Railroad	
ALS	Alton & Southern Railway	Genessee & Wyoming
AM	Arkansas & Missouri Railroad	
AMTK	Amtrak - National Railroad Passenger Corp	
AN	AN Railway	Genessee & Wyoming
ANR	Angelina & Neches River Railroad	
AO	Appalachian & Ohio Railroad	P&L Industries
AOK	Arkansas-Oklahoma Railroad	
AOR	Aliquippa & Ohio River Railroad	Genessee & Wyoming
APA	Apache Railway	
APD	Albany Port Railroad	
APNC	Appanoose County Community Railroad	
AR	Aberdeen & Rockfish Railroad	A&R Railroads
ARA	Arcade & Attica Railroad	
ARC	Alexander Railroad	
ARE	A & R Line	

SCAC	Railroad	Ownership
ARR	Alaska Railroad	
ARS	Arkansas Southern Railroad	Watco
ARZC	Arizona & California Railroad	Genessee & Wyoming
ASRY	Ashland Railway	
ASVX	Abilene & Smoky Valley Railroad	
ATLT	AT & L Railroad	Great Walton
ATN	Alabama & Tennessee River Railway	Omnitrax
ATRG	Alliance Terminal Railroad	Omnitrax
ATW	Atlantic & Western Railway	Genessee & Wyoming
AUT	Autauga Northern Railroad	Watco
AVR	Allegheny Valley Railroad	Carload Express
AWRR	Austin Western Railroad	Watco
AWRY	Adams-Warnock Railway	
AWW	Algers Winslow & Western Railway	
AZCR	Arizona Central Railroad	Western Railroad Builders
AZER	Arizona Eastern Railway	Genessee & Wyoming
BAP	Butte, Anaconda and Pacific Railway	Patriot Rail
BART	Bay Area Rapid Transit	
BAYL	Bay Line Railroad	Genessee & Wyoming
BB	Buckingham Branch Railroad	
BBAY	Bogalusa Bayou Railroad	Watco
BCLR	Bay Colony Railroad	GFA Rail Services
BCR	Bay Coast Railroad	
BCRY	Barrie-Collingwood Railway	
BDRV	Belvidere & Delaware River Railway	Black River and Western
BDTL	Ballard Terminal Railroad	
BDW	Bighorn Divide & Wyoming Railroad	
BEEM	Beech Mountain Railroad	
BGCM	Bountiful Grain & Craig Mountain Railroad	Williams & Patterson
BH	B&H Rail Corp	B&H Rail
BHC	Black Hills Central	
BHRR	Birmingham Terminal Railroad	Watco
BHWY	Boot Hill & Western Railway	
BIRR	Bellingham International Railroad	
BJRR	Baja California Railroad	
BJRY	Burlington Junction Railway	
BKRR	Batten Kill Railroad	
BLKM	Black Mesa & Lake Powell	
BLOL	Bloomer Line	
BLR	Blacklands Railroad	Blacklands
BLU	Blue Ridge Southern	Watco
BML	Belfast & Moosehead Lake Railroad	

SCAC	Railroad	Ownership
BNG	Blackwell Northern Gateway Railroad	US Rail Partners
BNML	Burlington Northern (Manitoba) Ltd	BNSF
BNSF	BNSF Railway	BNSF
BOP	Border Pacific Railroad	
BPRR	Buffalo & Pittsburgh Railroad	Genessee & Wyoming
BRAN	Brandon Railroad	
BRC	Belt Railway Co of Chicago	
BRFD	Branford Steam Railroad	
BRG	Brownsville & Rio Grande Railroad	Omnitrax
BRMI	Bluegrass Railroad Museum	
BRW	Black River & Western Railroad	
BSOR	Buffalo Southern Railroad	
BSR	Big Spring Rail System	
BSTX	Bi-State Transit (MO)	
BVRR	Boise Valley Railroad	Watco
BXN	Bauxite & Northern Railway	Genessee & Wyoming
CA	Chesapeake & Albemarle Railroad	Genessee & Wyoming
CAGY	Columbus & Greenville Railway	Genessee & Wyoming
CALA	Carolina Southern Railroad	RJ Corman
CASS	Cass Scenic Railroad	
CBEC	CBEC Railroad	
CBNS	Cape Breton and Central Nova Scotia Railway	Genessee & Wyoming, Canada
CBR	Coos Bay Railroad	
CBRW	Columbia Basin Railroad	Columbia Basin
CBRY	Copper Basin Railway	
CCET	Cincinnati East Terminal Railroad	
CCH	Columbus & Chattahoochee Railroad	Genessee & Wyoming
CCKY	Chattooga & Chickamauga Railway	Genessee & Wyoming
CCPN	Corpus Christi Terminal Railroad	Genessee & Wyoming
CCRA	Camp Chase Industrial Railroad	Carload Express
CCRL	Cleveland Commercial Railroad	Cleveland Commercial Railroad
CCRR	Claremont Concord Railroad	
CCT	Central California Traction	
CCUO	Chicago-Chemung Railroad Corp	
CDTX	California Dept of Transportation-CalTrain	
CEIW	Central Indiana & Western Railroad	
CEMR	Central Manitoba Railway	
CEMX	Cliffs Erie Mining Railroad	
CERA	Central Railroad Co of Indianapolis	Genessee & Wyoming
CF	Cape Fear Railway	
CFE	Chicago Ft Wayne & Eastern	Genessee & Wyoming
CFL	C F Lanaudiere Inc	

SCAC	**Railroad**	**Ownership**
CFNR	California Northern Railroad	Genessee & Wyoming
CFWR	Caney Fork & Western Railroad	Ironhorse Resources
CGR	CG Railway	
CHAT	Chattahoochee Bay Railroad	Genessee & Wyoming
CHB	Cleveland Harbor Belt	Cleveland Commercial Railroad
CHR	Chestnut Ridge Railway	
CHS	Charlotte Southern Railroad	Adrian & Blissfield
CIC	Cedar Rapids & Iowa City Railway	
CIND	Central Railroad of Indiana	Genessee & Wyoming
CIR	City of Rochelle Illinois	
CIRR	Chattahoochee Industrial Railroad	Genessee & Wyoming
CIRY	Central Illinois Railroad	
CKIN	Chesapeake & Indiana Railroad	Indiana Boxcar
CKSI	Carthage Knightstown & Shirley Railroad	
CLC	Columbia & Cowlitz Railway	Patriot Rail
CLNA	Carolina Coastal Railway	
CM	Central Montana Rail	
CMPA	Madison Railroad	
CMQ	Central Maine and Quebec Railway.	RAH
CMR	Central Midland Railway	Progressive Rail
CMRX	Capital MetroRail (Austin, TX)	
CMSL	Cape May Seashore Lines	
CMSX	Catskill Mountain	
CN	Canadian National Railway	Canadian National
CNAT	CN Aquatrain	
CNUR	C & NC Railroad	
CNYK	Central New York Railroad	Delaware Otsego
CNZR	Central New England Railroad	
COEH	Conecuh Valley Railroad	Genessee & Wyoming
COER	Crab Orchard & Egyptian Railroad	Progressive Rail
COP	City of Prineville Railway	
CORP	Central Oregon & Pacific Railroad	Genessee & Wyoming
CPDR	Carolina Piedmont Division South Carolina Railroad	Genessee & Wyoming
CPMY	Coopersville & Marne Railway	
CPR	CaterParrott Railnet	
CPRS	Canadian Pacific Railway	Canadian Pacific
CRL	Chicago Rail Link	Omnitrax
CSAO	Conrail Shared Assets Operation	
CSCD	Cascade & Columbia Railroad	Genessee & Wyoming
CSKR	C & S Railroad	
CSO	Connecticut Southern Railroad	Genessee & Wyoming
CSR	Camden & Southern Railroad	Arkansas Shortlines

SCAC	Railroad	Ownership
CSRX	Conway Scenic	
CSS	Chicago Southshore & South Bend Railroad	Anacostia & Pacific
CSXT	CSX Transportation	CSXT
CT	Columbia Terminal Railroad	
CTA	Chicago Transit Authority	
CTM	Chicago Terminal Railroad	Iowa Pacific
CTN	Canton Railroad	
CTR	Clinton Terminal Railroad	
CTRR	Cloquet Terminal Railroad	
CTRW	Carlton Trail Railway	Omnitrax
CTSR	Cumbres & Toltec Scenic Railroad	
CUMB	Cumberland Mine	
CUOH	Columbus & Ohio River Railroad	Genessee & Wyoming
CUVA	Cuyahoga Valley Scenic Railroad	
CVR	Cimarron Valley Railroad	Western Railroad Builders
CVSR	Cuyahoga Valley Scenic Railroad	
CWA	Central Washington Railroad	Columbia Basin
CWCY	Caldwell County Railroad	Southeast Shortlines
CWL	California Western Railine	
CWRO	Cleveland Works Railway	
CWRY	Commonwealth Railway	Genessee & Wyoming
CZRY	Carrizo Gorge Railway	Pacific Imperial
DAIR	D & I Railroad	
DAKS	Dakota Short Line	
DART	Dallas Area Rapid Transit	
DC	Delray Connecting Railroad	Transtar
DCLR	Delaware Coast Line Railroad	
DCON	Detroit Connecting Railroad	Adrian & Blissfield
DCRR	Dubois County Railroad	
DGNO	Dallas Garland & Northeastern Railroad	Genessee & Wyoming
DGVR	Durbin & Greenbrier Valley Railroad	
DL	Delaware-Lackawanna Railway	Genessee Valley
DLWR	Depew Lancaster & Western Railroad	Genessee Valley
DMVW	Dakota Missouri Valley & Western Railroad	
DN	Dakota Northern Railroad	KBN
DPR	Deseret Power Railway	
DQE	DeQueen and Eastern Railroad	Patriot Rail
DR	Dardanelle & Russellville Railroad	Arkansas Shortlines
DRIR	Denver Rock Island Railroad	
DRTD	Denver Regional Transit	
DSNG	Durango & Silverton	
DSRC	Dakota Southern Railway	Williams & Patterson

SCAC	Railroad	Ownership
DSRR	Delta Southern Railroad	
DT	Decatur Junction Railway	Pioneer Railcorp
DURR	Delaware & Ulster Rail Ride	
DVR	Devco Railway	
DVS	Delta Valley & Southern Railway	
EACH	East Camden & Highland Railroad	
EARY	Eastern Alabama Railway	Genessee & Wyoming
EBG	Eastern Berks Railroad	
EBSR	East Brookfield & Spencer Railroad	
ECBR	East Cooper & Berkeley Railroad	
ECO	Ecorail Inc	
ECTB	East Chattanooga Belt Railway	
ECTX	Electric City Trolley Museum	
EDW	El Dorado & Wesson Railway	
EE	Ellis & Eastern	
EEC	East Erie Commercial Railroad	
EFRR	Effingham Railroad	Effingham Railroad
EIRC	Eastern Illinois Railroad	
EIRR	Eastern Idaho Railroad	Watco
EJR	East Jersey Railroad & Terminal	
ELKR	Elk River Railroad	
ELS	Escanaba & Lake Superior Railroad	
EMRY	Eastern Maine Railway	New Brunswick and Maine
ENR	E & N Railway	
ESPN	East Penn Railroad	Regional Rail
ETL	Essex Terminal Railway	
ETRY	East Tennessee Railway	Genessee & Wyoming
EV	Everett Railroad	
EVWR	Evansville Western Railway	P&L Industries
EWG	Eastern Washington Gateway Railroad	US Rail Partners
EWR	Elkhart & Western Railroad	Pioneer Railcorp
FC	Fulton County Railroad, Inc	
FCCM	Compania De Ferrocarriles Chiapas Mayab	
FCEN	Florida Central Railroad	Pinsly Railroad
FCR	Fulton County Railroad, LLC	Omnitrax
FCRD	First Coast Railroad	Genessee & Wyoming
FEC	Florida East Coast Railway	RAH
FEVR	Fremont and Elkhorn Valley	
FGCX	Florida Gulf Coast Railroad Museum	
FGLK	Finger Lakes Railway	
FIR	Flats Industrial Railroad	
FLWB	French Lick West Baden & Southern Railway	

SCAC	Railroad	Ownership
FMID	Florida Midland Railroad	Pinsly Railroad
FMRC	Farmrail Corp	Farmrail
FNOR	Florida Northern Railroad	Pinsly Railroad
FP	Fordyce & Princeton Railroad	Genessee & Wyoming
FRR	Falls Road Railroad	Genessee Valley
FRTX	Fox River Trolley Museum	
FRVT	Fore River Transportation Corp	
FSR	Fort Smith Railroad	Pioneer Railcorp
FSRR	Ferrosur S A de C V	
FTRL	Foster Townsend Rail Logistics	
FVRR	Fredonia Valley Railroad	
FWCR	Florida West Coast Railroad	
FWRY	Fillmore Western Railway	
FWWR	Fort Worth & Western Railroad	Tarantula Corp.
FXE	Ferrocarril Mexicano SA De CV	
GC	Georgia Central Railway	Genessee & Wyoming
GCK	Georges Creek Railway	
GCRX	Grand Canyon Ry	
GCW	Garden City Western Railway	Pioneer Railcorp
GDLK	Grand Elk Railroad	Watco
GET	Gettysburg & Northern Railroad	Pioneer Railcorp
GEXR	Goderich-Exeter Ry	Genessee & Wyoming, Canada
GFR	Grand Forks Ry	
GFRR	Georgia & Florida RailNet	Omnitrax
GGRL	Geaux Geaux Railroad	
GITM	Golden Isles Terminal Railroad	Genessee & Wyoming
GLC	Great Lakes Central Railroad	Federated Railways
GNBC	Grainbelt Corp	Farmrail
GNRR	Georgia Northeastern Railroad	
GOVX	Government (local) owned rail line	
GR	Grand Rapids Eastern Railway	Genessee & Wyoming
GRLW	Greenville & Western Railway	Western Carolina Railway Service
GRNW	Great Northwest Railroad	Watco
GRR	Georgetown Railroad	
GRW	Gary Railway	Transtar
GRWR	Great Walton Railroad	Great Walton
GRYR	Grenada Railway	Affiliated Railroads
GS	Georgia Southern Railway	Pioneer Railcorp
GSM	Great Smoky Mountains Railway	
GSWR	Georgia Southwestern Railroad	Genessee & Wyoming
GTR	Great River Railroad	
GTRA	Golden Triangle Railroad	Genessee & Wyoming

SCAC	Railroad	Ownership
GU	Grafton & Upton Railroad	
GVSR	Galveston Railway	Genessee & Wyoming
GWR	Great Western Railway	Omnitrax
GWRC	Georgia Woodlands Railroad	Omnitrax
GWRS	Great Western Railway Ltd	
HAL	Hilton & Albany Railroad	Genessee & Wyoming
HB	Hampton & Branchville Railroad	Lines set as “X” in network
HBRY	Hudson Bay Railway	Omnitrax
HCRR	Honey Creek Railroad	
HCRY	Huron Central Railway	Genessee & Wyoming, Canada
HESR	Huron & Eastern Railway	Genessee & Wyoming
HIRR	Hainesport Industrial Railroad	
HLSC	Hampton Ry	Operated by PNWR (G&W)
HMCR	Huntsville and Madison County Railroad	
HODX	Heart of Dixie Railroad	
HOG	Heart of Georgia Railroad	Atlantic Western Transportation
HOS	Hoosier Southern Railroad	
HR	Heritage Railroad	
HRRC	Housatonic Railroad	
HRRX	Huckleberry Railroad	
HRS	Hollidaysburg & Roaring Spring Railroad	
HRT	Hartwell Railway	Great Walton
HTR	Heart of Texas Railroad	
HVRX	Heber Valley Railroad	
HVSR	Hocking Valley Scenic Ry	
IAIS	Iowa Interstate Railroad	
IANR	Iowa Northern Railway	
IARR	Iowa River Railroad	Williams & Patterson
IATR	Iowa Traction Railroad	Progressive Rail
IBT	International Bridge & Terminal	
ICRK	Indian Creek Railroad	
IERR	Indiana Eastern Railroad	
IHB	Indiana Harbor Belt Railroad	
ILW	Illinois Western Railroad	Effingham Railroad
IMRR	Illinois & Midland Railroad	Genessee & Wyoming
IN	Indiana Northeastern Railroad	
INPR	Idaho Northern & Pacific Railroad	Rio Grande Pacific
INRD	Indiana Rail Road Co	
IORY	Indiana & Ohio Railway	Genessee & Wyoming
IR	Illinois Railway	Omnitrax
IRRS	International Rail Road Systems	
IRYM	Illinois Railway Museum	

SCAC	Railroad	Ownership
ISRR	Indiana Southern Railroad	Genessee & Wyoming
ISW	Indiana Southwestern Railway	Pioneer Railcorp
ITMZ	Indiana Transportation Museum	
JAIL	Jackson & Lansing Railroad	Adrian & Blissfield
JPBX	Peninsula Corridor Joint Powers Board (Caltrain)	
JVRR	Juniata Valley Railroad	North Shore
KAW	Kaw River Railroad	Watco
KBSR	Kankakee Beaverville & Southern Railroad	
KCS	Kansas City Southern Railway	Kansas City Southern
KCSM	Kansas City Southern de Mexico	Kansas City Southern
KCTL	Kansas City Transportation Co	
KFR	Kettle Falls International Railway	Omnitrax
KGTR	Kingman Terminal Railroad	Patriot Rail
KJR	Kiski Jct Railroad	
KJRY	Keokuk Junction Railway	Pioneer Railcorp
KNOR	Klamath Northern Ry	
KO	Kansas & Oklahoma Railroad	Watco
KPR	Kelowna Pacific Ry	
KRL	Kasgro Rail Lines	
KRM	Kentucky Railway Museum	
KRR	Kiamichi Railroad	Genessee & Wyoming
KT	Kentucky & Tennessee Railway	
KTR	Kendallville Terminal Railway	Pioneer Railcorp
KWT	Kentucky West Tennessee	Genessee & Wyoming
KXHR	Knoxville & Holston River Railroad	Gulf & Ohio
KYLE	Kyle Railroad	Genessee & Wyoming
LAJ	Los Angeles Junction Railway	
LAL	Livonia Avon & Lakeville Railroad	B&H Rail
LAS	Louisiana Southern Railroad	Watco
LAWR	Lorain & West Virginia Railway	
LBR	Lowville & Beaver River Railroad	Genessee Valley
LBWR	Lubbock & Western Railroad	Watco
LC	Lancaster & Chester Railroad	Gulf & Ohio
LCR	Lake County Railroad	
LDRR	Louisiana & Delta Railroad	Genessee & Wyoming
LER	Logansport & Eel River Railroad	
LFCD	Linea Caojuila Durango	
LI	Long Island Railroad (NYA provides freight service)	
LINC	Lewis & Clark Railway	
LIRC	Louisville & Indiana Railroad	Anacostia & Pacific
LIRR	Lapeer Industrial Railroad	Adrian & Blissfield
LKPR	Lahaina Kaanapali & Pacific Railroad	

SCAC	Railroad	Ownership
LKRR	Little Kanawha River Rail	
LMR	Last Mountain Railway	
LNVT	Landisville Terminal & Transfer	
LNW	Louisiana & North West Railroad	Patriot Rail
LORL	Lucas Oil Rail Line	
LRPA	Little Rock Port Terminal Railroad	
LRS	Laurinburg & Southern Railroad	Gulf & Ohio
LRWN	Little Rock & Western Railway	Genessee & Wyoming
LRWY	Lehigh Railway	Owego and Harford
LS	Luzerne & Susquehanna Railway	Owego and Harford
LSI	Lake Superior & Ishpeming Railroad	
LSRC	Lake State Railway	Lake State
LT	Lake Terminal Railroad	Transtar
LVRB	Lehigh Valley Rail - Bethlehem Division	Lehigh Valley Rail Management
LVRJ	Lehigh Valley Rail - Johnstown Division	Lehigh Valley Rail Management
LVRR	Lycoming Valley Railroad	North Shore
LW	Louisville & Wadley Railway	
LWR	Lake Whatcom Railway	
LXVR	Luxapalila Valley Railroad	Genessee & Wyoming
MARC	Maryland Rail Commuter Service	
MAX	Metropolitan Area Express - Portland	
MBTA	Massachusetts Bay Transportation Authority	
MC	Massachusetts Coastal Railroad	Iowa Pacific
MCER	Massachusetts Central Railroad	
MCR	McCloud River Railroad	Lines set as “X” in network
MCRM	Mid-Continent Railway Historical Society	
MCSA	Moscow Camden & San Augustine Railroad	
MDDE	Maryland & Delaware Railroad	
MDOT	Michigan Department of Transportation	
MDS	Meridian Southern Railway	Owego and Harford
MDT	Miami-Dade Transit	
MDW	Minnesota Dakota & Western Railway	
ME	Morristown & Erie Railway	Morristown & Erie
MERR	Maine Eastern Railroad	Morristown & Erie
MET	Modesto & Empier Traction CO	
METW	Municipality of East Troy, Wisconsin Railroad	
MGRI	MG Rail	
MH	Mt Hood Railroad	Iowa Pacific
MHC	Mohall Central Railroad	Northern Plains
MHWA	Mohawk Adirondack & Northern Railroad	Genessee Valley
MIDH	Middletown & Hummelstown Railroad	
MJ	Manufacturers Junction Railway	Omnitrax

SCAC	Railroad	Ownership
MMID	Maryland Midland Railway	Genessee & Wyoming
MMRR	Mid-Michigan Railroad	Genessee & Wyoming
MMT	Mission Mountain Railroad	Watco
MNA	Missouri & North Arkansas Railroad	Genessee & Wyoming
MNBR	Meridian & Bigbee Railroad	Genessee & Wyoming
MNC	Motive Rail/Missouri North Central Railroad	
MNCW	Metro North Commuter Rail	
MNJ	Middletown & New Jersey Railway	Regional Rail
MNN	Minnesota Northern Railroad	KBN
MNNR	Minnesota Commercial Railway	
MNR	Maine Northern Railway	New Brunswick and Maine
MPLI	Minnesota Prairie Line	Twin Cities & Western
MPP	Manitou and Pike Peak Cog Railway	
MQT	Marquette Rail LLC	Genessee & Wyoming
MRA	Mineral Range Railroad	
MRI	Mohall Railroad	Northern Plains
MRL	Montana Rail Link	Washington Companies
MRMZ	Monticello Railway Museum	
MS	Michigan Shore Railroad	Genessee & Wyoming
MSCI	Mississippi Central Railroad	Pioneer Railcorp
MSDR	Mississippi Delta Railroad	
MSE	Mississippi Export Railroad	
MSN	Ballard Terminal Railroad D/B/A Meeker Southern RR	Ballard Terminal
MSO	Michigan Southern Railroad	Pioneer Railcorp
MSR	Mississippi Southern Railroad	Watco
MSRW	Mississippian Railway Cooperative	
MSTR	Massena Terminal Railway	Genessee & Wyoming
MSWY	Minnesota Southern Railway	
MTDB	Metropolitan Transit Development Board-San Diego Trolley	
MTS	San Diego Metropolitan Transit System	
MVRY	Mahoning Valley Railway	Genessee & Wyoming
MVT	Mt Vernon Terminal Railroad	
NARM	Northern Alabama Railroad	
NAUG	Naugatuck Railroad	
NBER	Nittany & Bald Eagle Railroad	North Shore
NBSR	New Brunswick Southern Railway	New Brunswick and Maine
NCIR	New Castle Industrial Railroad	
NCPR	North Carolina Ports Railway	
NCRC	Nebraska Central Railroad	Rio Grande Pacific
NCRL	NC Railroad	
NCRY	Nile Cty Railway	
NCVA	North Carolina & Virginia Railroad	Genessee & Wyoming

SCAC	Railroad	Ownership
NCYR	Nash County Railroad	Gulf & Ohio
NDCR	N D C Railroad	
NDR	Napoleon, Defiance & Western Railway	Pioneer Railcorp
NECR	New England Central Railroad	Genessee & Wyoming
NEGS	New England Southern Railroad	
NENE	Nebraska Northeastern Railway	BNSF
NERR	Nashville & Eastern Railway	Nashville & Eastern
NHCR	New Hampshire Central Railroad	
NHN	New Hampshire Northcoast Corp	
NHRR	New Hope & Ivyland Railroad	
NHVX	New Hope Valley Scenic Railroad	
NICD	Northern Indiana Commuter Transportation District	
NIRC	Northeast Illinois Regional Commuter (Metra Rail-Chicago)	
NJRC	New Jersey Rail Carrier	
NJT	New Jersey Transit	
NKCR	Nebraska Kansas & Colorado Railway	Omnitrax
NLA	North Louisiana & Arkansas Railroad	Arkansas Shortlines
NLR	Northern Lines Railway	Anacostia & Pacific
NMRX	New Mexico Rail Runner	
NNRX	Nevada Northern Railway	
NNW	Nebraska Northwestern Railroad	
NOGC	New Orleans & Gulf Coast Railway	Rio Grande Pacific
NOKL	Northwestern Oklahoma Railroad	
NOPB	New Orleans Public Belt Railroad	
NOW	Northern Ohio & Western Railway	Omnitrax
NPB	Norfolk & Portsmouth Belt Line Railroad	
NPR	Northern Plains Railroad	Northern Plains
NRI	Nebkota Railway	
NRTX	Nashville Regional Transportation Authority (Music City Star)	
NS	Norfolk Southern Railway	Norfolk Southern
NSHR	North Shore Railroad	North Shore
NSM	North Shore Mining Railroad	
NSR	Newburgh & South Shore Railroad	Omnitrax
NSRM	Nevada State Railroad Museum	
NSSR	North Shore Scenic Railroad	
NTZR	Natchez Railway	Affiliated Railroads
NVRR	Napa Valley Railroad	
NWP	Northwestern Pacific Railroad	
NWR	Nashville & Western Railroad	Nashville & Eastern
NYA	New York & Atlantic Railway	Anacostia & Pacific
NYGL	New York & Greenwood Lake Railway	
NYLE	New York & Lake Erie Railroad	New York and Lake Erie

SCAC	Railroad	Ownership
NYNJ	New York New Jersey Rail	
NYOG	New York & Ogdensburg Railway	Vermont Rail System
NYSW	New York Susquehanna & Western Railway	Delaware Otsego
OAR	Old Augusta Railroad	
OCTL	Oil Creek & Titusville Lines	New York and Lake Erie
OERM	Orange Empire Raiway Museum	
OHCR	Ohio Central Railroad	Genessee & Wyoming
OHIC	Ohi-Rail	Indiana Boxcar
OHIO	Ohio Terminal Railroad	Carload Express
OHRY	Owego & Hartford Railway	Owego and Harford
OLO	Ontario L'Original Railway	
OMID	Ontario Midland Railroad	
ONCT	Ontario Central Railroad	
ONT	Ontario Northland Transportation	
OPR	Oregon Pacific Railroad	
OPT	Orange Port Terminal Railway	
ORC	Ogeechee Railroad	
OSCR	Ohio South Central Railroad	
OSRR	Ohio Southern Railroad	Genessee & Wyoming
OTR	Oakland Terminal Railway	
OTVR	Otter Tail Valley Railroad	Genessee & Wyoming
OUCH	Ouachita Railroad	Arkansas Shortlines
OVRR	Ozark Valley Railroad	Williams & Patterson
PAL	Paducah and Louisville Railway	P&L Industries
PAM	Pittsburgh Allegheny & McKees Rock Railroad	
PAS	Pan Am Southern LLC	Pan Am
PAT	Port Authority of Allegheny Railroad	
PATC	Port Authority Transit Corporation (Philadelphia)	
PATH	Port Authority of New York and New Jersey Transit	
PBR	Patapsco & Back Rivers Railroad	
PBVR	Port Bienville Railroad	
PCC	Palouse River & Coulee City Railroad	Watco
PCN	Point Comfort & Northern Railway	Genessee & Wyoming
PDRR	Pee Dee River Railway	A&R Railroads
PGR	Progressive Rail	Progressive Rail
PHL	Pacific Harbor Lines	Anacostia & Pacific
PHRR	Port Harbor Railroad	
PI	Paducah & Illinois Railway	
PICK	Pickens Railway	Pickens
PIR	Pacific Imperial Railroad	Pacific Imperial
PJR	Port Jersey Railroad	
PKHP	Pickens Railway/Honea Path Div	Pickens

SCAC	Railroad	Ownership
PLV	Port of Longview	
PN	Pennsylvania Northeastern Railroad	
PNR	Panhandle Northern Railroad	Omnitrax
PNRW	Piedmont & Northern Railway	Patriot Rail
PNW	Prescott & Northwestern Railroad	Genessee & Wyoming
PNWR	Portland & Western Railroad	Genessee & Wyoming
POHC	Pittsburgh & Ohio Central Railroad	Genessee & Wyoming
POTB	Port of Tillamook Bay Railroad	
POVA	Pend Oreille Valley Railroad	
PRMU	Port of Ponce Railroad	
PRY	Pioneer Industrial Railway	Pioneer Railcorp
PSAP	Puget Sound & Pacific Railroad	Genessee & Wyoming
PSC	Pyco Industries Inc	
PSCC	Pennsylvania & Southern Railway	Raritan Central
PSRR	Pacific Sun Railroad	Watco
PSWR	Pennsylvania Southwestern Railroad	Watco
PT	Peninsula Terminal Co	
PTC	Plainview Terminal Co	
PTR	Port Terminal Railroad of South Carolina	
PTRA	Port Terminal Railroad Association	
PUCC	Port Utilities Commission of Charleston, SC	
PVJR	Portland Vancouver Junction Railroad	
PVRR	Pioneer Valley Railroad	Pinsly Railroad
PVS	Pecos Valley Southern Railway	Watco
PVTX	Privately owned railroad	
PW	Providence & Worcester Railroad	
QCR	Quebec Central Ry	
QGRY	Quebec Gatineau Railway	Genessee & Wyoming, Canada
QRR	Quincy Railroad	
RBMN	Reading Blue Mountain & Northern Railroad	
RCPE	Rapid City, Pierre & Eastern Railroad	Genessee & Wyoming
RCRY	Raritan Central Railway	Raritan Central
RJCC	R J Corman Railroad/Central Kentucky	RJ Corman
RJCK	R J Corman Railroad/Tennessee Terminal	RJ Corman
RJCL	R J Corman Railroad/Cleveland Line	RJ Corman
RJCM	R J Corman Railroad/Memphis Line	RJ Corman
RJCN	R J Corman Railroad/Allentown Lines	RJ Corman
RJCP	R J Corman Railroad/Pennsylvania Lines	RJ Corman
RJCR	R J Corman Railroad/Bardstown Line	RJ Corman
RJCV	R J Corman Railroad/WV Line	RJ Corman
RJCW	R J Corman Railroad/Western Ohio Line	RJ Corman
RL	Rutland Line	

SCAC	Railroad	Ownership
RLHH	RailLink Southern Ontario	
RLK	Railink Ottawa Valley	
RMRR	Rocky Mountain Railcar & Railroad	
RNA	Ripley & New Albany Railroad	Pioneer Railcorp
ROR	Rockton Rion & Western	SC Railroad Museum
RPP	Rusk Palestine & Pacific Railway	Iowa Pacific
RPRC	Richmond Pacific Railroad	
RRC	Redmont Railway	
RRRR	Rock & Rail	
RRVW	Red River Valley & Western Railroad	
RS	Roberval & Saguenay Railway	
RSL	RSL Railroad	
RSNR	Red Springs & Northern Railroad	
RSOR	Riceboro Southern Railway	Genessee & Wyoming
RSP	Roscoe, Snyder and Pacific Railway	
RSR	Rochester & Southern Railroad	Genessee & Wyoming
RSS	Rockdale Sandow & Southern Railroad	Genessee & Wyoming
RTA	Regional Transit Authority (Cleveland)	
RVCR	Raritan Valley Connector Railroad	
RVPR	Riverport Railroad	
RVSC	Rio Valley Switching	Ironhorse Resources
RVT	Rogue Valley Terminal Railroad	CCT Rail System
SAC	San Antonio Central	Watco
SAN	Sandersville Railroad	
SAPT	Savannah Port Terminal Railroad	Genessee & Wyoming
SAV	Sacramento Valley Railroad	Patriot Rail
SBG	Savage Bingham & Garfield Railroad	
SBK	South Brooklyn Railway	
SBLN	Sterling Belt Line Railway	
SBRR	Stourbridge Railroad	Morristown & Erie
SBVR	South Branch Valley Railroad	
SC	Santa Cruz & Monterey Bay Railway	Iowa Pacific
SCAX	Southern California Regional Rail Authority	
SCBG	Santa Cruz Big Trees & Pacific Railway	
SCIH	South Chicago and Indiana Harbor Railroad	
SCRA	Southern California Rail Authority-Metrolink	
SCRF	South Carolina Central Railroad	Genessee & Wyoming
SCS	Squaw Creek Southern Railroad	
SCSX	Silver Creek & Stephenson Railroad	
SCTR	South Central Tennessee Railroad	
SCXF	South Central Florida Express	US Sugar
SCXY	St Croix Valley Railroad	KBN

SCAC	Railroad	Ownership
SDIY	San Diego & Imperial Valley Railroad	Genessee & Wyoming
SDNR	San Diego Northern	
SDRX	Sound Transit (SeattleTransit)	
SE	Semo Port Railroad	
SEPA	Southeastern Pennsylvania Transportation Authority	
SERA	Sierra Northern Railroad	
SFS	Santa Fe Southern Railroad	
SGLR	Seminole Gulf Railway	GFA Rail Services
SH	Steelton & Highspire Railroad	
SHRX	Belton, Grandview and Kansas City Railroad	
SIND	Southern Indiana Railway	
SIRR	Staten Island Railroad	
SJVR	San Joaquin Valley Railroad	Genessee & Wyoming
SKOL	South Kansas & Oklahoma Railroad	Watco
SL	Salt Lake City Southern Railroad	Genessee & Wyoming
SLAL	South Plains Lamesa Railroad	
SLC	San Luis Central Railroad	
SLGG	Sidney & Lowe Railroad	
SLGW	Salt Lake Garfield & Western Railway	
SLOL	St. Louis Iron Mountain & Southern Railway	
SLQ	St Laurent & Atlantique Railroad	Genessee & Wyoming, Canada
SLR	St Lawrence & Atlantic Railroad	Genessee & Wyoming
SLRG	San Luis & Rio Grande Railroad	Iowa Pacific
SLRS	SMS Rail Service	
SLWC	Stillwater Central Railroad	Watco
SM	Saint Marys Railroad	
SMA	San Manuel Arizona Railroad	Capstone Mining
SMNR	Southern Manitoba Railway	
SMRR	Sisseton Milbank Railroad	Twin Cities & Western
SMRS	Southern Michigan Railroad	
SMV	Santa Maria Valley Railroad	
SMW	St Marys Railway West	
SNC	Saratoga & North Creek Railway	Iowa Pacific
SNR	Sunflour Railroad	
SNY	SMS Rail Lines of New York	
SOM	Somerset Railroad	CSXT
SORA	Southern Rails Cooperative Ltd	
SPSR	San Pedro & Southwestern Railroad	
SQVR	Sequatchie Valley Railroad	
SRC	Strasburg Railroad	
SRN	Sabine River & Northern Railroad	
SRNJ	Southern Railroad Co of New Jersey	

SCAC	Railroad	Ownership
SRRR	Swan Ranch Rail Road	Watco
SRT	Sacramento Regional Transit	
SRY	Southern Railway of British Columbia, Ltd	Washington Companies
SS	Sand Springs Railway	Omnitrax
SSC	Southern Switching Co	Ironhorse Resources
SSR	S&S Shortline Railroad	
STE	Stockton Terminal & Eastern Railroad	Omnitrax
STMA	St Maries River Railroad	
STR	Shawnee Terminal Railway	Pioneer Railcorp
SVI	Southern Railway of Vancouver Island	
SVRR	Shamokin Valley Railroad	North Shore
SVTX	Seaview Transportation	
SW	Southwestern Railroad	Western Railroad Builders
SWP	Southwest Pennsylvania Railroad	Carload Express
TASD	Terminal Railway Alabama State Docks	
TBRY	Thermal Belt Railway	Southeast Shortlines
TC	Temple & Central Texas Railway	Patriot Rail
TCCX	Tri-County Commuter Rail Authority (Miami)	
TCRY	Tri-City Railroad	
TCT	Texas City Terminal Railway	
TCWR	Twin Cities & Western Railroad	Twin Cities & Western
TFVM	Terminal Ferroviaria del Valle de Mexico SA de CV	
TI	Turners Island LLC	
TIBR	Timber Rock Railroad	Watco
TKEN	Tennken Railroad	
TLEW	Toledo Lake Erie & Western Railway	
TMBL	Tacoma Municipal Belt Line	
TMUS	Transmex/USA	
TN	Texas & Northern Railway	Transtar
TNER	Texas Northeastern Railroad	Genessee & Wyoming
TNHR	Three Notch Railroad	Genessee & Wyoming
TNMR	The Navajo Mine Railroad	Disconnected from national network
TPW	Toledo Peoria & Western Railway	Genessee & Wyoming
TR	Tomahawk Railway	Genessee & Wyoming
TRAX	Utah Transit Authority	
TRC	Trona Railway	
TREX	Trinity Railway Express	
TRMW	Tacoma Rail Mountain Division	
TRR	Thunder Rail Ltd	
TRRA	Terminal Railroad Association of St Louis	
TRRY	Trillium Railway	
TRUR	Tren Urbano	

SCAC	Railroad	Ownership
TSE	Texas South-Eastern Railroad	RJ Corman
TSR	Texas State Railroad	
TSRR	Tennessee Southern Railroad	Patriot Rail
TSU	Tulas-Sapulpa Union Railway	
TTIS	Transkentucky Transportation Railroad	
TTR	Talleyrand Terminal Railroad	Genessee & Wyoming
TVAX	Tennessee Valley Authority	
TVRM	Tennessee Valley Railroad Museum	
TXGN	Texas Gonzales & Northern Railway	TNW
TXN	Texas & New Mexico Railway	Watco
TXNW	Texas North Western Railway	TNW
TXOR	Texas and Oklahoma Railroad	
TXPF	Texas Pacifico Transportation	
TXR	Texas Rock Crusher Railway	TNW
TYBR	Tyburn Railroad	Regional Rail
TZPR	Tazewell & Peoria Railroad	Genessee & Wyoming
UCIR	Union County Industrial Railroad	North Shore
UCRY	Utah Central Railway	
UMP	Upper Merion & Plymouth Railroad	
UP	Union Pacific Railroad	Union Pacific
UPCS	Union Pacific Carrier Service	
UPT	Union Passenger Terminal (New Orleans)	
URR	Union Railroad	Transtar
USG	United States Government	
USR	Utah Southern Railroad	
USRP	US Rail Corporation	
UTAH	Utah Railway	Genessee & Wyoming
UTF	UTA Frontrunner	
VALE	Valley (Conn.)	
VCRR	Ventura County Railroad	Genessee & Wyoming
VR	Valdosta Railway	Genessee & Wyoming
VREX	Virginia Rail Express	
VRR	Vaughan Railroad	
VRRC	Vandalia Railroad	Pioneer Railcorp
VSOR	Vicksburg Southern Railroad	Watco
VSR	V & S Railway	Affiliated Railroads
VTR	Vermont Railway	Vermont Rail System
VVRR	Vermillion Valley Railroad	Indiana Boxcar
WBCR	Wabash Central Railroad	
WBRW	West Belt Railway	
WCLR	Waccamaw Coastline Railroad	
WCOR	Wellsboro & Corning Railroad	Genessee & Wyoming

SCAC	Railroad	Ownership
WE	Wheeling & Lake Erie Railway	WE
WFS	West Isle Line	
WGCR	Wiregrass Central Railroad	Genessee & Wyoming
WGNS	Wisconsin Great Northern Railroad	
WHOE	Walking Horse & Eastern Railroad	
WHRC	Windsor & Hantsport Ry	
WIR	Washington & Idaho Ry	Williams & Patterson
WKS	Wanamaker Kempton & Southern	
WMAT	Washington Metropolitan Area Transit Authority (Metro)	
WMI	West Michigan Railroad	Pioneer Railcorp
WMSR	Western Maryland Scenic Railroad	
WN	Wisconsin Northern Railroad	Progressive Rail
WNFR	Kanawha Rail	
WNYP	Western New York & Pennsylvania Railroad	B&H Rail
WOPR	West Oakland Pacific	
WPY	White Pass & Yukon Route Railroad	
WRM	Western Ry Museum	
WRRC	Western Railroad	
WRS	Western Rail Switching Inc	
WS	Walkersville Southern	
WSOR	Wisconsin & Southern Railroad	Watco
WSR	Warren & Saline River Railroad	Genessee & Wyoming
WSS	Winston-Salem Southbound Railway	
WSTX	Willamette Shore Trolley	
WTJR	Wichita Tillman & Jackson Railway	Rio Grande Pacific
WTNN	West Tennessee Railroad	
WTRM	Warren & Trumbull Railroad	Genessee & Wyoming
WTRY	Wilmington Terminal Railroad	Genessee & Wyoming
WURR	Wallowa Union Railroad	
WVC	West Virginia Central Railroad	
WVR	Willamette Valley Railroad	Willamette Valley
WW	Winchester & Western Railroad	Unimin
WWR	Western Washington Railroad	
WWRC	Wilmington & Western Railroad	
WWRX	White Water Railroad	
WYCO	Wyoming & Colorado Railroad	Western Railroad Builders
WYEC	Wye Transportation	
XXXX	Railroad Defunct	
YARR	Youngstown & Austintown Railroad	Genessee & Wyoming
YB	Youngstown Belt Railroad	Genessee & Wyoming
YRC	York Railway	Genessee & Wyoming
YRPL	Yelm Roy Prairie Line	

SCAC	Railroad	Ownership
YSRR	Youngstown & Southeastern Railroad	Indiana Boxcar
YSVR	Yellowstone Valley Railroad	Watco
YVRR	Yadkin Valley Railroad	Gulf & Ohio
YVT	Yakima Valley Transportation	
YW	Yreka Western Railroad	

APPENDIX C. SELECTED FACILITY LOCATIONS IN THE TRAGIS RAIL NETWORK

APPENDIX C. SELECTED FACILITY LOCATIONS IN THE TRAGIS RAIL NETWORK

The following list of facility locations provides the appropriate TRAGIS rail node name that should be used in the model. Each location is either identified by a specific node name or the nearest appropriate node name that should be used for routing to that site along with the appropriate railroad company that provides service at the site.

Alabama

Facility	*WebTRAGIS Name*	*Railroad*
Anniston Army Depot	ANNISTON ARMY DEPOT	NS
Bellefonte Nuclear Power Plant (never completed)	BELLEFONTE NP	NS
Browns Ferry Nuclear Power Plant	no direct rail access	
nearest rail node	TANNER	CSXT
Farley Nuclear Power Plant	FARLEY NP	CHAT

Arizona

Palo Verde Nuclear Power Plant	PALO VERDE NP	UP

Arkansas

Arkansas Nuclear One Power Plant	ARKANSAS ONE NP	UP
Pine Bluff Arsenal	PINE BLUFF ARSENAL	USG

California

Concord Naval Weapons Station	CONCORD NWS	UP
Diablo Canyon Nuclear Power Plant	no direct rail access	
nearest rail node	E SAN LUIS OBISPO	UP
Energy Technology Engineering Center	CHATSWORTH	UP
G E Vallecitos Nuclear Center	no direct rail access	
Humboldt Bay Nuclear Power Plant	no direct rail access	
Lawrence Berkeley National Laboratory	no direct rail access	
Lawrence Livermore National Laboratory	no direct rail access	
Lawrence Livermore Site 300	no direct rail access	
Rancho Seco Nuclear Power Plant	RANCHO SECO NP	UP
Rocketdyne	CHATSWORTH	UP
San Onofre Nuclear Power Plant	SAN ONOFRE NP	BNSF
Stanford Linear Accelerator Center	no direct rail access	

Colorado

Fort St Vrain Nuclear Power Plant	no direct rail access	
National Renewable Energy Laboratory	no direct rail access	
Rocky Flats Plant	ROCKY FLATS	UP
Rush Geotech	no direct rail access	

Connecticut

Haddam Neck (Conn Yankee) Nuc. Po. Plant	no direct rail access	
nearest rail node	PORTLAND	PW
Millstone Nuclear Power Plant	MILLSTONE NP	PW

Florida

Crystal River Nuclear Power Plant	CRYSTAL RIVER NP	FNOR

St Lucie Nuclear Power Plant	no direct rail access	
nearest rail node	FORT PIERCE	FEC
Turkey Point Nuclear Power Plant	no direct rail access	
nearest rail node	HOMESTEAD	CSXT
Georgia		
Hatch Nuclear Power Plant	HATCH NP	NS
Kings Bay Naval Submarine Base	KINGS BAY NSB	USG
Vogtle Nuclear Power Plant	VOGTLE NP	NS
Idaho		
Argonne National Laboratory-West	no direct rail access	
Idaho National Engineering & Env. Laboratory	INEEL	UP
Illinois		
Argonne National Laboratory	ARGONNE	BNSF
Braidwood Nuclear Power Plant	BRAIDWOOD NP	UP
Byron Nuclear Power Plant	BYRON NP	CPRS
Clinton Nuclear Power Plant	CLINTON NP	CN
Dresden Nuclear Power Plant	DRESDEN NP	CN
Fermi National Accelerator Laboratory	WARRENHURST	CN
G E Morris Operations	MORRIS OPERATION	CN
La Salle Nuclear Power Plant	LA SALLE NP	BNSF
Quad Cities Nuclear Power Plant	QUAD CITIES NP	CPRS
Zion Nuclear Power Plant	ZION NP	UP
Indiana		
Crane Naval Surface Warfare Center	CRANE NSWC	CPRS
Iowa		
Ames Laboratory	no direct rail access	
Duane Arnold Nuclear Power Plant	DUANE ARNOLD NP	PVTX
Kansas		
Wolf Creek Nuclear Power Plant	WOLF CREEK NP	UP
Kentucky		
Lexington-Blue Grass Army Depot	LEXINGTON-BLUE GRASS	CSXT
Paducah Gaseous Diffusion Plant	PADUCAH GDP	USG
Louisiana		
River Bend Nuclear Power Plant	no direct rail access	
nearest rail node	ZEE	GGRL
Waterford Nuclear Power Plant	WATERFORD NP SPUR	UP
Maine		
Maine Yankee Nuclear Power Plant	no direct rail access	
nearest rail node	MAINE YANKEE CUTOFF	CMQ
Maryland		
Calvert Cliffs Nuclear Power Plant	no direct rail access	

nearest rail access	BENEDICT/CHALK POINT	CSXT
Massachusetts		
Pilgrim Nuclear Power Plant	no direct rail access	
nearest rail access	PLYMOUTH (MBTA)	BCLR
Yankee-Rowe Nuclear Power Plant	no direct rail access	
nearest rail access	HOOSAC TUNNEL	PAS
Michigan		
Big Rock Point Nuclear Power Plant	no direct rail access	
nearest rail access	PETOSKEY	GLC
D C Cook Nuclear Power Plant	DC COOK NP	CSXT
Fermi Nuclear Power Plant	FERMI NP	CN
Palisades Nuclear Power Plant	no direct rail access	
nearest rail access	HARTFORD	CSXT
Minnesota		
Monticello Nuclear Power Plant	MONTICELLO NP	BNSF
Prairie Island Nuclear Power Plant	PRAIRIE ISLAND NP	CPRS
Mississippi		
Grand Gulf Nuclear Power Plant	no direct rail no access	
nearest rail access	CEDARS	VSOR
Missouri		
Allied Signal Aerospace Company	no direct rail access	
Callaway Nuclear Power Plant	no direct rail access	
nearest rail access	FULTON	KCS
Nebraska		
Cooper Nuclear Power Plant	no direct rail access	
nearest rail access	AUBURN	UP
Fort Calhoun Nuclear Power Plant	no direct rail access	
nearest rail access	CARGILL (BLAIR)	UP
Nevada		
Yucca Mountain Repository		
nearest rail access	CALIENTE	UP
New Hampshire		
Seabrook Nuclear Power Plant	no direct rail access	
nearest rail access	EAST KINGSTON	PAS
New Jersey		
Hope Creek Nuclear Power Plant	no direct rail access	
nearest rail access	SALEM	SRNJ
Oyster Creek Nuclear Power Plant	no direct rail access	
nearest rail access	LAKEHURST	CSAO
Princeton University Plasma Physics Laboratory	no direct rail access	
Salem Nuclear Power Plant	no direct rail access	
nearest rail access	SALEM	SRNJ

New Mexico		
Los Alamos National Laboratory	no direct rail access	
Lovelace Inhalation Toxicology Research Institute	no direct rail access	
Sandia National Laboratories	no direct rail access	
nearest rail access	ABAJO	BNSF
Waste Isolation Pilot Plant	WIPP	SW
New York		
Brookhaven National Laboratory	UPTON	NYA
FitzPatrick Nuclear Power Plant	FITZPATRICK NP	CSXT
Ginna Nuclear Power Plant	no direct rail access	
nearest rail access	PEEKSKILL	CSXT
Indian Point Nuclear Power Plant	no direct rail access	
nearest rail access	ONTARIO CENTER	OMID
Nine Mile Point Nuclear Power Plant	NINE MILE POINT NP1/NP2	CSXT
West Valley Demonstration Project	no direct rail access	
nearest rail access	ASHFORD	BPRR
North Carolina		
Brunswick Nuclear Power Plant	BRUNSWICK NP	USG
McGuire Nuclear Power Plant	MCGUIRE NP	CSXT
Shearon Harris Nuclear Power Plant	SHEARON HARRIS NP	CSXT
Sunny Point Marine Terminal	SUNNY POINT MARINE T	USG
Ohio		
Davis-Besse Nuclear Power Plant	DAVIS-BESSE NP	NS
Fernald Environmental Management Project	FERNALD	IERR
Mound Plant	MIAMISBURG MOUND ATC	NS
Perry Nuclear Power Plant	PERRY NP	NS
Portsmouth Gaseous Diffusion Plant	PORTSMOUTH GDP	NS
Oregon		
Trojan Nuclear Power Plant	TROJAN	PNWR
Umatilla Army Depot	ORDNANCE	UP
Pennsylvania		
Beaver Valley Nuclear Power Plant	BEAVER VLY NP (SHIPPINGPORT)	CSXT
Bettis Atomic Power Laboratory	no direct rail access	
Limerick Nuclear Power Plant	LIMERICK NP	NS
Peach Bottom Nuclear Power Plant	no direct rail access	
Pittsburgh Energy Technology Center	PITTSBURG PO	NS
Pittsburgh Naval Reactors Office	no direct rail access	
Susquehanna Nuclear Power Plant	SUSQUEHANNA NP	NSHR
Three Mile Island Nuclear Power Plant	THREE MILE ISLAND NP	NS
South Carolina		
Catawba Nuclear Power Plant	CATAWBA NP	NS
Oconee Nuclear Power Plant	no direct rail access	
nearest rail node	SENECA	NS

Robinson Nuclear Power Plant	ROBINSON NP	CSXT
Savannah River Site		
Site C	SRS SITE C	USG
Site D	SRS SITE D	USG
Site F	SRS SITE F	USG
Site H	SRS SITE H	USG
Site K	SRS SITE K	USG
Site L	SRS SITE L	USG
SRS Rail Yard	SRS RAIL YARD	USG
Summer Nuclear Power Plant	SUMMER NP	NS
Tennessee		
East Tennessee Technology Park (K-25 Site)	EAST TN TECH PARK	
Oak Ridge National Laboratory	no direct rail access	
Sequoyah Nuclear Power Plant	SEQUOYAH NP	NS
Watts Bar Nuclear Power Plant	WATTS BAR NP	NS
Y-12 Plant	Y12 PLANT	CSXT
Texas		
Comanche Peak Nuclear Power Plant	COMANCHE PEAK NP	FWWR
Pantex Plant	PANTEX PLANT	BNSF
South Texas Nuclear Power Plant	SOUTH TEXAS	UP
Utah		
EnviroCare	CLIVE	UP
Tooele Army Depot	TOOELE ARMY DEPOT	UP
Vermont		
Vermont Yankee Nuclear Power Plant	VERMONT YANKEE NP	NECR
Virginia		
North Anna Nuclear Power Plant	NORTH ANNA NP	CSXT
Surry Nuclear Power Plant	no direct rail access	
Nearest rail node	ZUNI	NS
Washington		
Columbia Nuclear Power Plant	COLUMBIA NP	USG
Hanford Site (Westinghouse Hanford, PNL)	HANFORD SITE	USG
West Virginia		
Morgantown Energy Technology Center	MORGANTOWN	CSXT
Wisconsin		
Kewaunee Nuclear Power Plant	no direct rail access	
nearest rail node	DENMARK	CN
La Crosse Nuclear Power Plant	LA CROSSE NP	BNSF
Point Beach Nuclear Power Plant	no direct rail access	
nearest rail node	DENMARK	CN

APPENDIX D. WEBTRAGIS POPULATION CALCULATION METHODOLOGY AND REPORTING

This Appendix expands on the content of Section 2.4 and provides more detail on the population calculation methodologies and population density distance reporting output available in WebTRAGIS. WebTRAGIS uses the same population density calculation methodology for all three available modes. Densities are based on the LandScan USA ambient population data which relies upon the 2010 U.S. Census population count data. Densities are determined by the application of an 800 meter buffer placed around the calculated route. This illustration of the basics of population calculation in WebTRAGIS will use a representative rail route from Sequoyah nuclear power plant (SEQUOYAH NP) on the Norfolk Southern (NS) railroad to the WCS Site in Texas (WCS SITE) on the Union Pacific (UP) and the Texas New Mexico (TNMR) railroads as seen in Figure D.1 and a highway route from the Watts Bar nuclear plant (WATTS BAR NP) in Tennessee to Charlotte, North Carolina (CHARLOTTE NE I485I85) seen in Figure D.2.

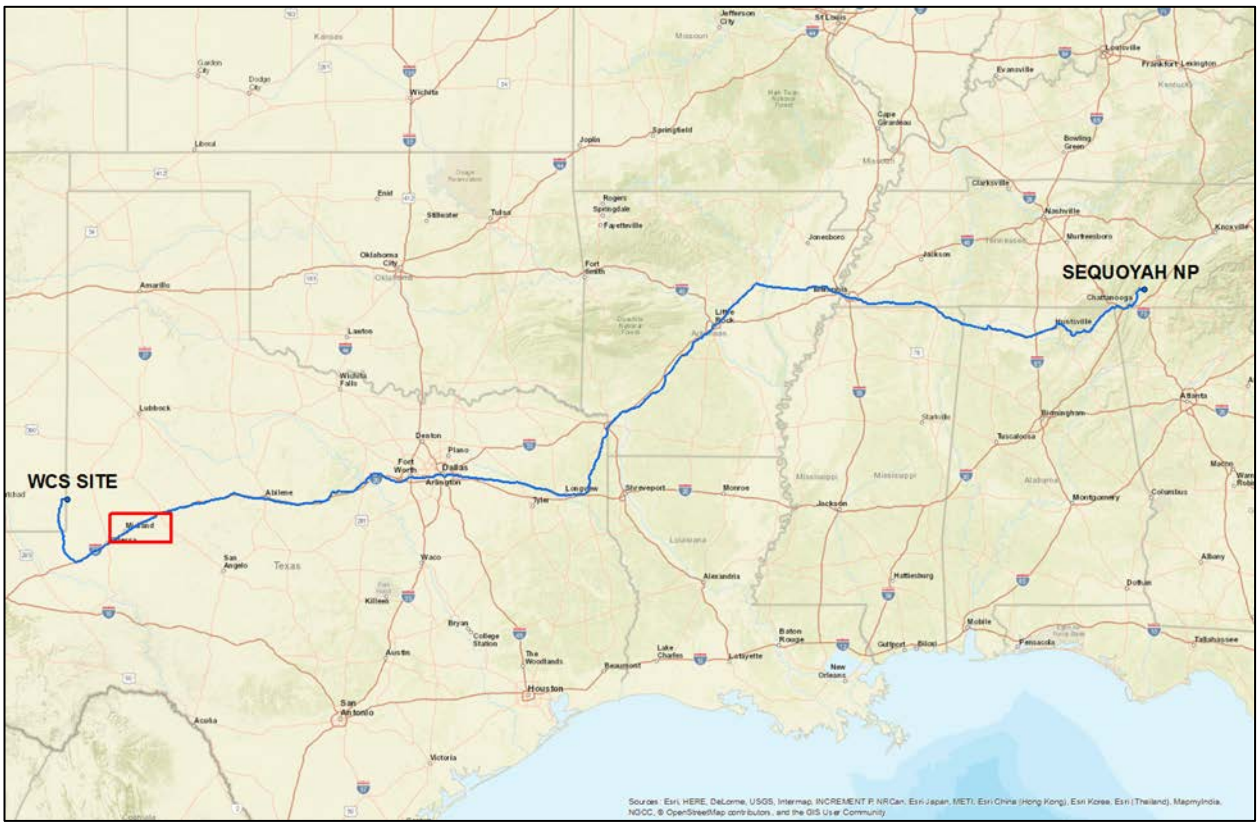

Figure D.1 Sequoyah NP to WCS Site Route

The railroad route passes through the city of Midland, Texas, an area highlighted by the red bounding box in Figure D.1. A more detailed map of Midland is provided in Figure D.3 which highlights link 48329002649 on the rail network including the associated LandScan population grid cells. The link is 3.513 miles long and moves from an area with low or zero population in the northeast to an area of higher population concentrations in the southwest.

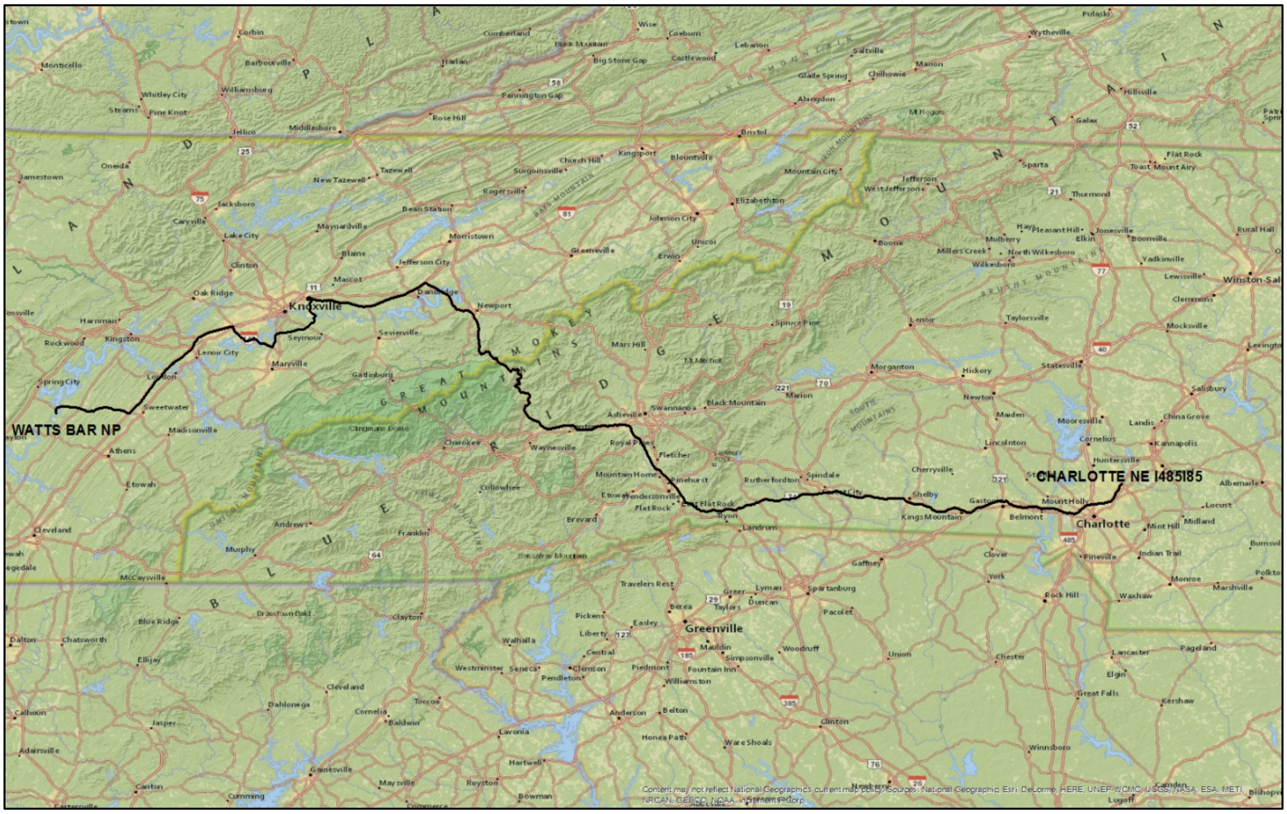

Figure D.2 Watts Bar NP to Charlotte, North Carolina

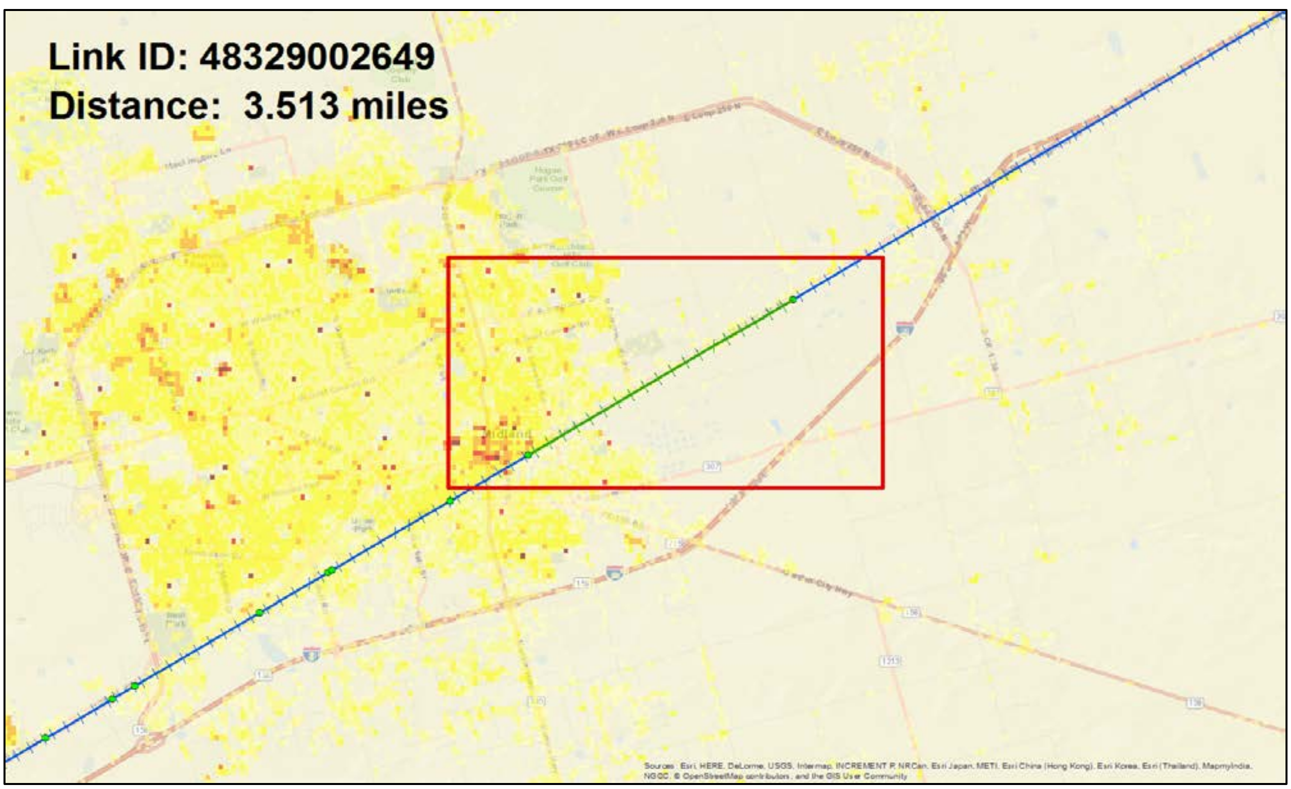

Figure D.3 Link Detail - Midland, Texas

In Fig. D.4, the link is viewed in isolation with an 800 meter buffer in red. The population within this buffer is then used to characterize various segments of the link as having high (urban), medium (suburban), or low (rural) population density.

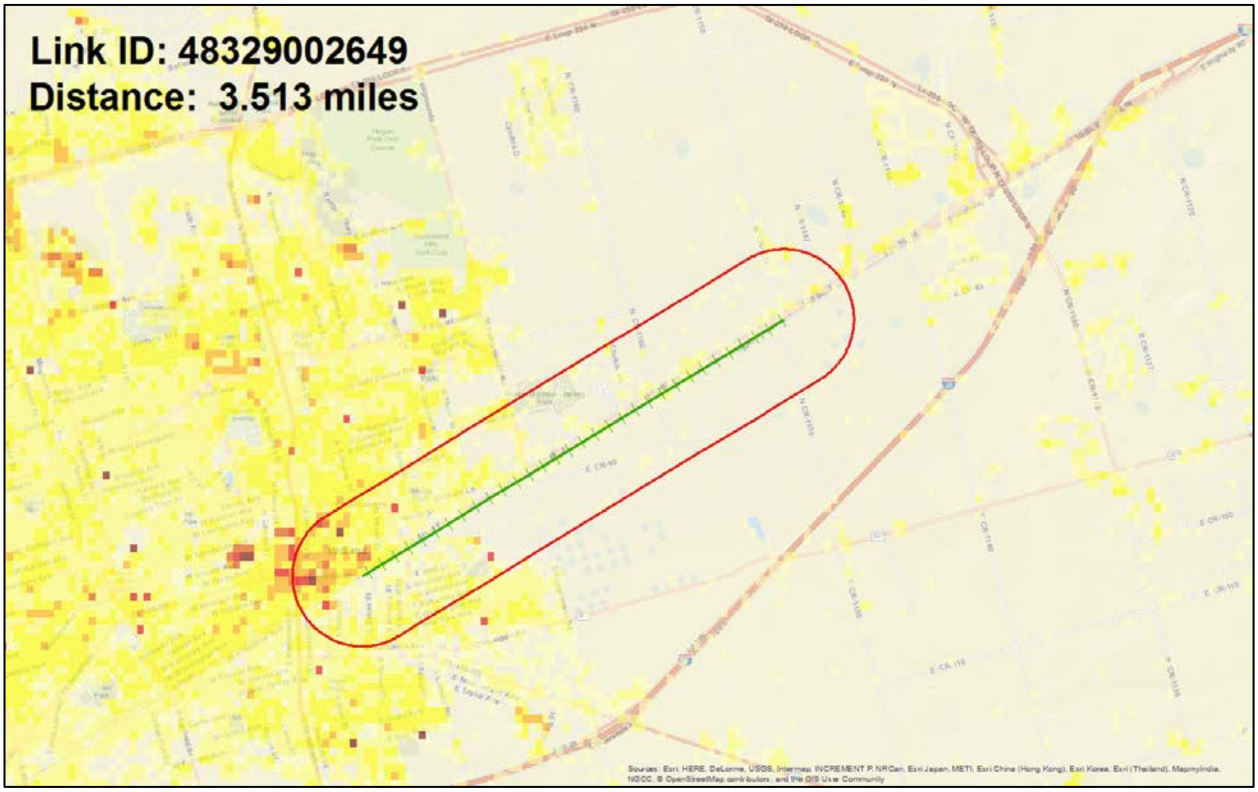

Figure D.4 Link Detail with Buffer - Midland, Texas

LandScan imposes a target surface grid and then assigns a population count to each grid based upon the U.S. census block group population counts and modifying features such as businesses, school, hospitals, or homes. As a result, populations are distributed within the block groups according to where people are most likely to be during the day or night. WebTRAGIS uses an ambient (day-night average) LandScan population value to determine the associated population densities. LandScan population is grouped into eight population classes: Those grid cells with 0 population are clear/uncolored, with the cells proceeding from light yellow to maroon as population counts increase. Fig. D.5 shows the LandScan population classes. Link 48329002649 with its 800 meter buffer and the ambient LandScan population grid cells in the area of the link are shown in Fig.D.6.

Figure D.3 Population Classes

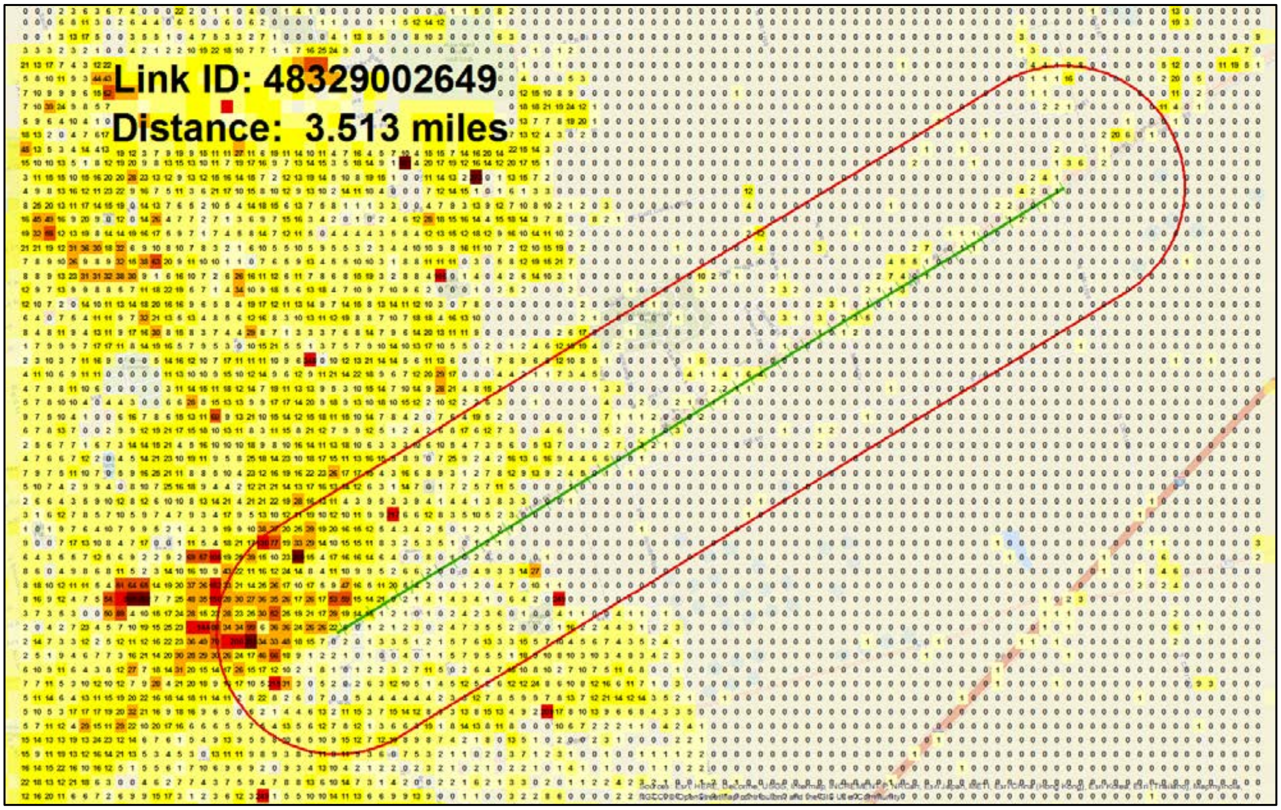

Figure D.5 LandScan population grid cells with counts

Fig. D.6 provides more detail of the southwestern portion of Link 48329002649 and the LandScan population grid cells. Each grid cell is approximately 90 meters square, with the buffer distance of 800 meters from the center line being roughly equivalent to one-half mile. Those cells falling within the buffer are then used to determine the link segment population density values.

As can be seen in Fig.D.6, the buffer passes through portions of some of the LandScan grid cells. As a result, a methodology needs to be adopted that provides a decision rule on whether to include a cell population. WebTRAGIS has adopted the straightforward methodology of assigning cells to the buffered population if the 800 meter buffered area includes the center point of a population grid cell. Fig.D.7 indicates how this method operates by showing the center points for the LandScan grid cells. The figure then shows those cells near the edge of the buffer whose center points are within the buffer and will have their population counts figured in the population density calculations as indicated by the green arrows, while cells that will have their counts excluded are identified by the red arrows.

Figure D.8 shows the results of the inclusion-exclusion process and the cells used to determine population density along the link. WebTRAGIS derives population densities using an 800 meter buffer around each network link along the transportation route as can be seen in Fig.D.9. Densities are reported in three categories:

- Rural/low: below 139 people/mi^2
- Suburban/medium: between 139 and 3,326 people/mi^2
- Urban/high: above 3,326 people/mi^2

Figure D.9 also begins to illustrate how WebTRAGIS uses the population grid cells to determine density distances and classify them according to the above schema.

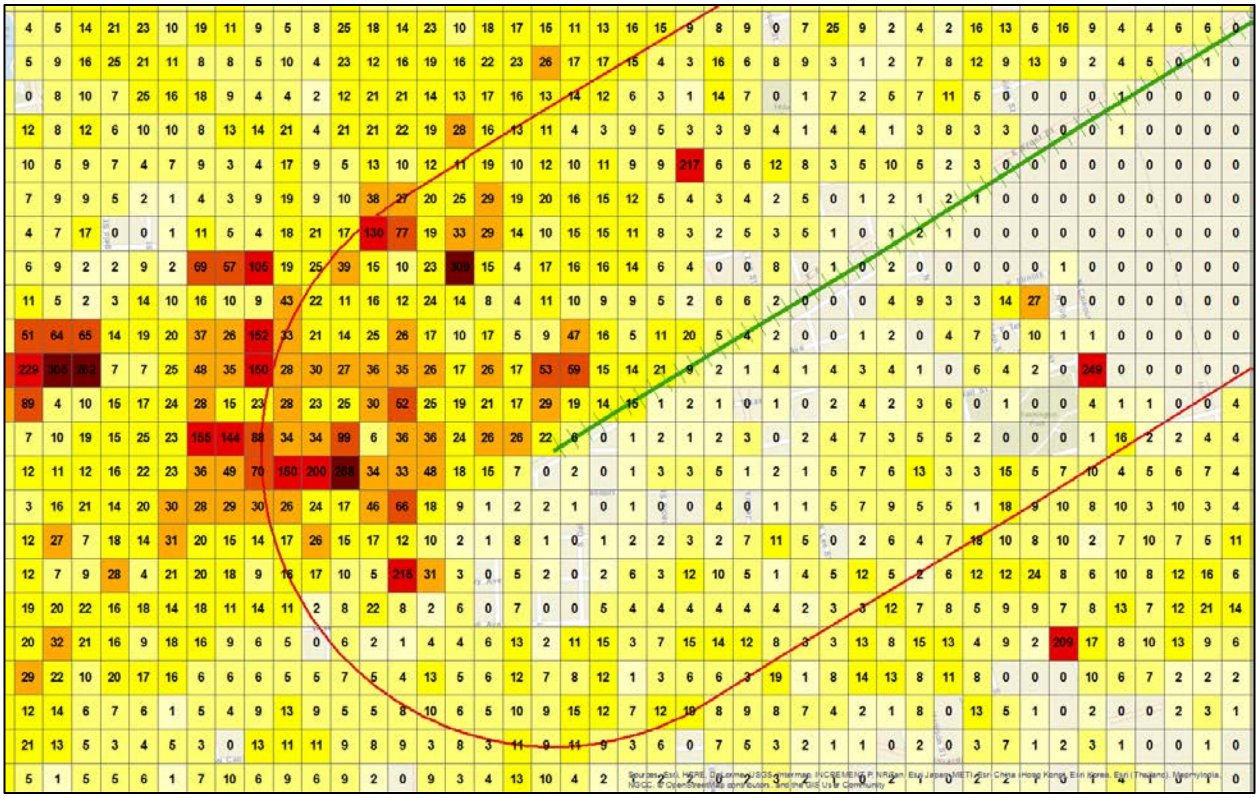

Figure D.6 Link Detail with LandScan population counts

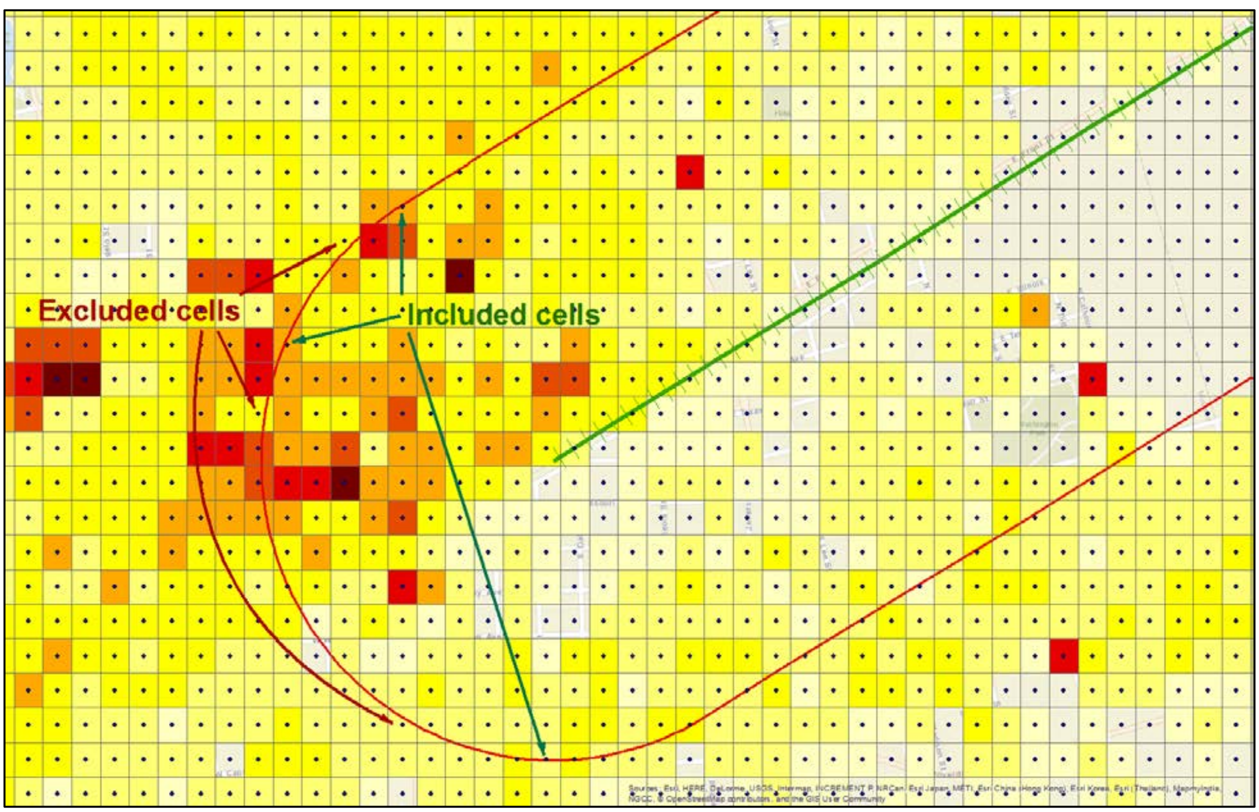

Figure D.7 Grid cell center point

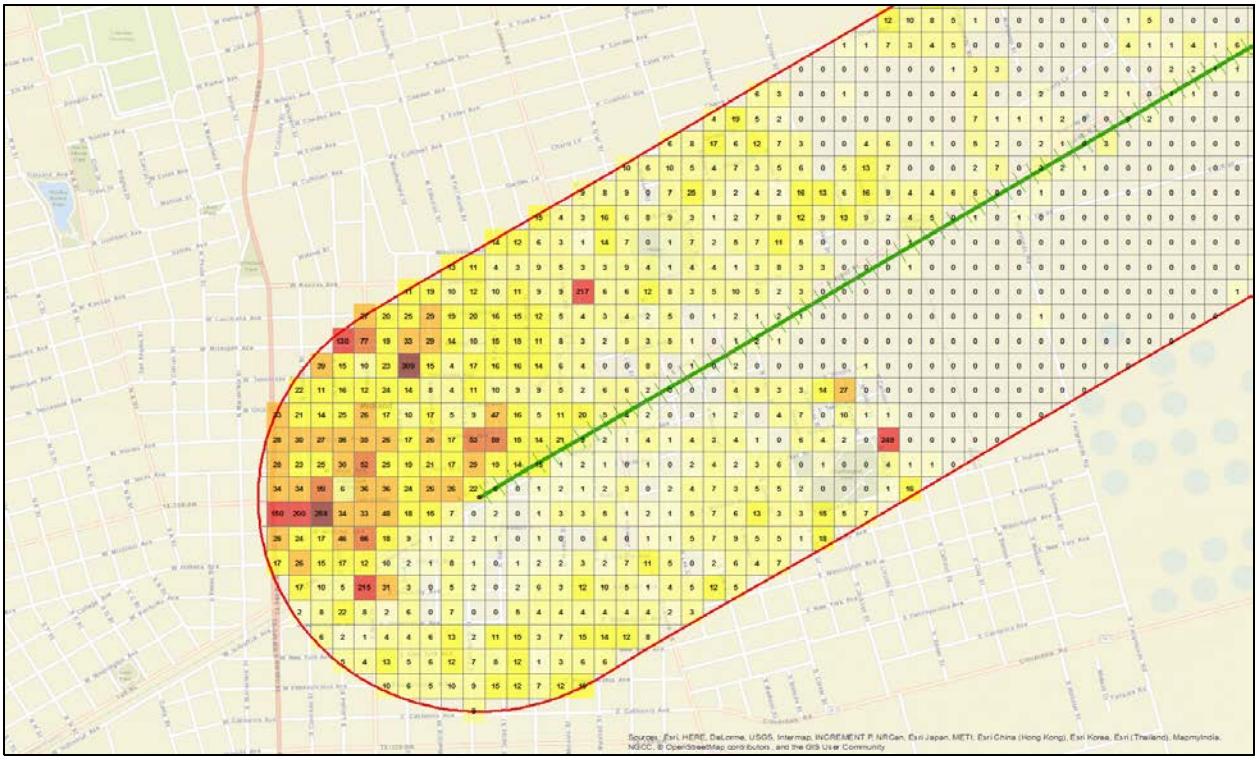

Figure D.8 Included population grid cells

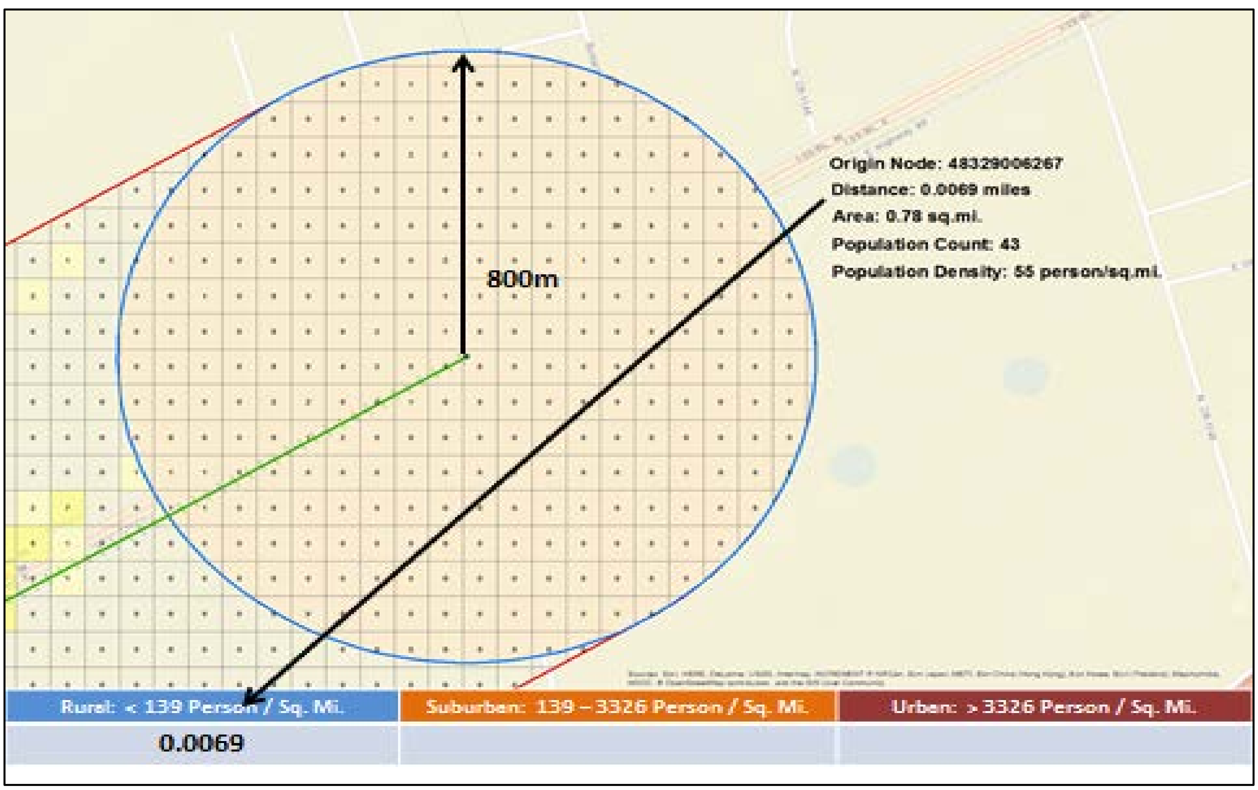

Figure D.9 Buffered distance and density

In Fig. D.9, an 800 meter blue buffer circle has been drawn around the starting node, 48329006267 for link 48329002649. Also, the LandScan population grid has been used to slice the link into separate link segments for each grid cell the link passes through. WebTRAGIS then determines the center points for each link segment. Fig. D.10 shows how the 800 meter buffer circles are then determined for each of the link segment centroids. WebTRAGIS proceeds by calculating the population density within the 800 meter buffer surrounding the starting node, and then proceeds to the subsequent centroid, determines the population in the next buffer and then calculates the appropriate density value.

Figure D.11 then shows how the distance density for the first link segment is calculated. The distance from the starting node to the first grid cell boundary is calculated to be 0.0069 miles. Within the 800 meter buffer distance surrounding the starting node, it is determined there is a population count of 43. The 800 meter circular buffer has an area of 0.78 square miles (sq.mi.), which yields a population density value of 55 persons per sq.mi., which falls in the Low/Rural population density class. As a result, the distance value of 0.0069 miles is placed into the Low/Rural population density group.

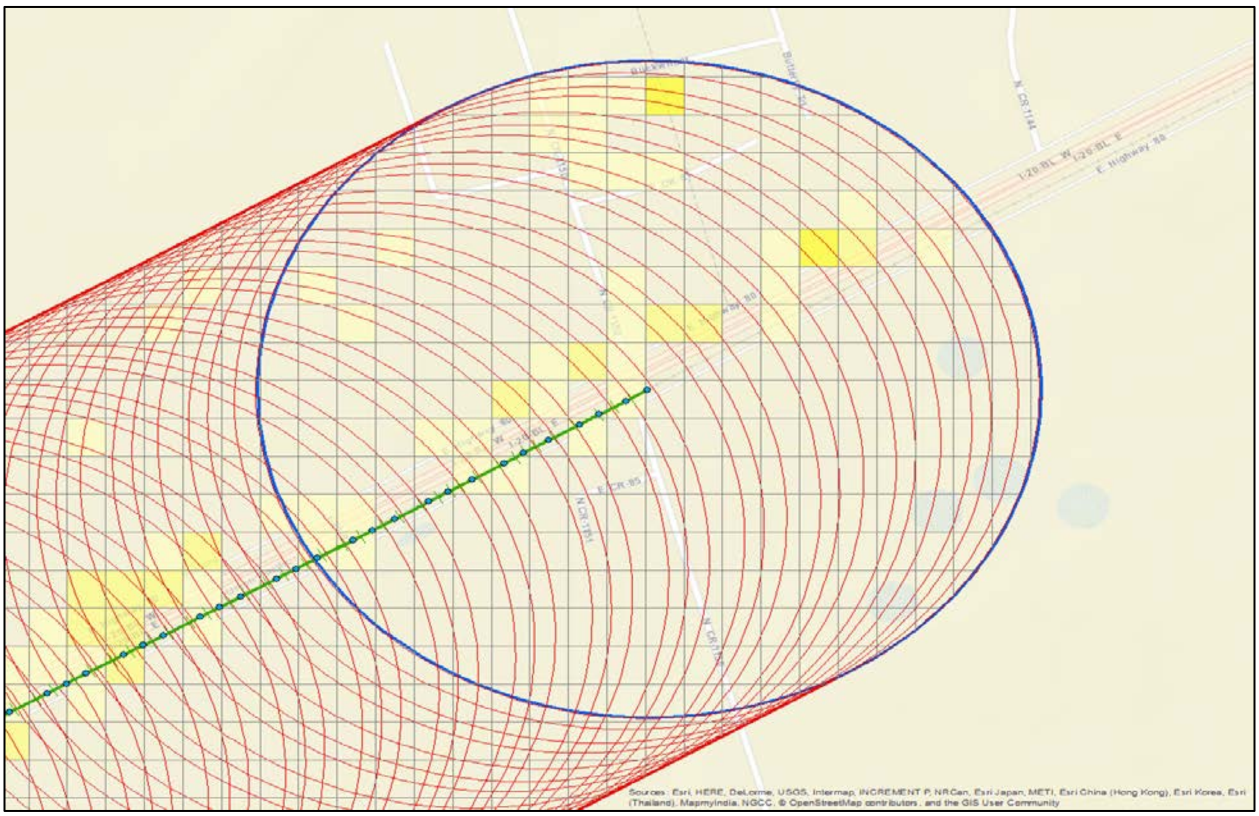

Figure D.10 Link segments and associated buffers

Figure D.11 illustrates more fully the link segmentation and density buffering WebTRAGIS uses for density distance calculations. As noted above, WebTRAGIS segments the link using the LandScan population grid cells providing a segmented link and distance value. Then, WebTRAGIS determines the center point for each of those link segments represented by the green points seen in Fig. D.11. Around each of these center points, an 800 meter buffer is drawn, the population in the buffer determined, and a population density value calculated and classified as Low/Rural, Medium/Suburban, or High/Urban. The associated segment distance is then placed in the appropriate class and WebTRAGIS proceeds to move down the link from the starting node to the end node. As can be seen in Fig. D.12, as WebTRAGIS moves down the link to the next segment center point, the segment distance and the buffered population cells change, resulting in new density values being calculated.

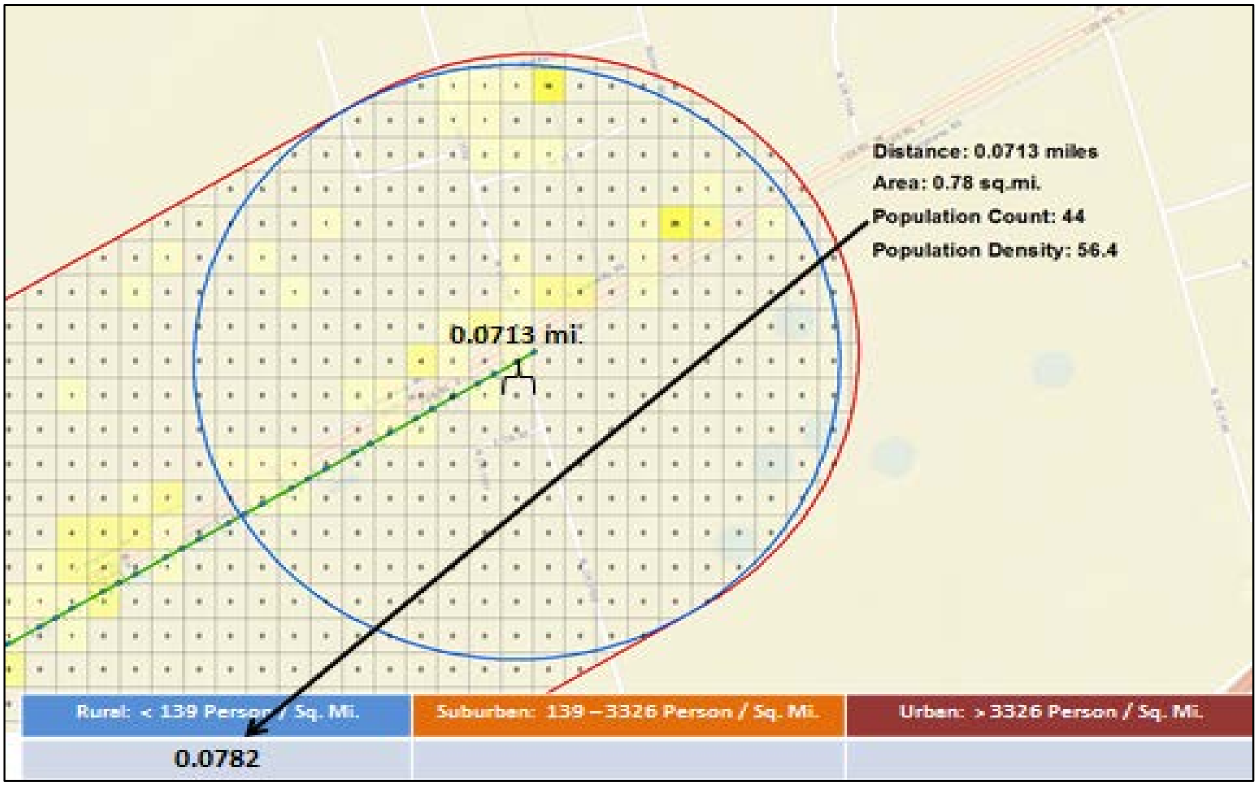

Figure D.4 New buffer and population density calculation

Figure D.5 Fully buffered link

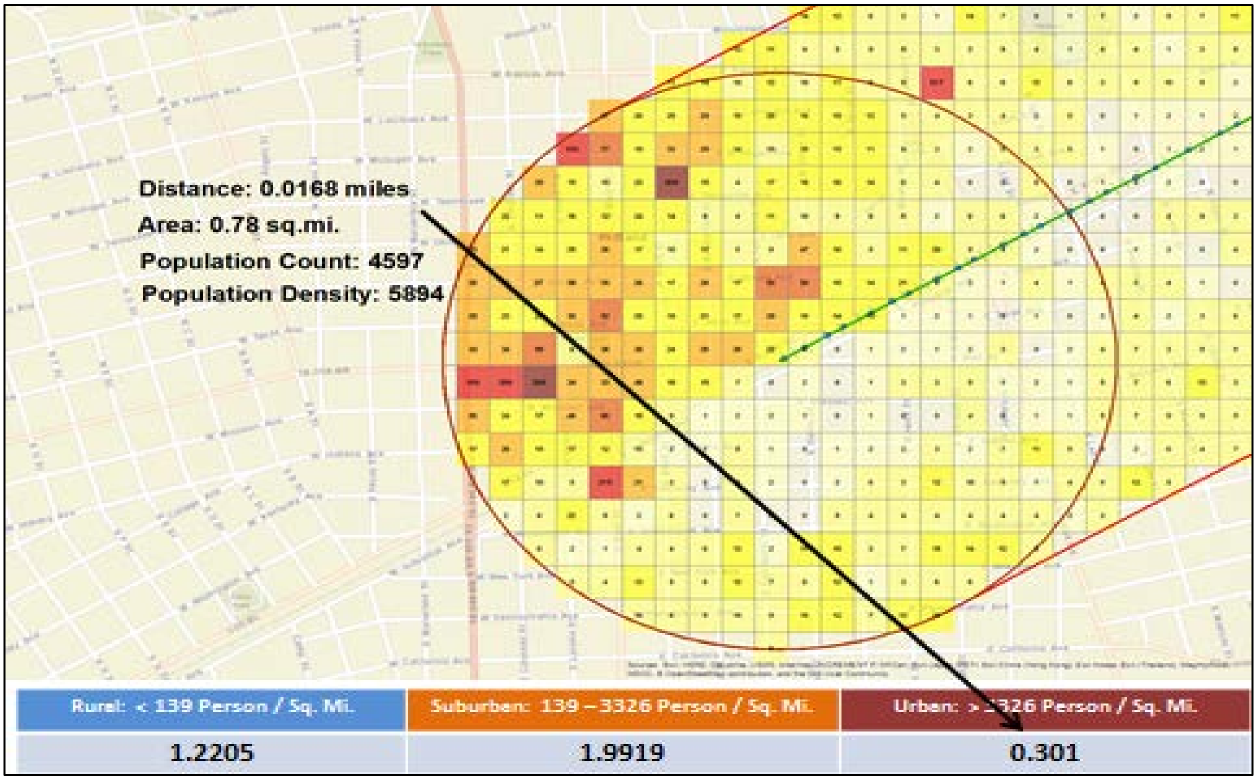

Figure D.6 Final population buffer and associated density classification

Figure D.13 illustrates the complete number of buffers used to calculate population densities and distance values. The final node buffer and density calculation is shown in Fig. D.14. The values in the density columns sum to the total link distance; 1.2205 + 1.9919 + 0.301 = 3.5134 miles.

By using the higher resolution 3-arc second population data available in LandScan, WebTRAGIS is able to more accurately profile the population count and density variations that may exist along any given network link. This allows for more accurate estimations of population impacts arising from the shipment of high-level radioactive waste such as population dose risk estimates calculated using the RADTRAN system.

Figures D. 15 – D.21 provide an extended illustration of population densities calculations can vary over long distances and with links that are not perfectly straight, as was the case with the rail network example above. In these figures, a section of the highway network between Farragut and Maryville, Tennessee is examined as part of a route from the Watts Bar nuclear plant to a location in Charlotte, North Carolina as seen above in Fig. D.2. Fig. D.15 shows link 47000015825 and its 800 meter buffer, while Fig. D.16 shows the link along with the LandScan population cell grid overlaid on top.

Once the population grid cells to be included are determined, WebTRAGIS will then segment the link using the LandScan population grid and determine the associated center points as show in Fig. D.17. Once the center points are determined, each point is then buffered at 800 meters as is shown in Fig. D. 18. At this point, WebTRAGIS determines the population counts for each buffer, calculates the population density and then classifies the link segment as Low/Rural, Medium/Suburban, or High/Urban. This is shown in Figures. D.19 and D.20 where the Low segments are green, Medium segments are purple, and High segments are blue. As can be seen in these figures, the Low, Medium and High segments may often be discontinuous along the same link. This reality underscores the value of using high-resolution population data when classifying link population densities for input into risk calculation programs.

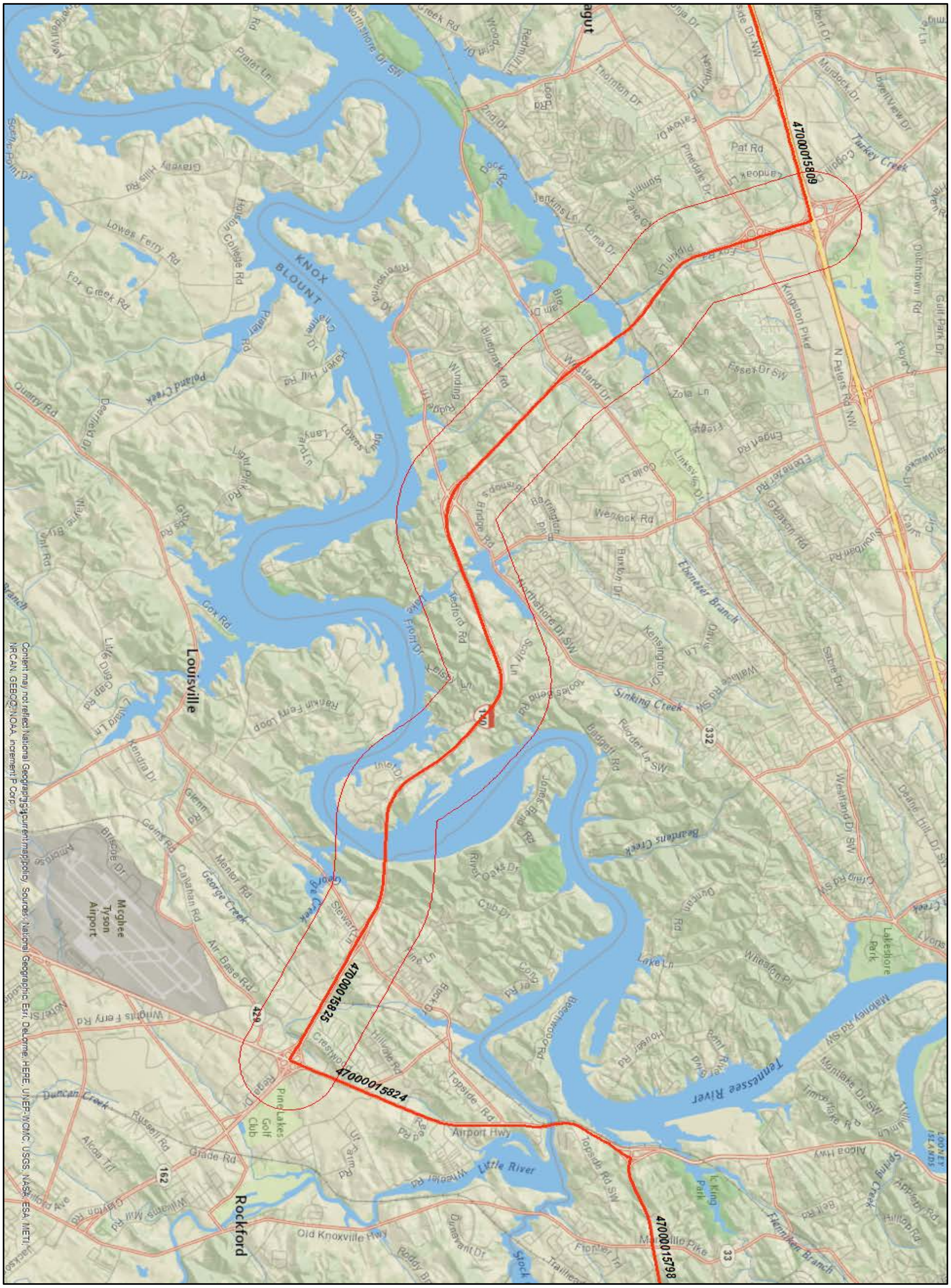

Figure D.7 Highway route detail

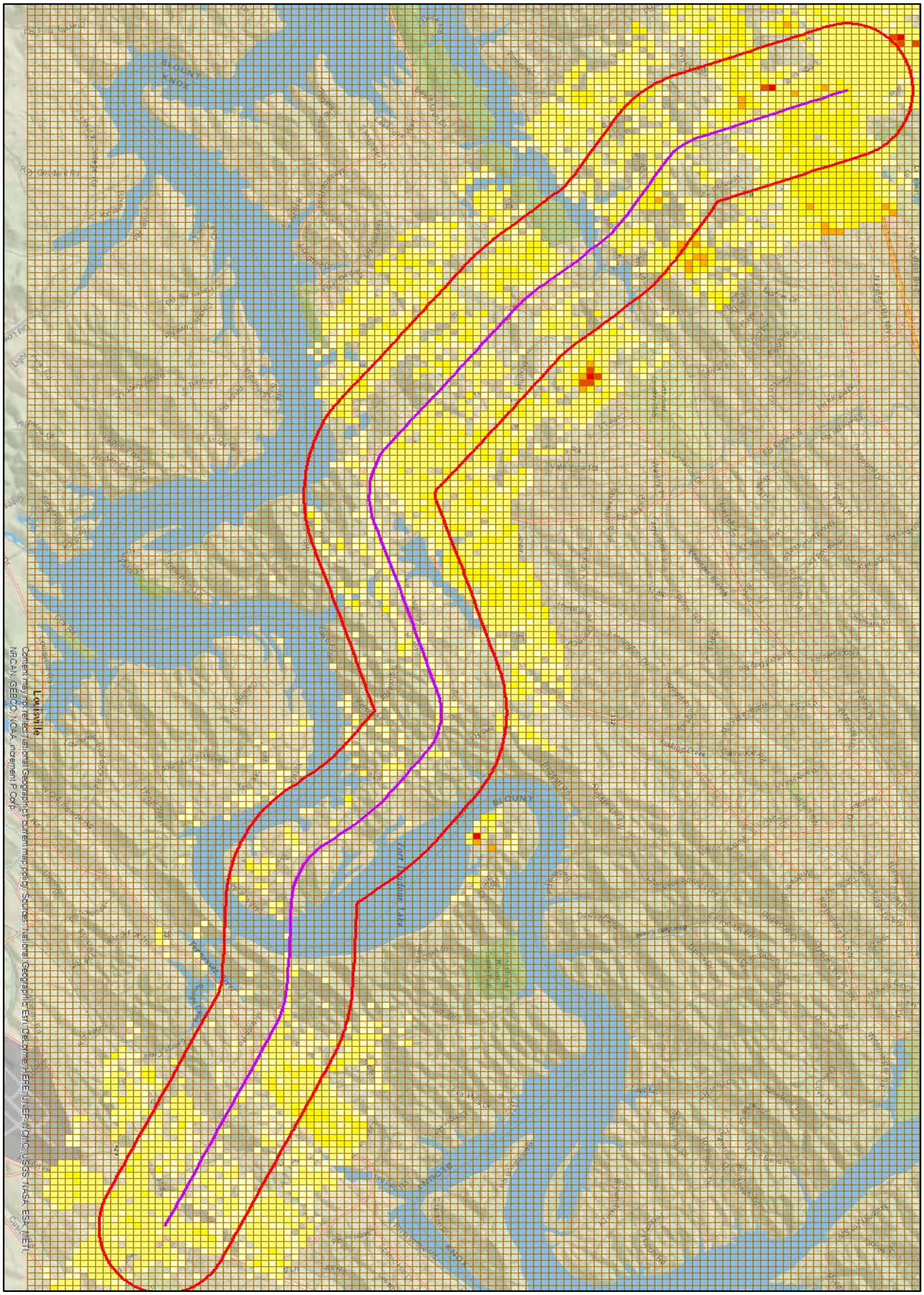

Figure D.8 Link 47000015825 with LandScan population grid

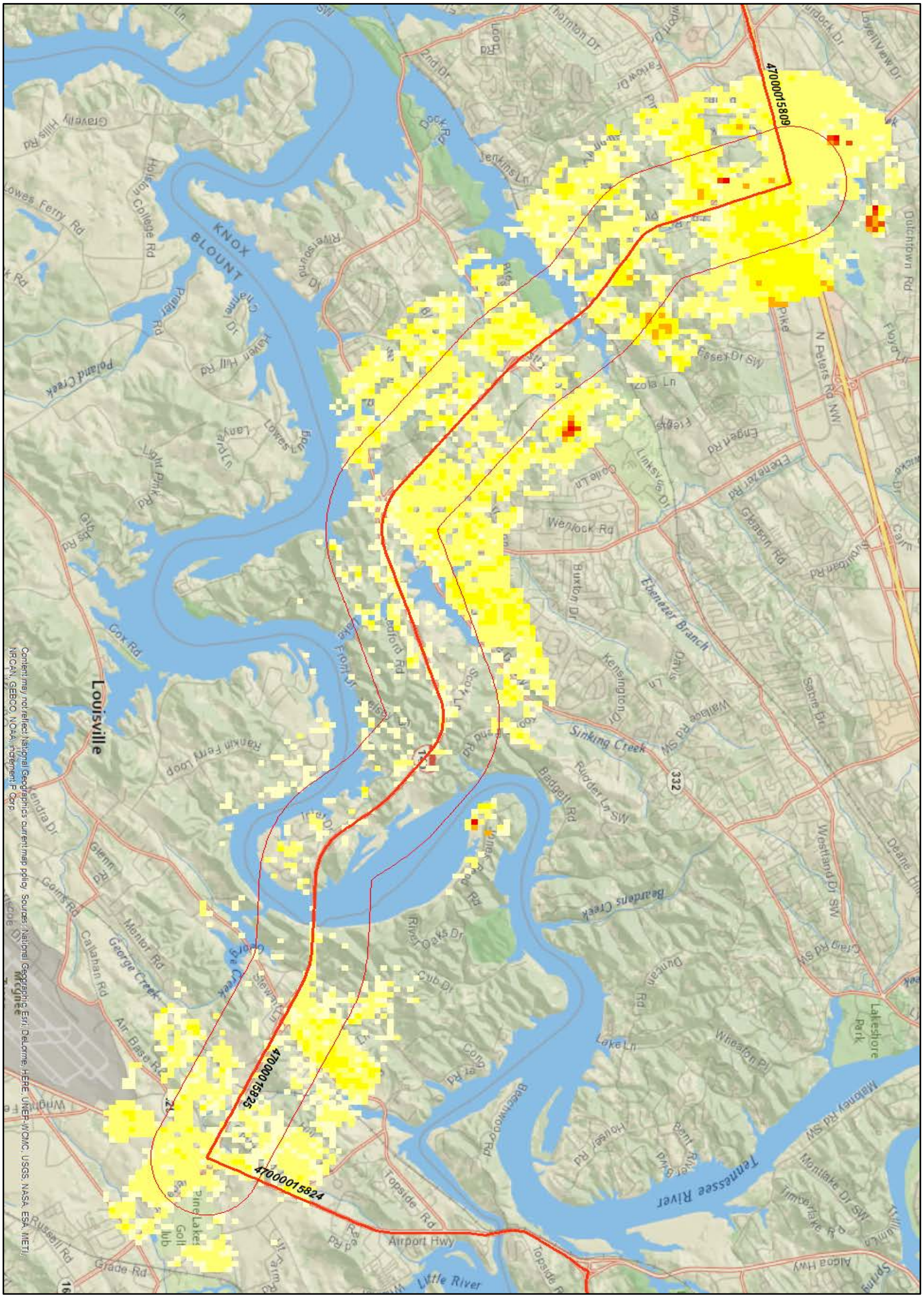

Figure D.9 Link 47000015825 with population buffer

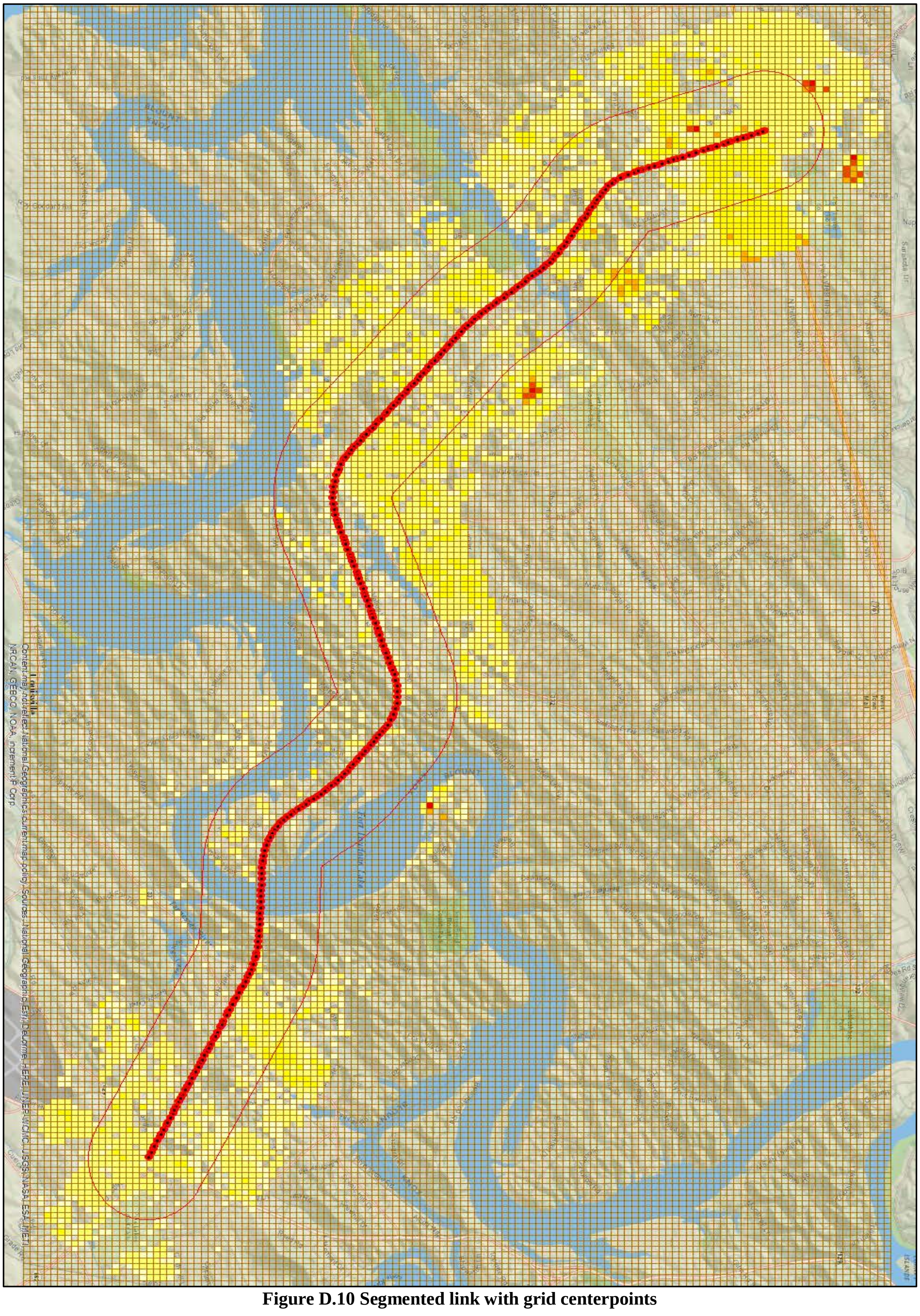

Figure D.10 Segmented link with grid centerpoints

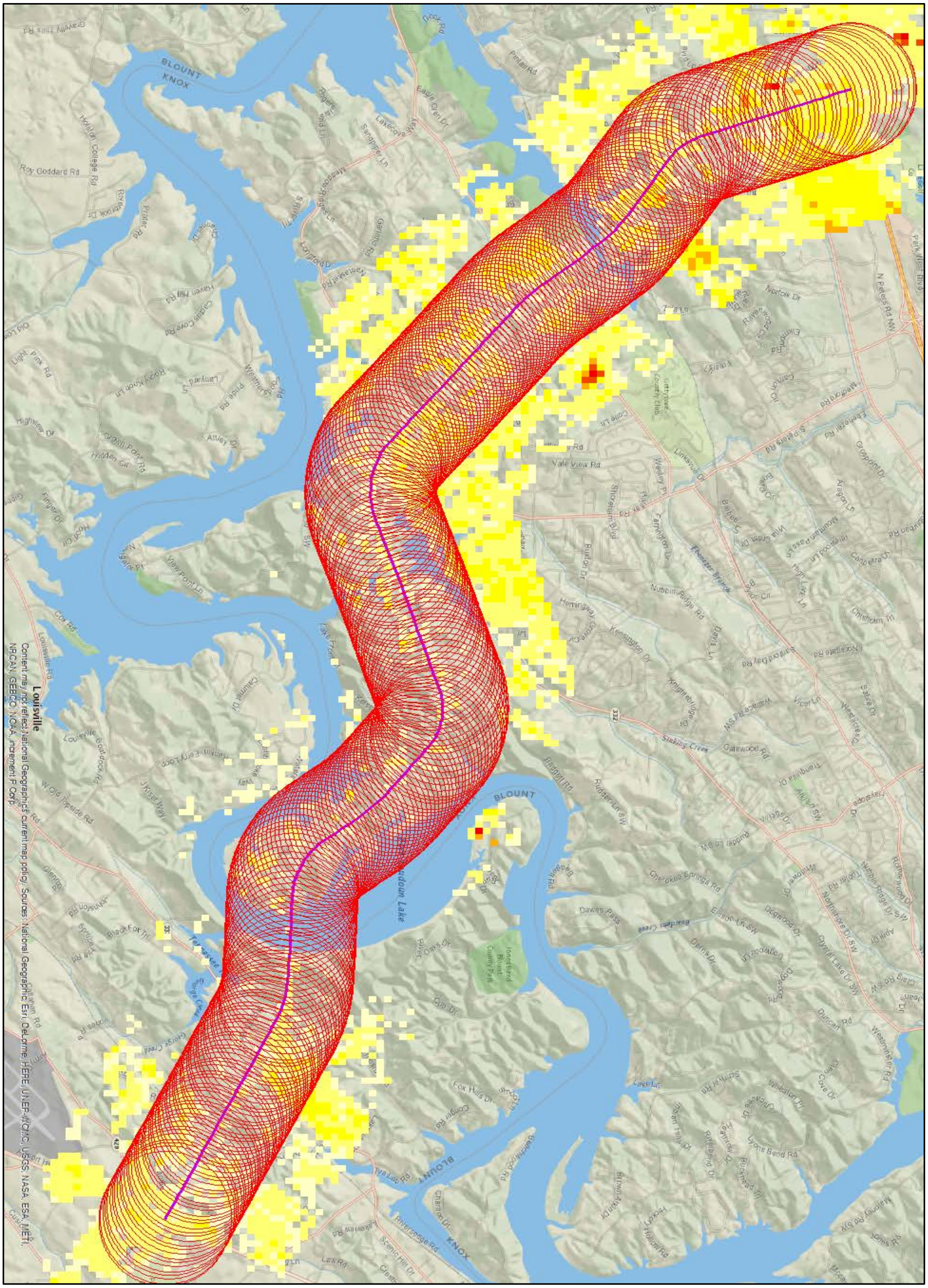

Figure D.11 Buffered center points

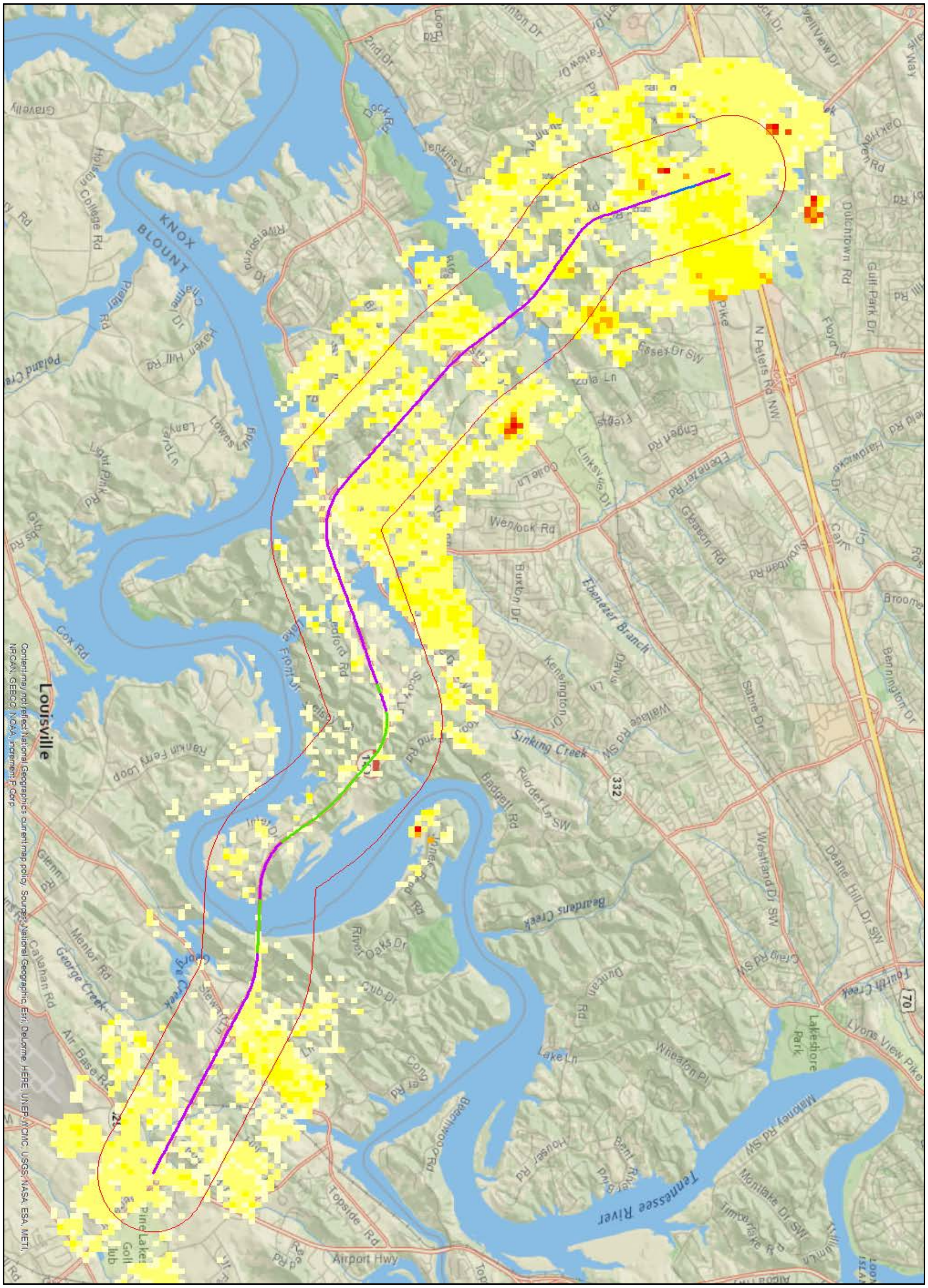

Figure D.12 Classified link segments with population

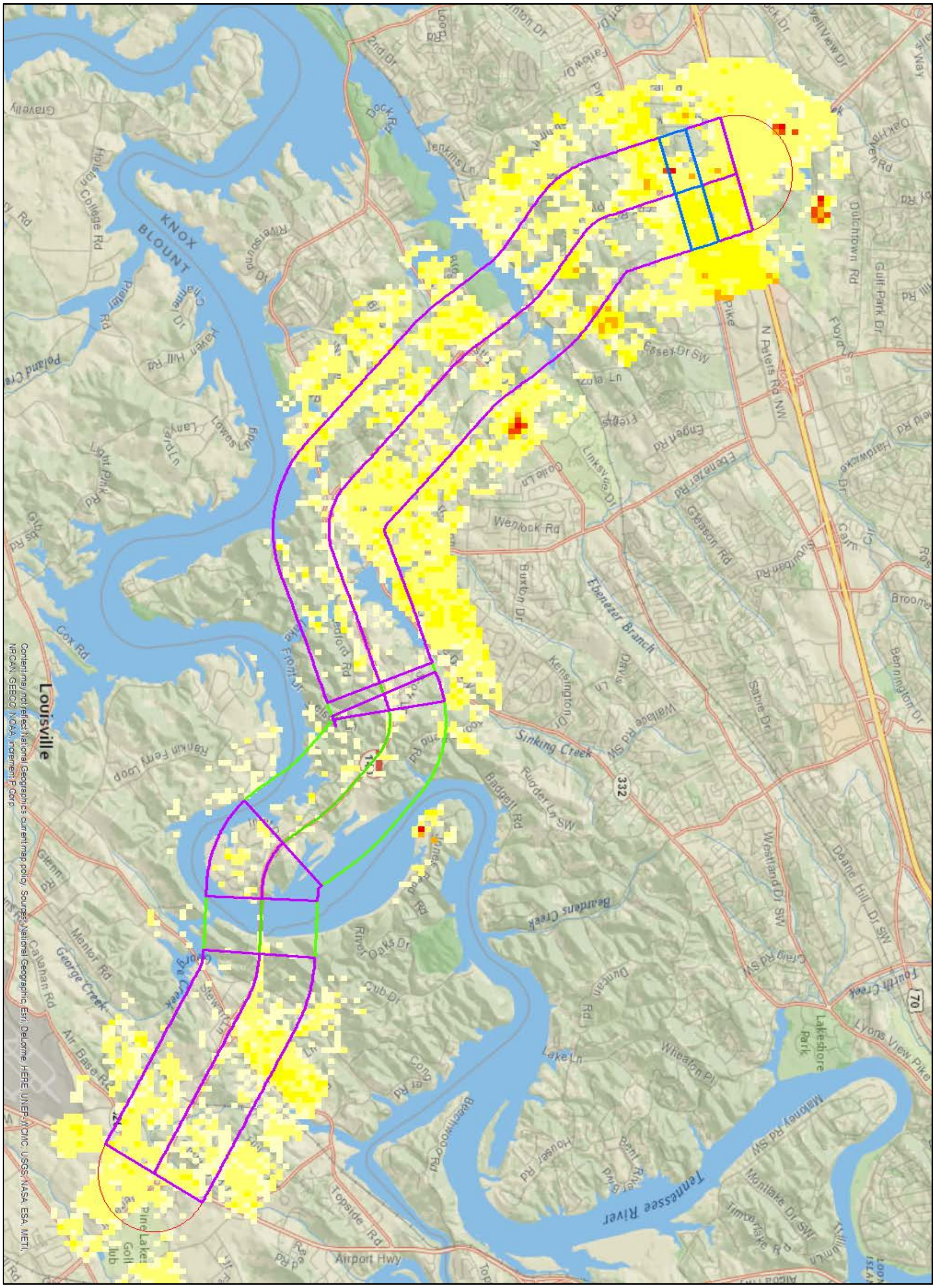

Figure D.13 Link segment with population showing density classification variations

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