

# Digital Mapping & Spatial Analysis

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Graduate Community of Learning  
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# Workshop Agenda

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1. Visualizing Spatial Data (Andrew)
2. Storytelling with Maps (Rachel)
3. Archaeological Application of GIS (Zach)

# CARTO

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- Map, Interact, Analyze
- Example 1: Bryn Mawr dining options
- Example 2: Carpenter Carrel Project
- Example 3: Terracotta Altars from Morgantina

# Leaflet: A JavaScript Library

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<http://leafletjs.com>

# Storytelling with maps #1: OdysseyJS (CartoDB)

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[Platform](#)

[Germany's way through the World Cup 2014](#)

[Tutorial](#)

# Storytelling with maps #2: Story Maps (ArcGIS)

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[Platform](#)

[Indiana Limestone](#) (example 1)

[Ancient Wonders](#) (example 2)

# Mapping Spatial Data with ArcGIS

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- **Mapping in GIS Basics**
- **Archaeological Applications**
- **Topographic Applications**

# Mapping Spatial Data with ArcGIS

## What is GIS - Geographic Information System?

A geographic information system (GIS) is a framework for gathering, managing, and analyzing data. Rooted in the science of geography, GIS integrates many types of data. It analyzes spatial location and organizes layers of information into visualizations using maps and 3D scenes. With this unique capability, GIS reveals deeper insights into spatial data, such as patterns, relationships, and situations - helping users make smarter decisions. - ESRI GIS dictionary.

- ArcGIS by ESRI - industry standard, expensive, intuitive functionality, PC
- Q-GIS - open source, industry standard, less than intuitive, Mac and PC
- GRASS - developed by the US military, open source
- AutoDESK - counterpart to AutoCAD for topography

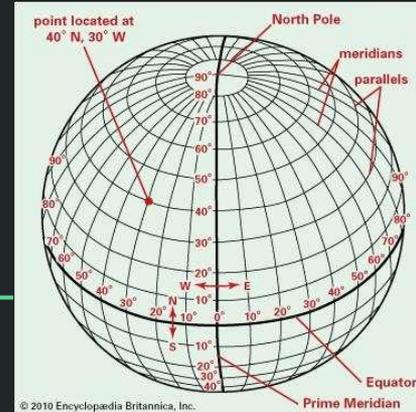
# Types of Spatial Data in ArcGIS: Basics

Every feature on the planet has its own unique latitude and longitude coordinates:

Houses, trees, streets, archaeological finds, you!

## How do we collect this information?

- Remote Sensing: Aerial photography, satellite imaging, LIDAR
- On-site Observation: total station data, ground penetrating radar, GPS

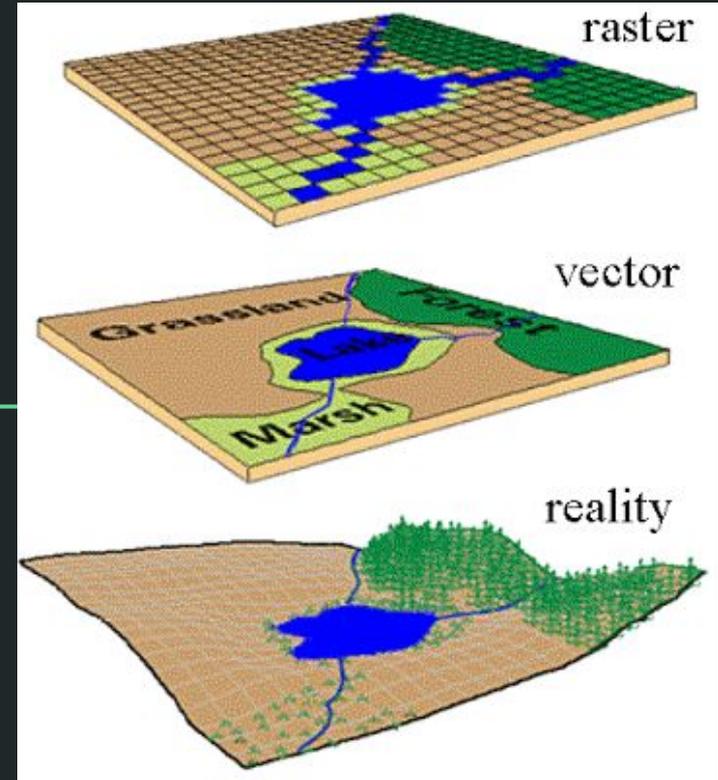


# Types of Spatial Data in ArcGIS: Basics

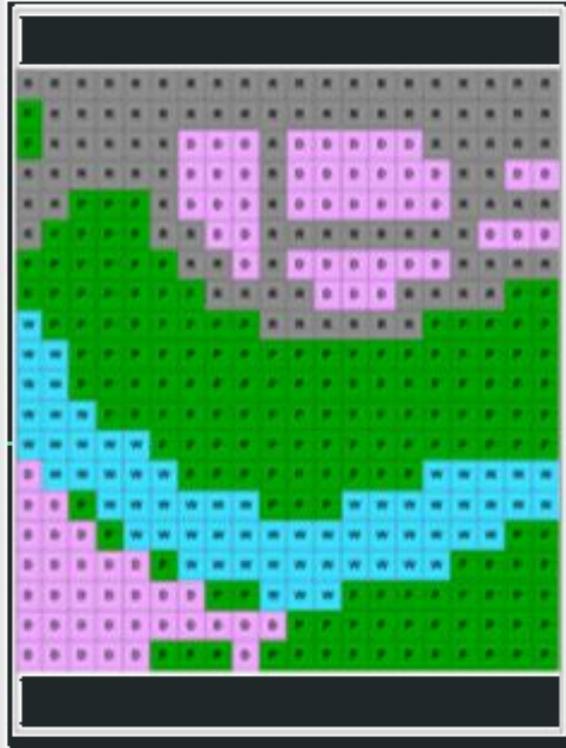
## Raster vs. Vector projections

**Raster Maps:** “a representation of the world as a surface divided into a regular grid of cells. Raster models are useful for storing data that varies continuously, as in an aerial photograph, a satellite image, a surface of chemical concentrations, or an elevation surface”

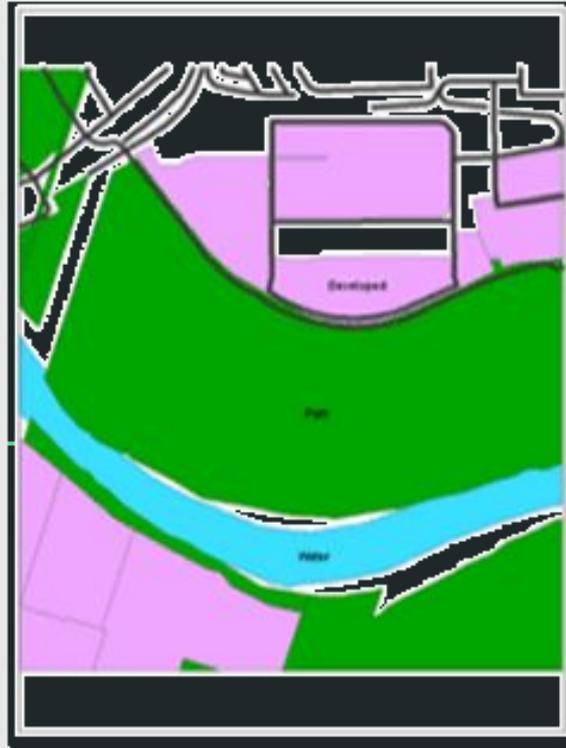
**Vector Maps:** a representation of the world using points, lines, and polygons. Vector models are useful for storing data that has discrete boundaries, such as country borders, land parcels, and streets.



Raster



Vector



Source: [giscommons.org/introduction-concepts](https://giscommons.org/introduction-concepts)

# Vector topography vs. raster, aerial topography at Bashtepa, Uzbekistan

The screenshot displays the ArcMap interface for a project named 'Bashtepa\_2016'. The main map area shows a vector topographic map of the Bashtepa site, overlaid on an aerial photograph. The topographic map features blue contour lines and various feature classes. The Table of Contents on the left lists the following layers:

- Bashtepa
  - E04SE
  - Feature Classes
    - Fortification
    - Pit\_Houses
    - Platform
  - Excavation
    - A03NE
    - E03SW
    - D03NE
    - C02SE
    - D01SE
    - D03SE
    - E04SE
    - E04SW
    - E05NW
    - E05SW
    - F03NW
    - F05SW
    - F05SE
    - F05NW
    - F05NE
    - G03SW
    - G05NE
    - G05SW
    - G05SE
    - G06SW

The status bar at the bottom right indicates a scale of 143,602 meters and a date of 9:29 AM on 4/17/2018. The Windows taskbar at the bottom shows various application icons and the system clock.

## The Ideal:

Map created in ArcGIS using raster and vector data imported into photoshop and illustrator for an aesthetic finish.



(We still have yet to do this for Bashtepa)

# Archaeological Applications of ArcGIS

**ArcGIS is a powerful tool for projecting and querying mass amounts of archaeological spatial data. ArcGIS, or open source alternatives such as Q-GIS, alongside AutoCAD Civil are industry standard.**

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## **Uses:**

- **Visualizing a site's "grid frame"**
- **Projecting spatial data about the excavation - architectural features, small finds, soil layers and transitions, height levels,**
- **Measuring distance at a small and large scales**
- **Calculating area of features**

# Archaeological Applications of ArcGIS

**Both raster and vector maps can (and should) be anchored to longitude and latitude coordinates. Longitude and Latitude coordinates are VECTOR points. They are conceptual and not real, converging at 0, 0 in the Gulf of Guinea off the west coast of Africa. All spatial references in lat./ long. are anchored to this point.**

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**This is ideal, but not necessary, and in some cases impractical for archaeological projects.**

- Requires a GPS capable of >1cm accuracy (Trimble). NO HANDHELDS!**

# Archaeological Applications of ArcGIS

## Total Station

A scary looking, but simple piece of equipment that uses a laser and triangulation to establish points in space in relation to other points in space. Accuracy ~3mm!

- Not tied to long/lat, (more expensive models now do)
- Data must be internally coherent so the station “knows” where you are in relation to other points in space.
- This requires the establishment of an “internal” or “floating” grid.”

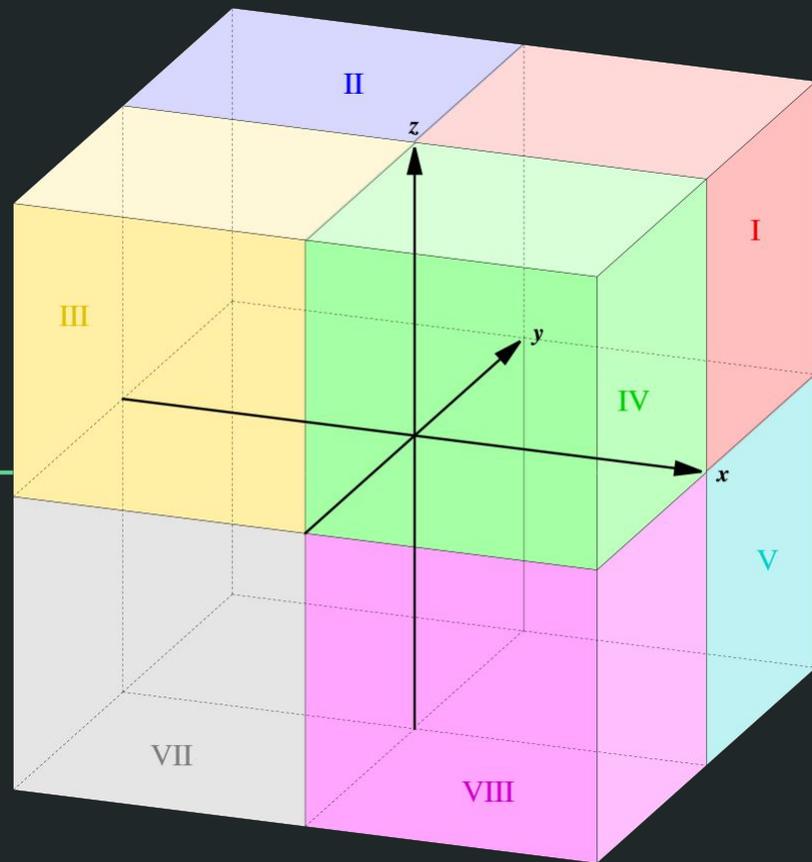


# Archaeological Applications of ArcGIS

## Floating Grids

Each archaeological site requires an internally coherent data frame, known as a grid, to which all points in space, i.e. your archaeological data, are spatially referenced. Without this your documentation is irreparably flawed.

**It is nothing more than an x, y, z geometric plane to which all points are measured in meters rather than lat./long.**



# Archaeological Applications of ArcGIS

## X, Y, Z data

X = Easting

Y = Northing

Z = Height

- Total Station:  
.txt file

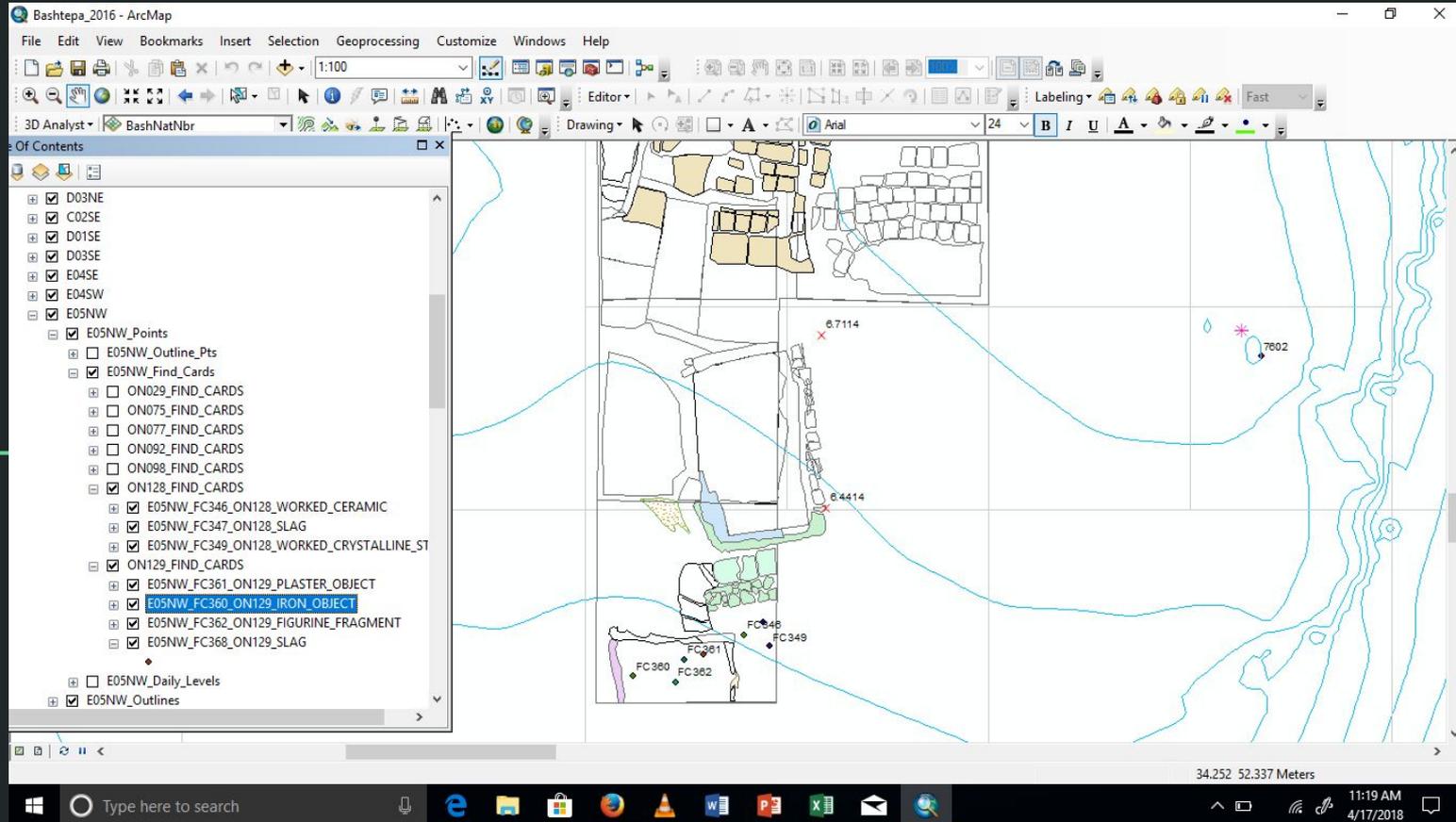
- ArcGIS needs  
.xml

- Code point  
attributes in  
excel

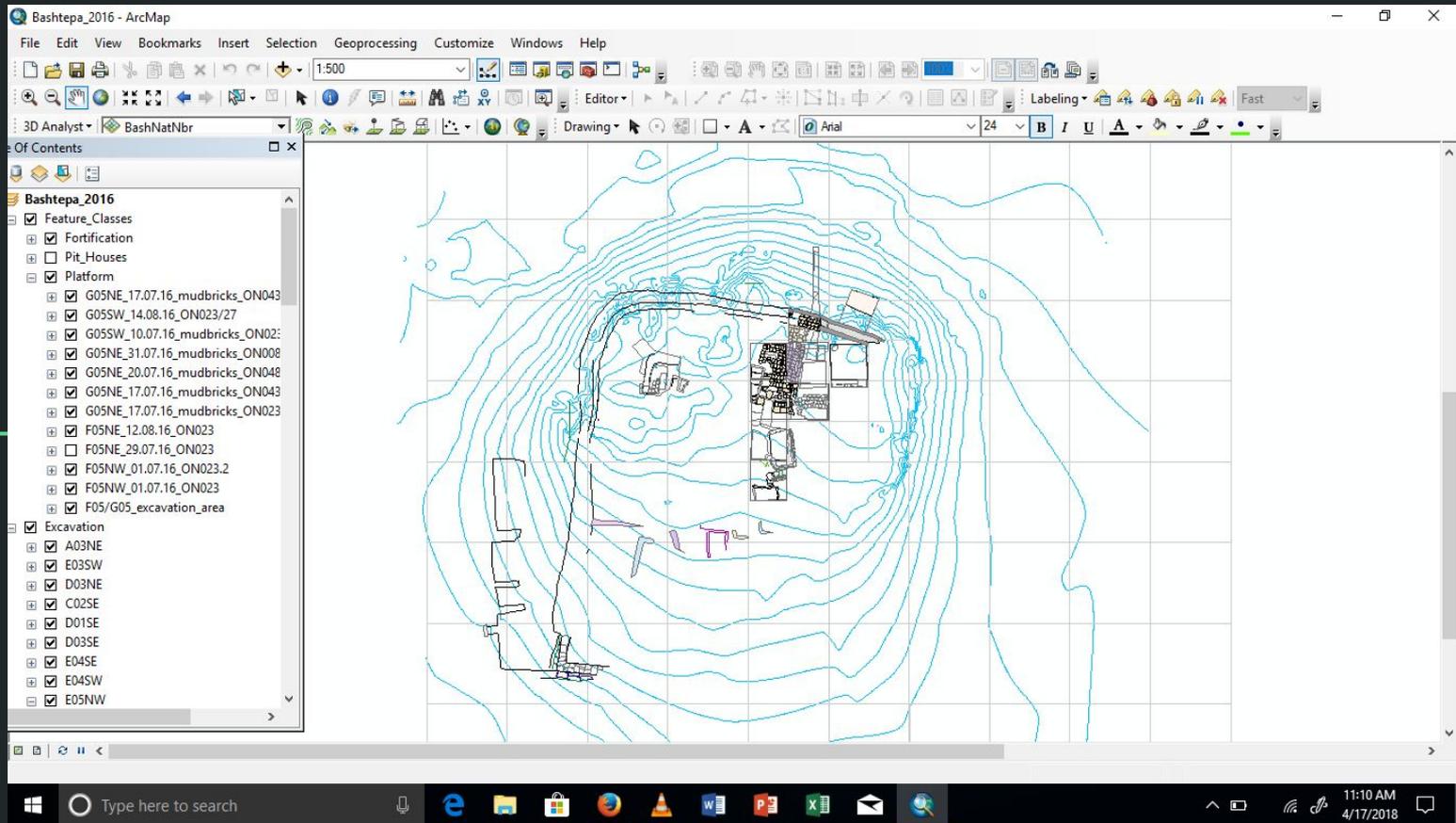
The screenshot displays a Windows desktop environment. On the left, a Google Docs presentation titled 'Digital Mapping & Spatial Analysis' is open, showing a list of coordinates and feature codes. In the center, a Notepad window titled 'BASH - Notepad' contains the same list of coordinates and feature codes. On the right, an Excel spreadsheet titled 'BASH\_29.07.17.day [Compatibility Mode] - Excel' is open, showing a table with columns A through L. The table contains numerical data and text labels, including 'OUTLINE', 'E05NW', 'ON041', 'WORKED STONE', 'IRON OBJECT', 'SLAG', and 'SPINDLE WHORL'. The status bar at the bottom of the Excel window shows 'Ready'.

	A	B	C	D	E	F	G	H	I	J	K	L
11	5865	41.3643	50.2444	4.8225	OUTLINE		E05NW		ON041	28.07.17		
12	5866	41.4902	50.1297	4.8101	OUTLINE		E05NW		ON041	28.07.17		
13	5867	41.6537	49.9818	4.8149	OUTLINE		E05NW		ON041	28.07.17		
14	5868	41.8089	49.8028	4.8138	OUTLINE		E05NW		ON041	28.07.17		
15	5869	41.9219	49.6692	4.8207	OUTLINE		E05NW		ON041	28.07.17		
16	5870	42.0712	49.5275	4.8203	OUTLINE		E05NW		ON041	28.07.17		
17	5871	42.1651	49.4789	4.8227	OUTLINE		E05NW		ON041	28.07.17		
18	5872	42.2079	49.4904	4.8154	OUTLINE		E05NW		ON041	28.07.17		
19	5873	42.2009	49.6231	4.8297	OUTLINE		E05NW		ON041	28.07.17		
20	5874	42.2323	49.67	4.8354	OUTLINE		E05NW		ON041	28.07.17		
21	5875	42.3116	49.6424	4.8386	OUTLINE		E05NW		ON041	28.07.17		
22	5876	42.4501	49.5344	4.8282	OUTLINE		E05NW		ON041	28.07.17		
23	5877	42.5582	49.436	4.8342	OUTLINE		E05NW		ON041	28.07.17		
24	5878	42.3955	49.7668	4.8391	OUTLINE		E05NW		ON041	28.07.17		
25	5879	42.2687	50.2319	4.8839	OUTLINE		E05NW		ON041	28.07.17		
26	5880	41.8487	50.3017	4.8464	OUTLINE		E05NW		ON041	28.07.17		
27	5881	41.5469	50.2831	4.8196	OUTLINE		E05NW		ON041	28.07.17		
28	5886	42.0677	47.3705	4.5698	FIND	WORKED STONE	E05NW	FC230	ON075 LA'	29.07.17		
29	5887	41.7818	47.3555	4.5491	FIND	IRON OBJECT	E05NW	FC231	ON075 LA'	29.07.17		
30	5888	41.5783	48.0419	4.5618	FIND	SLAG	E05NW	FC232	ON075 LA'	29.07.17		
31	5889	41.9493	49.1792	4.6306	FIND	WORKED STONE	E05NW	FC233	ON075 LA'	29.07.17		
32	5890	41.4423	49.4392	4.6936	FIND	SPINDLE WHORL	E05NW	FC234	ON075 LA'	29.07.17		

# Archaeological Applications of ArcGIS



# Archaeological Applications of ArcGIS



# Topographic Mapping

**TWO DAYS FOR COLLECTING DATA - TWO MINUTES TO PROJECT !!!**

ArcGIS has several built in apps for the purpose of creating topo maps at the click of a button.

The hard work is taking the points! These number in the thousands and the work is boring.



# Topographic Mapping



# Topographic Mapping

The screenshot shows the ArcMap interface for a project named 'Bashtepa\_2016'. The Table of Contents (TOC) on the left lists the following layers:

- Feature\_Classes
- Excavation
- Topography
  - Topographic\_Map
    - Contour\_Points
    - Contour\_10\_centimetre
    - Bash\_Contour\_topography\_10cm
    - Contour\_25\_centimetre
    - Bash\_Contour\_topography\_25cm
    - Contour\_half\_metre
    - Bash\_Contour\_topography\_50cm
    - BashNatNbr
  - Fix\_Points
  - Bashtepa\_mound\_datum
  - Orthorectification
- Feature\_Editing
  - Bash\_Polygons
  - Bash\_Polyline
- Point\_Data
  - Point\_data\_2016
  - Point\_data\_2017

The main map area displays a dense field of points forming a topographic map of a mound. The map is titled 'Bashtepa\_2016' and shows a complex, irregular shape with many small points. The scale is 1:500. The status bar at the bottom right indicates a distance of 78.711 72.77 Meters. The Windows taskbar at the bottom shows the system time as 11:32 AM on 4/17/2018.

# Topographic Mapping

Interpolation - visualizing the spatial relationship between 3D points.

The screenshot displays the ArcMap interface for a project named 'Bashtepa\_2016'. The main map area shows a topographic map with numerous 3D points scattered across the terrain. A 'Geoprocessing' menu is open, listing various tools such as Buffer, Clip, Intersect, Union, Merge, Dissolve, Search For Tools, ArcToolbox, Environments..., Results, ModelBuilder, Python, and Geoprocessing Options... The 'Table Of Contents' on the left shows a hierarchical view of the project layers, including 'Topography' and 'Topographic\_Map'. The 'Search' window on the right is active, displaying a search for 'interpolation' which has returned 41 items. The search results list several tools, including 'Areal Interpolation Layer To Polygons', 'Kriging (3D Analyst) (Tool)', 'Natural Neighbor (3D Analyst) (Tool)', 'Trend (3D Analyst) (Tool)', 'IDW (3D Analyst) (Tool)', 'Spline (3D Analyst) (Tool)', and 'Tono to Raster (3D Analyst) (Tool)'. The status bar at the bottom indicates a scale of 17,407 90,285 Meters and the system time is 12:34 PM on 4/17/2018.

# Topographic Mapping

The screenshot displays the ArcMap interface for a project named 'Bashtepa\_2016'. The main map area shows a topographic map with a color gradient from blue (low elevation) to brown (high elevation). A 'Natural Neighbor' tool dialog box is open on the right side of the map. The dialog box has the following fields:

- Input point features:** A dropdown menu with a folder icon to its right.
- Z value field:** A dropdown menu with a folder icon to its right.
- Output raster:** A text input field with a folder icon to its right.
- Output cell size (optional):** A text input field with a folder icon to its right.

At the bottom of the dialog box, there are buttons for 'OK', 'Cancel', 'Environments...', and 'Show Help >>'. The status bar at the bottom right of the map area shows '74.875 92.349 Meters'. The Windows taskbar at the bottom of the screen shows the system clock as 12:37 PM on 4/17/2018.

**Table Of Contents**

- Bashtepa\_2016
  - Feature\_Classes
    - Excavation
    - Topography
      - Topographic\_Map
        - Contour\_Points
          - Contour\_10\_centimetre
          - Bash\_Contour\_topography\_10cm
          - Contour\_25\_centimetre
          - Bash\_Contour\_topography\_25cm
          - Contour\_half\_metre
          - Bash\_Contour\_topography\_50cm
          - BashNatNbr**
          - Fix\_Points
          - Bashtepa\_mound\_datum
          - Orthorectification
- Feature\_Editing
  - Bash\_Polygons
  - Bash\_Polyline
- Point\_Data
  - Point\_data\_2016
  - Point\_data\_2017

# Topographic Mapping

## Contour Topography

The screenshot displays the ArcMap interface for a project named 'Bashtepa\_2016'. The main map area shows a topographic map with a color gradient from blue (low elevation) to brown (high elevation). Numerous black dots representing points are scattered across the map, with a higher concentration in the central, lower-elevation area. The Table of Contents on the left lists the following layers:

- Bashtepa\_2016
  - Feature\_Classes
  - Excavation
  - Topography
    - Topographic\_Map
    - Contour\_Points
    - Contour\_10\_centimetre
    - Bash\_Contour\_topography\_10cm
    - Contour\_25\_centimetre
    - Bash\_Contour\_topography\_25cm
    - Contour\_half\_metre
    - Bash\_Contour\_topography\_50cm
    - BashNatNbr
  - Fix\_Points
  - Bashtepa\_mound\_datum
  - Orthorectification
- Feature\_Editing
  - Bash\_Polygons
  - Bash\_Polyline
- Point\_Data
  - Point\_data\_2016
  - Point\_data\_2017

The Search window on the right shows a search for 'contour (spatial analyst)', returning 4 items. The Contour tool dialog box is open, showing the following settings:

- Input raster: [Empty field]
- Output polyline features: [Empty field]
- Contour interval: [Empty field]
- Base contour (optional): [Empty field]
- Z factor (optional): 0
- Z factor (optional): 1

Bashtepa\_2016 - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

1:800

Editor

Labeling

Fast

3D Analyst BashNatNbr

Drawing

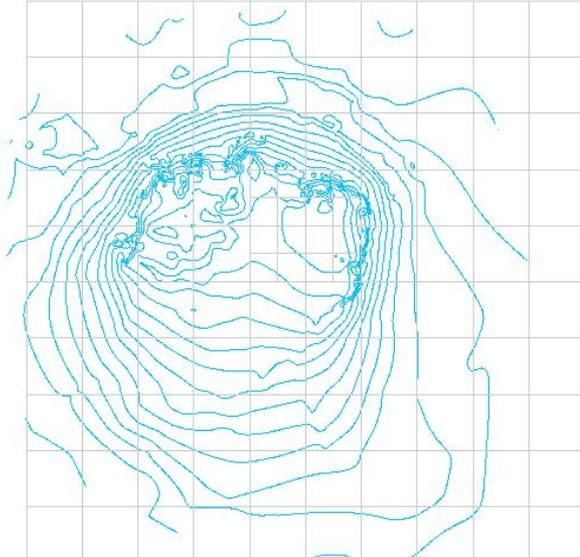
Anal

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**B** *I* U **A**

Table Of Contents

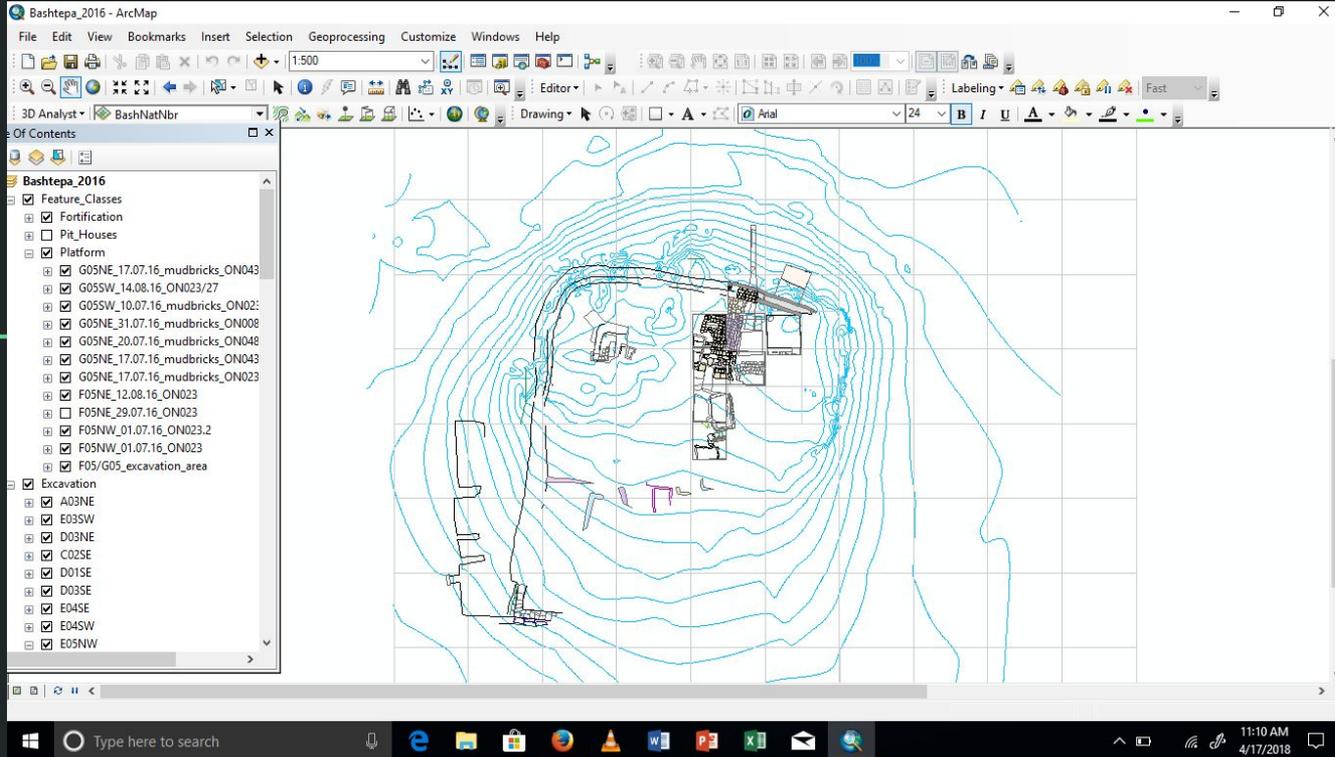
- Bashtepa
  - E04SE
  - Feature\_Classes
    - Fortification
    - Pit\_Houses
    - Platform
  - Excavation
    - A03NE
    - E03SW
    - D03NE
    - C02SE
    - D01SE
    - D03SE
    - E04SE
    - E04SW
    - E05NW
    - E05SW
    - F03NW
    - F05SW
    - F05SE
    - F05NW
    - F05NE
    - G03SW
    - G05NE
    - G05SW
    - G05SE
    - G06SW



143.602 89.389 Meters

# Overlaying

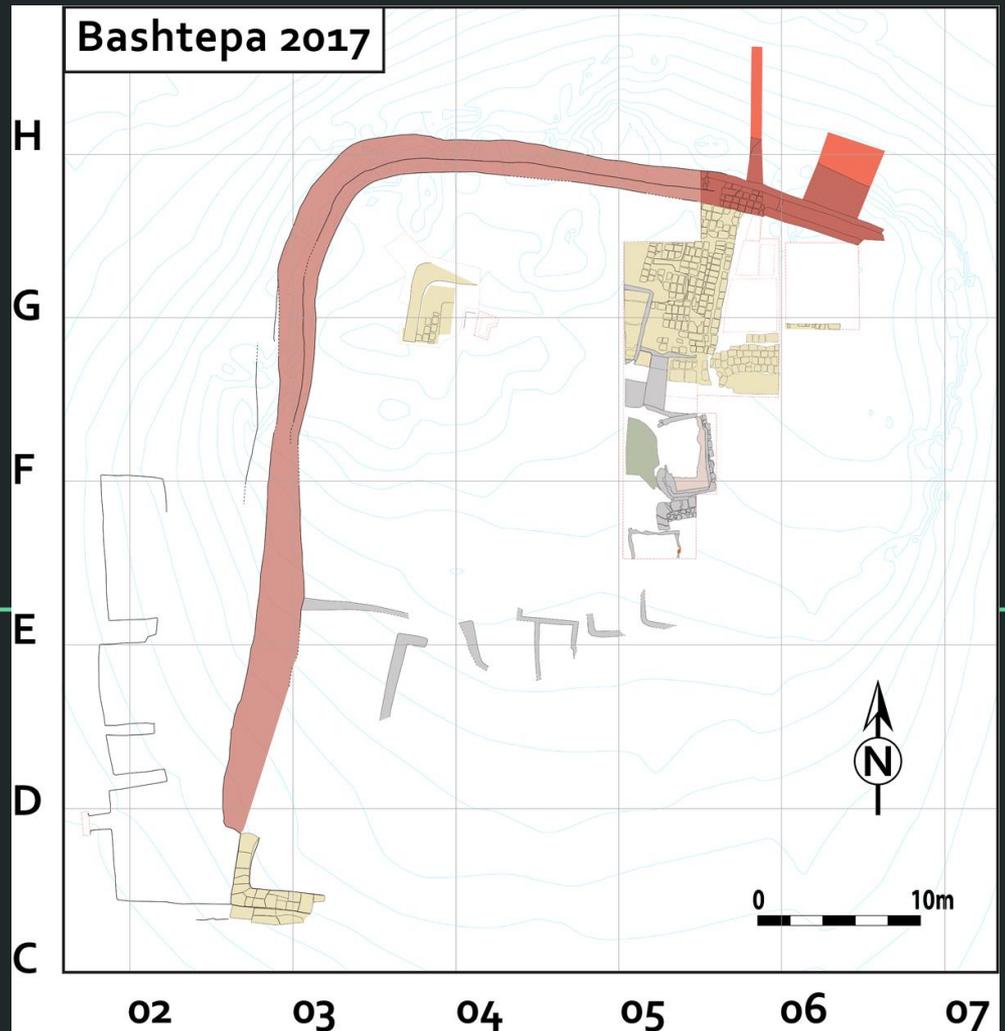
All within the same data frame, anchored to the same grid. Just a click of a button!



# Final Stage Making Your Map Publishable

**ArcGIS is horrible for making aesthetically pleasing, polished Maps. Major shortcoming.**

- Analytic tool, not graphic.
- Capability to import into Illustrator (vector) or Photoshop (raster).
- Many sites use AutoCAD Civil because the maps are publishable and spatially sound as you go.



# Google Maps APIs: Geocoding

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<https://developers.google.com/maps/documentation/>

# Additional Resources

- [Mapknighter.org](https://www.mapknighter.org) - make maps from aerial photos
- [Timeline.knightlab.com](https://www.timeline.knightlab.com) - make interactive timelines
- [Worldmap.harvard.edu](https://worldmap.harvard.edu) - open-source GIS mapping platform
  
- [Ancient World Mapping Center](#) (Antiquity À-la-carte)
- [Pleiades](#) - Gazetteer of Ancient Places
- [Digital Atlas of Roman and Medieval Civilization](#) (DARMC)
- [Digital Atlas of the Roman Empire](#) (DARE)
- ORBIS: [The Stanford Geospatial Network Model of the Roman World](#)