Oak Ridge Environmental Information System (OREIS): Formalizing the Shapes of Things on the Oak Ridge Reservation – 15393

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ABSTRACT

As representations of object and area boundaries on Earth's surface, shapes are important components of geographic information system platforms.   The US Department of Energy Office of Environmental Management in Oak Ridge, Tennessee recognizes the importance of shapes as boundary representations and has mandated the Oak Ridge Environmental Information System as the official repository of all geographic information system shapes related to CERCLA cleanup on the Oak Ridge Reservation.

INTRODUCTION

The Oak Ridge Environmental Information System (OREIS) was initiated by the U.S. Department of Energy (DOE) Oak Ridge Operations Office in 1991 to fulfill the Federal Facility Agreement (FFA) [1] requirement for storing environmental characterization and monitoring data related to cleanup of the Oak Ridge Reservation (ORR), which includes the East Tennessee Technology Park (ETTP), Oak Ridge National Laboratory (ORNL), the Y-12 National Security Complex (Y-12 NSC), and surrounding areas that are within the Oak Ridge National Priorities List (NPL) site. Clean-up activities are being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

OREIS is the repository for current, future, and legacy environmental characterization, monitoring, and remediation information. The system is used to capture and maintain geographic information system (GIS) and environmental sampling data which includes chemical, biological, ecological, radiological, and geophysical information.   OREIS is the central location for stakeholders (public, corporations, and regulatory parties) to access verified and validated environmental measurement, monitoring, and spatial data across the entire ORR.

With ETTP Zone 1 nearing a final Record of Decision (ROD), DOE has been taking steps to make OREIS an intuitive system to the future user who will be interested in DOE's clean up legacy of the ORR [2].   A recent focus of DOE's enhancements of OREIS has been on the formalization of shapes in the GIS component of OREIS.   Shapes are an important component of any GIS platform because they represent boundaries of areas of interest on earth's surface and the association of data with shapes is the essence of GIS.   Much of the user's interaction with a GIS platform is through shapes because shapes define the map boundaries for the areas of interest that the user wants to obtain data about.   The shapes themselves also inherently contain information in that the shapes tell the user something about the map area represented by the shape.   For example, political boundaries, roads, businesses, dwellings, and many more are represented on maps as shapes.   Shapes in a GIS platform are contained in files called shape files.

SOME EXAMPLES OF SHAPES IN OREIS

Shapes in OREIS, as in most GIS platforms, come in many sizes and, of course, shapes. The smallest and least complex shapes are those that represent sample locations. The largest and most complex shape is the shape that represents the ORR boundaries. In between is an assortment of shapes that represent, to name a few, boundaries of buildings (standing, demolished with slabs in place, demolished with slabs removed), areas addressed by RODs on the ORR, remediated areas, exposure units, and of course, roads, other infrastructure, and water bodies. For example, Figure 1 is a screen shot of the OREIS Spatial Query Tool (SQT) which is the front-end GIS user interface for OREIS. In the upper right hand corner of the SQT in Figure 1 is the map layer list with which users select the map layers, i.e., the shape files, to display. The map shown on Figure 1 represents a portion of ETTP. Some important shapes displayed on Figure 1 include sample locations (blue dots), exposure unit boundaries (solid line polygons), buildings that are standing (dark gray shapes), buildings that have been demolished to slab (light gray shapes), buildings and slabs that have been demolished (dashed line polygons), ETTP Zone 1 (dark green-colored shape), and ETTP Zone 2 (light green-colored shape).
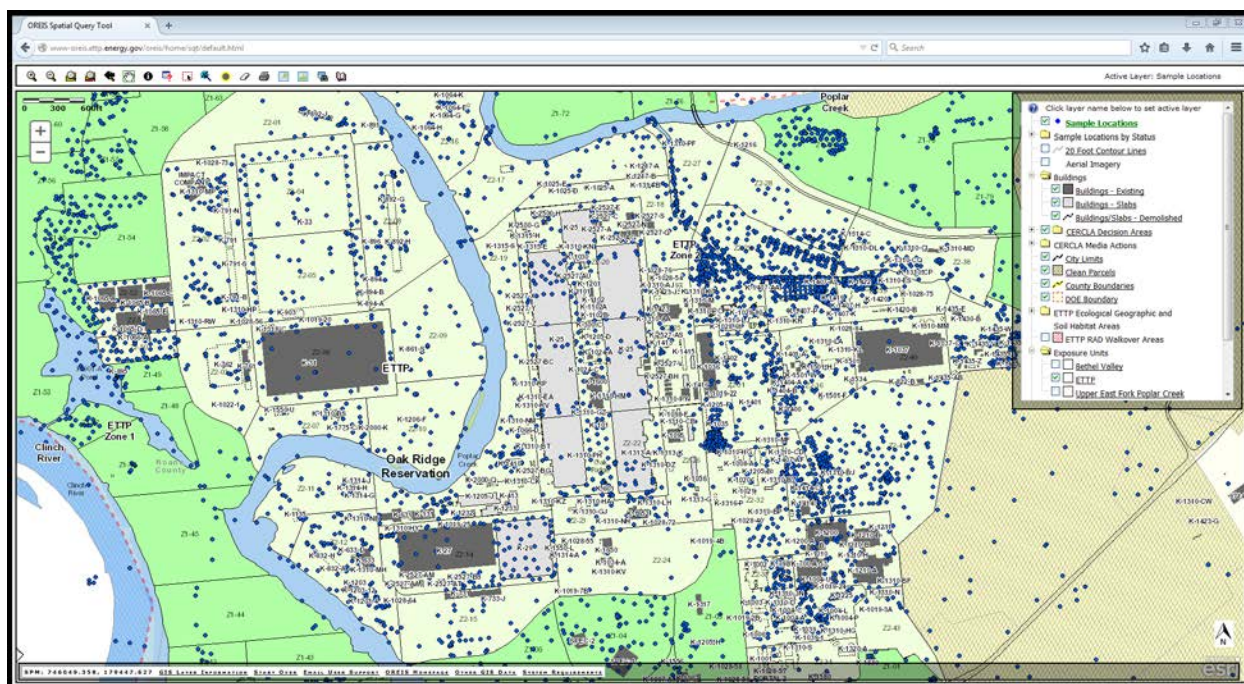

Figure1. Screen shot of the OREIS Spatial Query Tool showing some important shapes on a map portraying a portion of ETTP; the map layer list, which is used to turn shapes on and off is shown in the upper right.

Two important types of shapes for evaluating NPL sites are those representing the boundaries of areas over which decisions are made under CERCLA and those representing the sample locations from which data were collected to evaluate the areas of decision-making. For example, the area of decision-making at ETTP is the exposure unit. When exposure unit data are downloaded from OREIS, for example to evaluate an exposure unit under CERCLA, inaccuracies in exposure unit and/or sample location shapes can lead to inaccurate assignments of sample locations to exposure units resulting in inaccurate evaluation of the exposure unit.

THE SHAPE FILE DIRECTIVE

Certain areas of the ORR are nearing their close out in the CERCLA process.   A final ROD is under development for Zone 1 at ETTP and some unimpacted areas of the reservation are being removed from the NPL.   These recent developments have highlighted the need to formalize boundaries on the reservation and to control boundary record keeping.

A problem occurred during development of the ETTP Zone 1 Final Remedial Investigation/Feasibility Study (RI/FS) when shape files obtained from a DOE contractor did not accurately represent the area intended.   An ecological risk assessment conducted to support the Zone 1 Final RI/FS built on a previous ETTP baseline ecological risk assessment (BERA) by combining new data that had been collected since the BERA had been developed with data that had originally been included in the BERA.   The Final Zone 1 RI/FS also followed the BERA in using ecological area subdivisions of ETTP that had been developed for the BERA.   The shape files for the ETTP ecological areas were obtained from a separate contractor and when the files were imported into OREIS the shapes for some of the ecological areas included sample locations that were outside of the area boundaries in the BERA.   The problem is demonstrated in Figure 2. The area enclosed by the red line on Figure 2 is from the contractor's shape file for ecological areas in ETTP Zone 1.   The brown dots on Figure 2 are from sample location shape files in OREIS.   Several of the sample locations that fall inside the ecological area shape had existed at the time that the BERA was conducted but were assigned by the BERA to an ecological area adjacent to the one shown on Figure 2, i.e., the BERA did not include the data from those locations when assessing the ecological risk in the area shown on Figure 2.   The discrepancy forced a review of the ecological area shapes and the sample locations contained within those shapes resulting in several ecological area boundary revisions.

The lack of a single official shape file source had resulted in inconsistencies, and conclusion uncertainties, as well as additional, unnecessary costs to re-evaluate and back-fit the shape files.   As a result, DOE has decided to determine with a high degree of accuracy all boundaries on the ORR, including the ORR boundaries themselves, and to make OREIS the official repository of those boundary shape files.

In June 2014, the DOE issued the "Shape File Directive".   In it was mandated that OREIS be "the official repository and source for geographic shape files used in risk assessment decisions and post-remediation monitoring activities under CERCLA regulations."   The stated purpose of this directive was to ensure that all activities conducted on the ORR under CERCLA use shape files that are "precise, accurate, and consistent."   In practical terms, the Shape File Directive means that DOE contractors are required to obtain existing shape files from OREIS each time a project requiring shape information is under way and OREIS is to be updated with new shape files when they are developed during a project.
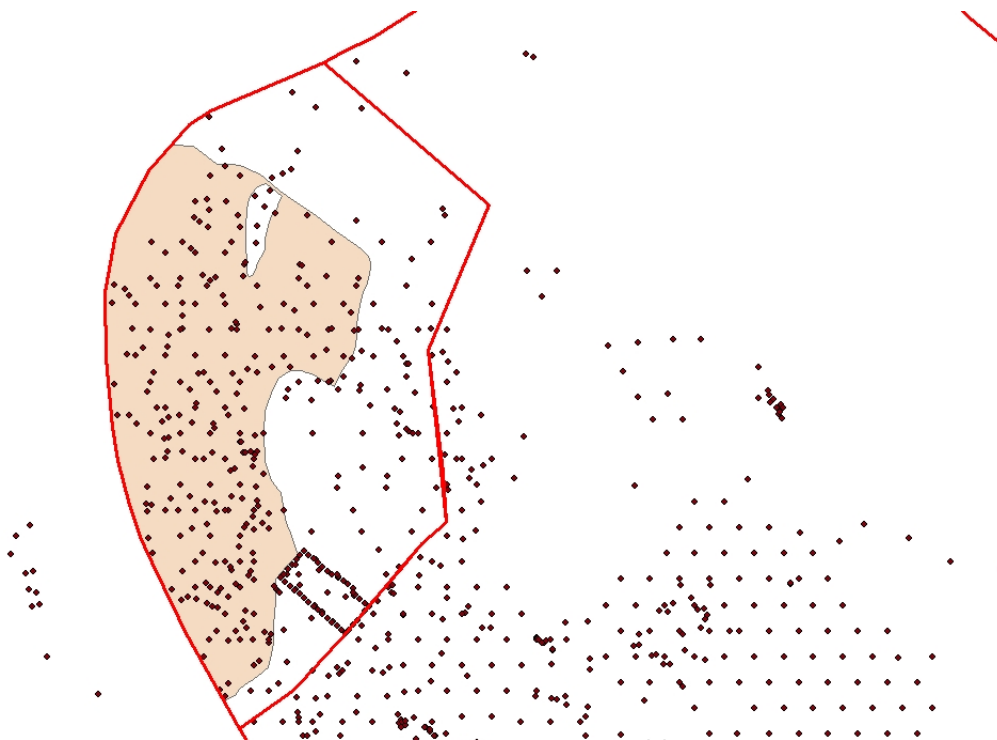
Figure 2. Comparison of two different shape files that represent the same ecological habitat area at ETTP. The area in brown is now the official DOE habitat shape file in OREIS, the shape file for the area enclosed by the red line was obtained from a contractor. The brown dots represent sample locations.

WHY GO BACK TO OREIS EACH TIME YOU WANT TO USE THE SAME SHAPE FILE?

A common question that arises when the requirements of the shape file directive are explained to DOE contractor personnel is, "After downloading a shape file from OREIS for one project, why is it necessary to download the same shape file for subsequent projects?"

- From an internal quality assurance perspective, DOE cannot monitor the accuracy of each of its contractors' GIS platforms. Instead, DOE oversees and is directly involved in the maintenance of the OREIS database and GIS platform thereby ensuring quality and consistency among all of its contractors by mandating that shape files be obtained from OREIS each time a shape is used or presented during a scope of work for DOE.
- Shapes change and referring to OREIS each time shapes are used is necessary in order to ensure that all of its contractors use the most current shapes. There are several reasons why shapes might change. One is that an existing shape may be found to be inaccurate and the shape would then be changed in OREIS to be an accurate representation of the feature that the shape is supposed to represent. Shapes also change as the ORR progresses through the CERCLA process. For example, the boundaries of three exposure units in Zone 2 of the East Tennessee Technology Park were recently changed to accommodate the creation of a National Historic Preservation Site.
- New shapes are added and shapes are removed or modified as remedial actions are conducted. As a result, in order to have the most accurate map representation of an area of interest, it is necessary to pull in new shapes from the OREIS repository.

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- Manipulation of shape files can cause discrepancies between the contractor's shape files and the official shape files in OREIS. For example, conversion of coordinate systems from OREIS's state plane meters system to the contractor GIS platform's coordinate system can create discrepancies between the contractor's system and OREIS and small discrepancies can add up over time.

REFERENCES

1. *Federal Facility Agreement for the Oak Ridge Reservation*, DOE/OR-1014, U.S. Department of Energy, U.S. Environmental Protection Agency-Region IV, Tennessee Department of Environment and Conservation, January 1, 1992.

2. *Oak Ridge Environmental Information System (OREIS) Enhancements*, Proceedings of the WM2013 Conference, February 24 - 28, 2013.