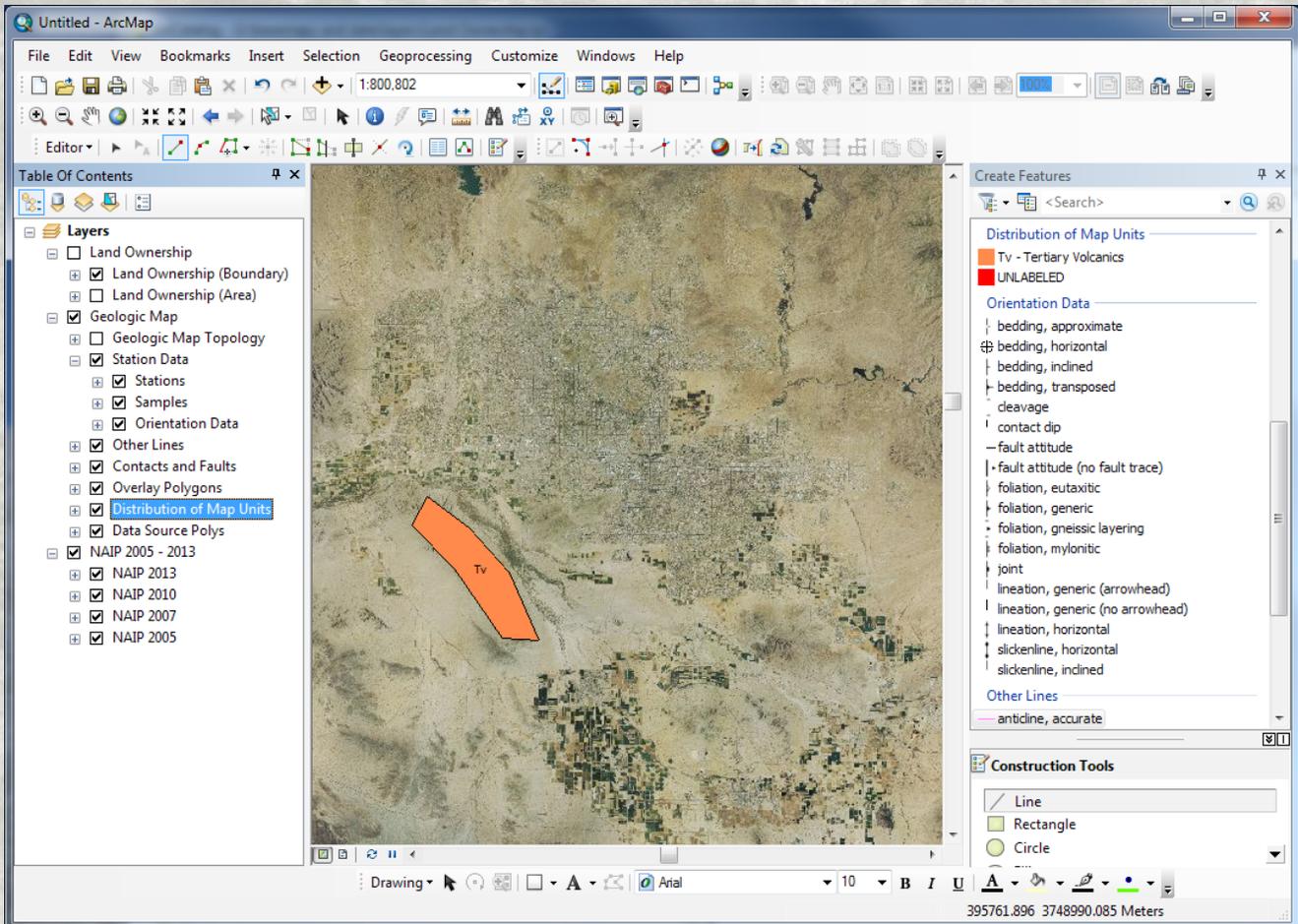


# THE AZGS GEOLOGIC MAP TOOLBAR FOR CREATING GEOLOGIC MAP DATA USING THE NCGMP09 DATABASE AND ESRI ARCMAP

Ryan C. Clark, Janel Day and Stephen M. Richard  
Arizona Geological Survey

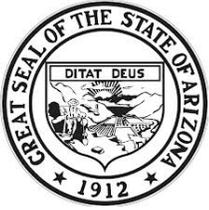


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# Arizona Geological Survey

M. Lee Allison, State Geologist and Director

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# The AZGS geologic map toolbar for creating geologic map data using the NCGMP09 database and ESRI ArcMap

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## Introduction

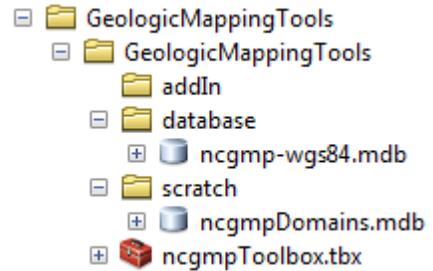
This report documents the design framework and purpose of a set of tools developed by the Arizona Geological Survey (AZGS) for use in geologic map production using the NCGMP09 database schema and ESRI ArcGIS software. Since the year 2000, the Arizona Geological Survey (AZGS) has published 103 geologic maps in digital format under the U.S. Geological Survey's National Cooperative Geologic Mapping Program (USGS NCGMP). These digital maps are published as Adobe Acrobat documents, and the data are maintained at the AZGS in GIS databases. The AZGS uses ESRI ArcGIS software for the production and management of geologic map data, starting with PC-ArcInfo in 1994, through an evolution of several database designs (Richard and Thieme, 1997; Richard and Orr, 2001; Richard, 2003; Richard et al., 2004; Richard et al., 2005). One of the earliest adopters of ArcGIS, the AZGS has been using ArcGIS for geologic map compilation, production and archiving for nearly 20 years.

In 2009, the US Geological Survey (USGS)-Association of American State Geologists (AASG) National Cooperative Geologic Mapping Program (NCGMP) proposed a standard geologic map database format for geologic map publications (NCGMP, 2010). This database schema is known as 'NCGMP09'. The design is intended to encode content "analogous to that contained in a traditional geologic map published by the USGS and by state geological surveys. It stipulates an ESRI database format in order to adhere to USGS policy and because this is the GIS software most commonly used in the USGS, in the state geological surveys, and in the larger community." The standard database design was developed and its adoption is being promoted to "reduce the costs of map production and publication (data compilation and synthesis, review, editing, cartography, pre-press, training, and tool development)", quoted text from NCGMP (2010). The AZGS was a major contributor to the development of NCGMP09, and was one of the early adopters of NCGMP09, with about 30 of its digital geologic maps in NCGMP09 geologic map databases.

While the database is designed particularly for data delivery, the AZGS has found that it can also be used for map compilation. To assist in this process, the AZGS has developed and maintains a toolset, the AZGS Toolset, which survey geologists use to compile geologic map data directly into NCGMP09 and produce map layouts from this database.

## Geologic Mapping Toolset

The Geologic Mapping Toolset includes an ArcGIS AddIn for ArcMap and an ArcGIS Toolbox. The Addin facilitates the creation of features, feature-level metadata and map unit description layout in ArcMap. The ArcGIS Toolbox has tools for creating an NCGMP09 Geologic Map Database.



## Development Background

During the transitions between various database schemas that the AZGS has undergone, there was a growing recognition of two things:

- complex database design offers long-term data management advantages
- complexity of data-entry workflow scales directly with complexity of database design

As the NCGMP09 database standard grew, it seemed to offer a nice balance in complexity. However, there were still aspects of the database design that required adjustments to the geologists' workflows that were unfamiliar. Some examples of these issues are:

- maintaining foreign key relationships between various tables such as MapUnitPolys and DataSources
- maintaining the integrity of HierarchyKeys in the DescriptionOfMapUnits table
- correlating symbology in an ArcMap project with RGB values in DescriptionOfMapUnits table

It was clear that we needed data-entry tools that presented the geologist with a familiar workflow while still maintaining the integrity of the data in NCGMP09 format. The AZGS geologists were familiar with ArcMap for geologic map generation, and so an ArcMap AddIn presented a simple mechanism for improving and simplifying the workflow.

Development of the toolbar began using C#.NET and ArcObjects in 2009 with limited funding from that year's STATEMAP project. At that time the NCGMP09 database had not been finalized, and so the toolbar operates on a database structure that is slightly different than the current version 1.1 of the schema. It is not our intention to "fork" the database schema, rather, we intend to correct these issues when resources are available to do so.

In subsequent years the toolbar has undergone minor bug-fixes but no significant further development has been undertaken. Realization of some significant bugs that prevented easy distribution of the AddIn led the AZGS to use ArcGIS Model Builder to develop the ArcGIS Toolbox to help crosswalk the AddIn to other agencies' environments.

## Components

There are two main components of the AZGS Toolset, the NCGMP Toolbar and the ArcGIS Toolbox. The NCGMP Toolbar is an ArcGIS AddIn for ArcMap. The AddIn presents the user with a toolbar that the geologist can use to perform various geologic map compilation functions. The ArcGIS Toolbox, developed in Model Builder, can be used in ArcMap or ArcCatalog to create a geologic map database that works with the NCGMP Toolbar.

### NCGMP Toolbar Functions

**Opening an existing NCGMP09 database:** The AddIn will only open a geologic map database created with one of the create database tools in the Geologic Mapping Toolset ArcGIS Toolbox.

**Creating and Managing Data Sources:** The toolbar provides a simple window for creating, managing and selecting data sources for individual or groups of features.

**Creating and Managing Description Of Map Units:** The Map Unit Legend Editor, accessible from the NCGMP Menu dropdown, provides a window that allows users to define new units, edit existing ones, adjust the ordering and hierarchy of the legend, and to indicate which polygons on the map depict a particular unit. The information entered into this form is written to the NCGMP database's DescriptionOfMapUnits table.

**Drawing the map unit legend onto an ArcMap layout:** When ArcMap is in layout mode, the toolbar allows a user to draw the contents of the DescriptionOfMapUnits table as a set of graphical elements on the layout. These graphical elements include a color patch, map unit abbreviation, map unit name, display age and map unit description.

**Provides symbols for common geologic features:** When a user begins editing geologic map data in ArcMap, the toolbar creates feature templates for many common geologic point and line measurements, such as contacts, thrust faults, and bedding measurements. Cartographic Representations are used by default.

**Updating feature identifiers and Data Source identifiers as edits are made:** An editor extension automatically manages various primary key fields defined in the NCGMP09 schema. As users create new features these fields are automatically populated. Similarly, users can select an "Active Data Source" record, and that Data Source will be automatically attached to each new feature.

**Digitizing structural measurements from scanned geologic maps:** After scanning and georeferencing an existing geologic map, the user can use a tool to digitize measurements from the map. The user clicks three times for each feature to be digitized. First, the user clicks the location of the measurement. Next, the user clicks the two endpoints of the strike line for that measurement. The tool then prompts the user to enter the dip value from the measurement.

## **The ncgmpToolbox**

The ncgmpToolbox contains tools to create a true geologic map database with map data and symbology. The tools can create a personal or file geodatabase, depending on user preference. Users can define a spatial reference and location for storing their new database.

The tools create a database schema that will allow users to compile geologic maps using the NCGMP Toolbar.

Symbology, as Cartographic Representations, is added to the ContactsAndFaults, OtherLines and OrientationDataPoints feature classes. Cartographic Representations are later used during the map editing process.

## **Development Notes**

### **Developers**

If you want to further develop and/or customize the toolset, you are considered a developer and can download the code here: <https://github.com/ncgmp09/azgs-toolbar>

### **Bugs and Issues**

Bugs and issues can be reported here: <https://github.com/ncgmp09/azgs-toolbar/issues>. Anyone who wants to report an issue must first create a GitHub account.

## **Updates, Maintenance and Future Development**

Updates to the NCGMP Toolbar will be posted to the GitHub repositories referenced above. Updates, maintenance and future development of the Geologic Mapping Toolset hinges on the availability of resources.

## References

- NCGMP (USGS National Cooperative Geologic Mapping Program), 2010, NCGMP09—Draft Standard Format for Digital Publication of Geologic Maps, Version 1.1, in Soller, D. R., Ed., Digital Mapping Techniques 2009, Workshop Proceedings: U.S. Geological Survey Open-File Report 2010–1335, p. 93-146.
- Richard, S.M., 2003, Geologic Map Database Implementation in the ESRI™ Geodatabase Environment: DMT 2003 USGS OFR
- Richard, S.M., Craigue, J.C., and Soller, D.R., 2004, Implementing NADM C1 for the National Geologic Map Database, in Soller, David R., Editor, Digital Mapping Techniques '04- Workshop Proceedings: U. S. Geological Survey Open-file Report 2004-1451, p. 111-144.
- Richard, S.M. and Orr, T.R., 2001, Data structure for the Arizona Geological Survey geologic information system; basic geologic map data, in Soller, D. R., Ed., Digital Mapping Techniques 2001, Workshop Proceedings: U. S. Geological Survey Open-File Report 01-223, p. 167-188, <http://pubs.usgs.gov/of/2001/of01-223/richard2.html>.
- Richard, S.M., and Thieme, J.P., 1997, Data structure for Arizona Geological Survey digital geologic maps: Tucson, Arizona Geological Survey Open File Report OFR-97-05, 11 p.

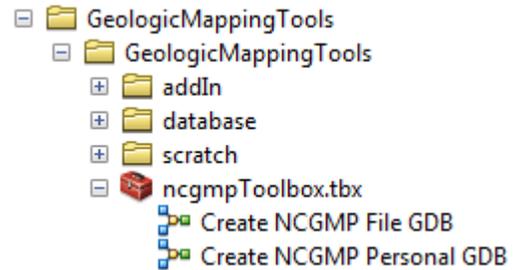
# Appendix I. Geologic Mapping Toolset

## About the Geologic Mapping Toolset

The Geologic Mapping Toolset contains resources to help capture and store geologic map data in a geologic map database.

Included in the template are:

1. A “template” geologic map database
2. Tools for creating a geologic map database
3. An ArcMap AddIn

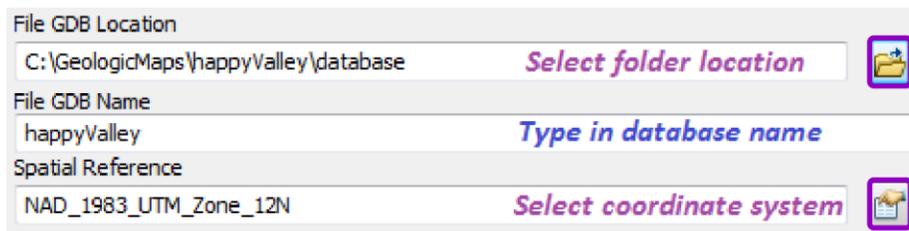


This document describes the toolbox and AddIn functions.

## Create new database

Open ArcMap or ArcCatalog to create a new geologic map database. If you are in ArcMap, click the ArcCatalog icon  on the Standard Toolbar to open ArcCatalog window. In ArcCatalog or with the ArcCatalog window open in ArcMap:

1. Navigate to the ncgmpToolbox. Click on the Connect to Folder icon  if you need to connect to the NCGMP directory that contains the toolbox. After you connect to the folder, you may need to expand the folder to see the contents inside.
2. Expand toolbox.
3. Double-click on **one** of the following:
  - **Create NCGMP File GDB to create a file geodatabase**
  - **Create NCGMP Personal GDB to create a personal geodatabase**
4. Once the tool opens:
  - a. Select a folder location.
  - b. Give the geodatabase a name.
  - c. Select a Spatial Reference (Coordinate System).

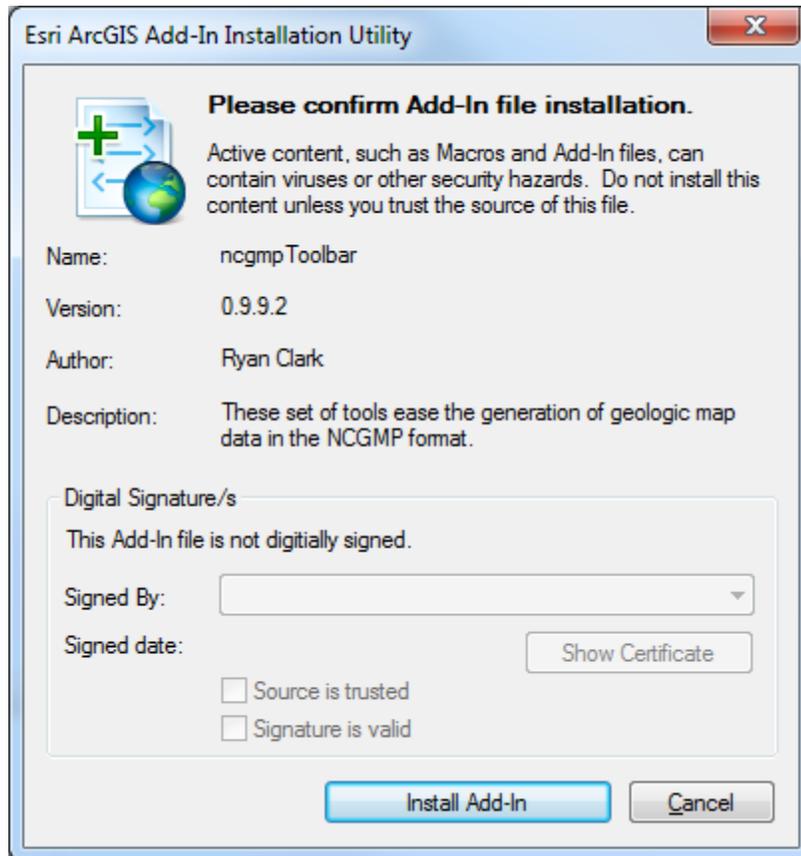


5. Click *OK*. Be patient! The tool takes about 5 minutes to run.

After the tool finishes, there should be a new database ready for use. Navigate to the database in ArcCatalog to view the contents of your new database!

## Installing the NCGMP Toolbar

1. Install the NCGMP toolbar:
  - a. In Windows Explorer, navigate to **NCGMPToolbar.esriAddIn** directory, Double-click **NCGMPToolbar.esriAddIn**, Click *Install Add-In*



- b. In ArcMap, click *Customize*, select *Customize Mode...*, click *Add from file...*, navigate to and select **NcmpToolbar.esriAddIn**, click *Open*, On **Toolbars** tab, check the box next to NCGMP Toolbar then close Customize window

Refer to ArcGIS Help Topics for more information on installing and configuring AddIns in ArcMap:

*Sharing and installing add-ins:*

[http://resources.arcgis.com/en/help/main/10.2/index.html#/Sharing\\_and\\_installing\\_add\\_ins/014p0000001m000000/](http://resources.arcgis.com/en/help/main/10.2/index.html#/Sharing_and_installing_add_ins/014p0000001m000000/)

*About configuring the user interface:*

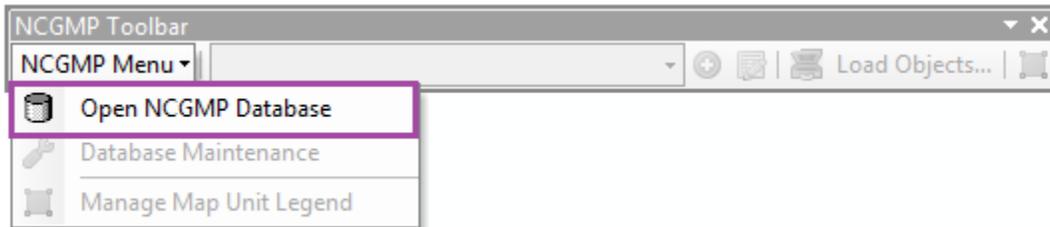
[http://resources.arcgis.com/en/help/main/10.2/index.html#/About\\_configuring\\_the\\_user\\_interface/00v000000014000000/](http://resources.arcgis.com/en/help/main/10.2/index.html#/About_configuring_the_user_interface/00v000000014000000/)

## Setting up ArcMap Project

### SECTION 1: Connect to NCGMP Database

In ArcMap:

1. Select *Open NCGMP Database* from the **NCGMP Menu** dropdown.
2. Navigate to your new NCGMP database.
3. Select the database and click select.

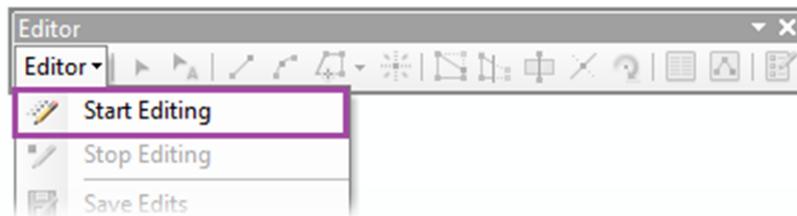


A new group layer, Geologic Map, is added to the ArcMap Table of Contents.

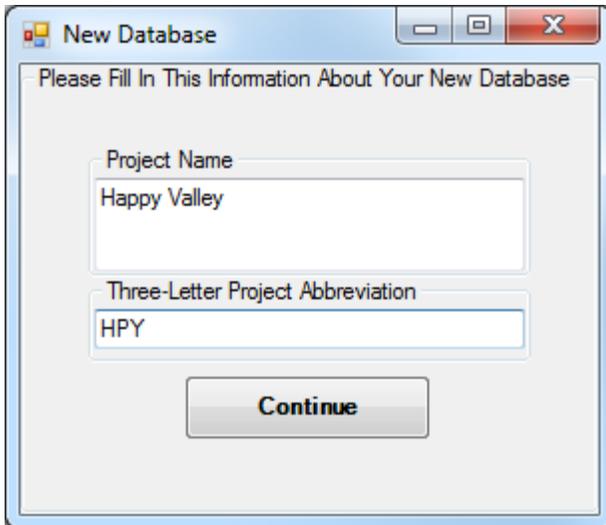
Add additional layers to the map as needed. These layers might include scanned field sheets, topographical maps, imagery, roads, PLSS, etc.

### SECTION 2: Start Editing

1. Select *Start Editing* from the **Editor** drop-down menu on the Editor Toolbar. (Note: you may need to add the Editor Toolbar to your ArcMap project.)

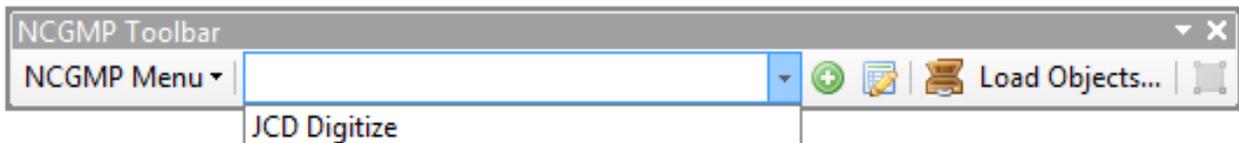


2. Type in project name and three-letter project abbreviation in New Database window.
3. Click Continue.



### SECTION 3: Manage available Data Sources

Click on the **Manage available Data Sources**  button. A new window pops up. Type appropriate text into the Source and Notes fields and click Save. Then **Select and Active Data Source** from the NCGMP Toolbar.

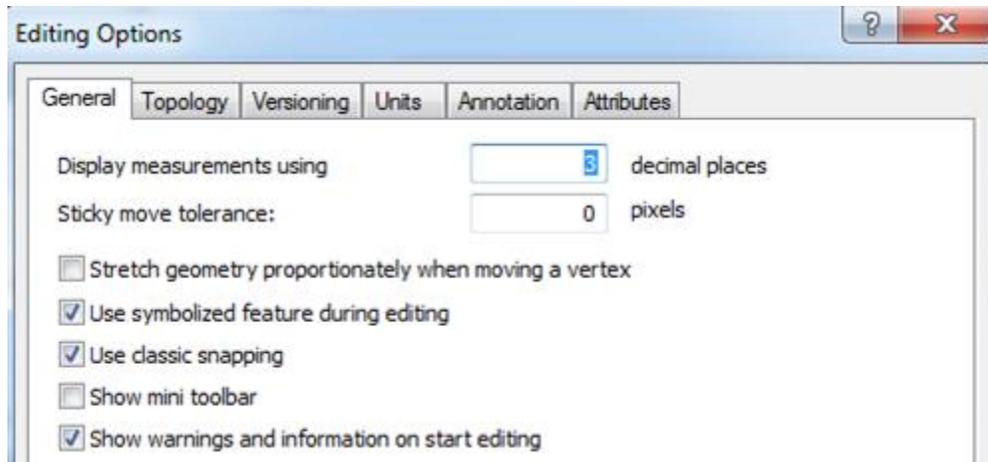


Managing available data sources can be done at any time during an edit session.

### SECTION 4: Configure snapping environment

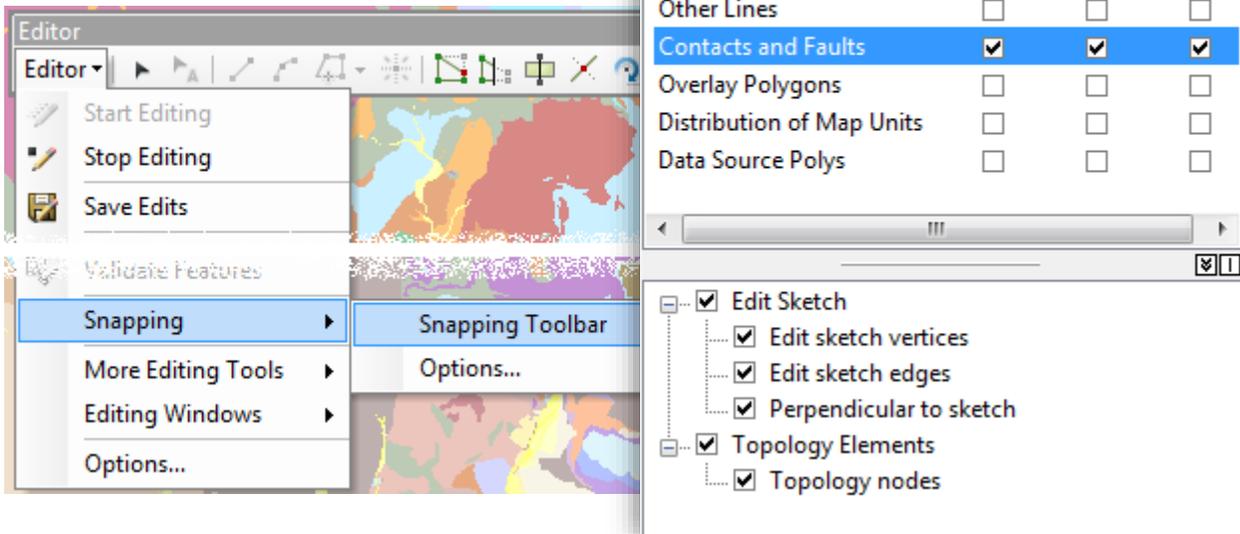
Configuring the snapping environment makes it much easier to draw contacts and faults that leave no gaps or overlaps.

1. From the **Editor** menu, choose *Options*. **Editing Options** window should pop up. Check the *classic snapping* box and uncheck *Show mini toolbar* box.



2. From the **Editor** menu, choose *Snapping* and then *Snapping Window...*

Snapping window opens. *Check* all three boxes on the **Contacts and Fault** row under **Snapping Environment**. Then, in the bottom part off the window, *check* the **Edit Sketch** box and the **Topology Elements** box.

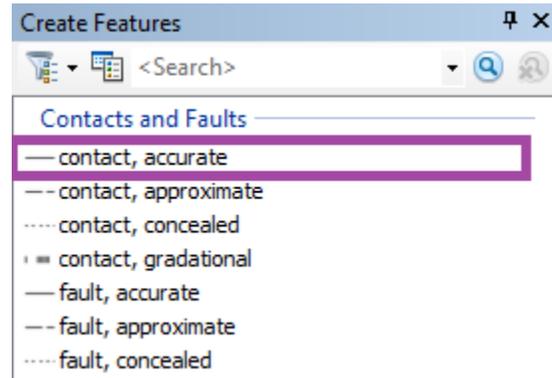


## SECTION 5: Draw Contacts

This is where the geologic map begins to take shape. Since contacts delineate the boundaries of mapped geologic units, digitize them first. Contacts will be used to construct geologic map unit polygons.

In an edit session:

1. Click on one of the **Create Features** templates under Contacts and Faults.
2. Start drawing contacts.

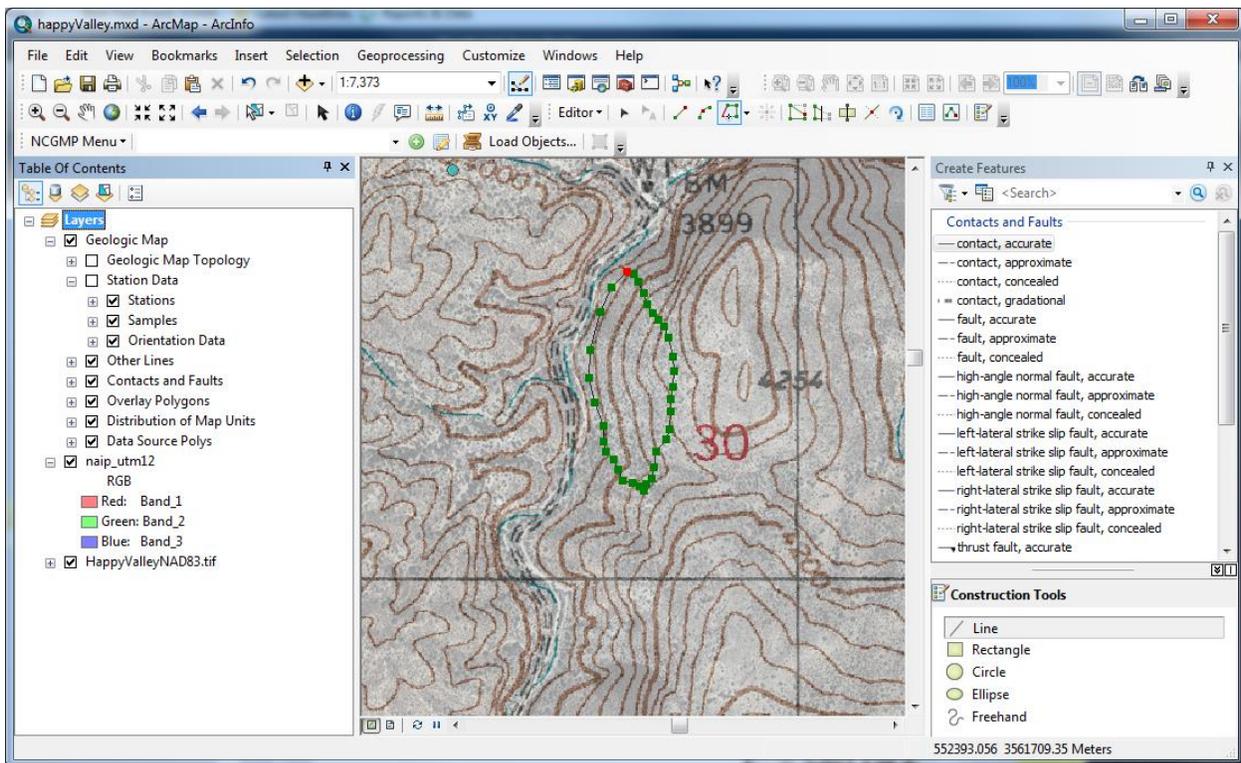


If you are digitizing a contact or fault that does not appear in the template, refer to ArcGIS Resource Center Help Topic on creating new feature templates:

[http://resources.arcgis.com/en/help/main/10.1/index.html#/Creating\\_new\\_feature\\_templates/01m7000006400000/](http://resources.arcgis.com/en/help/main/10.1/index.html#/Creating_new_feature_templates/01m7000006400000/).

Look up symbol for Contacts and Faults in [Section 1](#) and [Section 2](#) of the [FGDC Digital Cartographic Standard for Geologic Map Symbolization](#). REFNO in the FGDC Digital Cartographic Standard for Geologic Map Symbolization correspond to the ArcMap symbol and the Template Name in the ArcMap Create New Templates Wizard.

The image below shows a line representing a contact. This line will be used to build a map unit polygon.



## SECTION 6: Create Geologic Unit Legend Items

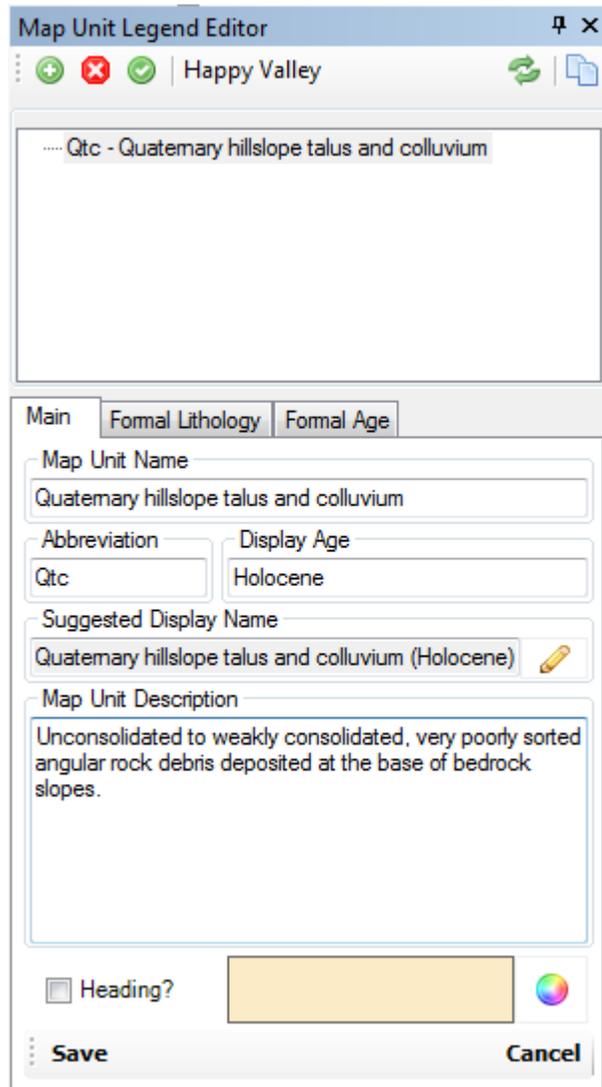
1. From the NCGMP Toolbar dropdown menu, select Manage Map Unit Legend



2. A new window opens, Map Unit Legend Editor
3. To add a new legend item:

- a. Click New Legend Item .
- b. Type in Map Unit Name. If creating a heading, check the heading box (lower left), then Save.
- c. Type in Abbreviation.
- d. Type in Display Age.
- e. Type in Map Unit Description. You can copy and paste text from a Word or Text document. It is recommended that you clear all text formatting before pasting text in Map Unit Description box.
- f. Click color wheel  to select map unit color. This color will propagate to the Distribution of Map Units Layer and to the ArcMap template.
- g. Click Save. The new legend item appears in the upper box. Units will display as normal text, headings will display as bolded text. The data is written to the DescriptionOfMapUnits table in the geodatabase.

4. Add additional legend items following the same process above.
5. Legend items can be imported from other map databases (Section 6) and hierarchy can be given to legend items (Section 7).

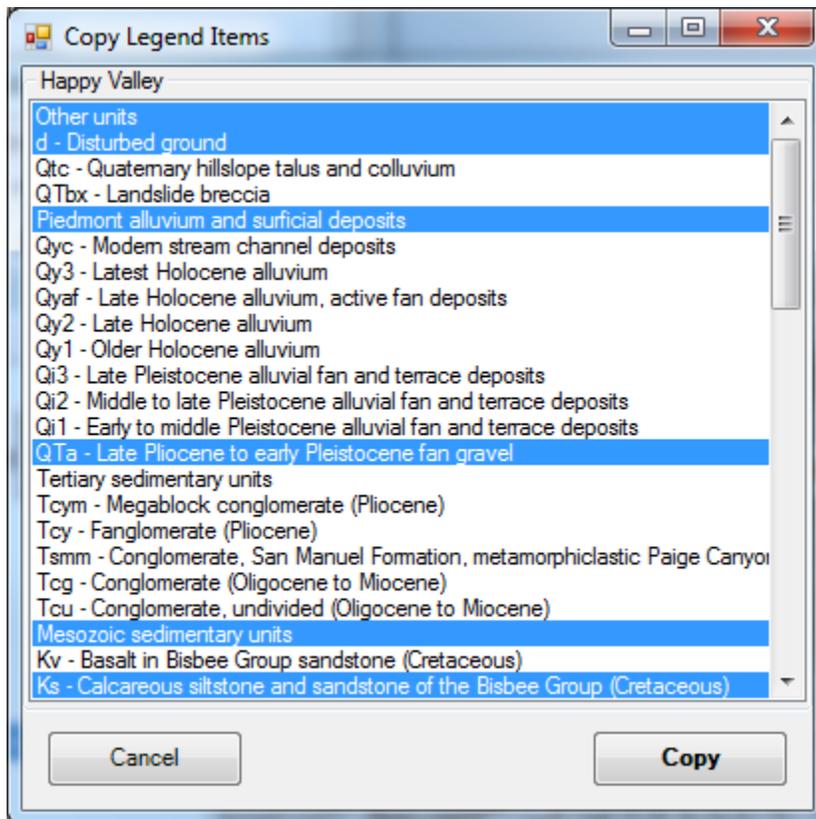


## SECTION 7: Importing legend items from another map database

You can import the geologic map unit legend from another geologic map database, as long as the database has the same schema as the one you are working in.

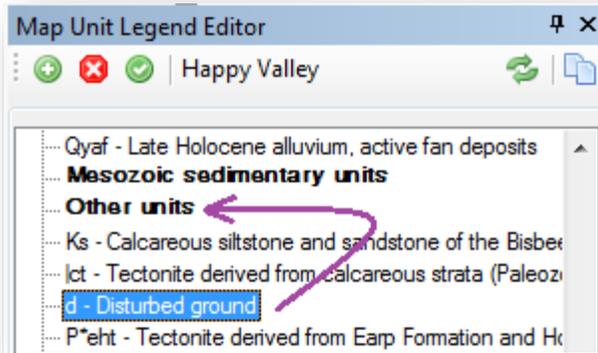
To import legend items from another geologic map database:

1. In the Map Unit Legend Editor window, click Copy Items from Another Legend 
2. A new window pops up: Please select an NCGMP database. Navigate to an existing NCGMP database that contains the legend items you'd like to import. Select the database.
3. Another window opens. Click on units to select them. Hold CTRL or SHIFT down to select multiple items. Click copy when you are done selecting items.



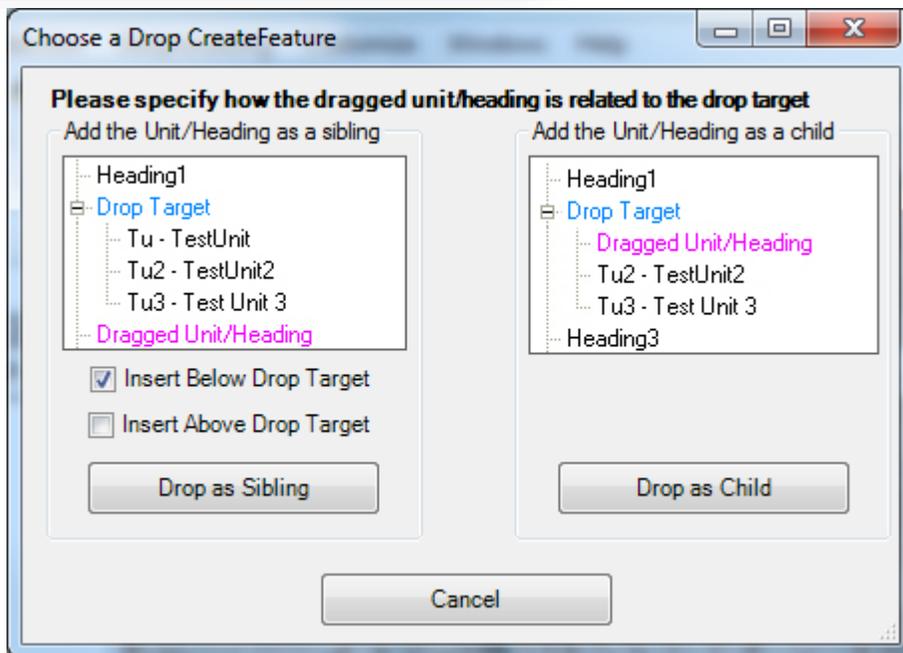
4. The imported legend items should now appear in the Map Unit Legend Editor window.

## SECTION 8: Organizing Map Unit Legend Editor

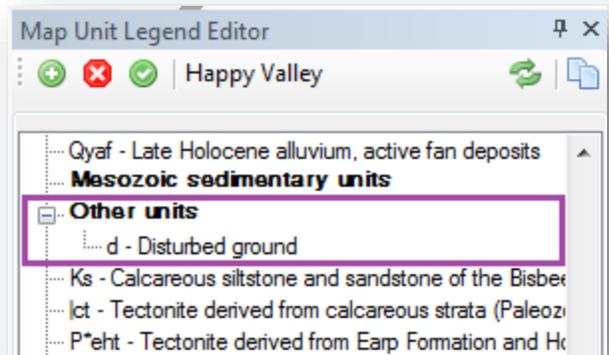


The order that the legend items appear in the Map Unit Legend Editor is the same order they will appear in the map layout. You can move legend items manually by:

1. Open Map Unit Legend Editor
2. Select a legend item
3. Drag it to the target location
4. Select the drop target



Choose drop target



Final result (Drop target child)

## SECTION 9: Constructing Polygons

Construct polygons from contacts and faults.

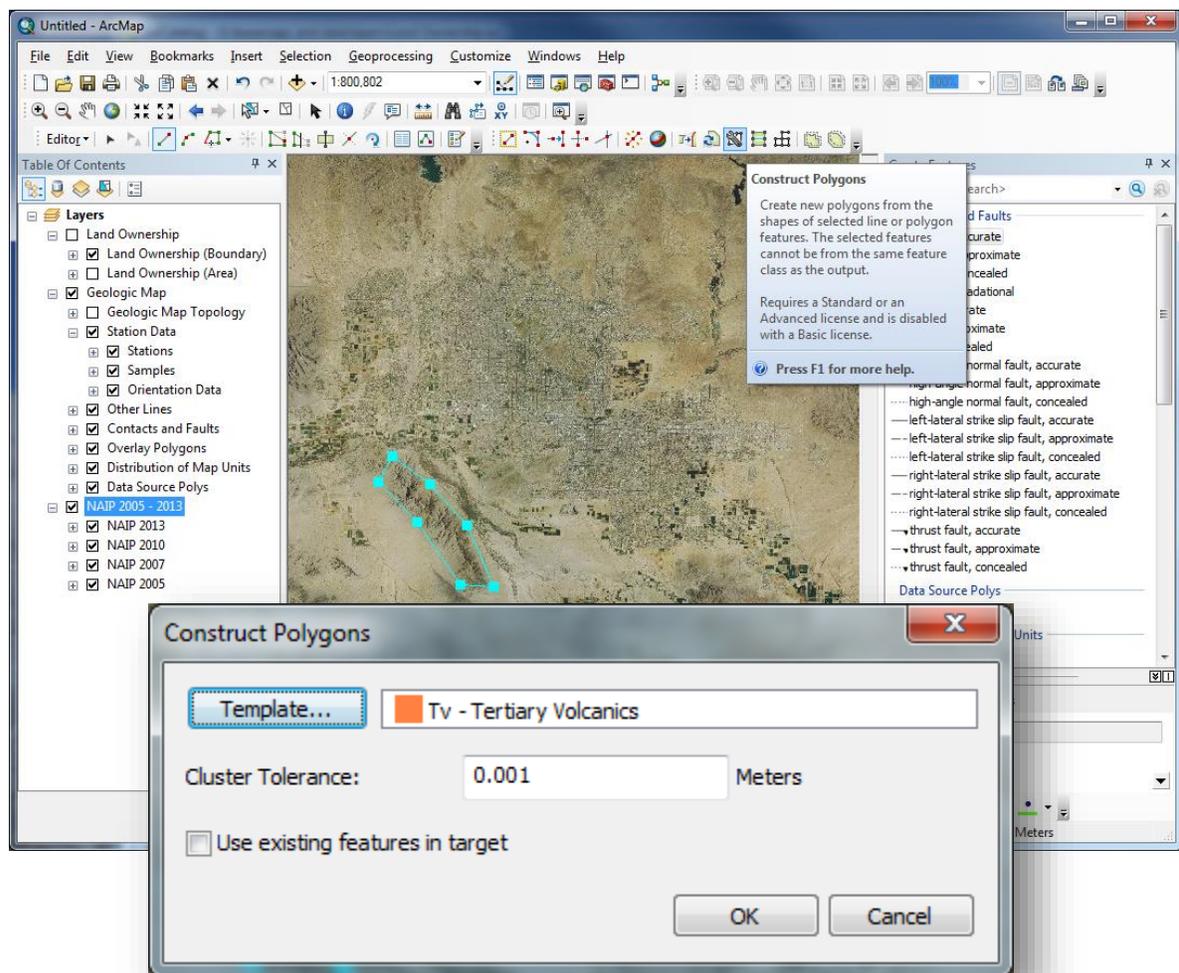
The only rule is that there can be no topological errors. Configuring the snapping environment before you begin to digitize should eliminate the potential for most topological errors. However, if topological errors do exist, you will have problems creating polygons. For more information on topology, please refer to help document:

<http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//00620000001000000.htm>

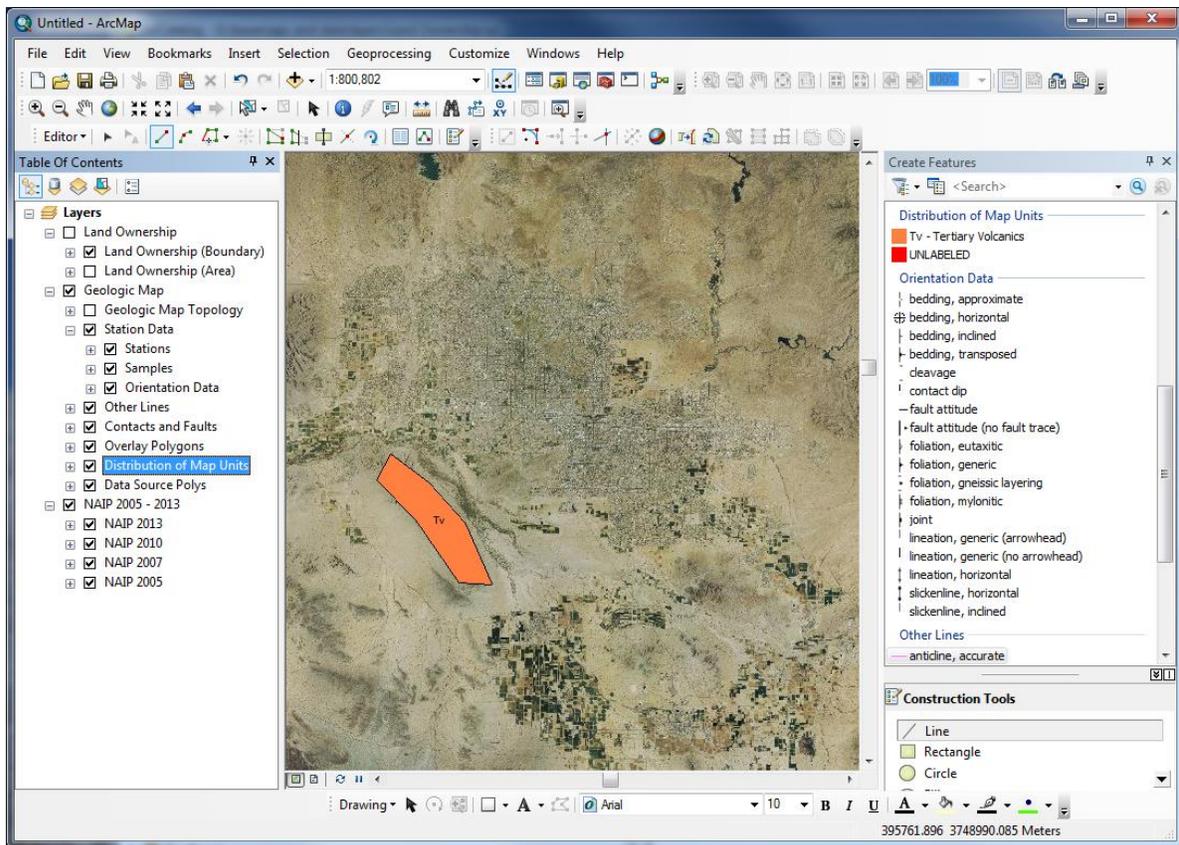
Ideally, the colors that you want to use to represent the geologic units have been defined (Section 5) before constructing polygons. However, polygon properties can be modified any time.

To construct polygons, in an ArcMap **Edit** session:

1. Select contacts and/or faults that define the geologic unit boundary
2. From the **Advanced Editing** Toolbar, click *Construct Polygons* 
3. **Construct Polygons** window opens, click *Template* to select map unit template
4. Click *OK* and complete polygon construction



A new polygon feature should be added to the **Distribution of Map Units** feature class in the database and should display on the map. Label **Distribution of Map Units** to display the map unit label in your map document. Use **Maplex Label Engine** to better control placement of labels.



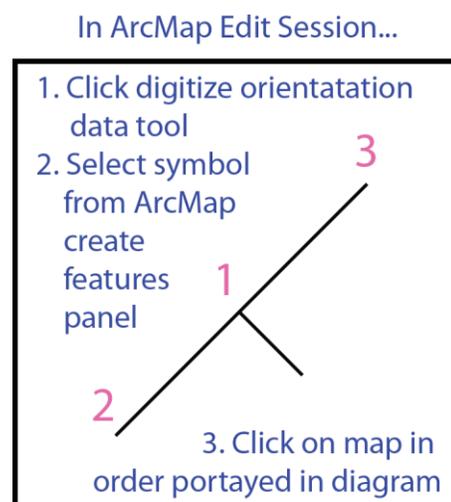
## SECTION 10: Digitize orientation data from a scanned geologic map

This section assumes that a scanned geologic map has been georeferenced in ArcMap.

To digitize orientation data in ArcMap from scanned maps, use the **Digitize orientation data from a scanned geologic map**.

In an edit session, select orientation data point feature template and then click on .

Click on the map in the order shown to the right (1, 2, 3) to create the feature. A window will pop up asking you to enter a dip value. Enter the value and click ok. The symbol should display on the map and the strike and dip values will be entered into the OrientationDataPoints feature class.



## SECTION 11: Map Layout

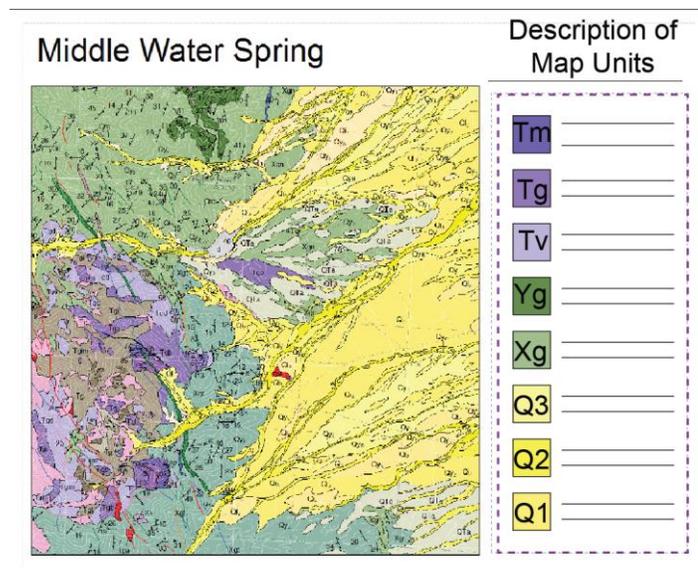
### 11.1 Plot Description of Map Units in ArcMap Layout View

To draw the description of map units on the map layout, use the **Draw a Map Unit Legend on Layout View** tool on the NCGMP Toolbar.

First, switch from Data View to Layout View in ArcMap. Then click the **Draw a Map Unit Legend on Layout View** icon.



Draw a box where the description of map units should go (i.e. dotted line in image). A color patch, label and description will display on the page.



The description of map units will plot as a row of columns, moving left to right across the page. The first column will plot in the area delineated by the box d

## 11.2: Plot Remaining Map Elements: Points & Line Legend, Scale bar, etc...

At the Arizona Geological Survey, geologic maps in the Digital Geologic Map series also include the additional map layout elements:

1. Title
2. Authorship
3. Publication date
4. Introduction
5. Acknowledgements
6. References
7. Map Citation
8. Locator map
9. Mapping responsibility diagram
10. Unit correlation diagram
11. Scale bar and scale text
12. Magnetic north declination arrow
13. UTM grid
14. Latitude/Longitude grid
15. Topographic/Basemap descriptive information
16. Spatial Reference/Projection information

Refer to ArcGIS 10.2 Help for information on preparing the map layout:

<http://resources.arcgis.com/en/help/main/10.2/index.html#//00s900000007000000>