Making Better Maps with ArcGIS 9.2

Using cartographic representations

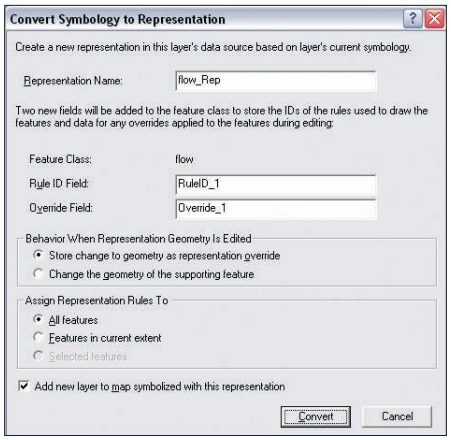
By Rhonda M. Glennon, ESRI, and J. Alan Glennon, University of California, Santa Barbara

In the mapmaking process, a cartographer has the freedom to choose the content, colors, symbols, scale, and position of spatial features to convey meaning and communicate the map's purpose. Traditionally, the rigid locations and formalities of a digital spatial database have limited flexibility in creating a map that matches the cartographer's vision.

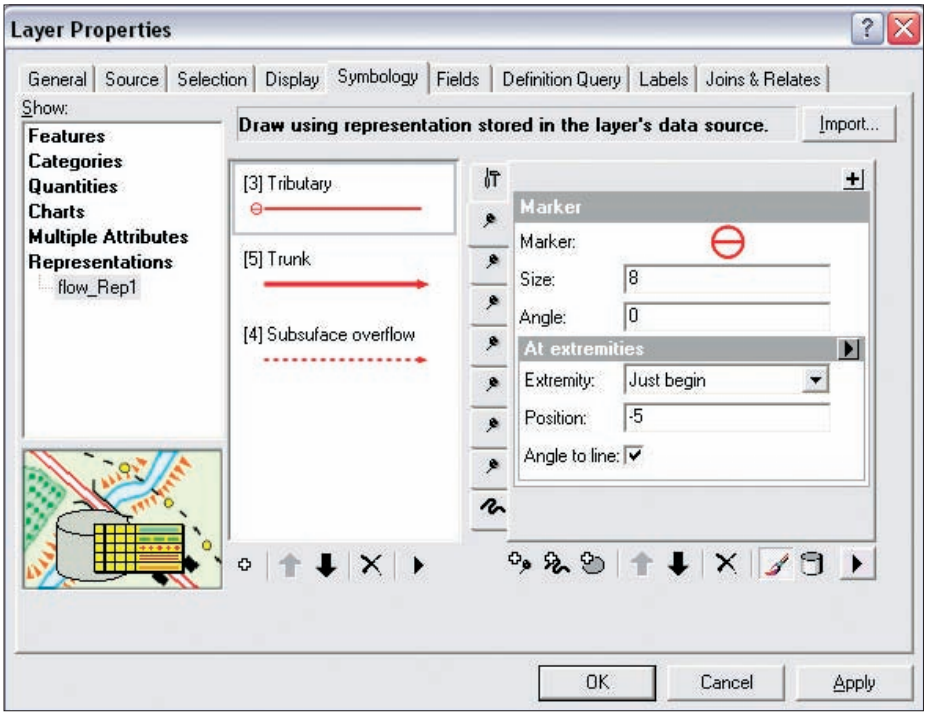
Functionality in ArcGIS 9.2 has begun removing these constraints. Cartographic representations allow control over how and where features in a spatial database will be depicted on a map. Because cartographic conventions can now be more easily implemented within GIS, there is less need for additional graphics software to produce the final map.

Kentucky's Mammoth Cave Watershed drains the world's longest cave. This article uses data for the Mammoth Cave Watershed to create a map employing cartographic representation functionality. Using GIS to map karst systems traditionally has been a difficult task because the locations of karst landforms are often inferred or approximated, so cartographic techniques require increased control over the placement of map features and the ability to make cartographic edits.

For instance, a mapped surface stream may drain into a sinkhole. From that point, the stream's exact path through the subsurface often remains uncertain until it reaches a surface outlet spring. The unmapped path is stored as a straight line in the database, but cartographically denoted either as a straight, dashed line from the input to output locations or as a dashed curve that accounts for known influences on the subsurface flow regime.



Converting a layer's current symbology creates representation rules.



In this example, representation rules are used to symbolize categories of groundwater flow routes. The right side of the Symbology tab shows the symbol layers and geometric effects that make up the rule selected in the list.

The new tools in ArcGIS 9.2 provide the flexibility to represent cases like these without creating additional datasets for cartographic purposes. While this article describes the specific application of cartographic representations to karst systems, it also provides a general overview of this functionality.

What Are Cartographic Representations?

ArcGIS 9.2 introduced cartographic representations (or simply representations), which provide a new way of categorizing and displaying data based on rules that define the appearance of map features. Representations allow edits to be made to an individual feature symbol on a map without changing the actual shape or position of that feature in the database.

As representations, features are drawn based on the symbols and properties specified for a particular representation rule. Rules are fundamentally made of one or more symbol layers: strokes that draw lines or polygon outlines; markers that draw points, features along a line, or locations inside a polygon; and fills that draw polygons as a solid or with a pattern. Different symbol layers can be combined in the same rule. For example, a rule defining both a stroke and a marker could be used to symbolize a line with an arrowhead. Geometric effects can be added to further alter symbol appearance by dashing or offsetting a line or even drawing a feature as a different type of geometry—for example, depicting a point feature as a polygon.

Representation information is stored in system tables of an ArcGIS 9.2 geodatabase and referenced by additional fields in the feature class attribute table. Representation rules can be created from scratch or from a layer's current symbology by right-clicking it in the ArcMap table of contents and clicking Convert Symbology to Representation. Rules can be built and edited in ArcMap on the

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Symbology tab of the Layer Properties dialog box or in ArcCatalog (because a representation is a property of a feature class). Although ArcView users can view representations, an ArcInfo or ArcEditor license is required to create or edit representations.

Making the Karst Map with Representations

Creating the karst map involved a series of steps.

- Symbolizing the data
- Building representation rules
- Editing the representations on the map

Once the data was added to the map, the layers were symbolized using the standard methods and symbols available in ArcMap. Then the symbology was converted to representations that translated the symbology into representation rules and symbols. For example, a layer symbolized as 10 categories using unique values became 10 separate representation rules—one rule for each category.

Although these representation rules were created from existing symbology, they required thoughtful consideration and some modifications to ensure they were appropriate and the results were aesthetically pleasing. Because representation markers are more flexible and sophisticated than standard markers, additional representation marker symbols were developed and integrated into the representation rules. Markers were typically used in rules containing a stroke symbol layer with properties specifying that the marker be placed at the endpoints of a line. Because the marker symbols are associated with a line, the markers followed automatically when a line was moved. This avoided the extra step of repositioning markers when the line was edited.

Some rules used geometric effects to improve the quality of the symbology and achieve certain cartographic results. For example, the Smooth Curve geometric effect was added to strokes to reduce jagged edges in lines, and the Dashes geometric effect on strokes created a dashed line. The Add Control Point geometric effect helped maintain corners on dashed lines by dictating that the middle of a dash should be present where lines change direction.

Once the representation rules were in place, the edits to move, reshape, or even hide certain map features were performed using the tools on the Representation toolbar. These actions were cartographic in nature and did not actually delete features or alter their positions in the core database. Overlaps among symbols and other quality issues were discovered by using the Detect Graphic Conflict geoprocessing tool (this tool is available only with an ArcInfo license). Where symbols were too close together at this scale, the symbols were resized or separated from each other.

In addition, representations have an invisibility property that allows individual features to be hidden without deleting them from the database. For example, the extent of one of the layers was larger than the study area, so the extraneous features were made invisible on the map but not deleted from the database. Making features invisible resulted in an override because the features' symbology was edited to draw differently (i.e., be hidden) from the symbology dictated by the representation rule.

The Benefits of Using Representations

When representations are used, rules can be defined and symbols manipulated to improve the map's clarity. Representations facilitated cartographic refinement that may not have been possible with standard symbology. For example, only changes to color, angle, size, and other basic properties can be performed on traditional marker symbols, whereas representation markers enabled edits to many more advanced options, such as symbol shape, position, and visibility. Because each component of a symbol, such as an individual dash, can be manipulated, it was not necessary to export the GIS data to a graphics package to complete the map.

Representations also simplified data management because they eliminated the need to create and maintain redundant copies of data for cartographic purposes. For example, symbolizing polygon outlines with dashes traditionally has been problematic because dashes may overlap where polygons share borders. In fact, cartographers have resorted to converting polygons to lines to work with just the outline. In this example, representations were used to produce clear dashed polygon outlines. In addition, multiple representations could be associated with a single feature class, so the same data could be portrayed uniquely on different map products and at different scales.

The map shows just a few examples of representations at work. There are many more uses

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Term	Meaning
Cartographic representation	Extra information added to a feature or feature class that defines rules for display on a map. Representations store symbology with the features in the geodatabase and allow editing of the appearance of individual features on maps.
Representation rule	The combination of symbology and geometric effects that define the appearance of features sharing a common representation rule.
Stroke	Type of symbol layer used to symbolize line geometry and polygon outlines.
Marker	Type of symbol layer used to symbolize points or significant locations in line or polygon representations.
Fill	Type of symbol layer used to symbolize polygon geometry.
Geometric effect	A dynamic process that alters the geometry of features as they are drawn on the map without affecting their underlying shape or spatial relationships. Geometric effects can act on a single symbol layer or on all symbol layers in a representation rule and can be chained together to create cumulative effects.
Override	An exception made to a property of a feature's representation rule so the feature is drawn differently than others sharing the same rule. These changes are stored in the attribute table's Override field.

New terminology for cartographic representations

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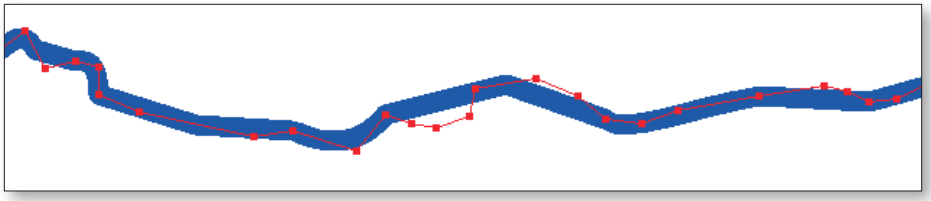
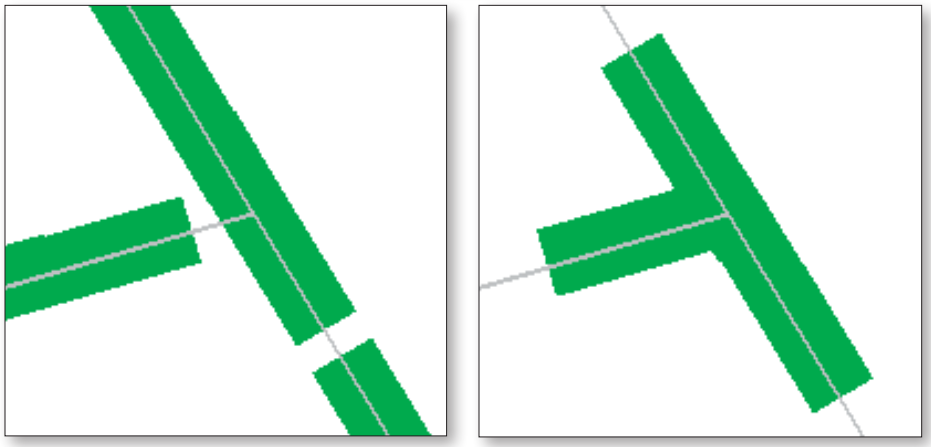
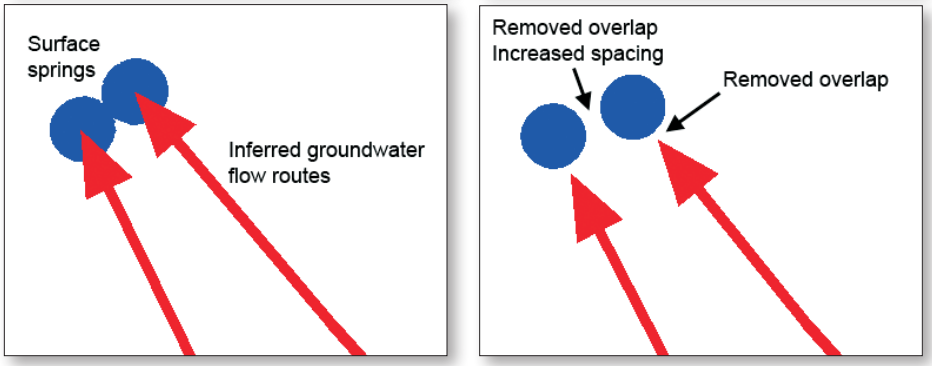


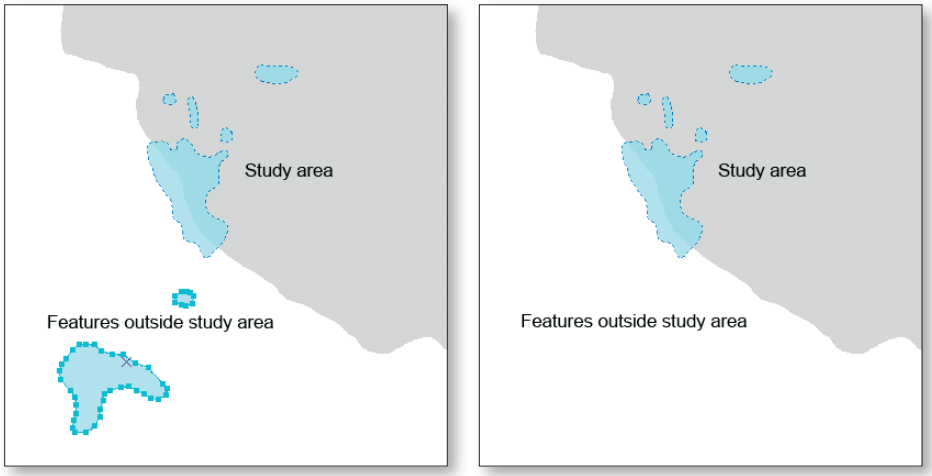
Applying the Smooth Curve geometric effect causes the original red line (with its vertices as stored in the geodatabase) to be displayed as the thick blue smoothed line.



The left graphic shows the default rendering of dashed outlines around adjacent polygons that often results in unclear corners, unequal spacing, or overlapping symbols. A representation shown in the right graphic allows for more precise placement of dash symbols.



The default placement of the symbols at the map's scale caused an undesirable overlap of the blue circles (representing springs) and the red arrowheads (representing inferred groundwater flow routes) as shown on the left graphic. The symbols are shown in the right graphic after they were repositioned and offset.



The selected water features, highlighted in cyan (as shown in the graphic to the left), were outside the study area, shown here in gray, so their representations were made invisible (as shown in the graphic to the right).

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and functionalities available with representations. For additional information, examples, and tutorials, see the "Cartographic representations" section in the ArcGIS Desktop 9.2 Help, available from the Help menu or online at webhelp.esri.com.

Acknowledgments
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References

Ray, J. A. 2001. "Spatial Interpretation of Karst Drainage Basins." In *Geotechnical and Environmental Applications of Karst Hydrology*, B. F. Beck and J. G. Herring, eds. Lisse: Swets & Zeitlinger, 235–244.

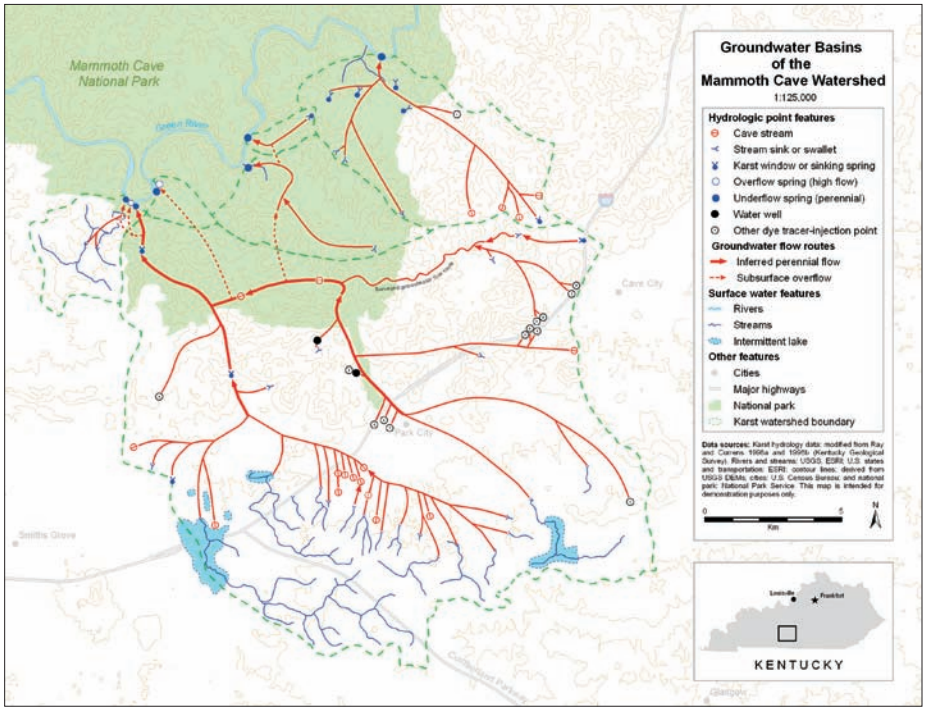
Ray, J. A., and J. C. Currens, 1998a. "Mapped Karst Ground-Water Basins in the Beaver Dam 30 x 60 Minute Quadrangle, Scale 1:100,000." *Kentucky Geological Survey Map and Chart Series 11 (19)*. Lexington, Kentucky: Kentucky Geological Survey.

Ray, J. A., and J. C. Currens, 1998b. "Mapped Karst Ground-Water Basins in the Campbellsville 30 x 60 Minute Quadrangle, Scale 1:100,000." *Kentucky Geological Survey Map and Chart Series 11 (17)*. Lexington, Kentucky: Kentucky Geological Survey.

Data Credits
Karst hydrology data was modified from Ray and Currens 1998a and 1998b (copyright, Kentucky Geological Survey). Symbology information was gathered from Ray 2001. Other data included rivers and streams from the U.S. Geological Survey (USGS) and ESRI, U.S. states and transportation from ESRI, cities from the U.S. Census Bureau, and national park boundaries from the National Park Service. Contour lines were derived from USGS digital elevation models.

About the Authors

Rhonda M. Glennon is a product engineer in the software development department at ESRI in Redlands, California. She has a master's degree in geoscience from Western Kentucky University and a bachelor's degree in political science. ***J. Alan Glennon*** is a doctoral student in geography at the University of California, Santa Barbara. He received his bachelor's degree in park administration from Texas A&M University and a master's degree in geoscience from Western Kentucky University.



The final map product, created entirely using ArcMap, takes advantage of the flexibility of cartographic representations.