

GIS4DAR

GIS TRAINING WORKSHOP

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G70



TABLE OF CONTENTS

INTRODUCTION	3
About the Training/Tutorial	3
Case Example: Interisland Ocean Cable Project	3
ARCGIS SOFTWARE.....	5
GIS TERMINOLOGY	6
USING ARCCATALOG	8
Exercise 1: Using ArcCatalog to Explore Geospatial Data	8
1.1 Connecting to folder(s).....	8
1.2 Viewing data with the Contents, Preview, and Description tabs	9
1.3 Adding a metadata enclosure.....	13
1.4 Viewing the properties of a data layer	14
Exercise 2: Organizing Frequently Used Coordinate Systems	15
Exercise 3: Working with a Geodatabase	17
3.1 Creating a working folder.....	17
3.2 Creating an empty geodatabase.....	17
3.3 Importing data into geodatabase.....	17
3.4 Creating a feature dataset and importing data into it	18
3.5 Creating a raster catalog and loading it	19
3.6 Import and project bathymetry grids into geodatabase	22
USING ARCMAP	24
Exercise 1: Getting to Know the ArcMap User Interface	24
1.1 The ArcMap user interface	24
1.2 Setting the map document properties.....	25
1.3 Adding data to the table of content	26
1.4 Interacting with the map layers.....	27
Exercise 2: Working with Tabular Data (Excel spreadsheet)	32
2.1 Adding and plotting out tabular data	32
2.2 Creating a feature class from tabular data.....	34
Exercise 3: Creating and Exporting a Bathymetry Map	35
3.1 Visualizing bathymetry.....	35
3.2 Symbolizing features	37
3.3 Creating a map layout and setting the layout properties	39
3.4 Inserting a map inset	44
3.5 Inserting a map extent indicator.....	45
3.6 Inserting a scale bar	47
3.7 Inserting a north arrow	48
3.8 Inserting a legend.....	49
3.9 Creating a graticule grid.....	51

3.10	Inserting a map title and logo	52
3.11	Exporting a map	53
Exercise 4: Suitable Cable Routes – Raster Calculator Method.....		55
4.1	Creating the source and destination layers	55
4.2	Creating a custom toolbox in ArcToolbox	56
4.3	Creating a new model and setting its properties	57
4.4	Convert marine features classes to raster grids	59
4.5	Deriving slope and reclassing slope categories	63
4.6	Reclassing depth categories.....	65
4.7	Reclassifying marine raster grids	68
4.8	Deriving a total cost layer using raster calculator	70
4.9	Cost distance and direction analysis.....	71
4.10	Least cost path analysis (Finding the shortest cable routes).....	73
Exercise 5: Suitable Cable Route - Weighted Overlay Method		76
Exercise 6: Creating Profile Graph		80
Exercise 7: Adding Model Parameters - Optional		82
Exercise 8: Hyperlinking, Adding Attachments and Geotagging Photos		84
8.1	Convert survey locations to point layer	84
8.2	Hyperlinking images to survey point layer	85
8.3	Adding images as attachments to survey point layer	87
8.4	Viewing attachment(s) of a feature	88
8.5	Creating point features from geotagged photos.....	90
Exercise 9: Connecting to and Using Public GIS Server.....		92
Exercise 10: Adding ESRI Online Basemaps.....		96
APPENDIX A – HAWAII COORDINATE SYSTEMS		97
APPENDIX B – ACCESSING HAWAII STATE GIS DATABASES AND WEB SERVICES.....		98

INTRODUCTION

About the Training/Tutorial

A GIS (Geographic Information System) is a computer-based system for the input, storage, analyses, and display of spatial data. This training workshop provides an introductory to intermediate training in GIS using ArcGIS Desktop 10.4.1. No GIS experience is required. The purpose of this training is to get you up and going using and applying GIS to your research without spending a lot of time learning it. The training is hands-on and project-based, meaning you will learn how to apply GIS to a project from start to finish. More specific to the software, ArcGIS 10.4.1 that will be taught, you will learn how to:

- Use the ArcCatalog application to store, organize and manage spatial data such as creating geodatabase and metadata.
- Use the ArcMap application to view spatial data and make maps/visuals; and learn the basics of cartographic design.
- Use the ArcToolbox application to process/analyze spatial data, such as deriving slope from a bathymetry model (or DEM) and doing data conversion.
- Use the Model Builder application to create models and create a project work-flow process.
- Use the Spatial Analyst Toolbar to do raster analyses, such as calculating the shortest or least cost path from one location to another.

The training is broken up into 2 sections, an ArcCatalog section with 3 exercises and an ArcMap section with 10 exercises. The ArcGIS Desktop 10.4.1 with a Standard or Advanced license plus separate Spatial Analyst and an optional 3D Analyst Extensions are required.

Case Example: Interisland Ocean Cable Project

The case example being used in this tutorial is based on a project done in 2009 conducted by UH Manoa, School of Ocean and Earth Science and Technology (SOEST). More information for the survey project can be at: http://www.hawaiicleanenergyinitiative.org/storage/interisland_cable.pdf (last accessed 8/24/2017). Note that the methods used in this tutorial are only for the purpose of teaching GIS/ArcGIS, and are not necessarily reflective of the actual methods used in the real project.

Case scenario: As part of a renewable energy initiative, the Hawaiian Electric Company (HECO), with assistance from the State of Hawaii (DBEDT) is planning to integrate wind energy into the Oahu electrical system. The wind energy is expected to come from one or more wind farms on Lanai and/or Molokai and transmitted to Oahu via an interisland, undersea cable system. The proposed plan is to have either 1) two, 200 MW wind farms: one on Lanai and another on Molokai to integrate with Oahu's electric grid, or 2) a single 400 MW facility either on Lanai or Molokai to integrate with Oahu's electrical grid system. A later phased cable extension to Maui is also being looked at.

Your Task: To determine if it's feasible to have such an undersea power transmission system and if so suggest possible cable transmission routes.

Project Data

The data used for the project are listed below. Note that some data may have been modified to meet the pedagogical needs of this tutorial. The dataset should not be used outside of the training/tutorial.


Filename	Description	Source	Coordinate System
coast_n83.shp	Hawaii coastlines	HI State GIS Program	NAD 1983, UTM Z4
hillland.tif	Lanai hillshade	HI State GIS Program	NAD 1983, UTM Z4
hillmau.tif	Maui hillshade	HI State GIS Program	NAD 1983, UTM Z4
hillmol.tif	Molokai hillshade	HI State GIS Program	NAD 1983, UTM Z4
hillloah.tif	Oahu hillshade	HI State GIS Program	NAD 1983, UTM Z4
studyarea.shp	Polygon of project area	Derived from bathy10m	NAD 1983, UTM Z4
bathy10m_Rast	10m bathymetry grid	SOEST, UH Manoa	WGS 1984
hillshade10m	10m hillshade of project area	SOEST, UH Manoa	WGS 1984
BRFAplan.shp	Bottom restricted fishing area	HI State GIS Program	NAD 1983, UTM Z4
cablesExist	Existing undersea cables	HI State GIS Program	NAD 1983, UTM Z4
DumpingArea.shp	Dumping areas in marine waters	HI State GIS Program	NAD 1983, UTM Z4
Explosives.shp	Explosive dumping areas	HI State GIS Program	NAD 1983, UTM Z4
hihwnms.shp	HI humpback whale sanctuary	HI State GIS Program	NAD 1983, UTM Z4
mma.shp	Marine managed areas	HI State GIS Program	NAD 1983, UTM Z4
oreczones.shp	Ocean recreation zones	HI State GIS Program	NAD 1983, UTM Z4
sewerlines.shp	Offshore sewer lines	HI State GIS Program	NAD 1983, UTM Z4

Data from Hawaii Statewide GIS Program can be found at <http://geoportal.hawaii.gov/> (new site) or <http://planning.hawaii.gov/gis/download-gis-data> (old site).

See Appendix B for more information on accessing Hawaii Statewide GIS Data. State agency participants have direct access to the State's geodatabases.

ARCGIS SOFTWARE

ArcGIS is a scalable, desktop GIS software consisting of two integrated applications; ArcCatalog and ArcMap, and is available in three license levels: Basic, Standard, and Advanced (previously called ArcView, ArcEditor, and ArcInfo respectively). Each license level has a different set of functionalities that is hierarchical, going from basic to intermediate to advance. For a complete list of ArcGIS 10.x functionality, see the matrix pdf at: <http://www.esri.com/library/brochures/pdfs/arcgis101-desktop-functionality-matrix.pdf> (last accessed 8/11/2017).

 If a function is greyed out, it means that you don't have the correct license level to use it or you don't have the extension turned on/activated. Use the ArcGIS Administrator tool to see which license level you have then if needed activate extension/toolbar. Start button >> ArcGIS >> ArcGIS Administrator. You may need to have administrative privilege to access this tool.

Shown below is a general comparison of the license level functionalities.

	Basic	Standard	Advanced
Building Maps and Exploring Geographic Information			
Visualize and explore spatial patterns	✓	✓	✓
Build maps from database or online sources	✓	✓	✓
Interactively set symbols and labels for great looking maps	✓	✓	✓
View CAD data and/or satellite images	✓	✓	✓
Perform data conversion for CAD, raster, and dBase formats	✓	✓	✓
Generate map-based charts to visualize and explore data	✓	✓	✓
Create and edit simple feature geometry	✓	✓	✓
Multuser Editing and Advanced Data Management			
Allow multiple users to simultaneously edit the same data		✓	✓
Manage your data in a multuser enterprise geodatabase		✓	✓
Store historical snapshots of your data		✓	✓
Take advantage of complete GIS editing capabilities including interactive tools and templates		✓	✓
Automate the editing process		✓	✓
Advanced Analysis and Data Conversion			
Conduct advanced GIS data analysis and modeling			✓
Create atlas like, publication quality maps with high-end cartographic tools			✓
Perform data conversion for coverages			✓



ArcCatalog is the application for viewing and managing your spatial data. It resembles Windows Explorer, but is specifically designed to work with GIS data. In this regard, ArcCatalog should always be used to delete, move, copy, or rename spatial data files. This is where you browse and manage your spatial data, including viewing, editing or creating documentation (i.e. metadata) for your data. It organizes and manages all GIS information such as maps, globes, data sets, models, metadata, and services.



ArcMap is the central application in ArcGIS Desktop for all map-based tasks including cartography, map analysis, and editing. This is where you create, display, and interact with your maps. You can view, query, edit, and analyze your spatial data within a map environment. ArcMap provides an easy transition from viewing a map to editing its spatial features as well as providing a basis for understanding the relationship between your data.

GIS TERMINOLOGY

This section goes over some common GIS terms that are useful to know.

Vector Data: Data format in which geographic features and spatial phenomenon are represented as points, lines or polygons.

Raster Data (Grid): Data format in which geographic features and spatial phenomenon are represented as a grid of cells. Each cell contains a single attribute value and its location (XY) is defined by its place (row and column) in the grid.

Shapefile (SHP): A vector data storage format that stores the location, shape, and attribute of geographic features in a set of related files having the same prefix but different extensions (*.shp, *.dbf, *.shx, *.prj, *.sbn, *.sbx). Proprietary to ArcGIS/ESRI but is such a common format that it is often used to refer to any vector GIS data. Most if not all GIS software is capable of reading shapefiles.

Coverage: A folder-based, binary vector or raster data storage format in which features of a data layer is stored as primary features (e.g. arcs, nodes, polygons, labels, points or cells) and secondary features (e.g. tics, map extent, links, annotation). ArcInfo coverage files are often exported as interchange files with *.e00 extension. This file format is proprietary to ArcGIS/ESRI.

Geodatabase (GDB): A general term for any database that contains spatial information that can be mapped, such as latitude and longitude. A geodatabase is a “container” for your spatial data. In ArcGIS, there are three types of geodatabases, each primarily defined by their storage capacity – personal geodatabase (*.mdb), file geodatabase (*.gdb), and ArcSDE geodatabase (*.sde). More information on geodatabase types can be found here: http://resources.arcgis.com/en/help/main/10.1/index.html#/Types_of_geodatabases/003n0000000700000/

Feature Dataset: A collection or group of feature classes stored in a geodatabase. For example, a Street feature dataset may contain the features classes, major and minor roads.

Feature Class: A collection or group of common features having the same spatial representation as points, lines, or polygons, and a common set of attribute columns. For example, cities can be represented as a point feature class. Feature classes are stored in a geodatabase, and are also generically referred to as layers.

Layer(s): A layer or layers define how a particular theme of spatial data is symbolized and labeled in your map. For example, a map can contain layers, such as streets, streams, parcels, etc.

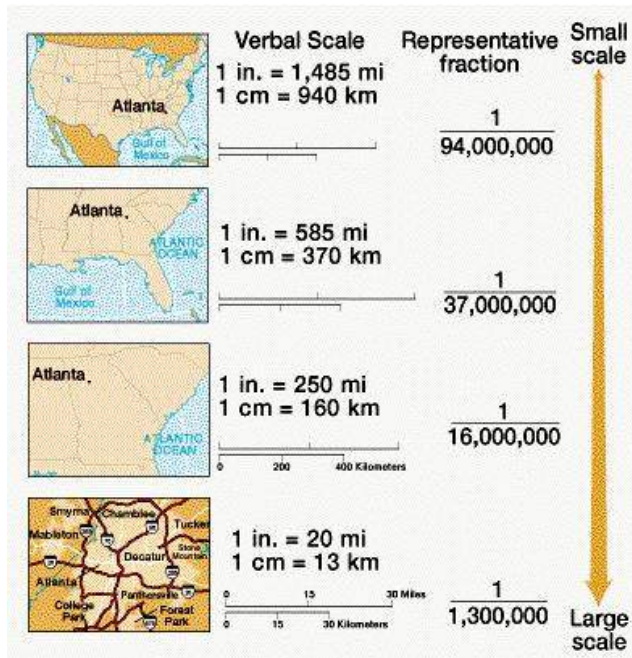
Layer File: File format with *.lyr extension that stores a reference to a data source (e.g. shapefile) and its properties, such as symbology.

Coordinate System: A coordinate system is the spatial reference of a spatial dataset, and is what allows GIS to easily integrate datasets with different spatial references into a common spatial reference framework.

There are two general types of coordinate systems: one is the global or spherical coordinate system, such as latitudes and longitudes, commonly referred to as geographic coordinate systems (GCS).

The other is projected coordinate system (PCS), which is based on a map projection such as Transverse Mercator, Albers Equal Area, or Robinson; all of which provide various methods to project maps of the earth's spherical surface onto a two-dimensional Cartesian coordinate plane. These are sometimes referred to as map projections.

Map Scale (large vs. small): A large scale map (e.g. 1:25,000) is one that covers a smaller area but show greater detail whereas a small scale map (e.g. 1:250,000) covers a larger area and shows less detail. The figure below illustrates map scales.



USING ARCCATALOG

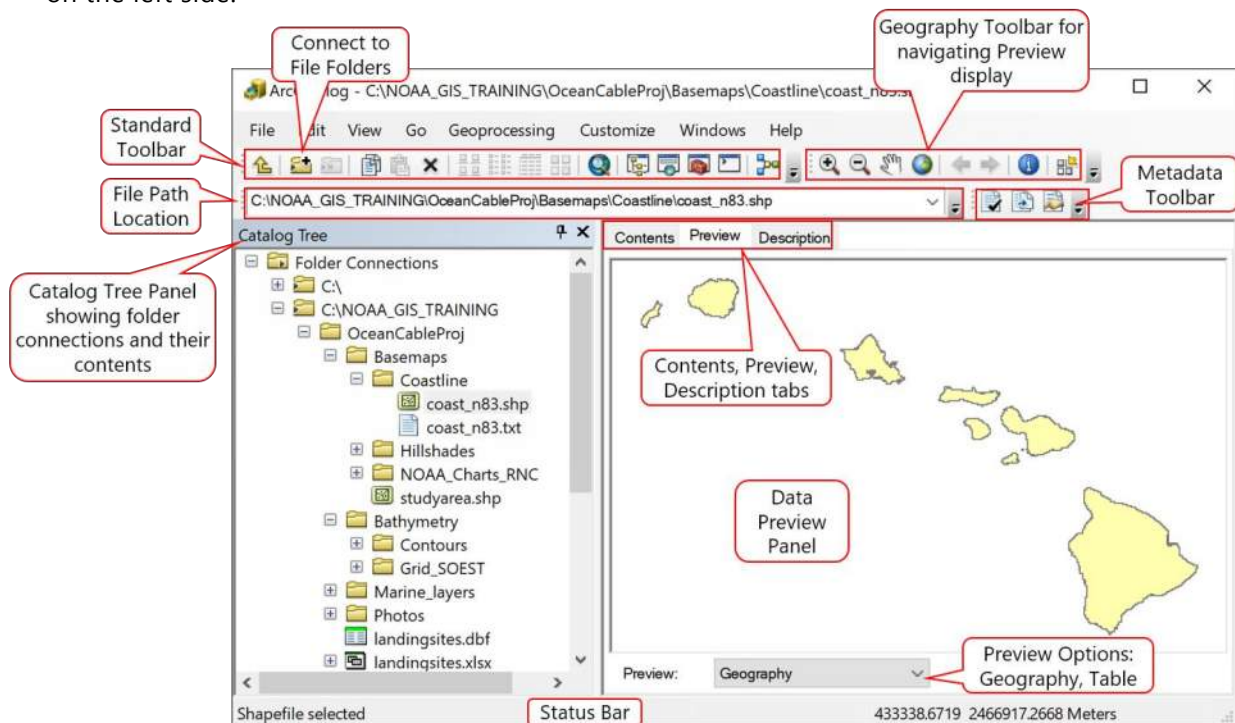
This section provides a brief overview of ArcCatalog and goes over the basics of how to use the application to connect to and work with various types of geospatial data, including viewing and editing metadata to add enclosures. Many of the operations shown in the ArcCatalog application can also be done via the Catalog window in ArcMap as well.

Exercise 1: Using ArcCatalog to Explore Geospatial Data

Open ArcCatalog and familiarize yourself with the user interface.

1. Open ArcCatalog from your desktop or go to Start button >> All Programs >> ArcGIS >> ArcCatalog. Note your ArcCatalog window may look different.

The ArcCatalog window opens with two frames. The left frame displays a list of all “mapped” drives on your computer. This is called the catalog tree or simply a directory tree. The right frame is called the Catalog Display and has tabs that let you explore the contents of the directory tree on the left side.



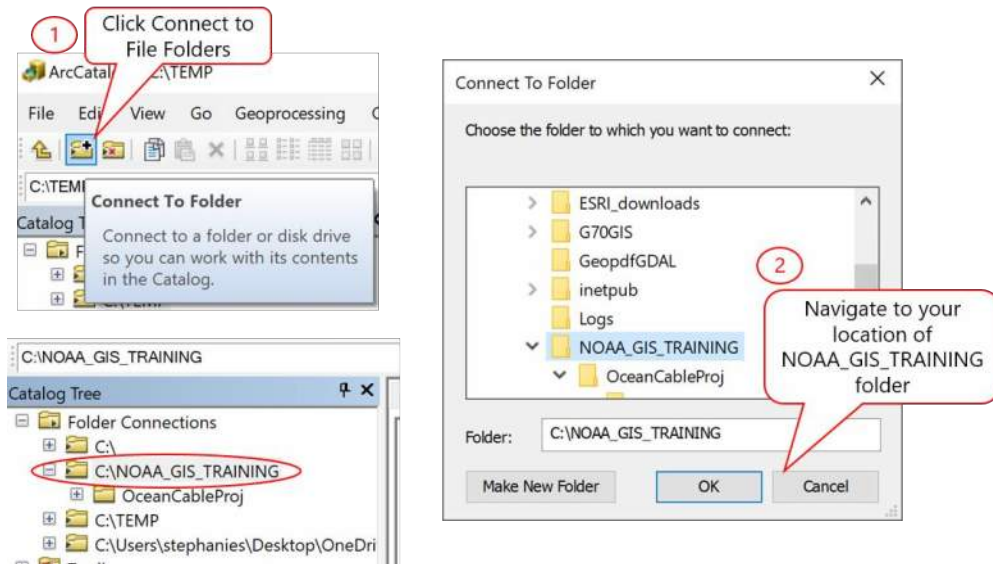
- If you “mouse” over a button on a toolbar, a tool tip will pop up describing the tool/button’s function.
- To display or hide a toolbar, go to Customize menu >> Toolbars >> Check appropriate toolbar to display/hide. You can also right click in any grey area to get the content menu to display/hide a toolbar.
- The Geography Toolbar is only active when in Preview window/tab.
- The toolbars can be floating or docked anywhere in the ArcCatalog window.

1.1 Connecting to folder(s)

You won’t be able to view your dataset unless you create a connection to it first, so the first task is to make a direct folder connection to your GIS training folder in ArcCatalog. Once connected, you will use ArcCatalog to access and manage all your geospatial data. Folder connections need to only be done once; ArcCatalog will remember these connections until it is removed.

Home Workspace = **C:\NOAA_GIS_TRAINING**

1. On the Standard Toolbar, click the Connect to Folder button. Alternatively, you can also right click on Folder Connections >> Connect to Folder. Or go to File Menu >> Connect to Folder.
2. Navigate to your location of the training folder, NOAA_GIS_TRAINING >> OK.
3. The training folder should now be displayed in the Catalog Tree.



- Folder connections can be renamed (e.g. C:\NOAA_GIS_Training to GIS_Data. This will only change the name of your folder connections not the actual folder name. A folder with a small triangle pointing to the right as shown here indicates it is a folder connection.
- An alternative way to add a folder connection to the Catalog Tree is by typing in the file path to your workspace in the File Path Location Toolbar

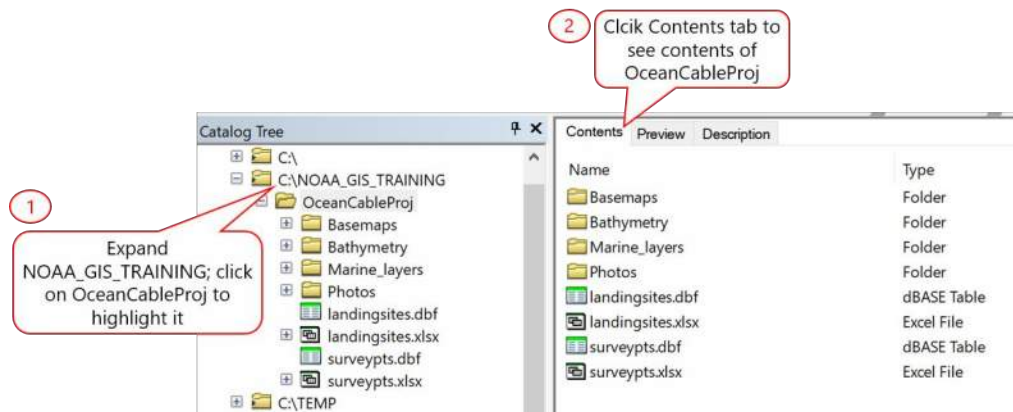
1.2 Viewing data with the Contents, Preview, and Description tabs

The Contents, Preview, and Description tabs allow you 3 different ways to view the contents, properties, geography, tables, and descriptive information for items highlighted/selected in the Catalog Tree.

The Contents Tab

The Contents Tab is the default tab which shows the contents of the selected item (e.g. file, folder, geodatabase) in the Catalog Tree.

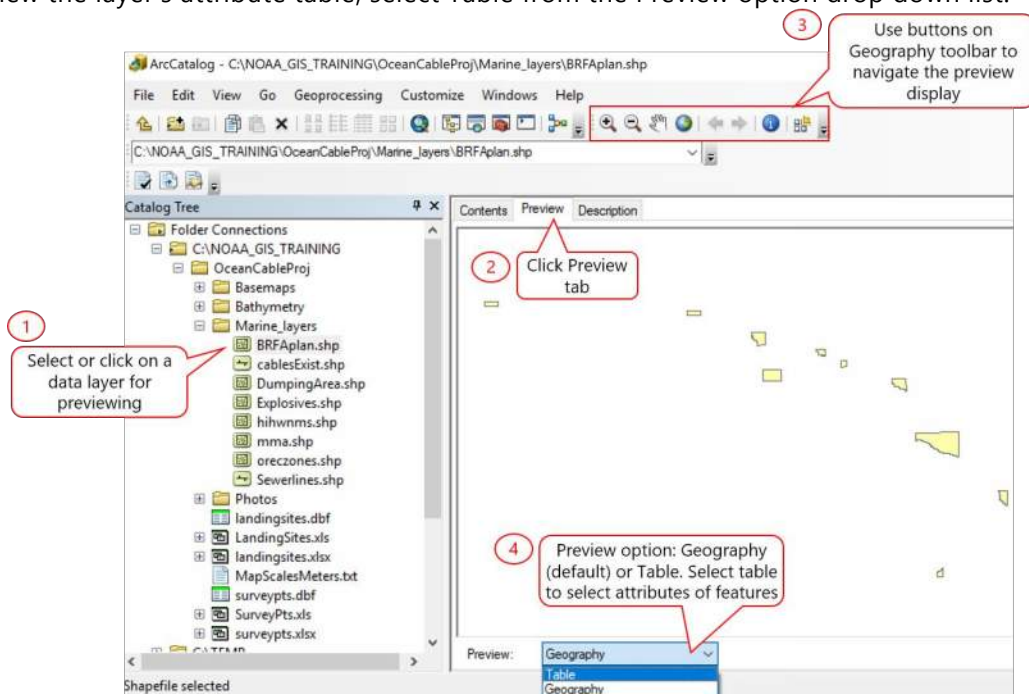
1. In the Catalog Tree Panel, navigate to NOAA_GIS_TRAINING and expand the OceanCableProj folder. You should see several other data subfolders. Click on any subfolder to select it.
2. Click the Contents tab if not already the default selection. The Contents tab will show the contents of your highlighted folder or subfolder selection (e.g. OceanCableProj). Alternatively you can also just expand the folder to see its content.



The Preview Tab

This tab provides a preview of the selected data layer. By default, the Preview tab will show the geography of the selected data layer. The data layer's attribute table can be viewed by selecting Table from the Preview option drop down list.

1. In the Catalog Tree, select or click on a data layer (e.g. BRFAplan.shp) of interest in one of the folder/subfolder.
2. Click the Preview tab. This will show you a preview of the data layer.
3. Use the buttons on the Geography toolbar to navigate the Preview display.
4. To view the layer's attribute table, select Table from the Preview option drop down list.



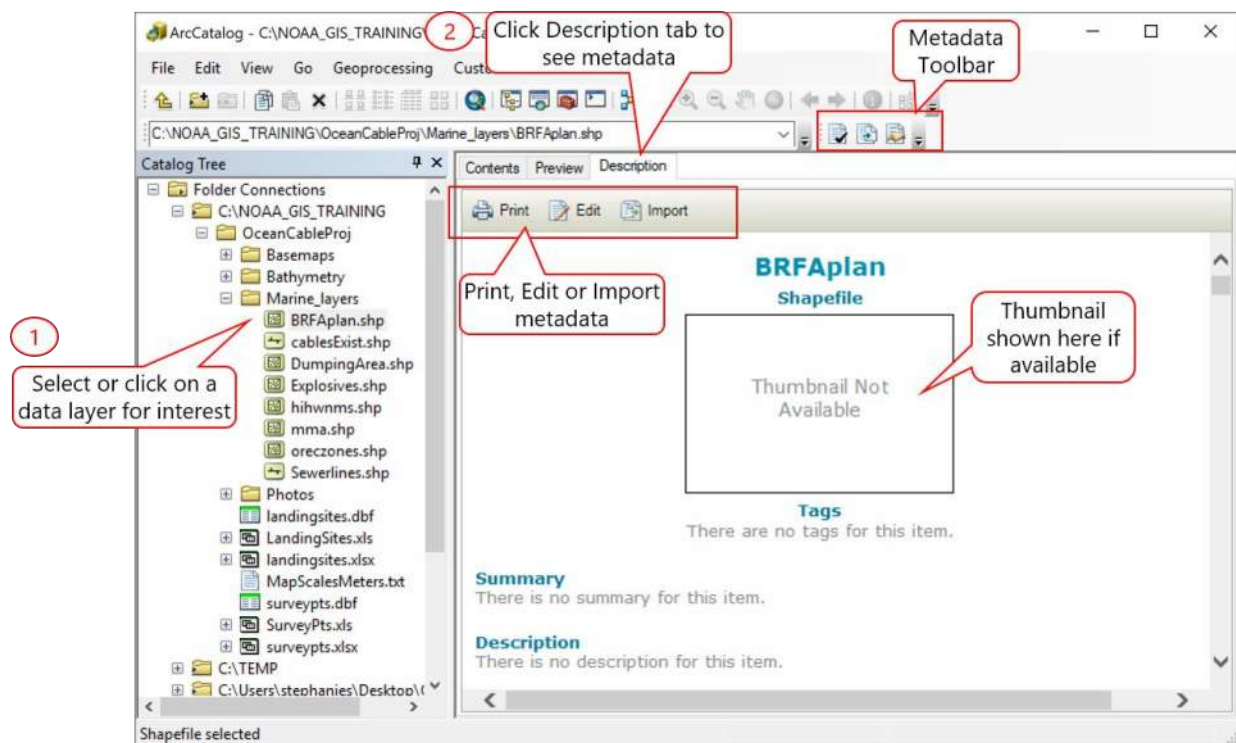
- If the Geography toolbar is not shown, turn it on by going to Customize menu >> Toolbars >> Geography.
- The Geography toolbar will become active when in Geography view of the Preview window, allowing you to interact (e.g. zoom in, zoom out, create thumbnails) with the data layer of interest.
- Refresh the Catalog tree panel (View menu >> Refresh or F5) if you don't see a file or folder in the Catalog Tree panel after working (i.e. creating, deleting, moving) with it in Windows Explorer

The Description Tab

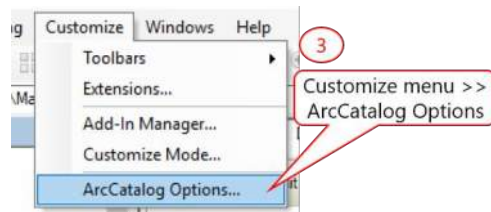
This tab provides metadata information of the highlighted data layer of interest, such as coordinate system, abstract, source, credit, and so on. This is where you can import, export, and edit metadata associated with a particular data layer.

Metadata can come in many formats (e.g. separate xml or text files or it can be included as part of the data file in the header). There may or may not be much information to view if the metadata itself is not part of the data file but in an external file instead, such as a text file. Metadata in formats such as text, HTML, XML, etc. can also be imported. However, the files have to be properly formatted in the metadata standard and style you're using for it to be imported correctly. Sometimes that may be more work than it's worth; in which case you can add it as an enclosure to the layer or leave it as a separate metadata file. See section 1.3 below on how to add a metadata enclosure.

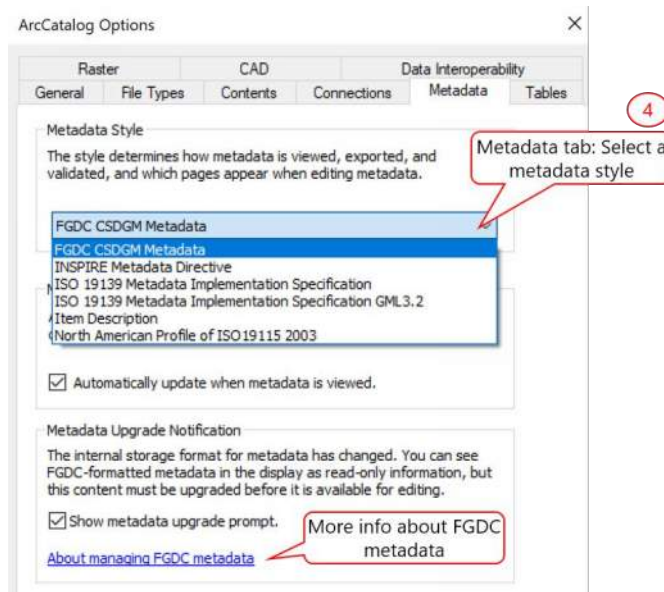
1. Select/highlight a data layer (e.g. BRFApplan.shp) of interest from your data folder.
2. Click the Description tab. This will display the highlighted data layer's metadata. The default metadata viewing style is Item Description. This style is designed to provide a brief description of the data and does not adhere to a specific metadata standard.



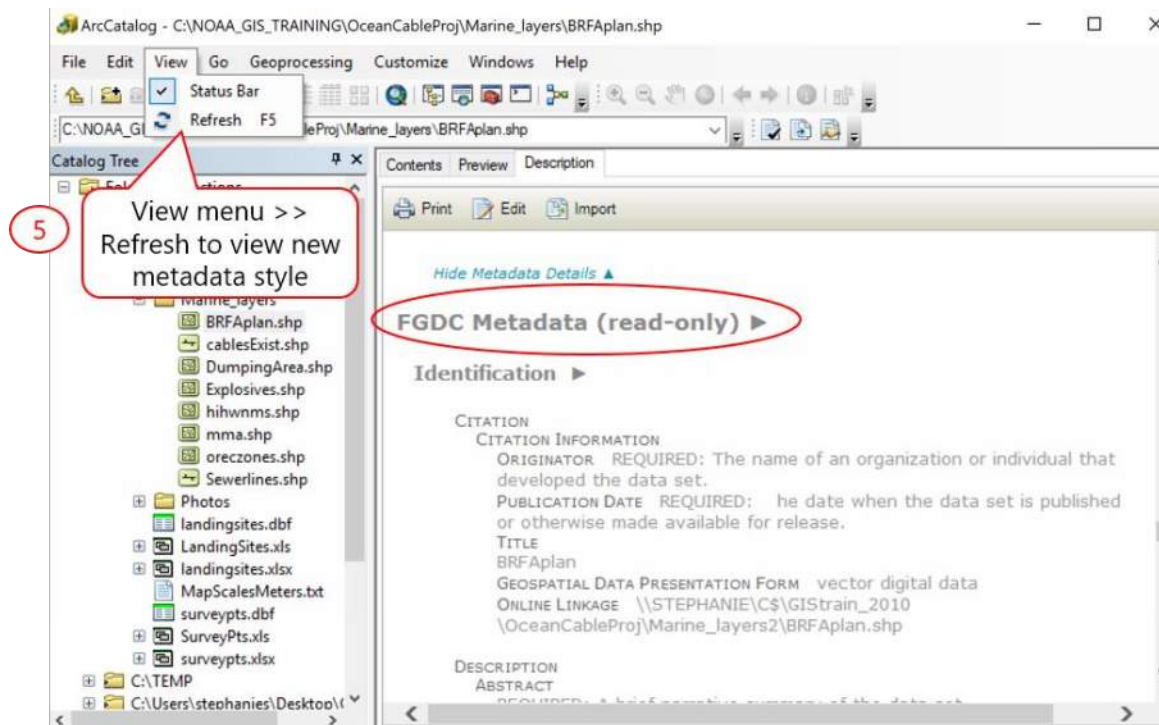
3. The default metadata viewing style lets you see and edit a simple, filtered set of metadata properties for a layer. To see a layer's complete metadata, change to a different metadata viewing style. Go to Customize Menu >> ArcCatalog Options >> Metadata tab



4. In the Metadata tab:
 - a. Under Metadata Style: select a viewing style (e.g. FGDC CSDGM Metadata).
 - b. Click Apply/OK



5. To see the new metadata viewing style applied, you need to refresh the view. Go to View Menu >> Refresh

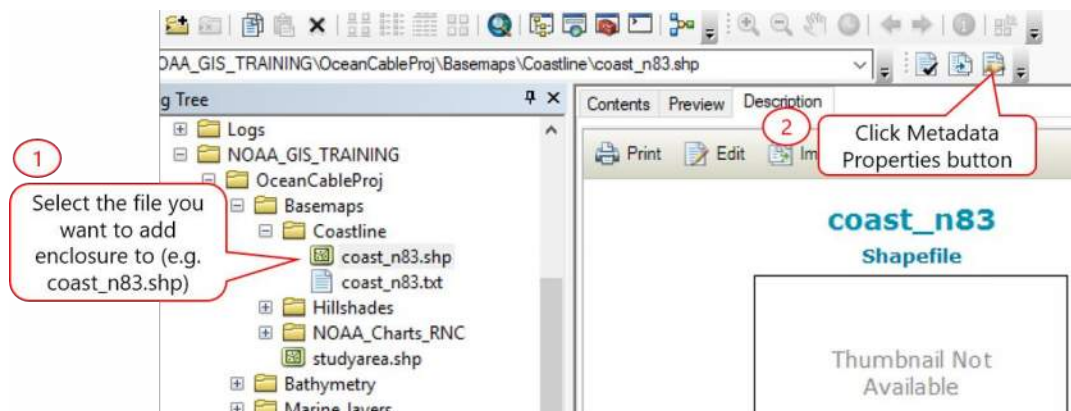


For more information on metadata standards for the United States, see the Federal Geographic Data Committee (FGDC) website: <http://www.fgdc.gov/metadata/geospatial-metadata-standards> (last accessed 8/14/2017). As part of a global geospatial data infrastructure initiative, the FGDC has endorsed several metadata standards that support and align with the International Standards Organization (ISO) metadata standards. See FGDC's ISO implementation guide at: <http://www.fgdc.gov/metadata/metadata-publications-list> (last accessed 8/14/2017).

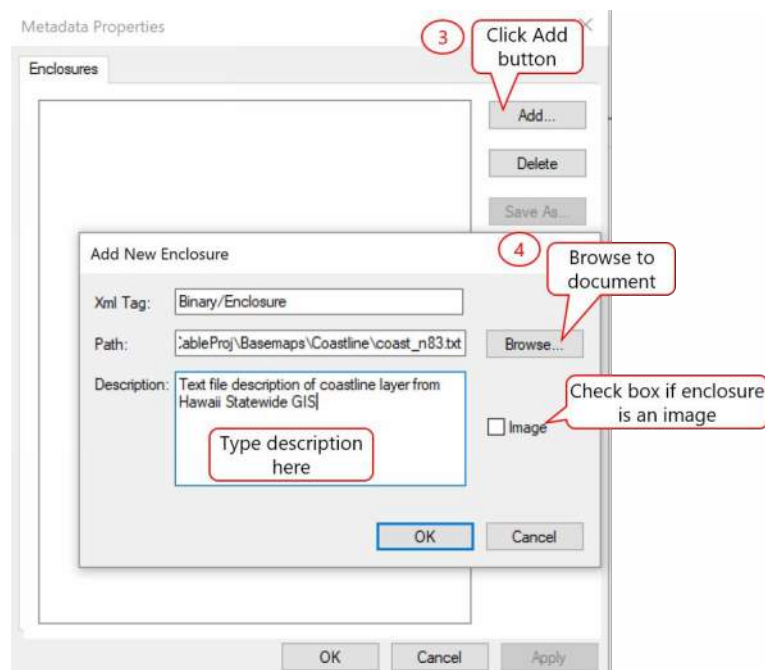
1.3 Adding a metadata enclosure

External files (e.g. pdf, word doc, or jpg) related to a data layer can be enclosed within a layer's metadata.

1. In the Catalog Tree, select the data layer (e.g. coast_n83_.shp) that you want to include an enclosure
2. On the Metadata toolbar, click the Metadata Properties button



3. In the Metadata Properties window: Click Add button
4. In Add New Enclosure window: Browse to your document (e.g. coast_n83.txt). Check the Image box if your file is an image. Also type a description of the file being enclosed. Click OK >> OK when done.

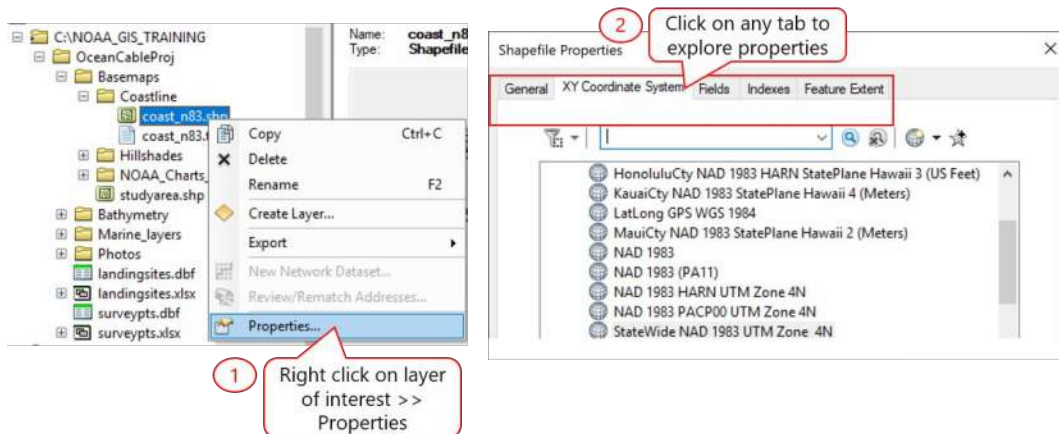


5. You should now see the enclosure. Double click on it to view it. You can also add more documents or delete existing enclosures.



1.4 Viewing the properties of a data layer

1. Select/highlight a data layer of interest >> Right click on the data layer >> Properties.
2. View detailed information of the selected data layer by clicking on any of the tabs in the layer's Properties window. Close out when done.

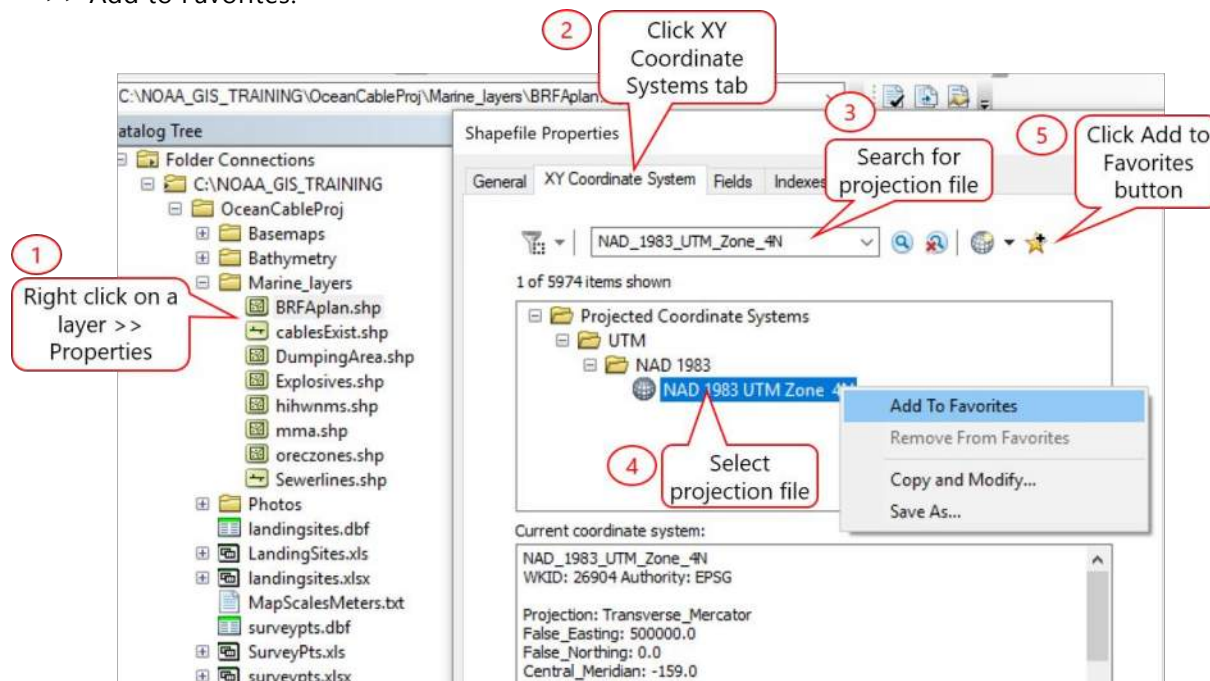


Exercise 2: Organizing Frequently Used Coordinate Systems

This section is considered optional but highly recommended as navigating through the hundreds of coordinate systems in ArcGIS to find the one you need, can be time consuming. Organizing frequently used projection files into a Favorites folder of its own will provide easier access to them. See the Hawaii Coordinate Systems page at the end of this document for more information.

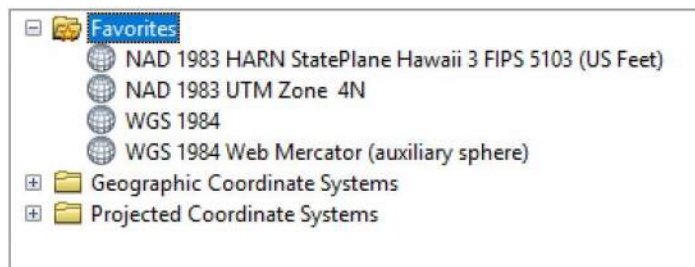
In this exercise, you will add 4 of the commonly used coordinate systems to your Favorites folder. Coordinate systems in Favorites can be accessed in both ArcCatalog and ArcMap.

1. In the Catalog Tree, right click on a data layer (e.g. coast_n83.shp) >> Properties.
2. In the Layer Properties window: Click the XY Coordinate Systems tab
3. Search for the projection with the filename: NAD_1983_UTM_Zone 4N
4. Select the projection file when found
5. Click the Add to Favorites button. Alternatively, you could also right click on the projection file >> Add to Favorites.



6. Follow steps 3-5 above to add the following projections files to your Favorites folder
 - NAD_1983_HARN_StatePlane_Hawaii_3_FIPS_5103_Feet
 - GCS_WGS_1984
 - WGS_1984_Web_Mercator_Auxiliary_Sphere

Under Favorites you should see the projections files you just added



The projection files you add to Favorites are stored in the Coordinate System folder in Application Data\ESRI\Desktop10.4\ArcMap\Coordinate Systems folder in the Windows profile directory. For Example: C:\Users\Stephanie\AppData\Roaming\ESRI\Desktop10.4\ArcMap\Coordinate Systems. The Coordinate System folder doesn't exist or isn't created until you add a projection file to Favorites. You can also copy and paste projection files into this folder and it will show up in Favorites.

Exercise 3: Working with a Geodatabase

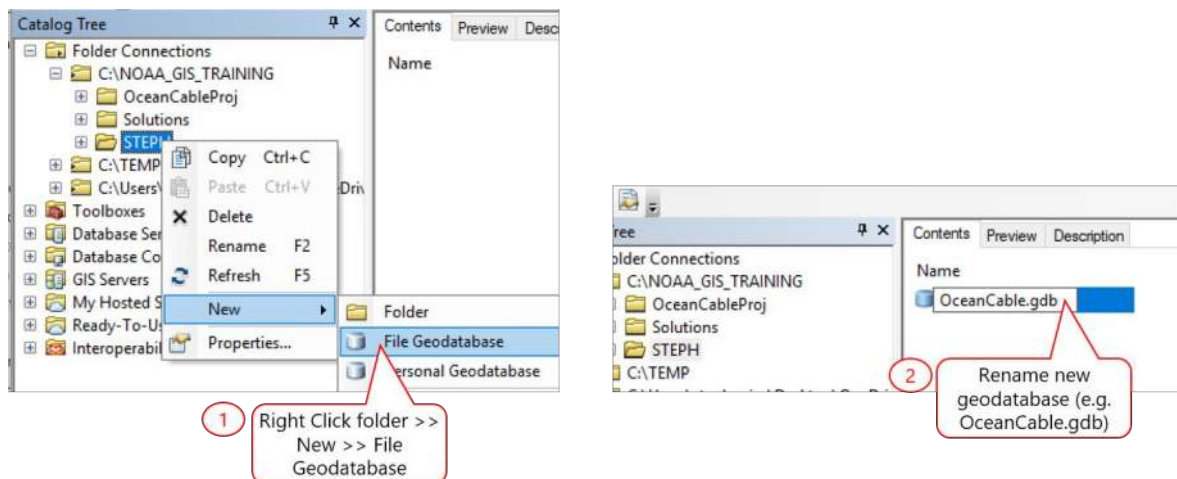
The first thing you do when starting a project is to assemble the needed data. For the sake of time and convenience, the project data has already been downloaded for you. As noted earlier the project datasets consist of several shapefiles. Instead of using the project datasets as they are (*i.e.* in their original formats), you will create a geodatabase to store copies of the original datasets. For this exercise, you will first, create a working folder and make a direct connection to it, then create a geodatabase to store and manage a working copy of the original project dataset, and finally import the original project datasets from the OceanCableProj folder to your own geodatabase (*e.g.* OceanCable.gdb).

Creating a working folder

1. In the Catalog Tree, navigate to C:\NOAA_GIS_TRAINING >> Right click on the folder >> New >> Folder. Type in a name for your working folder (*e.g.* STEPH).
2. If you want, create a direct connection to your working folder. Click the Connect to Folder button then navigate to your folder and click OK.

3.2 Creating an empty geodatabase

1. In the Catalog Tree, right click on your working folder (*e.g.* STEPH) >> NEW >> File Geodatabase
2. Rename the new geodatabase (*e.g.* OceanCable.gdb). As a general best practice don't start a folder or filename with a number, special character or have spaces

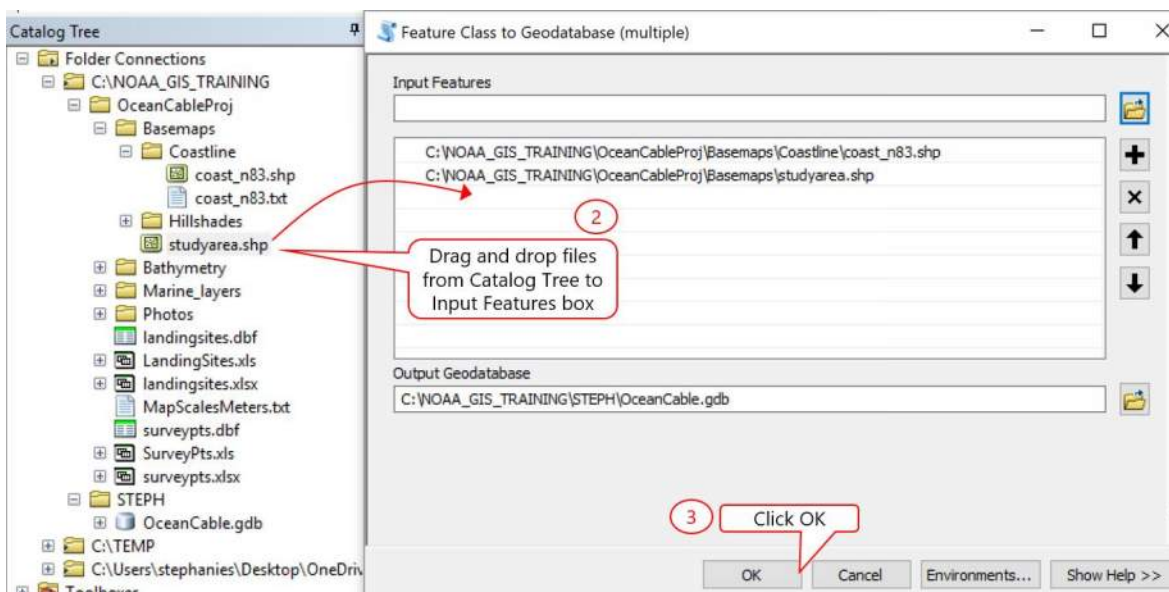


3.3 Importing data into geodatabase

The project datasets come from multiple sources and so have different coordinate systems. If a data layer has a coordinate system that is defined or can be read by ArcGIS then the software will reproject on the fly in ArcMap so you can view the data layers together. However, this is only for viewing purposes. Data layers in different projections should be reprojected into a common coordinate system when doing GIS analysis, otherwise you may inadvertently introduce errors into the analysis process. For this project/tutorial, you will use the projection system of NAD 1983, UTM Zone 4 (all of the Statewide GIS data are in this projection system). For those data layers that are not

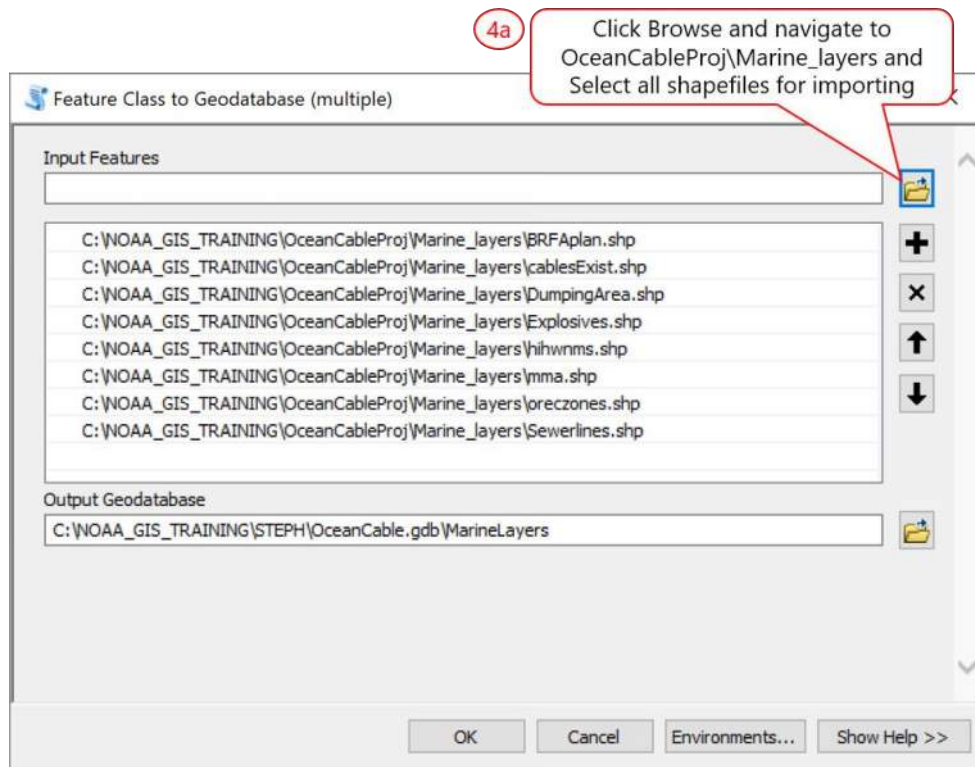
already in this coordinate system, you will reproject them at the same time as you are importing them into the geodatabase.

1. In the Catalog Tree, right click on your geodatabase (e.g. OceanCable.gdb) >> Import >> Feature Class (multiple)
2. In the Import Feature Class window:
 - Drag and drop the following layers from the Catalog Tree to the Import Input Feature box.
 - OceanCableProj\Basemaps\Coastline\coast_n83.shp
 - OceanCableProj\Basemaps\studyarea.shp
3. Click OK and wait for it to process. A popup box will show up when processing is complete – close it



3.4 Creating a feature dataset and importing data into it

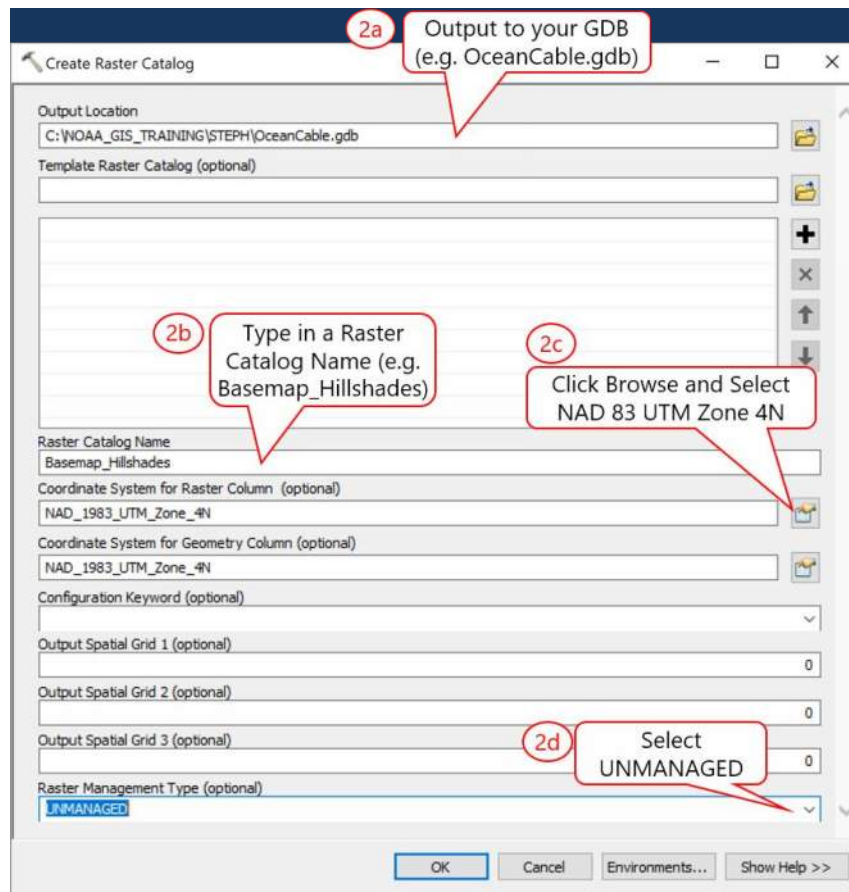
1. Right click on your geodatabase (e.g. OceanCable.gdb) >> New >> Feature Dataset
2. In the New Feature Dataset window:
 - a. Give the Feature Dataset a name, MarineLayers>> Click Next
 - b. XY Coordinate System: Select NAD 1983 UTM Zone 4 (from Favorites)
 - c. Z Coordinate System: use default settings >> Click Next
 - d. Accept the defaults for the XY Tolerance, Z, and M options >> Click Finish
3. Right Click on your Feature Dataset, MarineLayers >> Import >> Feature Class (multiple)
4. In the Import Feature Class window:
 - a. Click the Add button and navigate to the OceanCableProj\Marine_layers folder and select all the shapefiles for importing (use Shift + to select all files)
 - b. Click OK to run
 - c. Close popup box when done



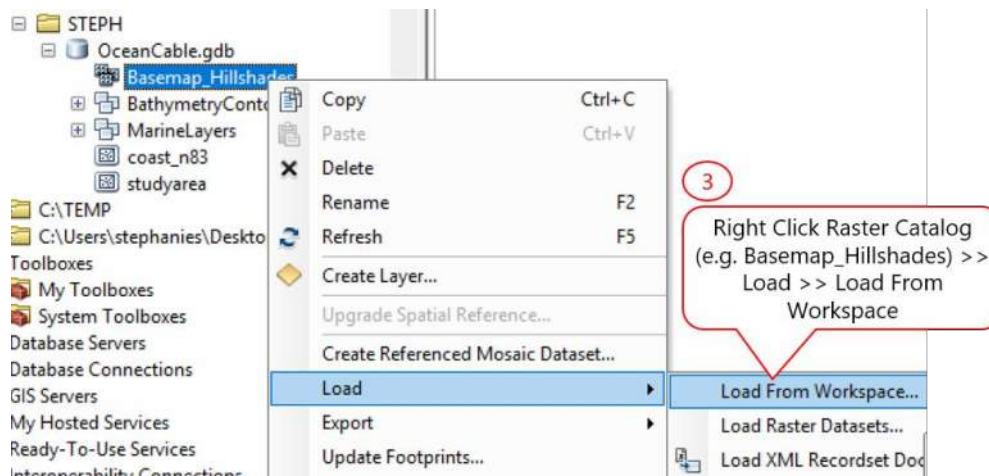
3.5 Creating a raster catalog and loading it

Raster data in a geodatabase can be imported/stored as individual layers or as a managed/unmanaged raster catalog, which are useful when you have many raster layers. A managed raster catalog will store copies of the rasters in ArcGIS's grid format in the geodatabase – when you delete a record from the catalog the raster is also deleted. An unmanaged raster catalog will store only the path to the raster data, however, if you move the original raster images then the link in the raster catalog will need to be reset. In this exercise, you will create an unmanaged raster catalog for the hillshade images.

1. Right click on your GDB (e.g .OceanCable.gdb) >> New >> Raster Catalog
2. In the New Raster Catalog window:
 - a. Output Location: this should already be filled in but just make sure it is to your GDB (e.g. OceanCable.gdb)
 - b. Raster Catalog Name: Type in a name for your raster catalog (e.g. Basemap_Hillshades)
 - c. Coordinate System for Raster Column: Click the Browse to button then select NAD 83 UTM Zone 4N as the coordiante sytem to use. Notice that the Coordinate Sytsem for Geometry Column is automatically filled in as well.
 - d. Raster Management Type: Use the drop down arrow and select UNMANGED
 - e. Click OK and wait for it to finish processing

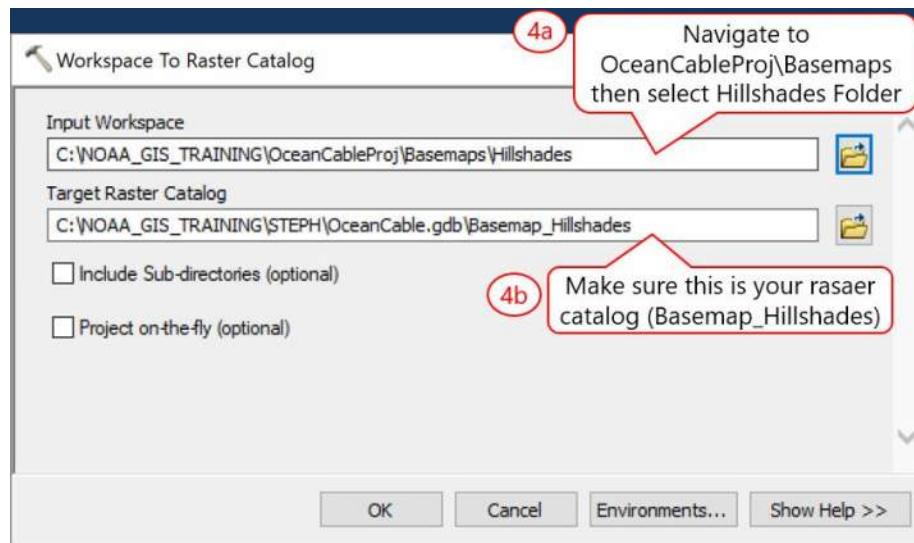


3. Load raster images into the empty Raster Catalog, right click on the raster catalog (e.g. Basemap_Hillshade) >> Load >> Load From Workspace



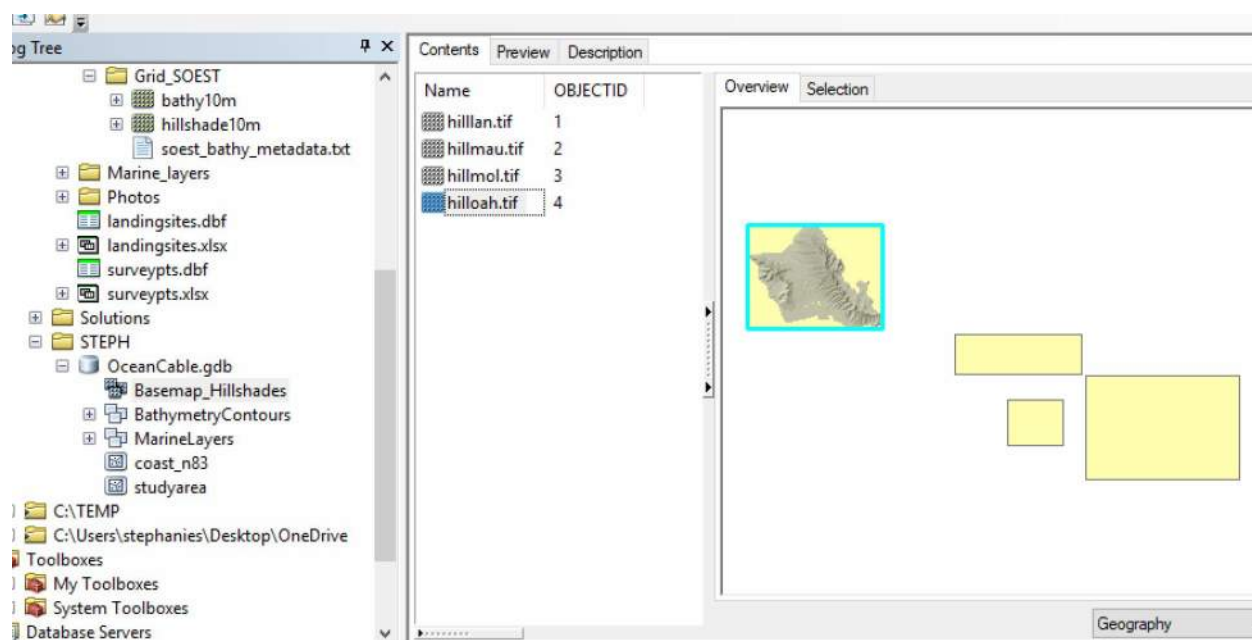
Use the Load Raster Dataset if your raster images are not in the same folder

4. In the Load From Workspace window:
 - a. Input Workspace: Navigate to OceanCableProj\Basemaps folder then select Hillshades
 - b. Target Raster Catalog: this should be filled in already, but just make sure this is your raster catalog (e.g. Basemap_Hillshades)
 - c. Click OK and wait for it to process. Close completed geoprocessing popup box.

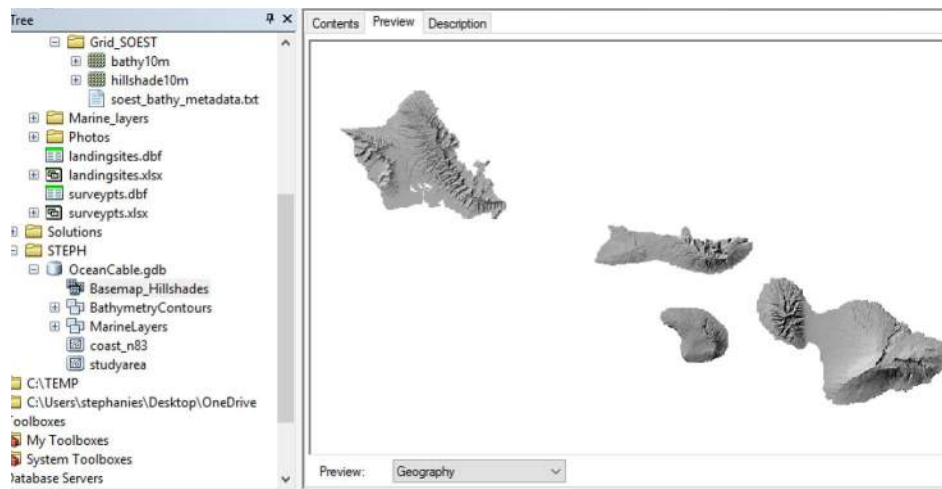


- Check the box to Include Sub-directories within your workspace if you have subdirectories and want to use them
- Check the box to Project on-the-fly if your raster images are in one coordinate system and you are loading them into a raster catalog that has a different coordinate system. For the example above, the raster catalog was set up to be in the same coordinate system as the hillshade images.

The four hillshade images should be loaded into your raster catalog. You can preview the images in the raster catalog using the Contents (expand window to see overview) or Preview tabs. Each of the images in the raster catalog is of 4 different islands, but when viewed in a catalog you see a mosaic as all the images are georeferenced and in their proper location. The contents of the raster catalog are shown below.



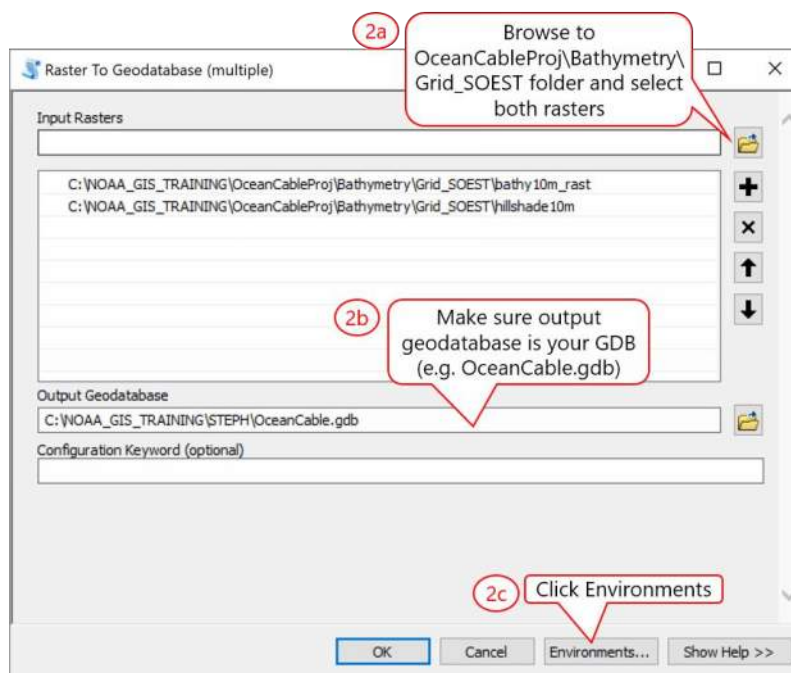
Below is a preview of the raster catalog – notice how the preview looks like a mosaic of the 4 tiffs.



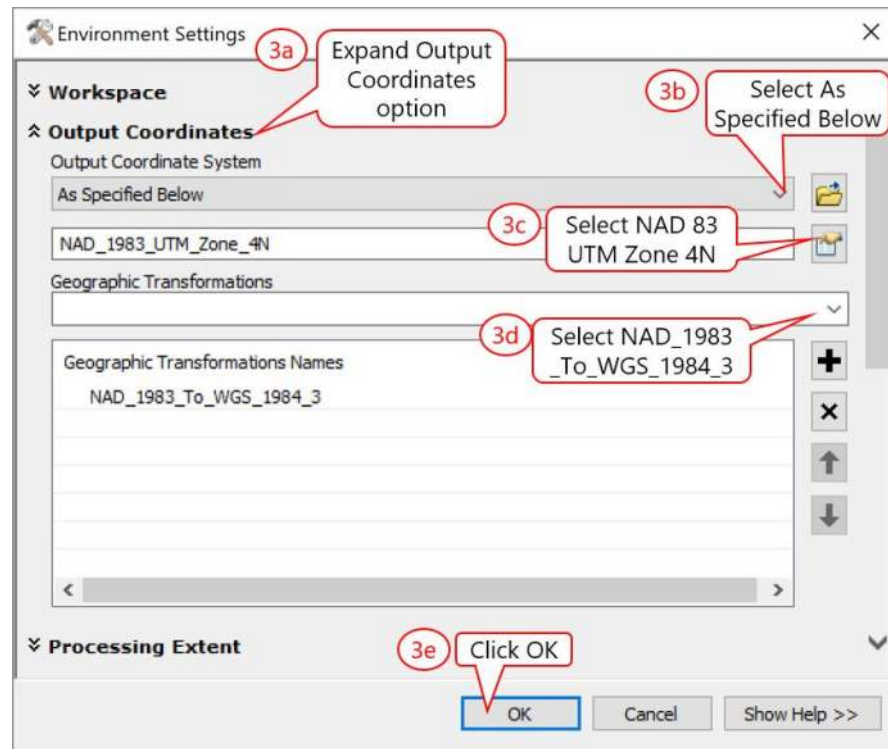
3.6 Import and project bathymetry grids into geodatabase

For this exercise, you will import the bathymetry raster grid and the corresponding derived bathymetric hillshade into your GDB. Both of these grids are in coordinate system WGS 1984 – in other words it is unprojected or in Lat/Long. You will be projecting the grids into NAD 83 UTM Zone 4N at the same as you import them into the GDB. Note you could also use the Project tool in ArcToolbox to project the bathymetry grid and output directly to your geodatabase.

1. Right click on your GDB (e.g .OceanCable.gdb) >> Import >> Raster Datasets
2. In the Rasters to Geodatabase window:
 - a. Input Raster: Browse to OceanCableProj\Bathymetry\Grid_SOEST folder and select both rasters (bathy10m_Rast and hillshade10m).
 - b. Output Geodatabase: this should already be filled in (just make sure it is your GDB)
 - c. Click the Environments button

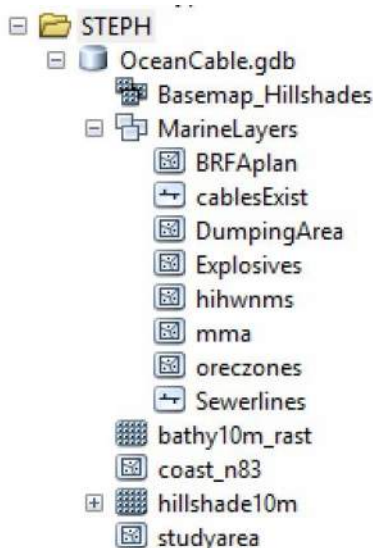


3. In the Environment Settings window:
 - a. Expand the Output Coordinates option
 - b. Output Coordinate System: Select As Specified Below
 - c. Select coordinate system: NAD_1983_UTM_Zone_4N
 - d. Geographic Transformations: use drop down arrow and select NAD_1983_To_WGS_1983_3
 - e. Click OK
 - f. Back in the Raster to Geodatabase window: Click OK and wait a couple minutes for it to process. Close completed popup.



See ESRI webpage on NAD 83 to WGS 84 transformations (last accessed on 8/20/2017):
<http://support.esri.com/en/technical-article/000005929>

Your GDB should contain the data files shown below.



USING ARCMAP

ArcMap is the main application where you view spatial data, create maps and do most of the GIS analyses. When you open ArcMap, it either creates or opens a map document (*.mxd file) depending on the startup dialog option selected. A map document may contain one or more layers of geographic data (i.e. map layers) in one or more data frames with various supporting map elements, such as a legend, labels, and a scale bar. Layers on a map are contained in data frames.

This section gives a brief overview of ArcMap and goes over the basics of how to use the application to work with geospatial data. There are 10 main exercises in this section.

Exercise 1: Getting to Know the ArcMap User Interface

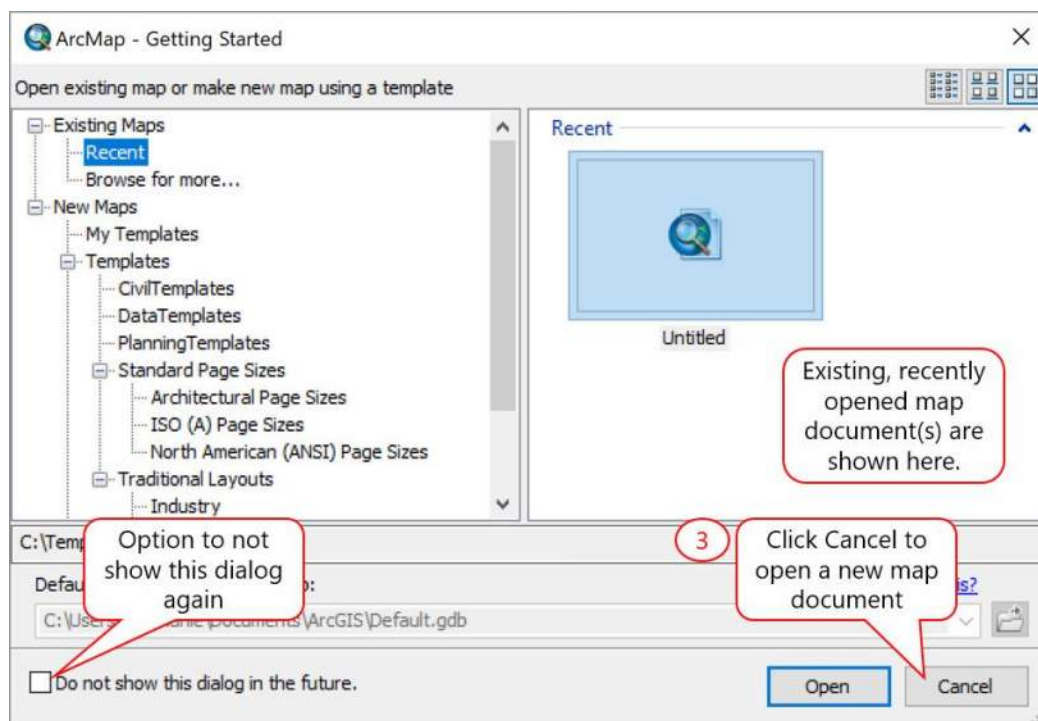
1.1 The ArcMap user interface

Open ArcMap and familiarize yourself with the user interface.

1. Open ArcMap from your desktop or go to Start >> All Programs >> ArcGIS >> ArcMap. A Getting Started dialog box will pop up.
2. If you do not want to see the Getting Started dialog box again, check the option not to show again.

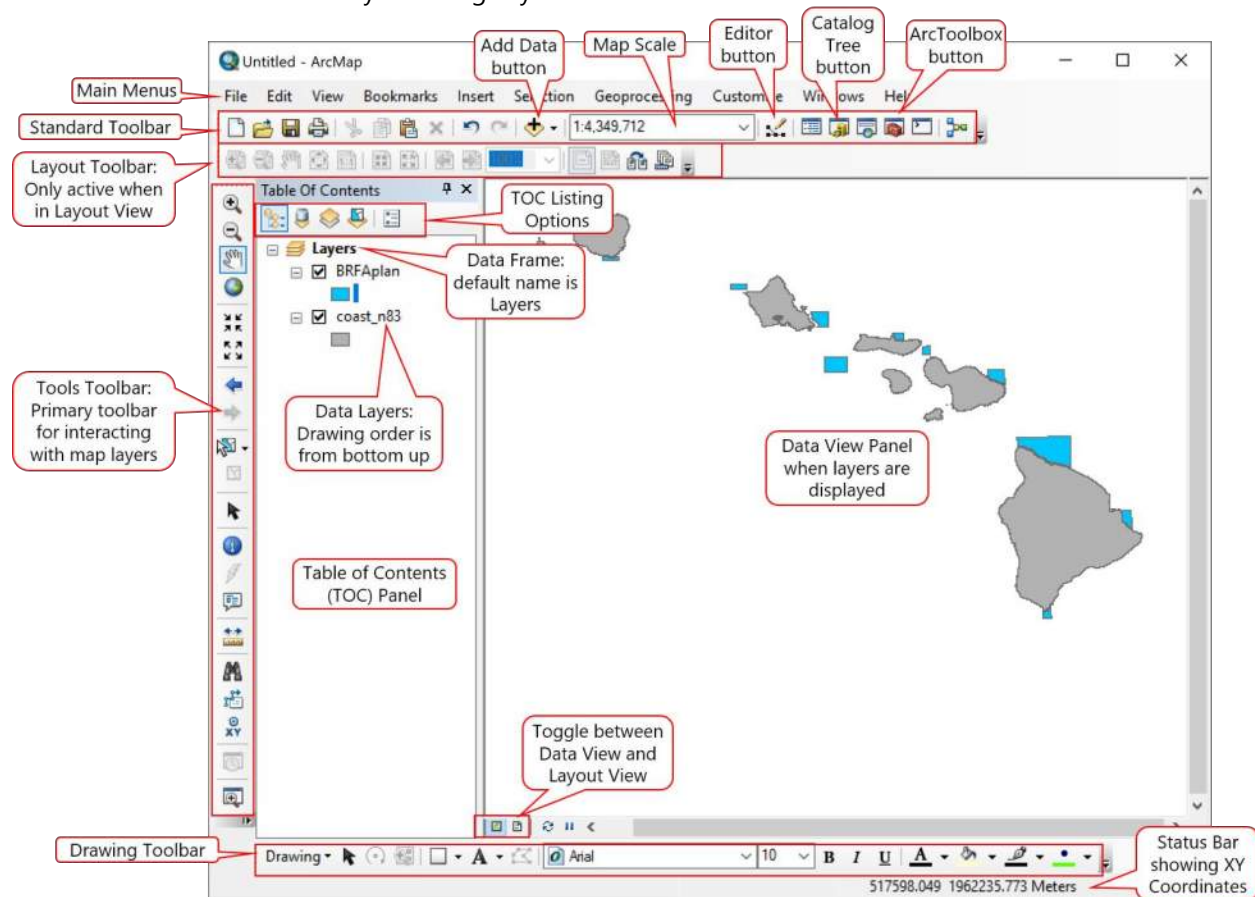
To show the Getting Started dialog box again, go to Customize menu >> ArcMap Options >> General Tab >> Start Up Options.

3. Click Cancel to open a new map document.



ArcMap offers two types of map views: a data view and a layout view. ArcMap will open to the default data view. The data view panel is where map layers are symbolized, analyzed, and compiled into GIS datasets. A table of contents (TOC) panel organizes and controls the drawing properties of the data layers in the data frame. The layout view is where map layouts are done. Note all the toolbars can be floating or docked anywhere on the ArcMap window.

Note: Your user interface may look slightly different

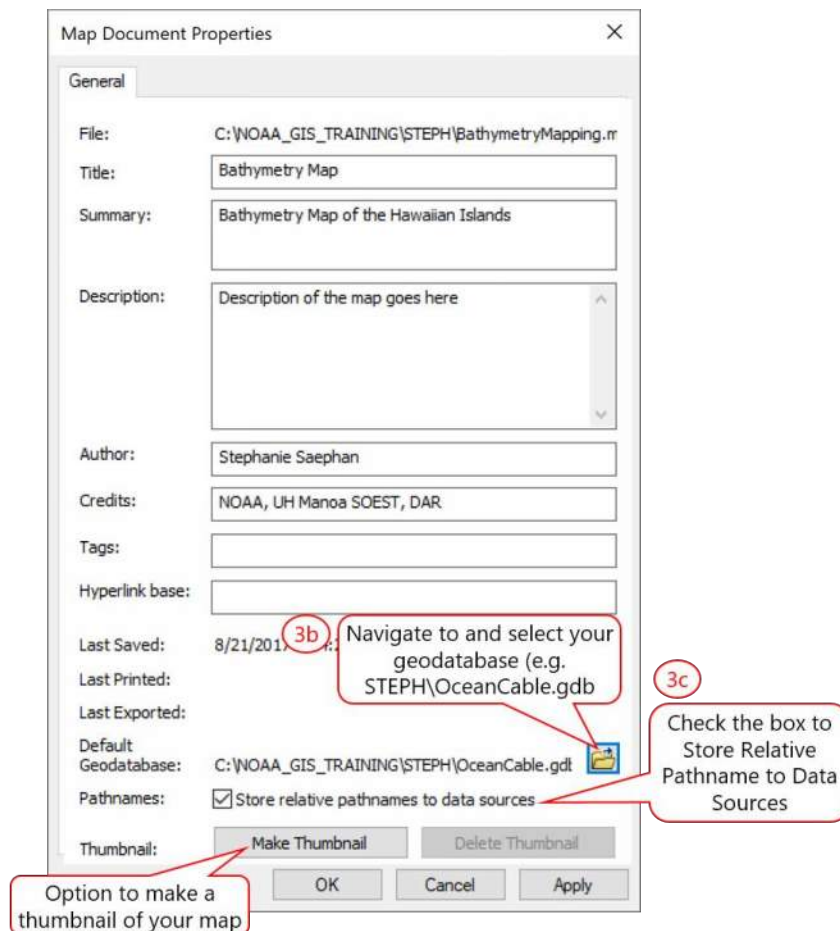


1.2 Setting the map document properties

This exercise goes over how to set the map document properties, such as map title, description, author, credits, and relative file names. When you save a map document the data source references are either saved with relative or absolute pathnames - the default is with absolute pathnames. To avoid having a map document with missing data when moving files around and for portability, save your map documents with relative pathnames. The relative pathname setting only works for data stored in a common disk drive (*i.e.* data cannot span disk drives).

1. To set up the map document properties, go to File menu >> Map Document Properties
2. In the Map Document Properties window:
 - a. Optional: Input information about the current map document
 - b. Default GDB: Click the Browse to button, navigate to and select your geodatabase (e.g. OceanCableProj/STEPH/OceanCable.gdb)
 - c. Check the box to store relative pathnames to data sources – this is to avoid missing data links should the data or document be moved
 - d. Optional: Make thumbnail – no need for it now since you have a blank map

- e. Click OK to close window



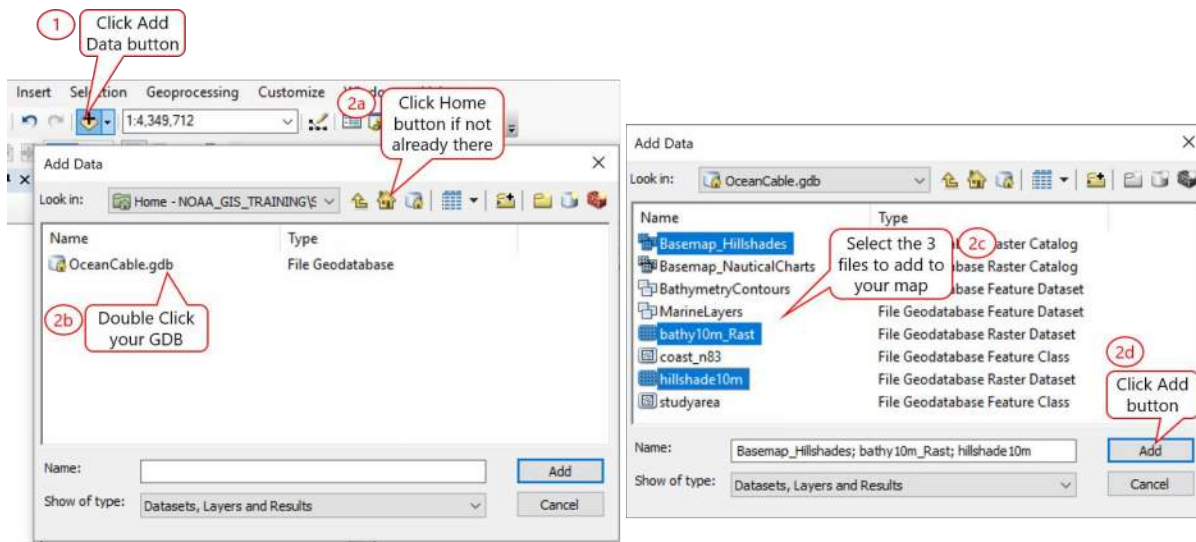
- The Make Thumbnail button in the Map Properties window will create a snapshot of the map document/map for previewing in ArcCatalog.
- The option to use relative pathnames to data sources in the Map Properties window is only for the current map document. To use relative pathnames as the default for all new map documents that you open, go to Customize menu >> ArcMap Options >> General Tab >> General Options.
- Default Geodatabase can also be set by right clicking on a geodatabase in the Catalog Tree >> Make Default Geodatabase.




1.3 Adding data to the table of content

In order for you to properly explore the ArcMap user interface you'll need to add in some data layers.

1. Click the Add Data button. Always use this button to add data – do NOT use the File/Open option
2. In the Add Data window:
 - a. If not already located in your Home folder (e.g. STEPH) then Click the Home button to navigate quickly to the working folder in which your map document and geodatabase resides.
 - b. Navigate to and double click on your GDB (e.g. OceanCable.gdb)
 - c. Select the following layers to add to the map
 - Basemap_Hillshades
 - bathy10m_Rast
 - hillshade10m

d. Click Add button



-  In general, the first layer added to your map will set the coordinate system of your data frame. If you add data layers with different coordinate systems then ArcMap will project them on the fly based on the coordinate system of the data frame. The coordinate system of the data frame can be changed by right clicking on the data frame name in the table of contents >> Properties >> Coordinate System Tab.
-  The default Data Frame name will be “Layers”. To rename it, click once on the data frame name then click again to get a text cursor, type new name.
-  The Go to Home button will bring to directly to the folder in which your current map document resides.


3. Save your map document in your working folder (e.g. STEPH\BathymetryMapping.mxd)

1.4 Interacting with the map layers

Using the Tools Toolbar to navigate the map display

Now that you've added some data to your map, you can start using the Tools toolbar to move around and explore the data in your map. The Tools toolbar is one of the primary ways that you interact with data layers displayed on your map or Data View panel. The toolbar contains tools for working with the contents within the active data frame of your map. The Tools toolbar can be used in both the Data View and Layout View. Some buttons are only active when certain types of data are present (*e.g.* Hyperlink button will only be active if the feature(s) has a hyperlink). Explore the tools on the Tools Toolbar at your own pace.

Note: your Tools Toolbar may be floating or docked somewhere on the ArcMap window.

-  Place the mouse pointer over a button to see the function described in the status bar and popup box

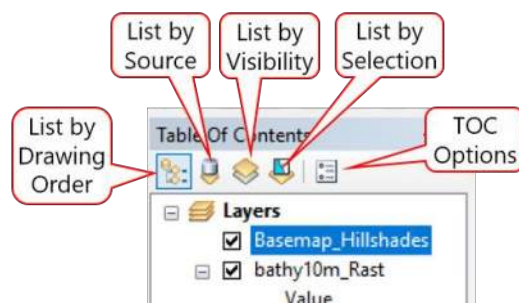


Functions on the Tools toolbar

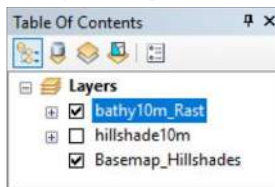
Button	Name	Function
	Zoom In	Allows you to zoom in to a geographic window by clicking a point or dragging a box.
	Zoom Out	Allows you to zoom out from a geographic window by clicking a point or dragging a box.
	Pan	Allows you to pan the data frame.
	Full Extent	Allows you to zoom to the full extent of your map.
	Fixed Zoom In	Allows you to zoom in on the center of your data frame.
	Fixed Zoom Out	Allows you to zoom out on the center of your data frame.
	Back	Allows you to go back to the previous extent.
	Forward	Allows you to go forward to the next extent.
	Select Features	Allows you to select features graphically, by clicking or dragging a box around them. You can also use the Select By Polygon, Lasso, Circle, and Line tools to select features using graphics drawn to the screen.
	Clear Selection	Unselects all the currently selected features in the active data frame.
	Select Elements	Allows you to select, resize, and move text, graphics, and other objects placed on the map.
	Identify	Identifies the geographic feature or place on which you click.
	Hyperlink	Triggers hyperlinks from features.
	HTML Pop-up	Triggers HTML pop-up windows from features.
	Measure	Measures distances and areas on your map.
	Find	Finds features in the map.
	Find Route	Allows you to calculate point-to-point routes and driving directions.
	Go To XY Location	Allows you to type an x,y location and navigate to it.
	Open Time Slider Window	Opens a time slider window for working with time-aware layers and tables.
	Create Viewer Window	Allows you to create a new viewer window by dragging a rectangle.

Exploring the Table of Contents (TOC) panel options

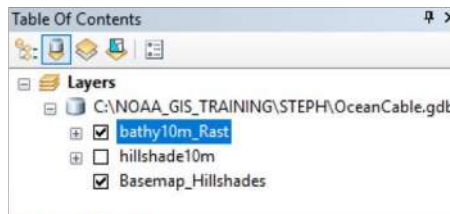
The TOC panel lists all the data layers in your map. This is where you can turn layers on and off, access the layers' properties as well as the properties of the data frames, and change the order in which layers are drawn. You can choose how the layers are viewed in the TOC with the List by Drawing Order (default), List by Source, List by Visibility or List by Selection buttons.



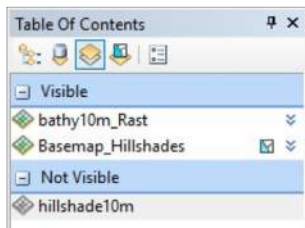
List by Drawing Order



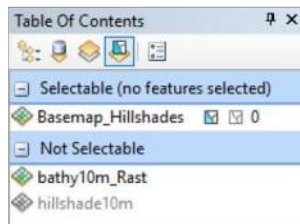
List by Drawing Source



List by Visibility

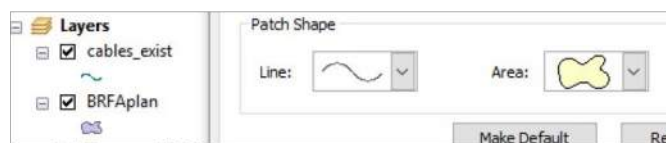
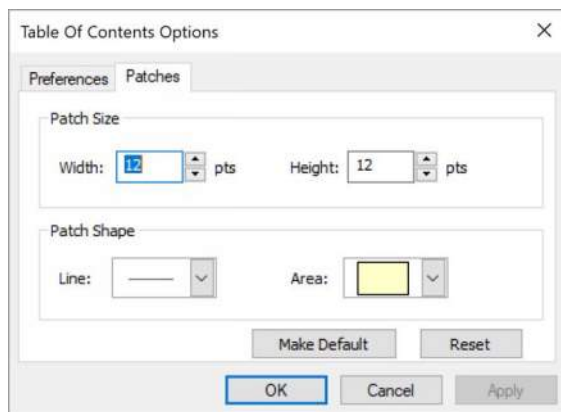


List by Selection



Tabular data added to the TOC/Data Frame will automatically go into the List by Source view

The TOC Options allows you to change the preferences and the patch size and shape of the polygon or line used to represent a vector data layer in the TOC. The example below shows a line layer displayed as a squiggly line and a polygon layer shown in an irregular shape instead of a square.



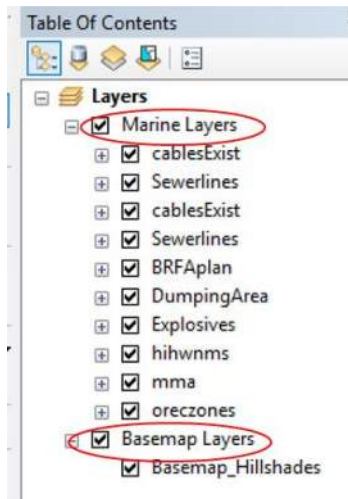
Turning layers on and off

Turn map layers on and off by checking box next to the layer name. For layers in a group and subgroups, turning of the main group will turn off all layers, turning off a subgroup will turn off all layers within that subgroup.



Grouping data layers

Data layers can be grouped. To do this you need to add a new group layer. Right click on the Data Frame name (e.g Layers) >> New Group Layer. You can also add a new basemap group as well. The example below shows a Marine Layers Group with individual layers under it. A Basemap Group is also shown with a raster catalog of the Hawaiian Island hillshades.



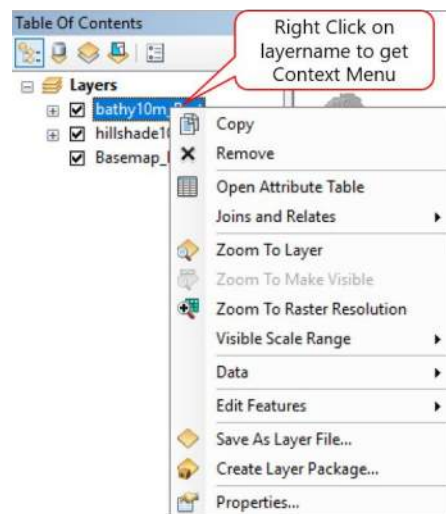
Change a layer's drawing order

Change a layer drawing order by dragging and dropping it on top of or below another layer in the TOC. Layers are drawn from the bottom up. For example, drag and drop Basemap_hillshades layer to the bottom of the layer stack.



Context menu

The context menu of a layer can be accessed by right clicking on the layer name in the TOC.



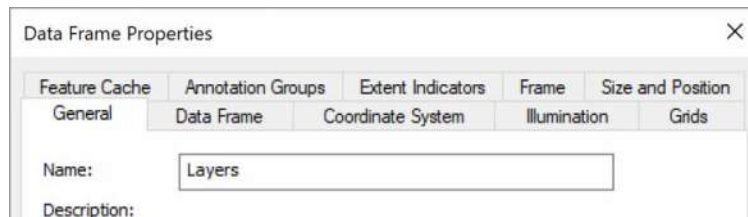
Layer properties (context menu)

View a layer's properties by right clicking on the layer name >> Properties. A quicker shortcut is to just double clicking on the layer name. Spend a few minutes exploring the different tabs in the Layer Properties window. When you are done, close it.



Data frame properties



View the data frame's properties by right clicking on the data frame >> Properties. Or just double click on the Data Frame name. Spend a few minutes exploring the different tabs in the Data Frame Properties window. When you are done close it.



Exercise 2: Working with Tabular Data (Excel spreadsheet)

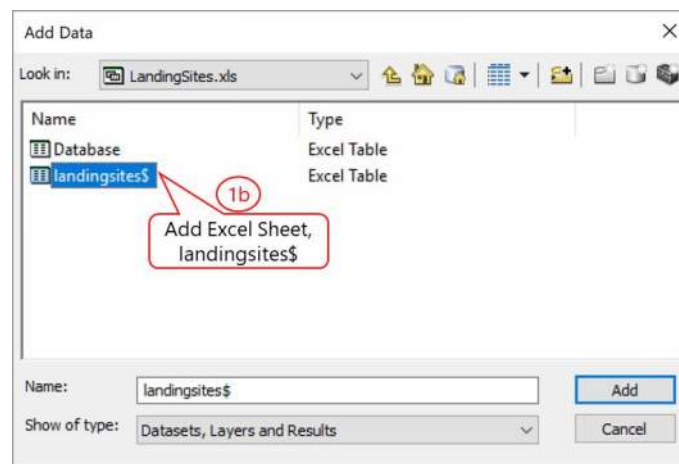
Tabular data can be added, view, and used in ArcMap; and if the tables contain spatial information such as XY coordinates then the data in the tables can be mapped. ArcGIS can directly read text files (*.txt, *.csv) and Excel files (*.xlsx and *.xls). Other tabular data sources, such as MS Access file formats (*.mdb and *.accdb) can be accessed through an OLE DB connection. Although ArcGIS can read tabular data in several formats as noted, they are read-only and cannot be edited without being converted into a GIS layer.

To lay the cables you need to know where the landing sites are going to be. The State have already identified potential landing sites for the project. The five sites: Pearl/Honolulu Harbor and Kaneohe Bay (Oahu), Ilio Point (Molokai), Kaena Point (Lanai), and Kahalui Bay (Maui) are in an Excel file. For this exercise, you will add the Excel spreadsheet to your map, plot out the points then create a feature class from it to use in later parts of the training.

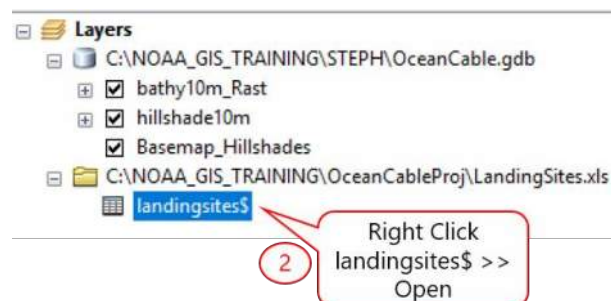
-  More info on using MS Access in ArcGIS (last accessed 8/20/2017): <http://desktop.arcgis.com/en/arcmap/10.4/manage-data/tables/understanding-how-to-use-microsoft-access-files-in-arcgis.htm>
-  More info on using Excel in ArcGIS (last accessed 8/20/2017): <http://desktop.arcgis.com/en/arcmap/10.4/manage-data/tables/understanding-how-to-use-microsoft-excel-files-in-arcgis.htm>

2.1 Adding and plotting out tabular data

1. Click the Add Data button
 - a. Navigate to your OceanCableProj folder and double click on LandSites.xls
 - b. Select the Excel sheet, landingsites\$ > > Add



2. Notice the TOC automatically switched to the List by Source view. Right click on landingsites\$ > > Open



The Point_X and Point_Y fields are longitudes and latitudes of the sites, and X_UTM and Y_UTM fields are the XY coordinates in UTM Zone 4. Notice that the longitudes and latitudes are in decimal degree format.

Table						
landingsites\$						
	RecID	POINT_X	POINT_Y	X_UTM	Y_UTM	Si
	1	-157.044991	20.917998	703322.108464	2314311.109531	Kaena Poi
	2	-157.734937	21.443566	631091.994075	2371768.80187	Kaneohe B
	3	-157.96536	21.31607	607305.155913	2357480.918007	Pearl Harb
	4	-157.260536	21.215116	680540.736896	2346947.406268	Ilio Point
	5	-156.475007	20.915942	762629.937	2314911.6515	Kahalui Br

3. Plot out the cable landing sites on the map using the X_UTM and Y_UTM fields. In the TOC, right click on landingsites\$ >> Display XY Data.

Alternatively, you could also go to File Menu >> Add Data >> Add XY Data

4. The fields in the Display XY Data window should already be filled in with the approximate parameters but make sure the X Field = X_UTM, Y Field = Y_UTM, and Projection is NAD 83 UTM Zone 4N.
 - a. Click OK
 - b. Note warning about no Object ID field. Click OK

Display XY Data

A table containing X and Y coordinate data can be added to the map as a layer

Choose a table from the map or browse for another table:

landingsites\$

Specify the fields for the X, Y and Z coordinates:

X Field: X_UTM

Y Field: Y_UTM

Z Field: <None>

Coordinate System of Input Coordinates

Description:

Projected Coordinate System:
Name: NAD_1983_UTM_Zone_4N

Geographic Coordinate System:
Name: GCS_North_American_1983

☐ Show Details

☒ Warn me if the resulting layer will have restricted functionality

[About adding XY data](#)

OK Cancel

Table Does Not Have Object-ID Field

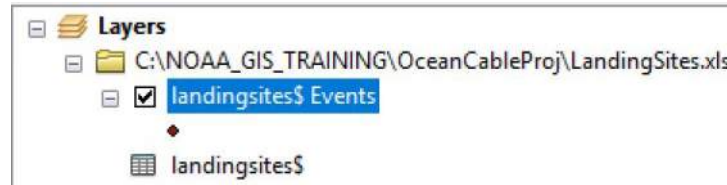
The table you specified does not have an Object-ID field so you will not be able to select, query, or edit the features in the resulting layer, or define relates for them.

After you create this layer, you can export it to a shapefile or feature class if you need these functions. To export a layer, right-click it in the Table Of Contents and choose Data>Export Data. Add the exported data to the map as a new layer.

4b Note warning about object ID and click OK

OK Cancel

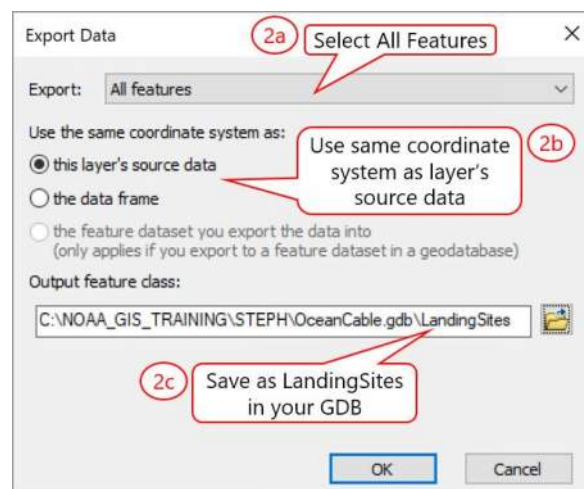
A temporary landingsites\$ Events is added to your TOC. This layer will not persist after the session ends unless the map document is saved. There should be 5 points representing cable landing sites on your map.



2.2 Creating a feature class from tabular data

In this section, you will convert the events layer, landingsites\$ Events from the previous section into a more permanent feature class so that you can work with it later on in the tutorial.

1. Right click on landingsites\$ Events >> Data >> Export Data
2. In Export Data window:
 - a. Export: All Features
 - b. Coordinate System: Use this layer's source data
 - c. Output Feature Class: Save as LandingSites in your GDB (e.g. OceanCable.gdb\LandingSites)
 - d. Click OK
 - e. Click Yes to popup asking if you want to add exported data to map



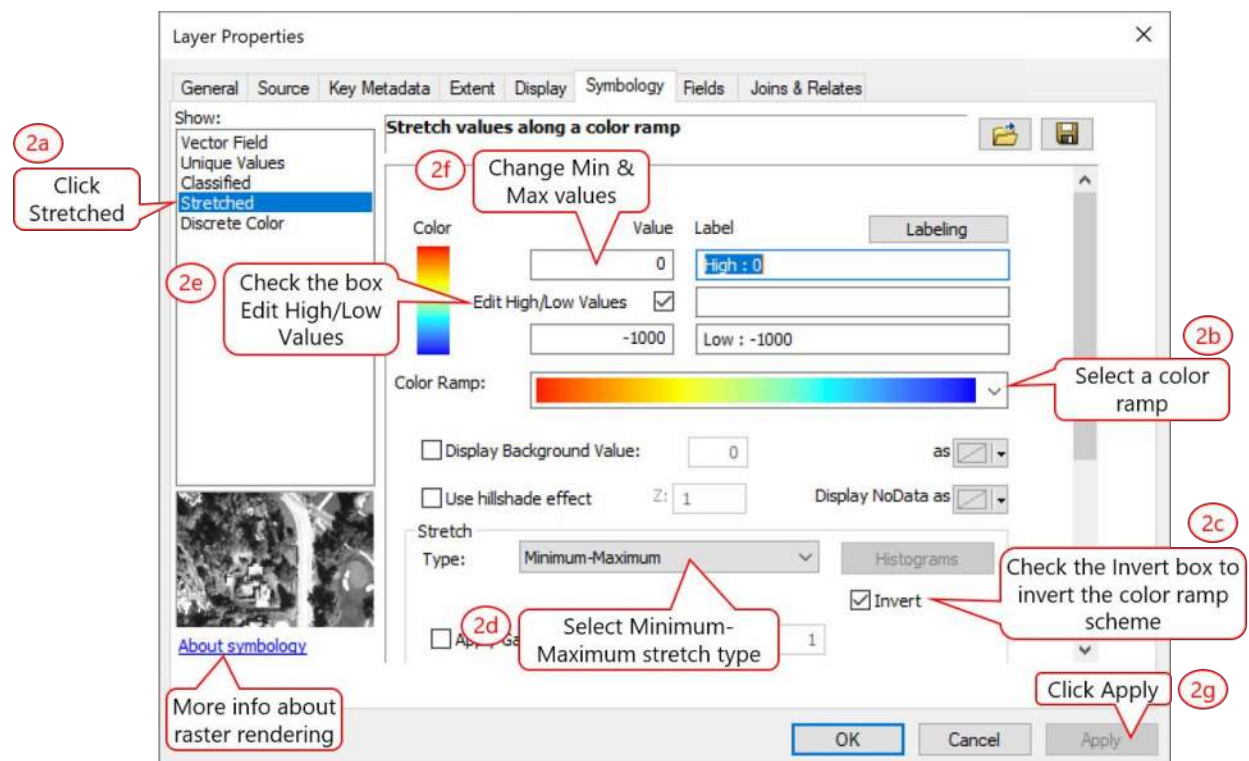
3. After the feature class has been created for the landing sites, you can go ahead and delete the Excel file and the temporary landingsites\$ Events from the TOC by right clicking on the filename >> Remove. This is so you don't have layers you don't need any more cluttering up the TOC).
4. Save your map document

Exercise 3: Creating and Exporting a Bathymetry Map

This exercise will guide you through some basic steps in making a map in the Layout view. You'll be making a map showing the bathymetric grid with the landing sites by their location and include a map inset with an extent indicator and latitude/longitude graticule grid. Additionally, you will also include a legend, scale bar, north arrow, and other map elements to your map.

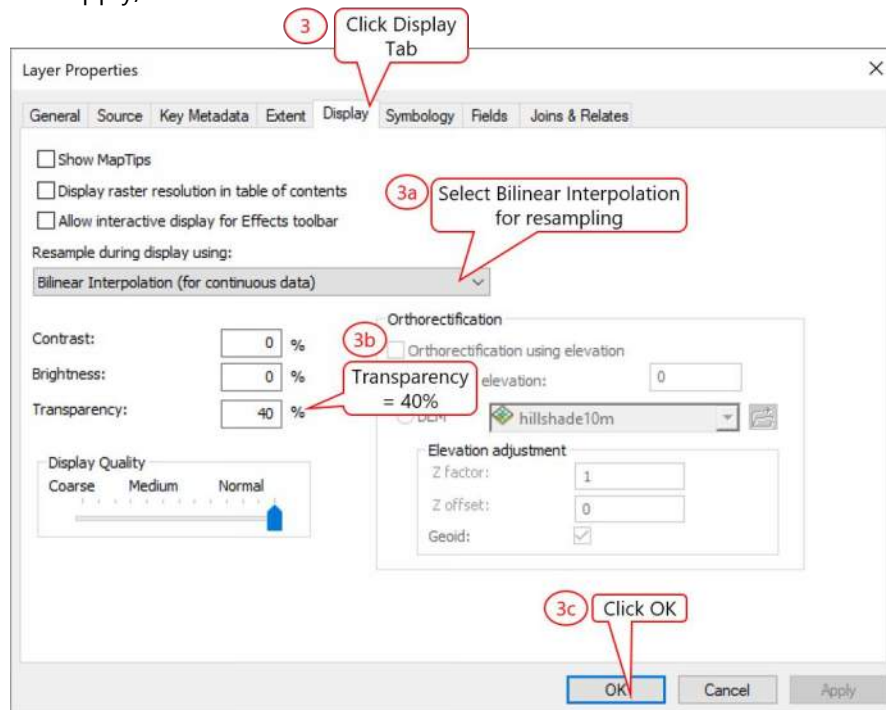
3.1 Visualizing bathymetry

1. In the TOC, right click on bathy10m_Rast >> Properties >> Symbology Tab
2. In the Symbology Tab:
 - a. Show: Stretched. For this layer the most appropriate way to show the data is stretched display which should already be selected
 - b. Color Ramp: Select the color bar that goes from red to blue. Bathymetry is often shown using red for shallow areas and blue for deeper areas
 - c. If the color is reversed (blue to red) check the Inverse box
 - d. Stretch Type: Select Minimum-Maximum
 - e. Check the box Edit High/Low Values
 - f. Change the high value to 0 and the low value to -1000. Note this is only scaling the values for display purpose only – it does not change the values of the raster cells. The renderer will stretch the available colors (0-255) over the indicated min-max range. Values below the minimum value indicated are shown with the same color as the minimum value and values above the maximum value will be shown like the maximum color
 - g. Click Apply (don't click OK yet – see next step)



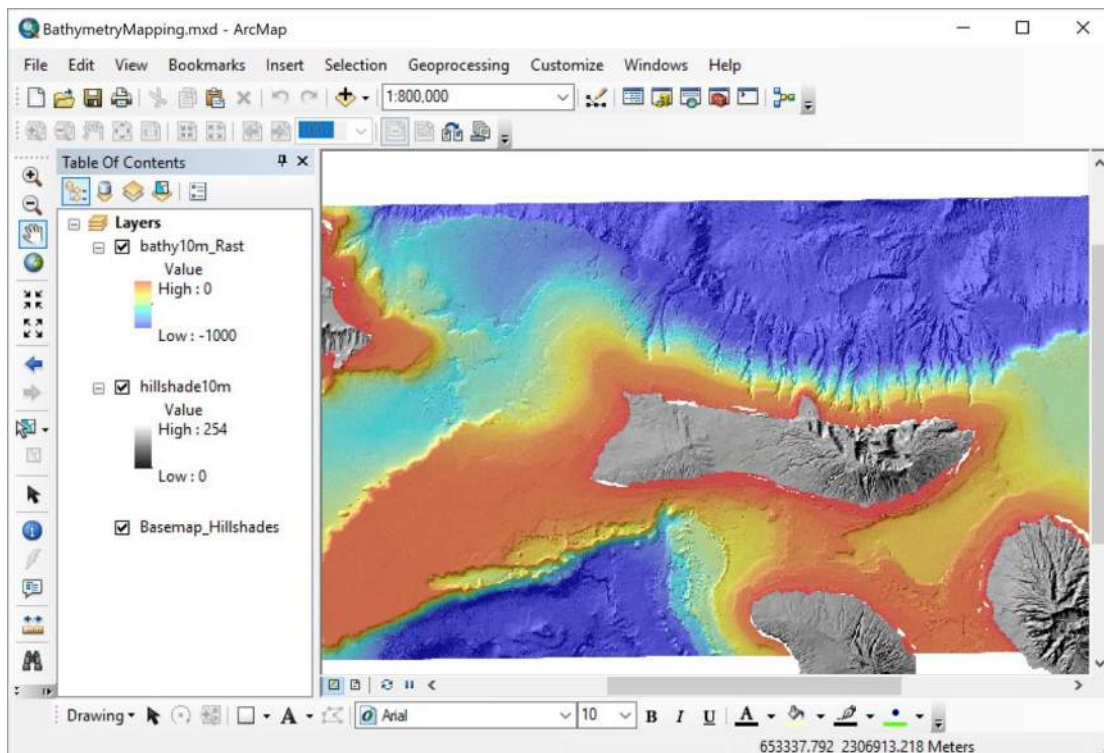
3. Click over to the Display Tab:

- Resample during display using: click the drop down arrow and select Bilinear Interpolation (for continuous data).
- Transparency: type in 40% or 50%
- Click Apply/OK



- Don't forget to save your map document.

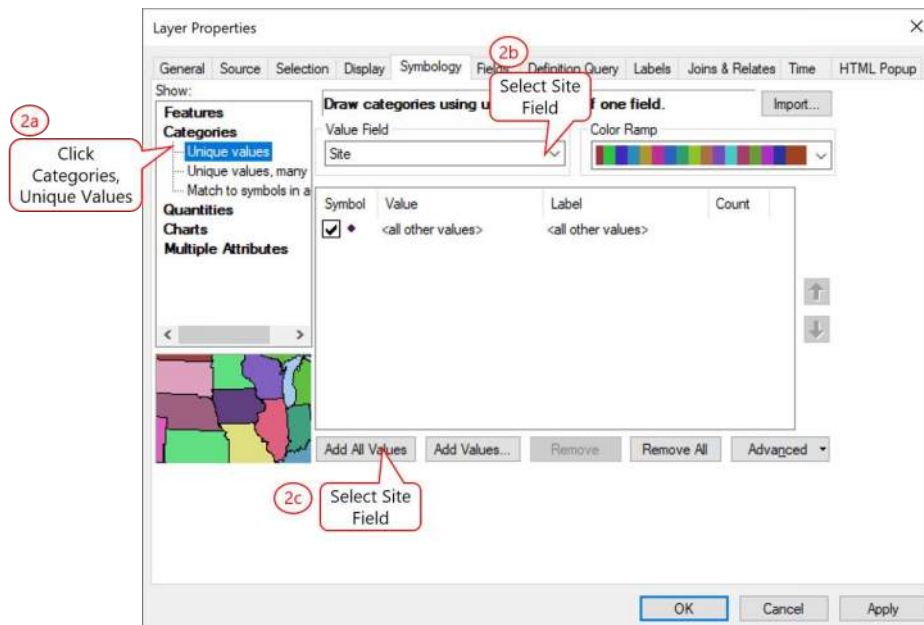
Your display should have something that look like the example below. Note that bathy10mRast is on top of hillshade10m. Change your layer drawing order if needed.

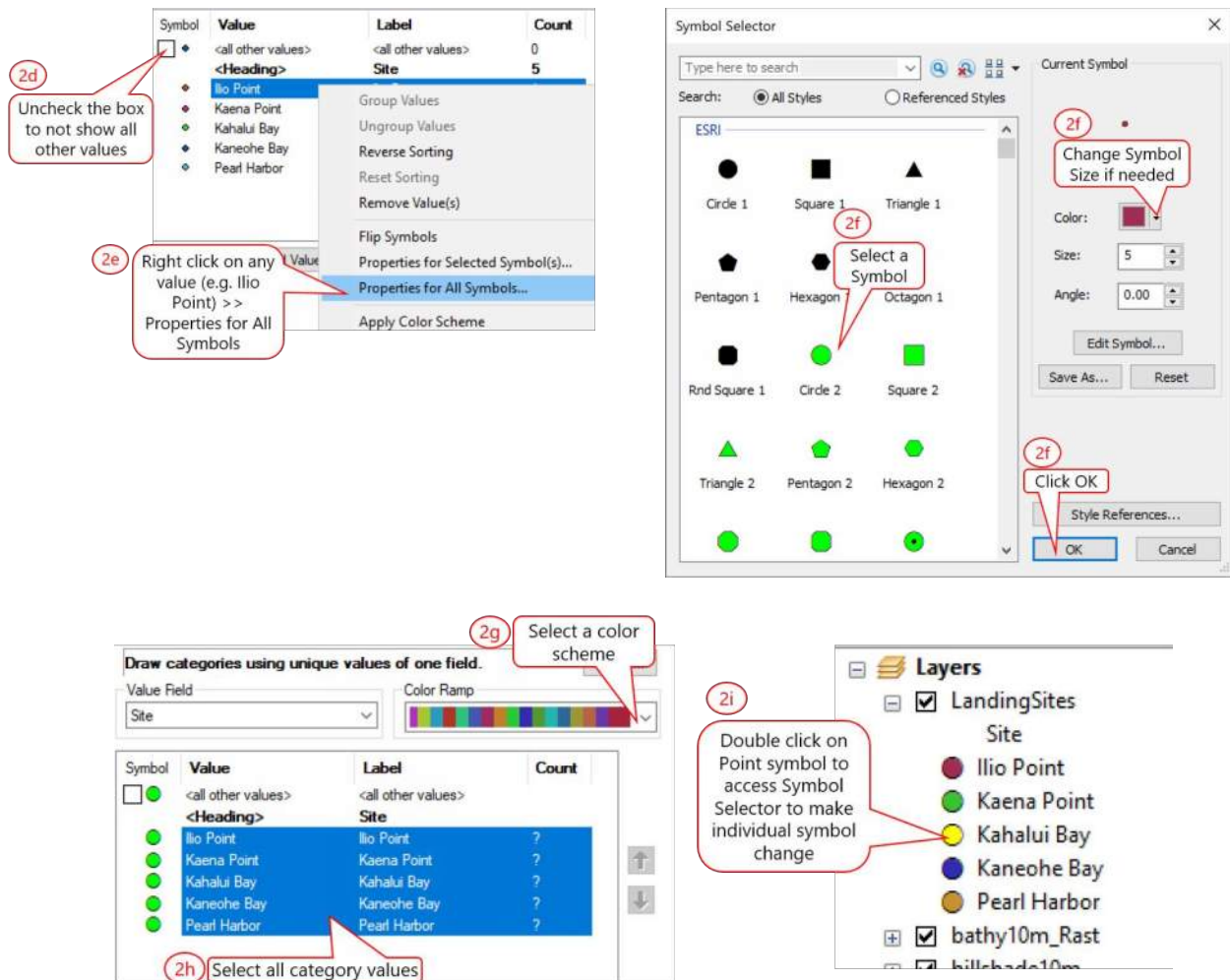


3.2 Symbolizing features

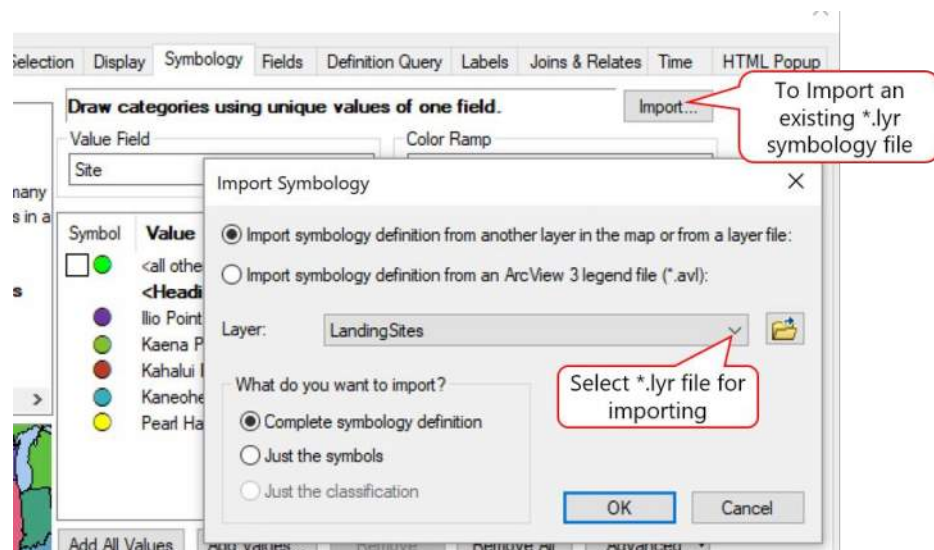
When a data layer is added to the TOC, ArcMap will display it using a default symbol (e.g. point, line, or polygon) and a randomly assigned color. You may want to customize how the data are represented in the map to better suit your needs. As an example, here you will just will color code the landing sites by location.

1. Double click on LandingSites layer name to bring up the Layer Properties window >> Symbology Tab (you could also right click on the layer name >> Properties)
2. In the Symbology tab:
 - a. Show: Categories, Unique values
 - b. Value Field: Select Site field
 - c. Click Add All Values button
 - d. Uncheck the box to show all other values so it doesn't show up on the map or in the legend. There are no data in this category since you've already added all the values to be mapped.
 - e. Right click on any category value (e.g. Ilio Point) >> Properties for All Symbols
 - f. In the Symbol Selector window:
 - Select a symbol to represent the landing sites
 - Change the color and size
 - Click OK
 - g. Select all category values (use Shift key to select all)
 - h. Select a color scheme from a list of color ramps
 - i. If you don't like a particular symbol, color or size you can change it by double clicking on the Point symbol to access the Symbol Selector to change it.





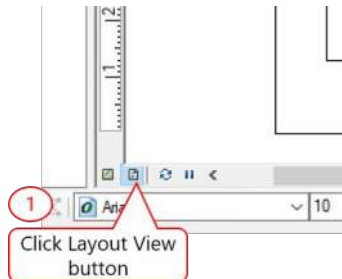
3. Once you have the feature symbology set up you can save it for use by others.
 - a. Right click the layername (e.g. LandingSites) in the TOC >> Save as Layer File. In general the layer name and *.lyr symbology file should match
 - b. The saved symbology file (.lyr) can be imported via Import button in Symbology Tab of the layer properties window



3.3 Creating a map layout and setting the layout properties

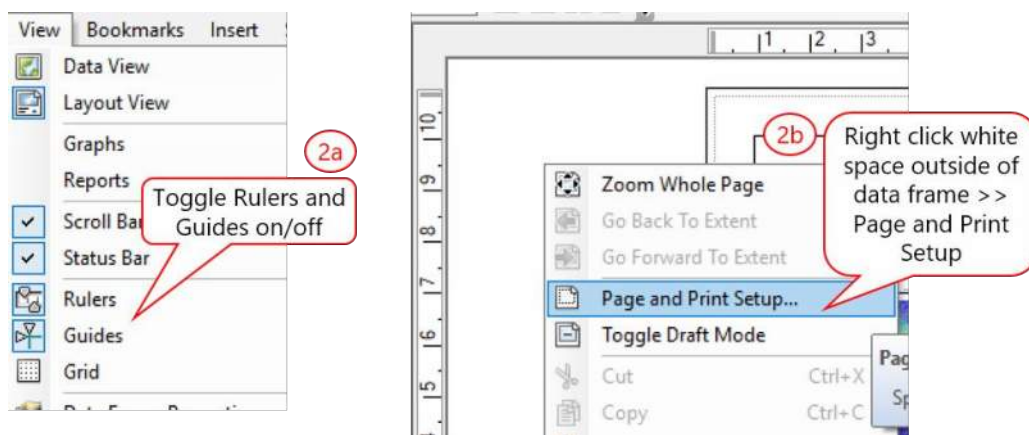
Page Layout

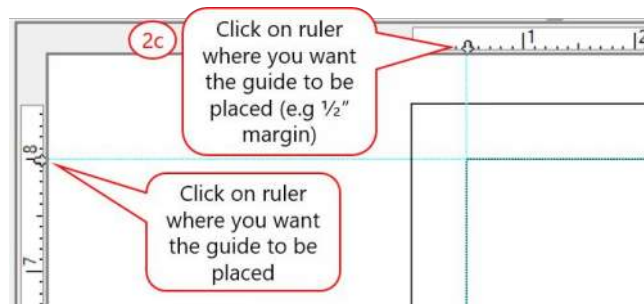
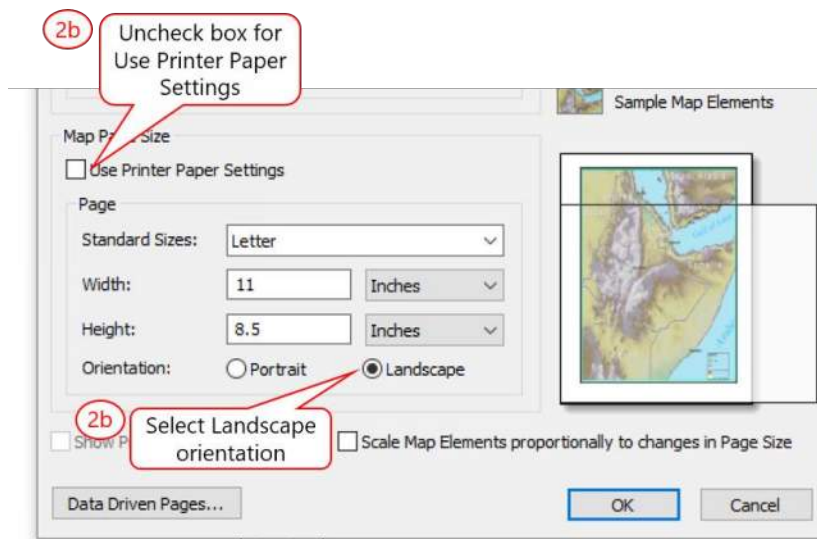
1. Switch to Layout View. Click the Layout View button in the lower, left hand corner of the interface or go to View menu >> Layout View



The Layout View shows the map frame (i.e. data frame) in the center of an 8.5x11 portrait map.

2. Set up page size and toggle on rulers, guides, and grid to help you position map elements in the layout.
 - a. Display the ruler and guides if not shown. Go to View Menu >> Toggle on Rulers and Guides if not already on. Alternatively, you can right click in any white space outside the data/map frame to access context menu
 - b. The default page size is 8.5x11 portrait – change the page orientation to Landscape. Page and Print Setup can be accessed via a context menu. Right click in any white space outside of the data frame >> Page and Print Setup. Uncheck the box for Use Printer Page Setting, select to Landscape orientation >> Click OK
 - c. Set ½ inch page margins using guides. Click on the ruler where you want the guides to be placed
 - d. More options can be set through the ArcMap Options window. To access this, go to Customize menu >> ArcMap Options >> Layout View Tab



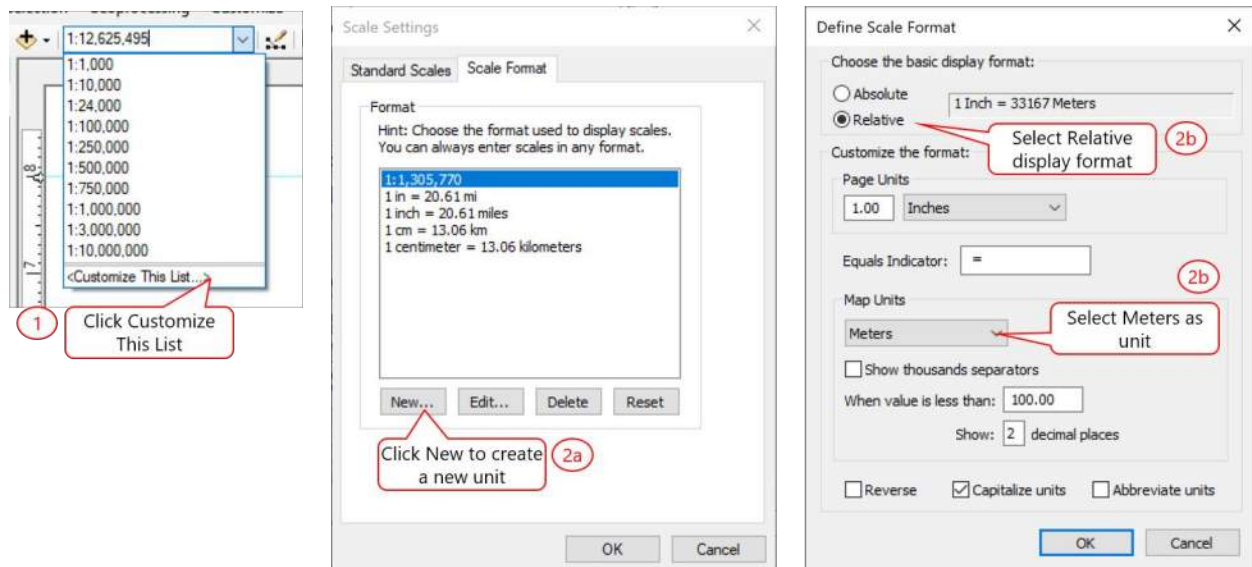


3. Adjust the map frame size so that it fits within your page. Click on the map frame and drag the corners so it snaps to the 1/2 inch guides you've set
4. Use the buttons on the Layout Toolbar to help you view and adjust your map layout

Specifying a Map Scale and Unit

When you zoom in/out of the map, notice the map scale changing on the Standard Toolbar. The map scale may or may not have a unit to it. You can create a scale unit and change how the scale format is display (e.g. 1 in = 4000ft or 1 in = 300 meters) on your map.

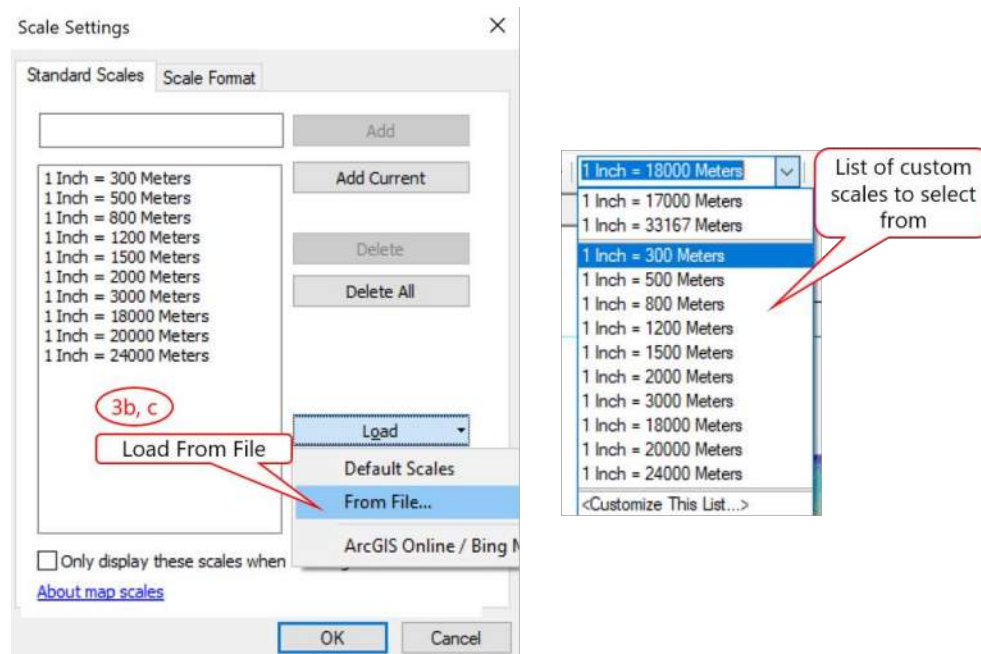
1. To specify or change a specific map scale unit, click the drop down arrow >> Customize This List.
2. In the Scale Settings window:
 - a. Click Scale Format Tab
 - Click New to create a Meters unit (since our map layers are in meters)
 - b. Define Scale Format window:
 - Select the Relative display format
 - Select Meters for the unit
 - Select any other options you want,
 - c. Click OK when done



3. Back in the Scale Settings window:

- Click the Standard Scales Tab. Load a predefined list of scales.
- Click Load drop down arrow >> Load from File.
- Navigate to OceanCableProj\MapScaleMeters.txt and load text file. The map scales text file is a listing of scales in Meters.
- Click OK

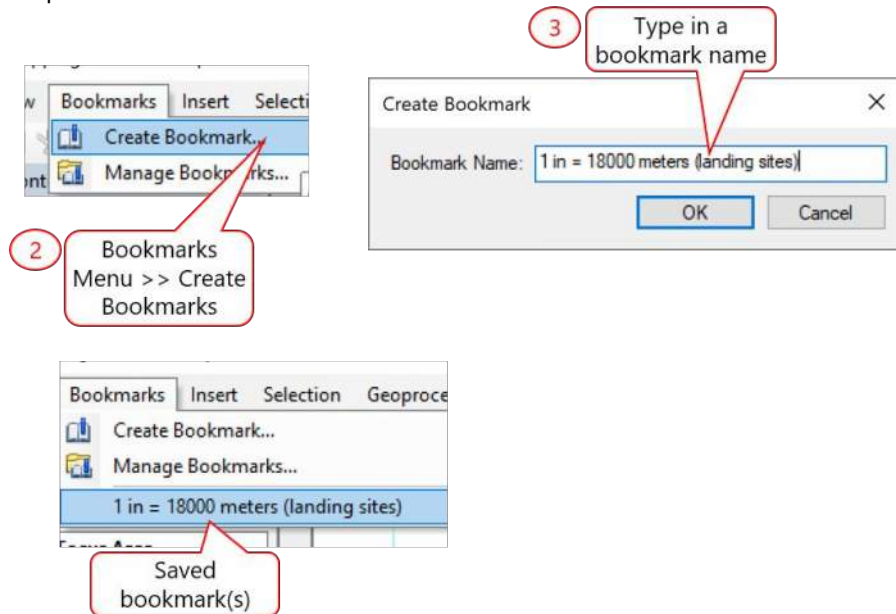
You should now see a list of custom standard scales in meters (e.g. 300, 500, etc)



Creating a spatial bookmark – optional

The Create Bookmark option in the Bookmarks Menu is a handy tool for saving the current map extent and makes it easier to return to the bookmarked extent after navigating away. Saved spatial bookmarks are listed in the Bookmarks Menu and are stored as part of the map document. The Manage Bookmark dialog allows you to manage your saved bookmarks, including being able to import and export bookmarks saved with other map documents.

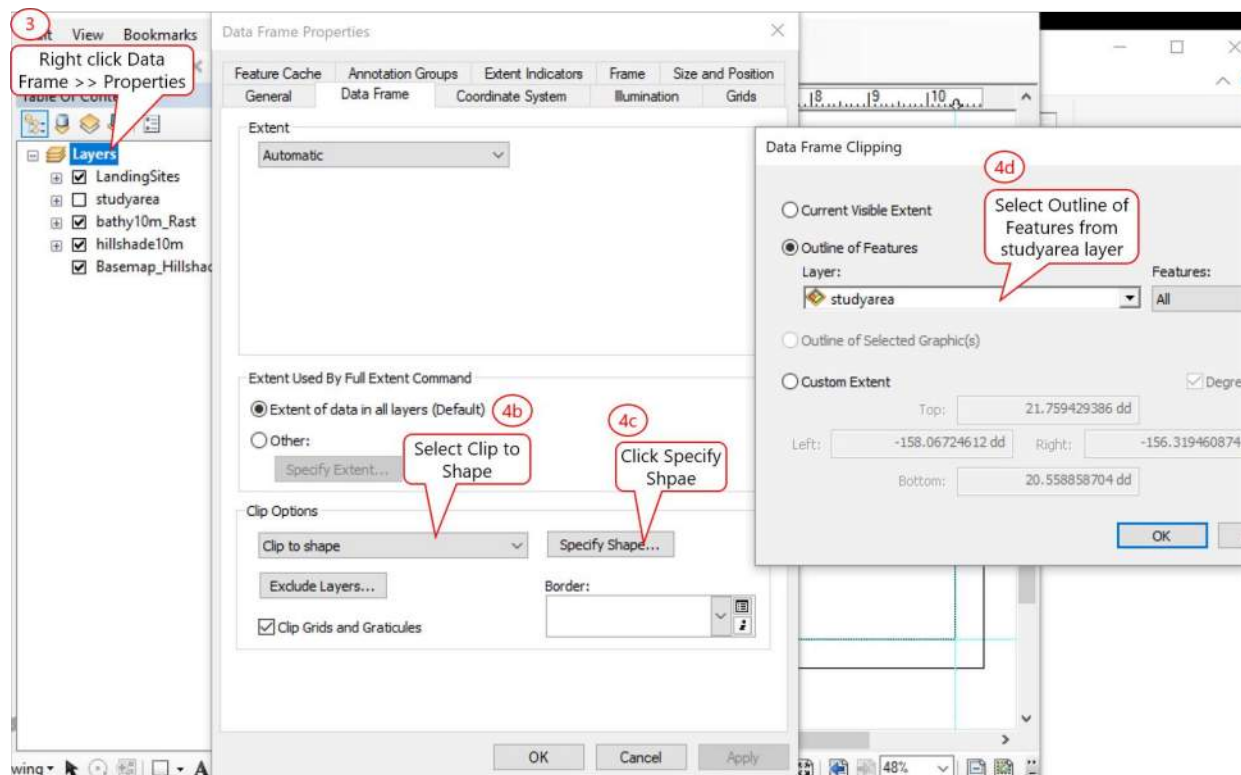
1. Right click on LandingSites layername >> Zoom to Layer. Alternatively, you could select a map scale (e.g 18,000 meters) to change your extent
2. Go to Bookmarks Menu >> Create Bookmarks
3. In the Create Bookmark window: Type in a name for the bookmark. Save bookmarks can be accessed from the Bookmarks Menu
4. Save your map document



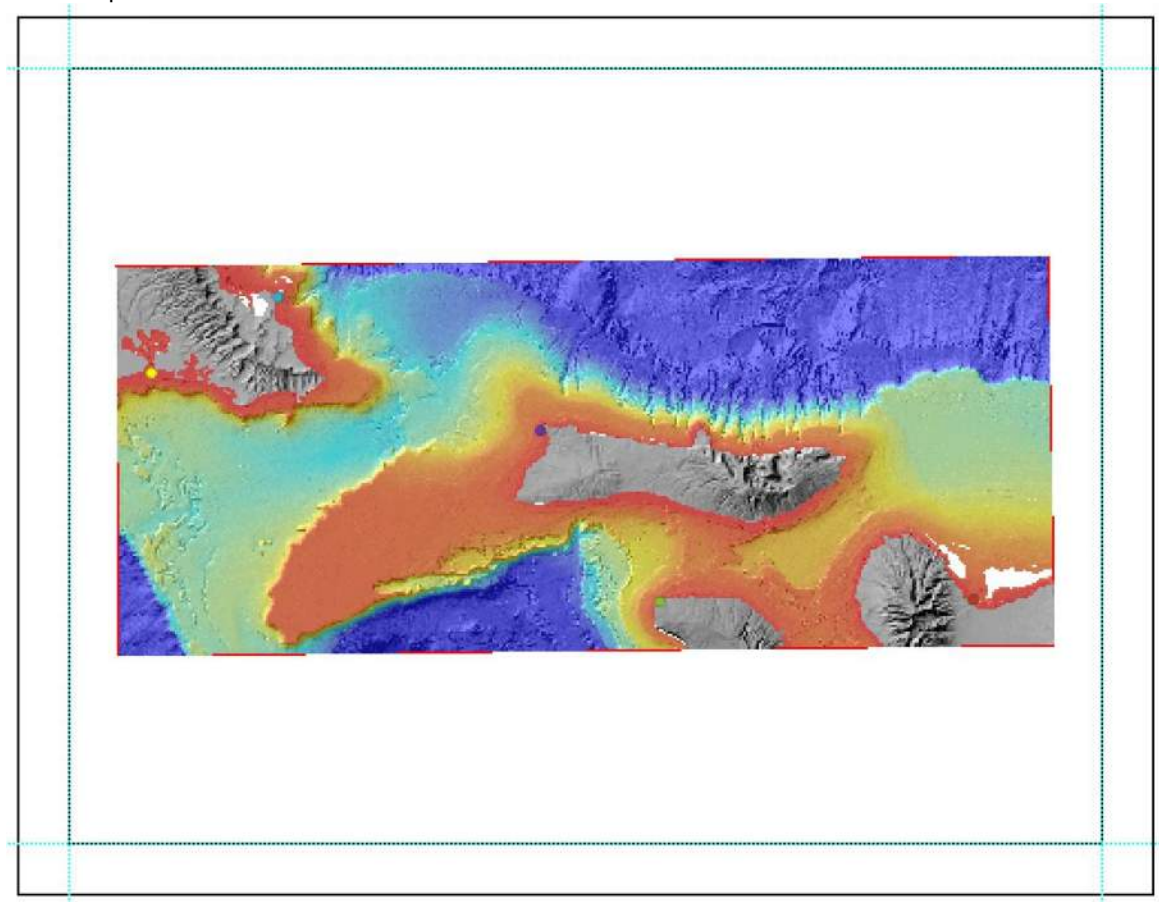
Clip map extent to shape – optional

Lets say you want to clip the map extent to show only the study focus area. Clipping to a map extent doesn't actually clip the data – this is only for viewing puposes.

1. First add the study area polygon to your map. Use the Add Data button to add the studyarea feature class from your OceanCable.gdb
2. Change the symbology for the studyarea to an outline with no fill
3. Right click on the Layers Data Frame >> Properties. Or double click Layers data frame name
4. In the Data Frame Properties window:
 - a. Click Data Frame Tab
 - b. Clip Options: Select Clip to Shape
 - c. Click Specify Shape button
 - d. Select Outline of Features from studyarea layer. Then Click OK
 - e. Click Apply/OK



Your map extent should now look like this:

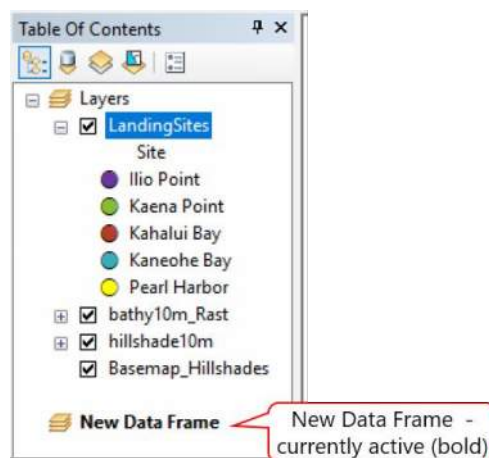


5. Turn off or remove the studyarea layer in the TOC and save your map document

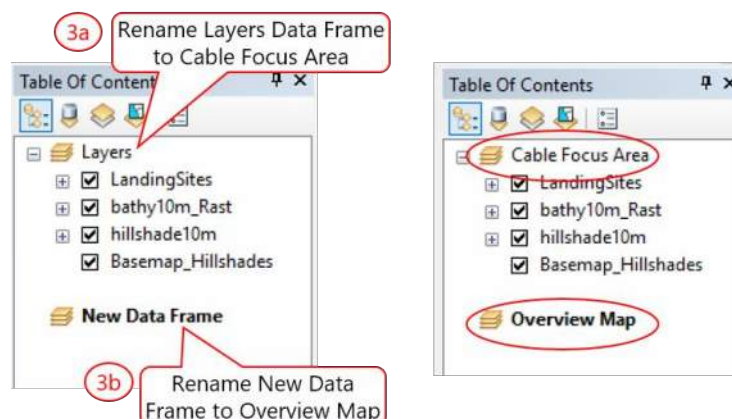
3.4 Inserting a map inset

ArcMap opens with one default data frame called Layers. If you're making a basic map using a simple layout then having one data frame will suffice. However, if you want to have a map inset in your map layout then you need to add another data frame. Within a map document you can have multiple data frames to help you create your map(s) and organize components of your map layout. The map you will be making will have two data frames: one will be the primary map focusing on the study area, and the second one will be an inset showing an overview of the Hawaiian Islands

1. Make sure your TOC is in the List by Drawing Order view (1st button at top of TOC).
2. Go to Insert Menu >> Data Frame. A new data frame will be added to the TOC. Notice that the new data frame name is bold – this indicates that it is currently the active frame. Notice also that the Data Display Panel is empty because the new data frame has no data to display yet.




3. Rename the two data frames. To rename a data frame, click on the data frame once to select it then click it again to get a cursor then type in a new name. Alternatively, you can access the Data Frame Properties window >> General Tab to rename a data frame
 - a. Rename the Layers Data frame to "Cable Focus Area"
 - b. Rename the New Data Frame data frame to "Overview Map"

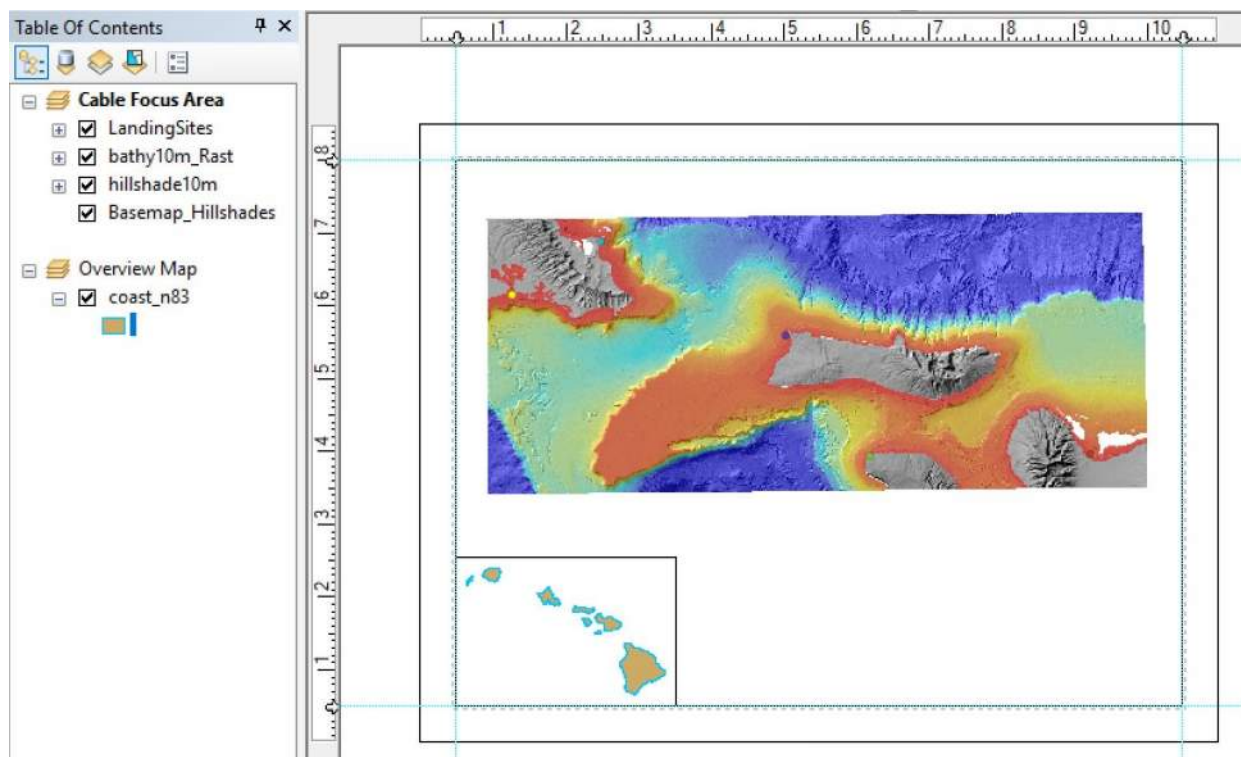


4. Add data to Overview Map data frame. Make sure the Overview Map data frame is active - in bold (Right click >> Activate).
 - a. Click the Add Data button then navigate to your OceanCable.gdb.

- b. Select the coast_n83 feature class and Add to your map
5. In the Overview Map data frame, change the symbology for the coastline layer if you want to use a different color than the default
 - a. In the TOC, click on the colored square symbol below the layername to bring up the Symbol Selector window.
 - b. In the Symbol Selector window, select the Hollow symbol then select an outline color. Change the outline width if you want to. Click OK.
6. In the Layout View, resize and move your Overview Map frame in the page layout (e.g. bottom left corner of the map/page)
7. If after you resize and move the Overview Map frame the map is cut off or something then in the TOC, right click on coast_n83 >> Zoom to Layer (to see all the islands)

 The Tools toolbar buttons will also work in the Layout view as well as in Data view. For example, you can click on the Pan button and change the map extent of your map frame in the layout

Here is an example map layout with an inset:

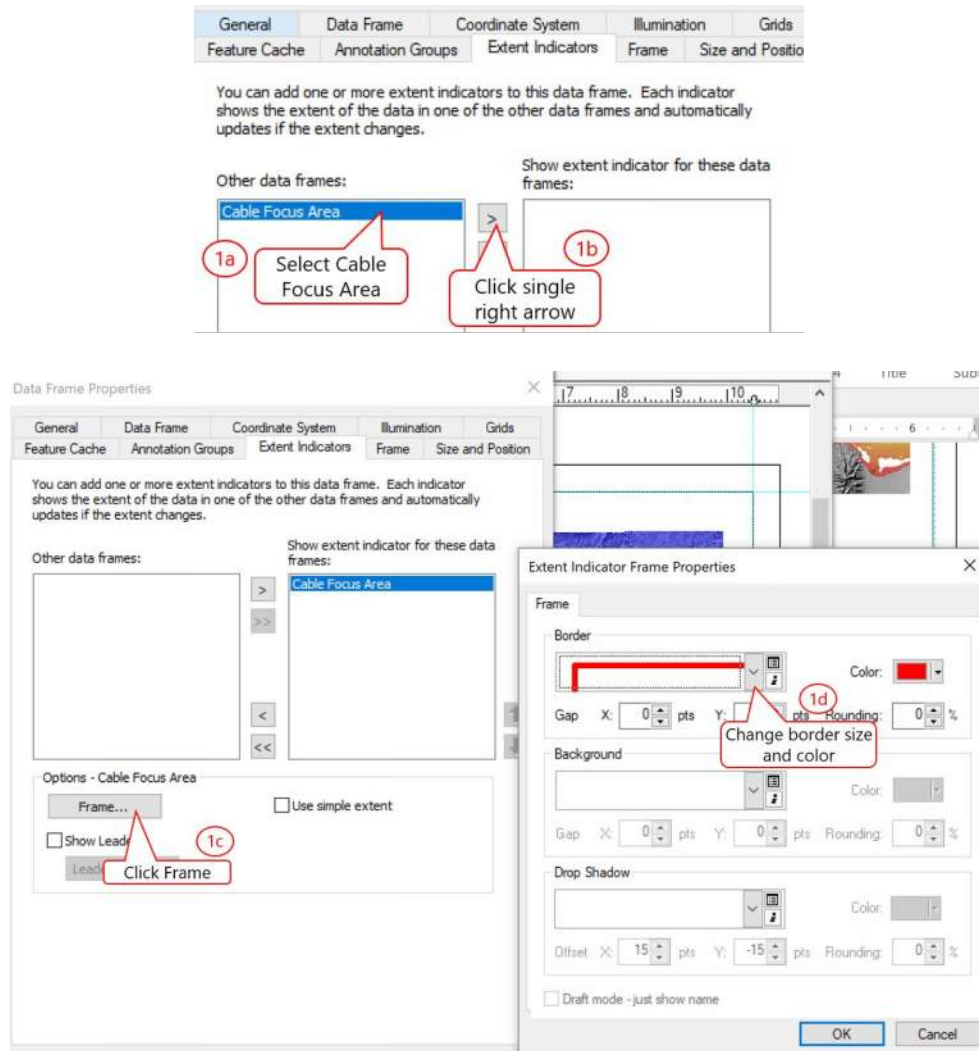


3.5 Inserting a map extent indicator

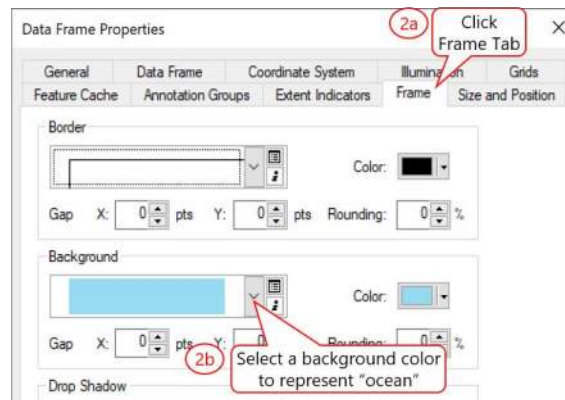
A map extent indicator shows the extent of the data in a data frame. For example, in the overview map of the Hawaiian Islands you may want to show on the map frame the extent or coverage of the Focus Area Map. The map extent indicator will automatically change as your view changes in the main focus map.

1. Make sure the Overview Map data frame is active (right click >> Activate). Right click on Overview Map data frame >> Properties

- In the Extent Indicator Tab: Select Cable Area Focus Data Frame
- Click the single arrow pointing to the right - the Frame button becomes active.
- Click the Frame button and use the wizard to change the color and border size of the extent box. Click OK
- Click Apply but don't close the window yet



- Changing the background color of the Overview Map Frame to create an "ocean."
 - Click the Frame Tab
 - Change the Background color to blue.
 - Click OK





Below is the Overview Map Frame showing the extent (red square) of the Cable Area Focus Data Frame.

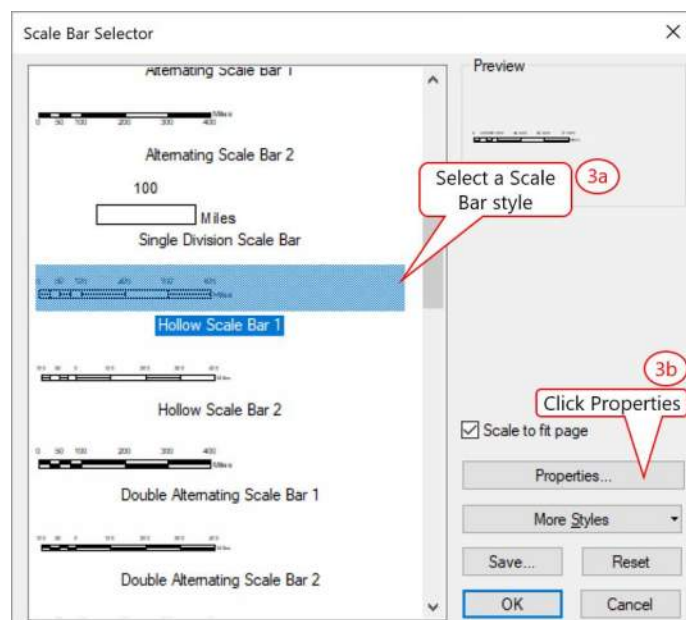



3.6 Inserting a scale bar

Before you insert a scale bar in your map, first check the coordinate system of the data frame to make sure that it is set to something that is logical for your map and easily understood. For example, a coordinates system in WGS 84 has “units” in latitudes/longitudes or rather decimal degrees, which is not easily translated to meters or miles that are more easily understood.

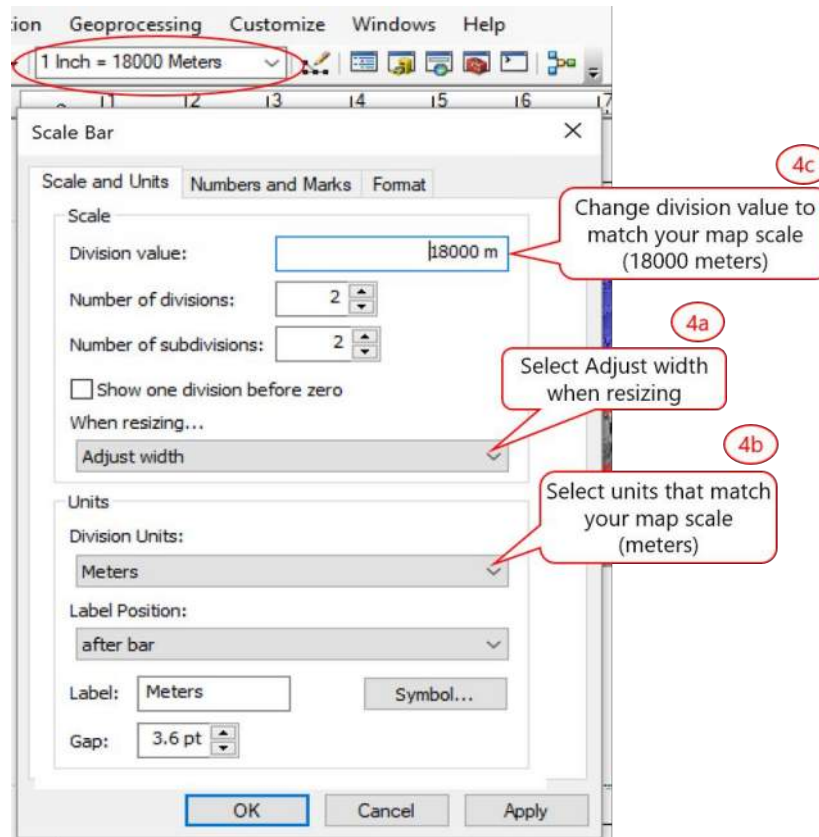
-  Most GIS web servers will use the coordinate system: WGS 1984 Web Mercator Auxiliary Sphere.
-  When using layers (turning on/off) from GIS web servers the coordinate system of the data frame will be automatically switched to that of the GIS web server. Keep this in mind when doing analyses or calculations with units.

1. Make the Cable Focus Area data frame active if it is not – this is the data frame which the scale bar will be based on.
2. To insert a scale bar, go to Insert menu >> Scale bar.
3. In the Scale Bar Selector window:
 - a. Select a scale bar to display (e.g. Hollow Scale Bar 1)
 - b. Click Properties button

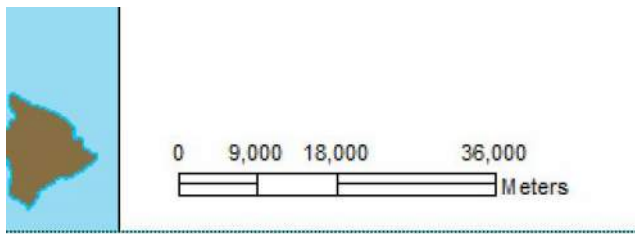


-  The Scale Bar properties can also be accessed by double click on the scale bar or by right clicking on the scale bar >> Properties

4. In the Scale Bar Properties window: Scale and Units Tab
 - a. When Resizing: Selection Adjust Width option
 - b. Division Value: type in the map scale you're using (e.g. 1"=18000 m). This is to ensure that the scale when printed at the set page size will be properly defined
 - c. Optional - change the number of divisions and subdivisions (e.g. 2 & 2).
 - d. Click OK if not making any other scale bar property changes. Otherwise click Apply then use the Numbers and Marks and Format Tab options to make more changes.



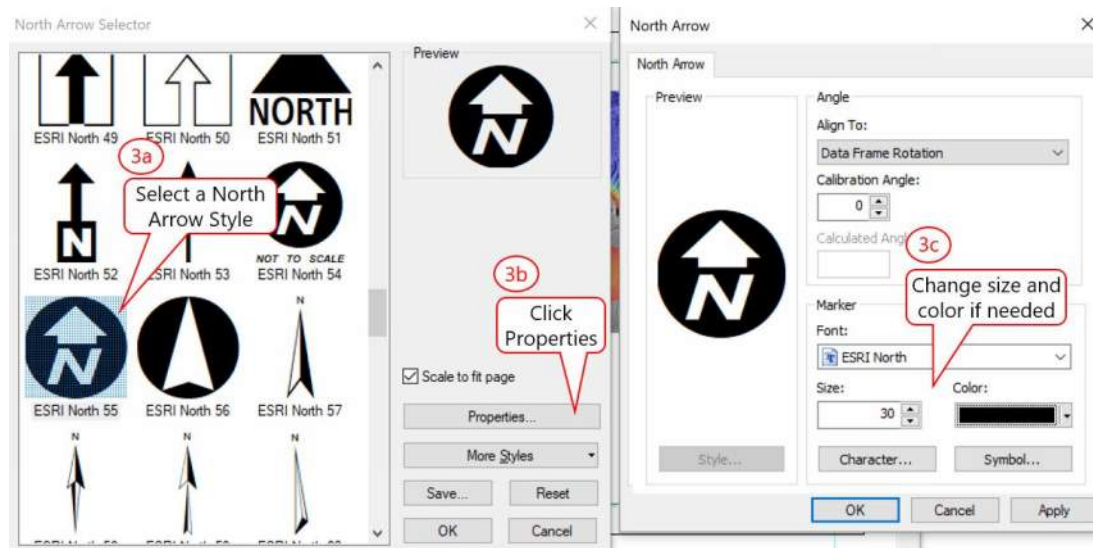
The scale bar will be added to the middle of your map. Move it to the desired location on your map. This map scale will be correct when printed exactly at 8.5x11 with no page scaling applied (e.g. no fit to page size on printer)



3.7 Inserting a north arrow

1. Use the Zoom to Whole Page button on the Layout toolbar to zoom to the entire map page.
2. Go to Insert menu >> North Arrow.

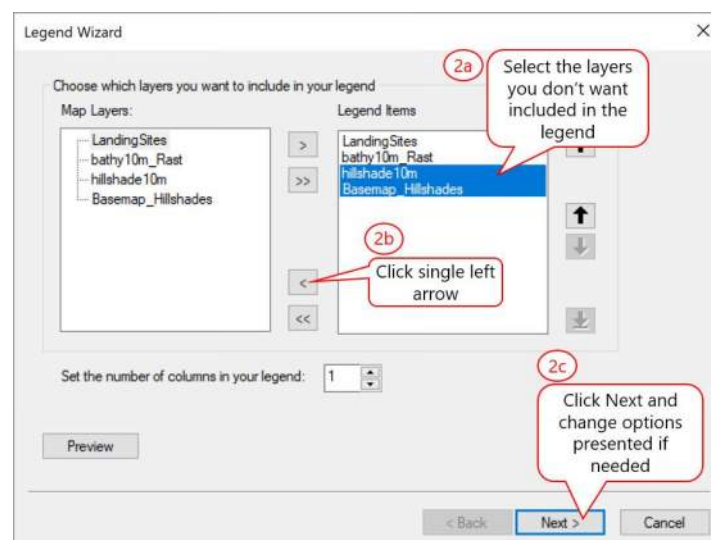
3. In the North Arrow Selector window:
 - a. Select a north arrow symbol (e.g. ESRI North 55)
 - b. The default North Arrow size is really large, so click the Properties button and change symbol size (e.g. 30)
 - c. Click OK to close window



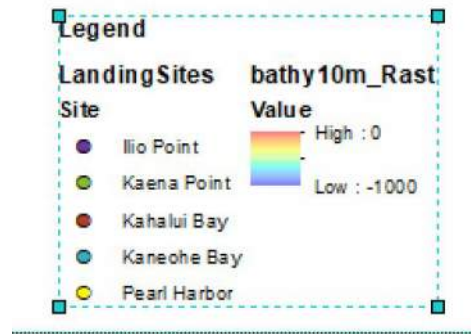
4. Move the north arrow next to any desired location on your map.

3.8 Inserting a legend

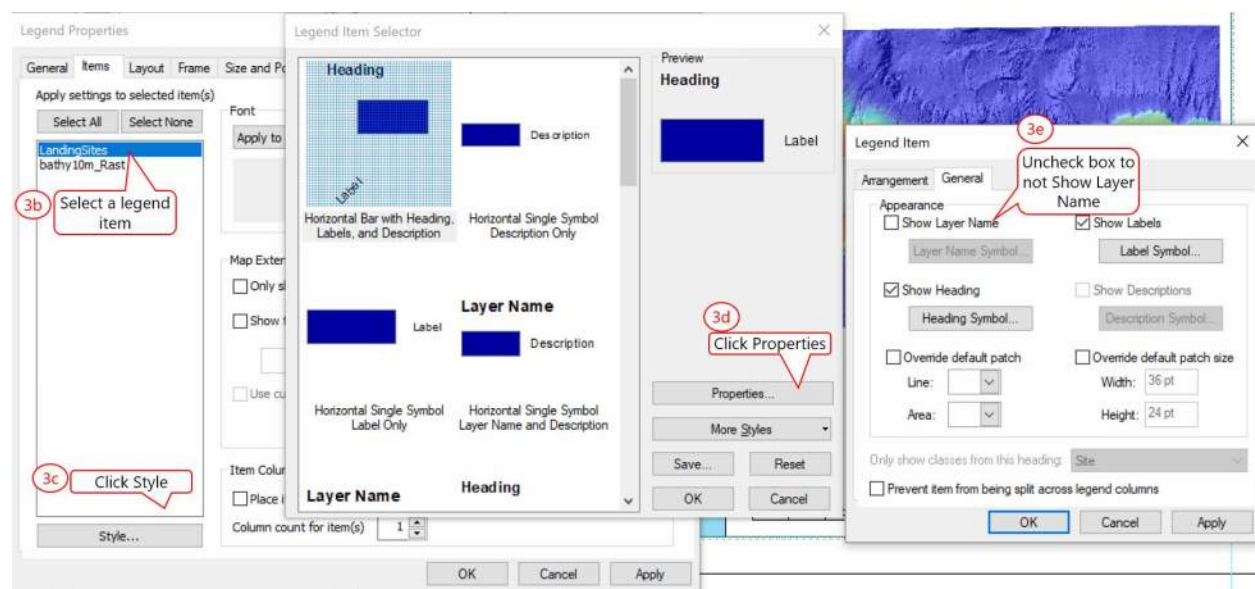
1. Go to Insert Menu >> Legend
2. In the Legend Wizard window:
 - a. In the Legend Items: Select the basemap imagery layers that you don't want displayed in the legend
 - b. Click the single arrow point to the left to remove them from the legend.
 - c. Click Next to follow through the legend wizard, making any changes you like, such as legend item list order, patch size, add frame, etc.



This is an example of a legend in 2 columns with legend items showing the Layer name, Heading, and Labels.

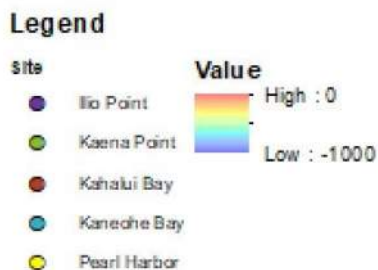


3. To change the appearance of your legend items:
 - a. Right click on the Legend >> Properties
 - b. In the Legend Properties window: Select a legend item (e.g .LandingSites) that you want to change the appearance for
 - c. Click Style button
 - d. Legend Item Selector window: Click Properties
 - e. Legend Item >> General Tab: Uncheck the box Show Layer Name. Click OK >> Click OK >>Click Apply

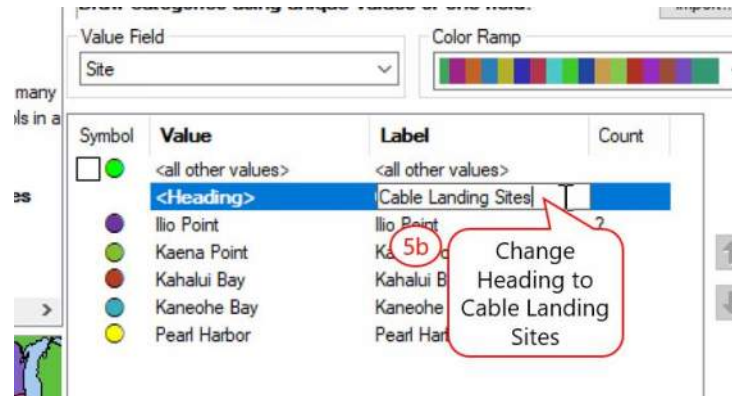


4. Follow step 3 above to change the appearance for legend item, bathy10m_Rast

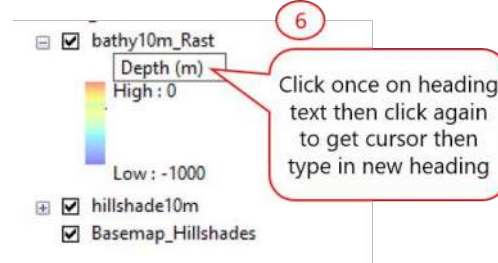
Your legend should look something similar to this:



5. The legend item labels are linked to their corresponding layers in the TOC. Any changes made to the layer's properties will be reflected in the legend. Change the Heading labels for LandingSites
 - a. Open LandingSites Layer Properties window (hint: double click on the layer name): go to Symbology Tab
 - b. Click the "Site" heading and change it to "Cable Landing Sites"



6. Change the heading label for bathy10m_Rast. In the TOC, click on the heading "Value" once then click it again to get a cursor then type in the new heading "Depth (m)"



7. On the Layout Toolbar use the Zoom 1:1 ratio button to view the legend as it would appear printed out at the specific page size.
8. Save your map document

3.9 Creating a graticule grid

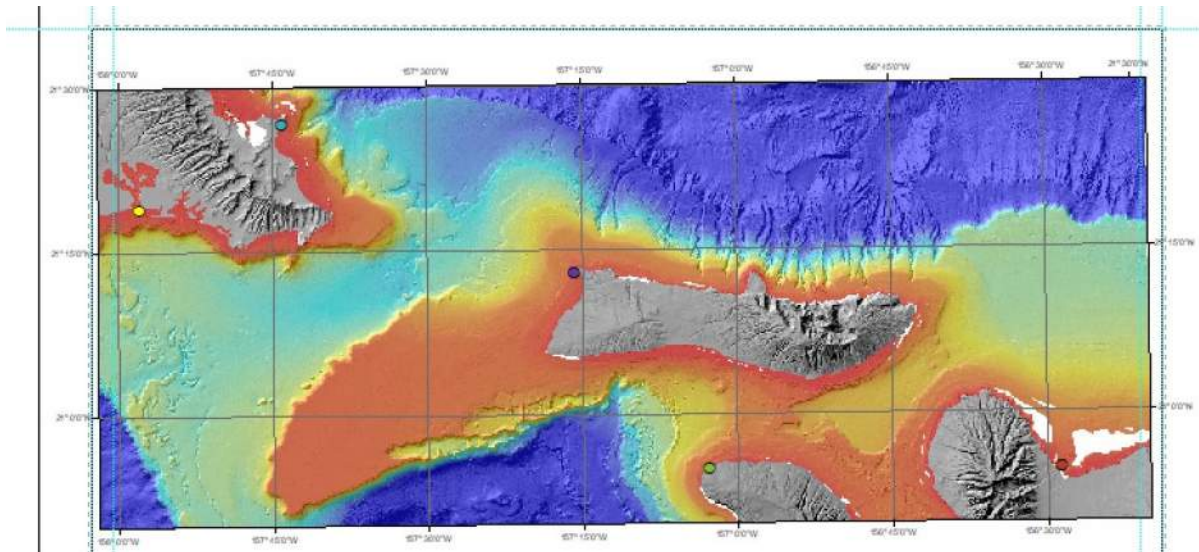
For this exercise, you will add a latitude/longitude graticule grid to the main map frame, Cable Focus Area.

1. Make sure Cable Focus Area data frame is active the double click on data frame name to quickly access the Data Frame Properties window
2. In the Data Frame Properties window:
 - a. Go to the Grid Tab >> Click New Grid button.
 - b. What do you want to create: Select Graticule: divide map by meridians and parallels
 - c. Grid name: give your grid a name or leave as default name >> Click Next
 - d. Graticule Appearance: Select Graticule and Labels option.
 - e. Intervals: Change the parallel and meridian intervals to 15 minutes (make sure deg. & sec are 0). Click Next
 - f. Axes and Lables: Accept default options, Click Next.
 - g. Graticule Border and Neatline: Accept default options. Click Finish.

- h. Back in the Grid Tab: Click Apply/OK. You can always change the graticule options by going back into the data frame properties >> Grid Tab >> Select the Graticule name >> Properties.



The graticule should be added to the main map frame, like the image below.



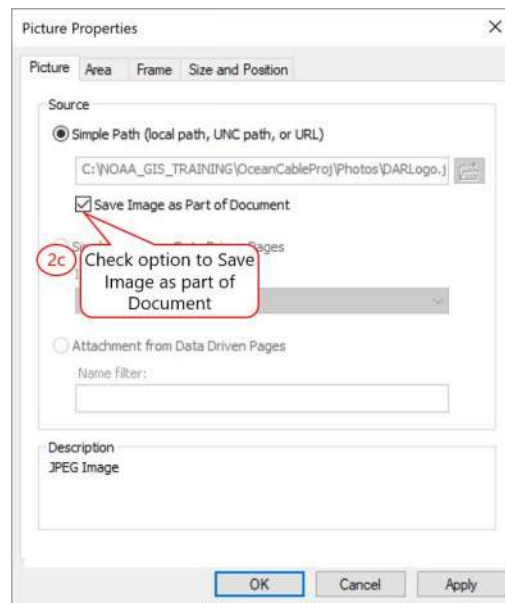
3.10 Inserting a map title and logo

1. Turn on the Drawing toolbar by going to Customize Menu >> Toolbars >> Draw. To insert a map title, you can either use the Add New Text button on the Drawing Toolbar or go to Insert Menu >> Title. The insert title option will insert the title of your map document into your map page, positioned at top center. Give your map a logical title. Use the tools on the Drawing toolbar to change font size, font type, etc. if needed



2. To insert a logo, go to Insert Menu >> Picture.
 - a. Navigate to OceanCableProj\Photos\Logos folder and insert DARLogo.jpg or NOAA_logo.jpg
 - b. Resize and move the jpegs as needed

- c. Save the jpg as part of the map document so others can see the logo even without access to the image itself. Right click on the jpg >> Properties >> Picture tab; check the box to save image as part of document.

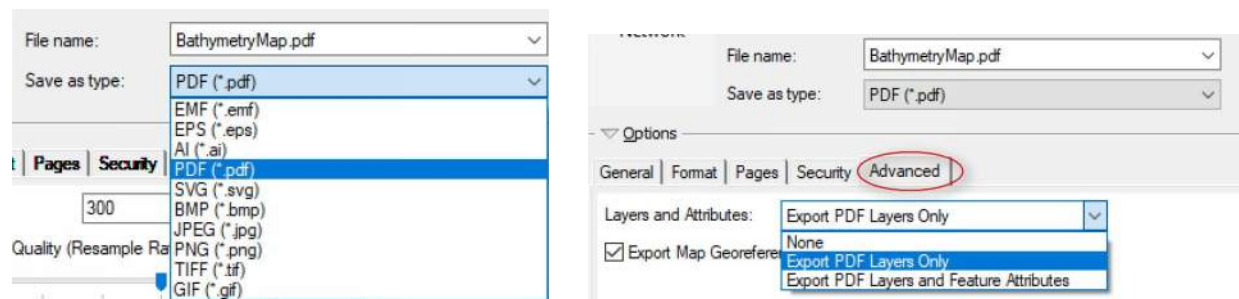


3. Click the Zoom to Whole Page button on the Layout toolbar to view the entire map. Edit/adjust any map elements as needed to your preference
4. Save your map document

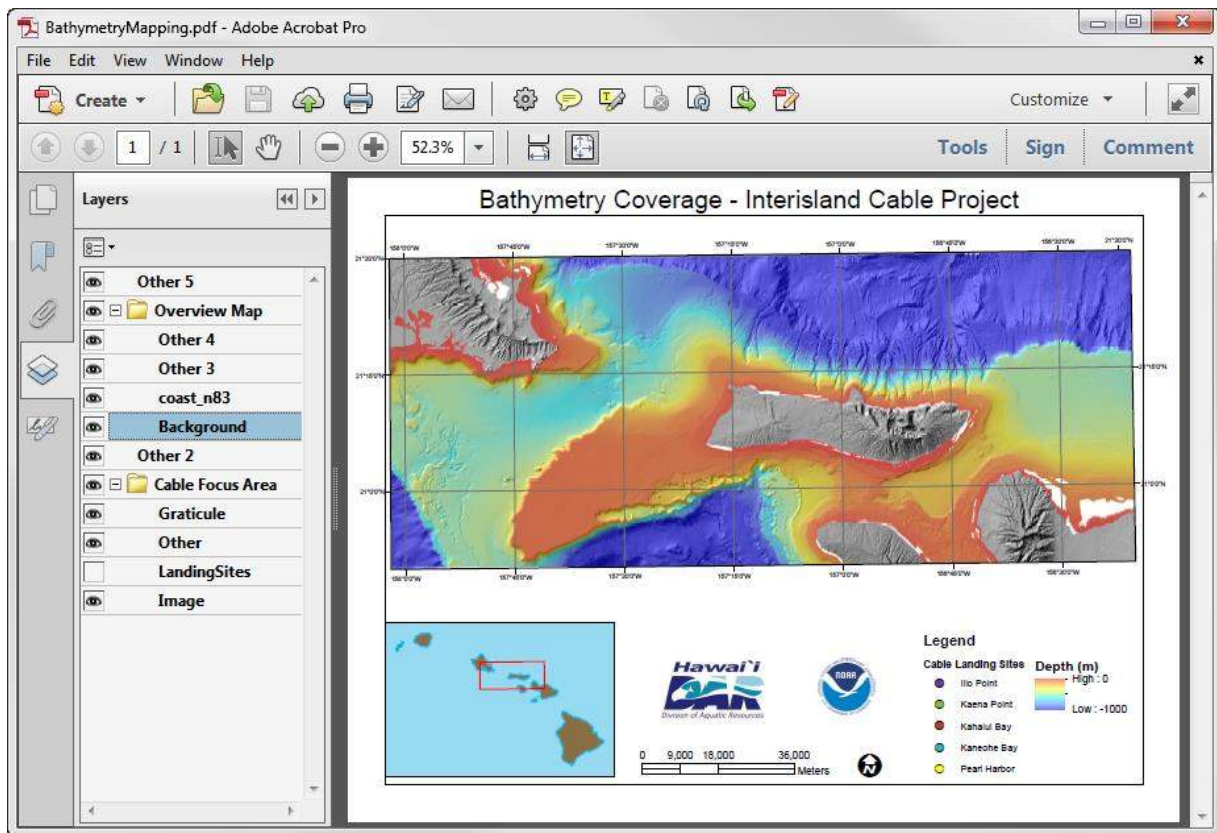
3.11 Exporting a map

1. To export the map, go to File Menu >> Export Map.
2. In the Export Map window: set the options for either jpg or pdf.

Note: exporting to pdf has the options to export layers and map spatial coordinate information with the pdf. These options are in the Advanced tab.



Below is an example of a pdf saved with the Export PDF with Layers option. The layers in the pdf can be turned on or off. Latitude and longitude coordinates are also shown on the map. The example pdf is shown as displayed in Adobe Acrobat XI Pro.



Exercise 4: Suitable Cable Routes – Raster Calculator Method

In this section, you will do a Least Cost Path Analysis to find where potential cable routes should go based on the criteria listed below:

- keep depth above 800m for better navigation and less weight of cable during laying;
- cables can be lain on slopes up to 30 degrees and up to 45 degrees with anchoring;
- minimize length in whale sanctuary and other marine protected/restricted areas;
- minimize crossing of steep slopes, hard grounds, important benthic habitats, precious corals and dumped materials; and
- minimize crossing existing telecom cables

The Least Cost Path Analysis is a raster or cell based analysis, which means all vector layers need to be converted to raster grids which all need to have the same cell size (*e.g.* unit of analysis) and spatial extent. In addition, you will need to reclassify all the layers (*i.e.* criteria) into a common scale system so you can combine them to produce a single cost surface. Two slightly different methods for deriving a cost are provided so you get a chance to see that there is more than one way of doing an analysis. The first method uses the Raster Calculator to calculate a total cost surface and considers the criteria to be of equal influence. The second method shown in Exercise 4 uses the Weighted Overlay Tool and accounts for some criteria having more influence than others.

Most of Exercise 4 will be done using models, which you will create in Model Builder. Model Builder is a module in ArcGIS that allows you to create, edit, and manage models. There are two ways to use Model Builder: 1) as an application that allows you to do exploratory project work – exploring the processes/analyses; 2) as an application where you build generic tools that can be reused and shared. The latter one requires advance programming/scripting knowledge, which is beyond the scope of this tutorial. The benefit of using Model Builder is that you can keep track of your procedures and use it again on other datasets as well as share it with others.

For this exercise, you will find the potential undersea cable routes from wind farms at Ilio Point, Molokai and Kaena Point, Lanai (sources) to substations at Pearl Harbor and Kaneohe Kaneohe Bay, Oahu (destinations). You could certainly do all this in one big model but here it is broken into more manageable pieces or smaller models – that way if something goes wrong you'll know which portion to fix.

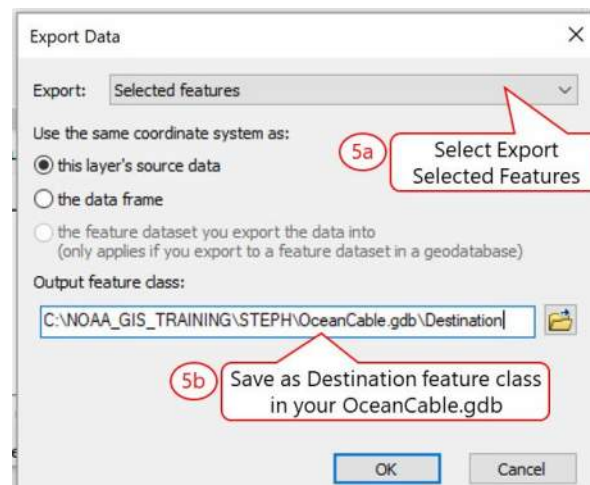
Creating the source and destination layers

To find the route from one place to another you need to know the source and destination points. You will create two source layers (wind farms at Ilio Point, Molokai and Kaena Point, Lanai) with 1 point each and a destination layer with 2 points (Pearl Harbor and Kaneohe Bay substations).

1. Optional – make a copy of your map document by doing a Save As...CableRoutes.mxd for example.
2. In the TOC, right click on LandingSites layer name >> Open Attribute Table
3. In the Attribute Table, select the 2 records for Pearl Harbor and Kaneohe Bay. Leave the Attribute Table open

Table						
LandingSites						
	POINT_Y	X_UTM	Y_UTM	Site		Sh
	20.917998	703322.108464	2314311.109531	Kaena Point	Lanai	Point
	21.443566	631091.994075	2371768.80187	Kaneohe Bay	Oahu	Point
	21.31607	607305.155913	2357480.918007	Pearl Harbor	Oahu	Point
	21.215116	680540.736896	2346947.406268	Ilio Point	Molokai	Point
	20.915942	762629.937	2314911.6515	Kahalui Bay	Maui	Point


4. Right click on LandingSites layer name >> Data >> Export Data
5. In Export Data window:
 - a. Export: Select Selected Features
 - b. Use the same coordinate system as: use default option (this layer's source data)
 - c. Output feature class: save as Destination in your GDB (e.g. OceanCable.gdb\Destination)
 - d. Click OK and add exported layer to your map




6. With the Attribute Table still open, select the record for Ilio Point and export it. Save as feature class, IlioPoint_wf in your GDB (e.g. OceanCable.gdb\IlioPoint_wf) then add it to your map
7. Select the record for Kaena Point and export it. Save as feature class KaenaPoint_wf in your GDB (e.g. OceanCable.gdb\KaenaPoint_wf) then add it to your map
8. You may now remove your LandingSites layer from the TOC

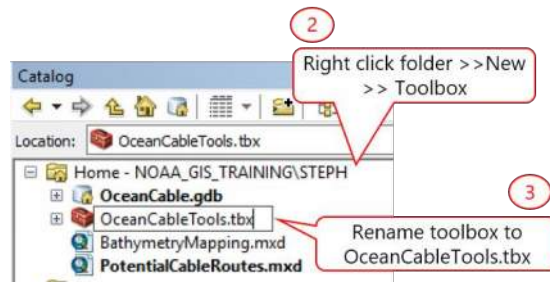
4.2 Creating a custom toolbox in ArcToolbox

Here you will create a custom toolbox to store the models you're going to create in section 4.3.

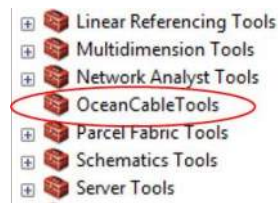
1. Open the Catalog Panel by clicking the Catalog button 
2. In the Catalog Panel: Right click on your working folder (e.g. STEPH) >> New >> Toolbox

 You can also create a new toolbox in a geodatabase as well as in a folder

3. Rename your new toolbox to OceanCableTools.tbx



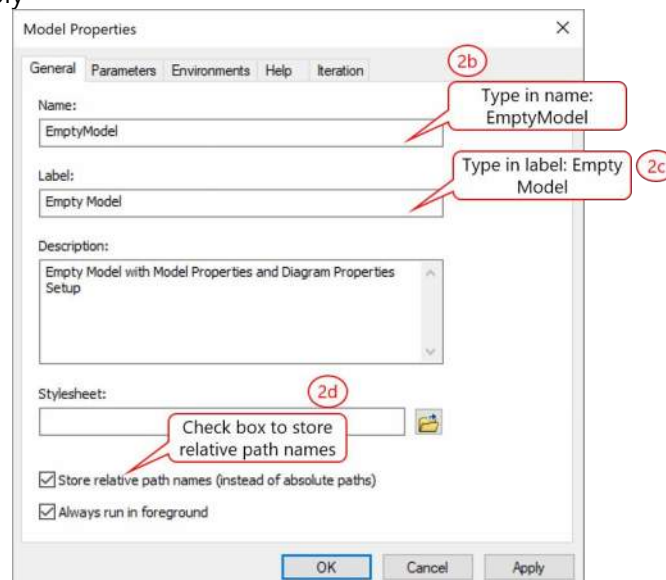
4. Display ArcToolbox by click the ArcToolbox button (red toolbox)
5. Add the custom toolbox, OceanCableTools.tbx to ArcToolbox. You can drag and drop OceanCableTools.tbx from the Catalog panel to the ArcToolbox panel or you can Right click on ArcToolbox >> Add Toolbox >> Navigate to and Add OceanCableTools.tbx



4.3 Creating a new model and setting its properties

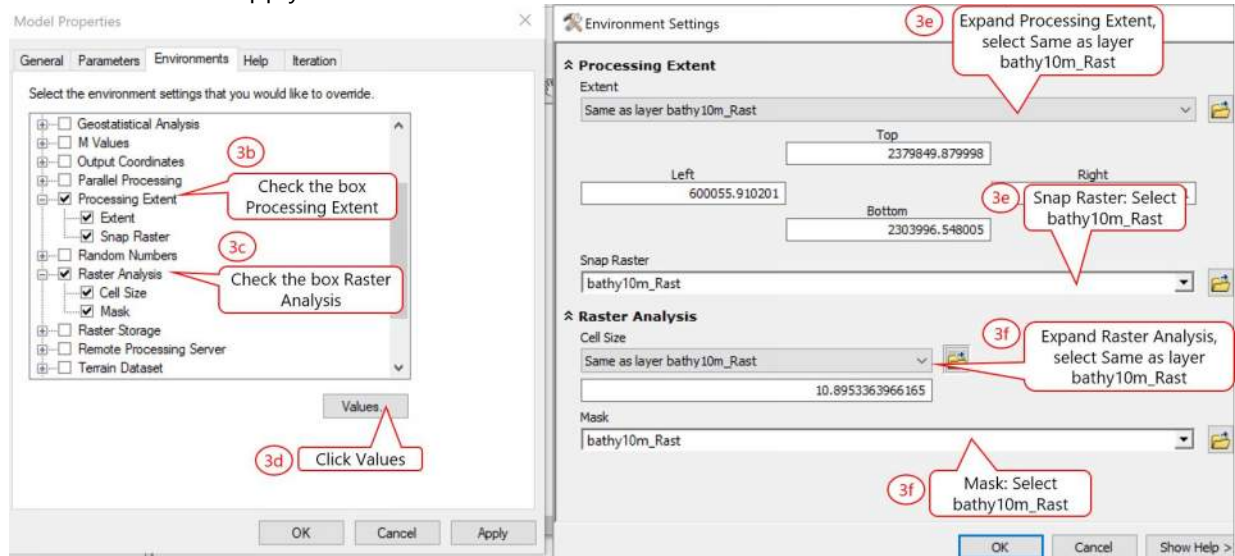
This part is optional but since you will be creating several models, it's useful and time saving to have an empty model with the Model and Diagram Properties set up already. All you'll have to do then is copy the empty model and change the name and label, making the model set much faster.

1. In ArcToolbox, right click OceanCableTools >> New >> Model. Model window will popup
2. In the Model window:
 - a. Go to Model Menu >> Model Properties >> General Tab
 - b. Name: Type in "EmptyModel" (this is the model filename)
 - c. Label: Type in "Empty Model" (this is what will be displayed in the toolbox)
 - d. Check the box to store relative path names
 - e. Click Apply

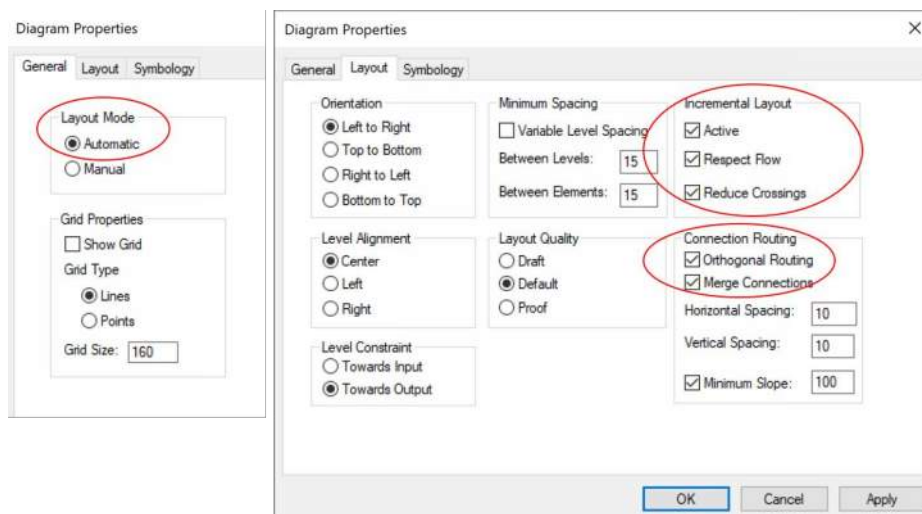


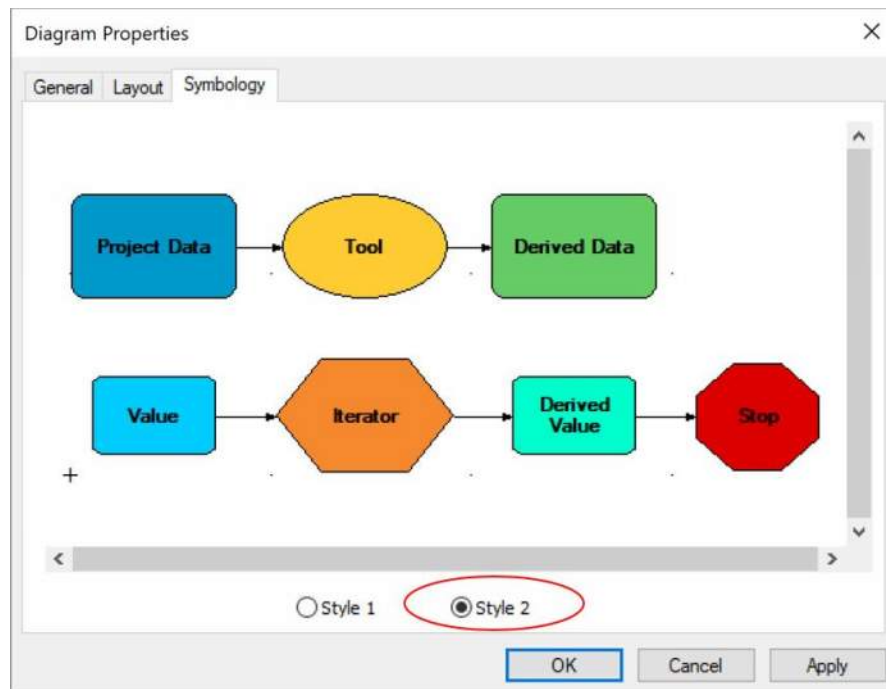
3. In the Model Properties window:


- Click Environments Tab
- Check the box Processing Extent
- Check the box Raster Analysis
- Click Values button
- Expand Processing Extent:
 - Extent: Select Same as layer bathy10m_Rast (this is the layer you'll derive the Slope from)
 - Snap Raster: Select bathy10m_Rast
- Expand Raster Analysis:
 - Cell Size: Select Same as layer bathy10m_Rast
 - Mask: Select bathy10
- Click OK
- Click Apply/OK



- Optional – Diagram Options. This is an optional step if you want to make the diagrams in your model appear like the example in this tutorial.
 - Go to Model Menu >> Diagram Properties
 - Make your changes and click Apply/OK when done





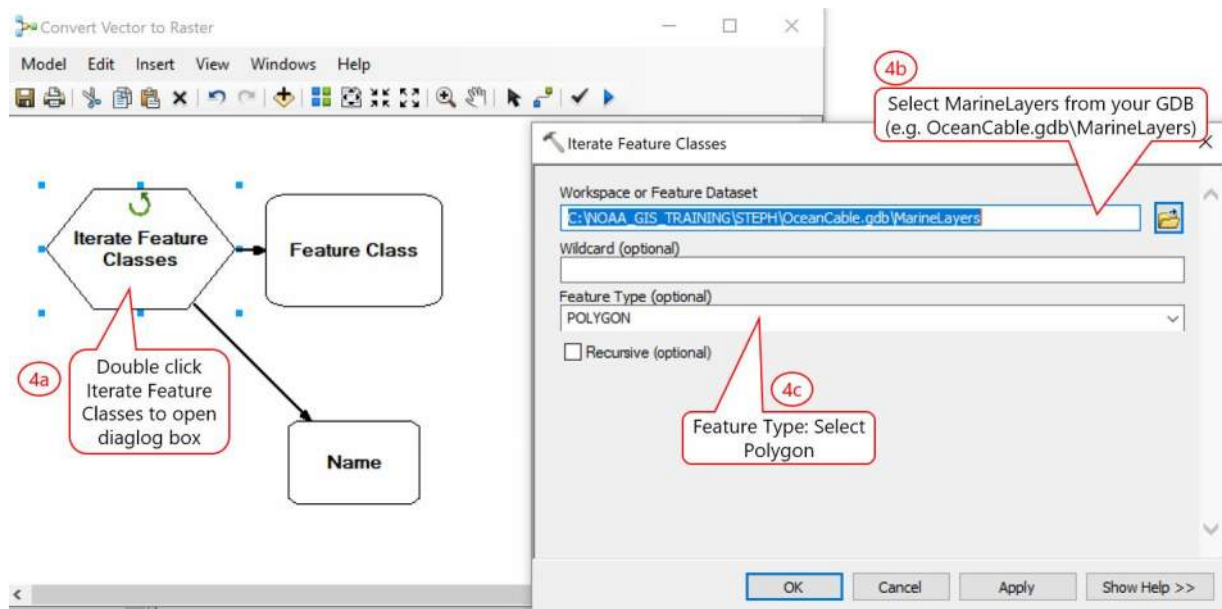
 You can export the Model Diagram into a jpg or png for use in documentation of your workflow process: Model Menu >> Export >> To Graphics

4.4 Convert marine features classes to raster grids

As noted earlier the Least Cost Path Analysis to finding suitable cable routes that you will be doing is a raster-based analysis and requires that all layers be in raster format. In this exercise, you will convert all of the marine feature classes to raster grids, using 2 methods: one using a model and the other use a batch grid.

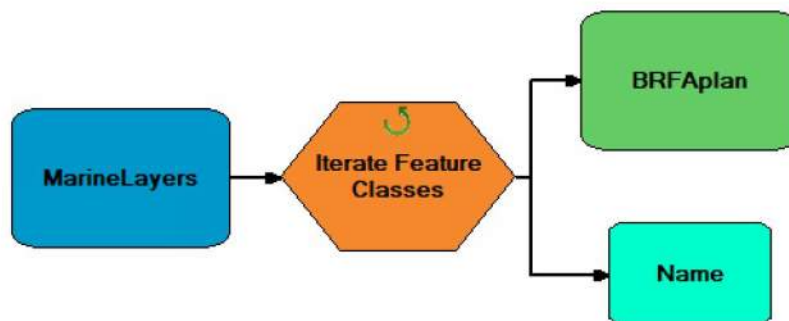
Convert Polygon to Raster Model

1. In ArcToolbox, go to your custom toolbox, OceanCableTools >> Make a copy of the Empty Model (Right click >> Copy >> Paste)
2. Right click on the copy of the Empty Model (2) >> Edit to open it
 - a. Click Model Menu >> Model Properties >> General Tab
 - b. Name: Type in "Poly2Rast" (this is the model filename)
 - c. Label: Type in "Convert Polygon to Raster" (this is what will be displayed in the toolbox)
3. Add an Iterator and set it up to loop through each of the marine_layers feature dataset. In the model window go to Insert Menu >> Iterators >> Feature Classes
4. In the model window:
 - a. Double click Iterate Feature Classes to open dialog window
 - b. Workspace or Feature Dataset: Select the MarineLayers Feature Dataset from your GDB (e.g. OceanCable.gdb\MarineLayers)
 - c. Feature Type: Select Polygon (you want this to be polygon because you'll add in the Polygon to Raster Tool in the next step)
 - d. Click OK.





5. Click Auto Layout  button to rearrange the diagrams and then Save your model

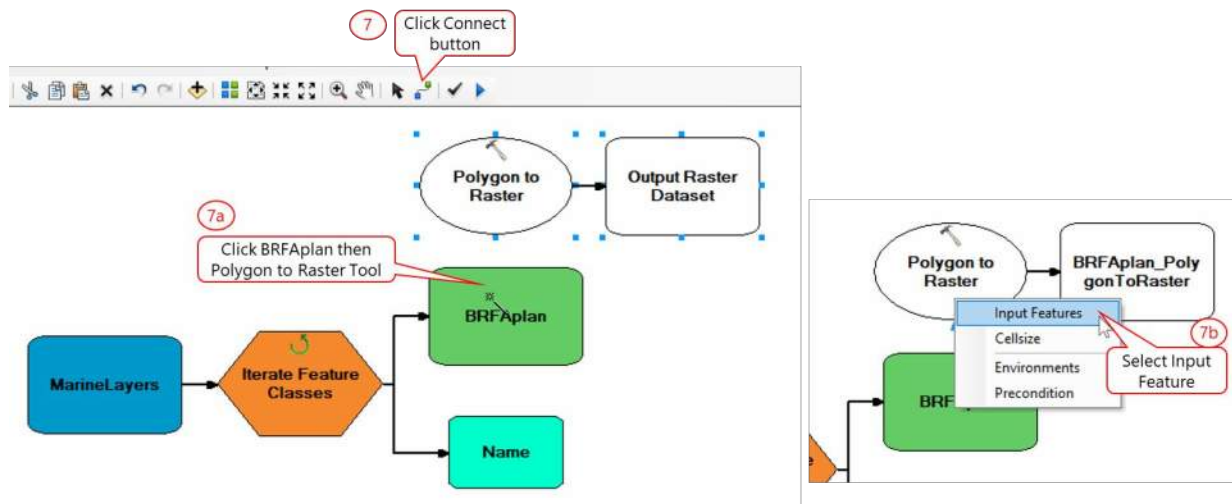
Here is what your Model should look like (BRFAplan is the first layer in the dataset)



This only sets up the iterator to loop through the files, you'll have to include a function (e.g. Polygon to Raster tool) in the Model.

6. In ArcToolbox, go to Conversion Tools >> To Raster >> Drag and drop Polygon to Raster tool into your model window

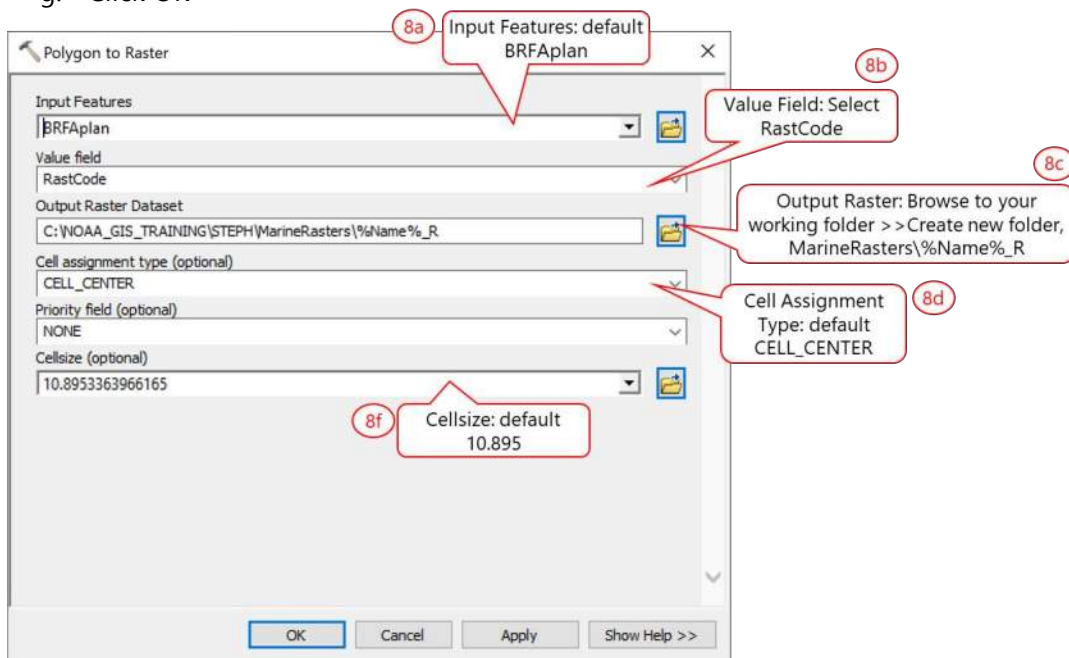
7. Click the Connect button  and connect the feature class to the tool (your mouse will turn into a "magic pencil")
- Click on BRFAplan (green square output) then click on Polygon to Raster Tool.
 - Select Input Feature from the popup menu
 - Click Select button 
 - Save your Model



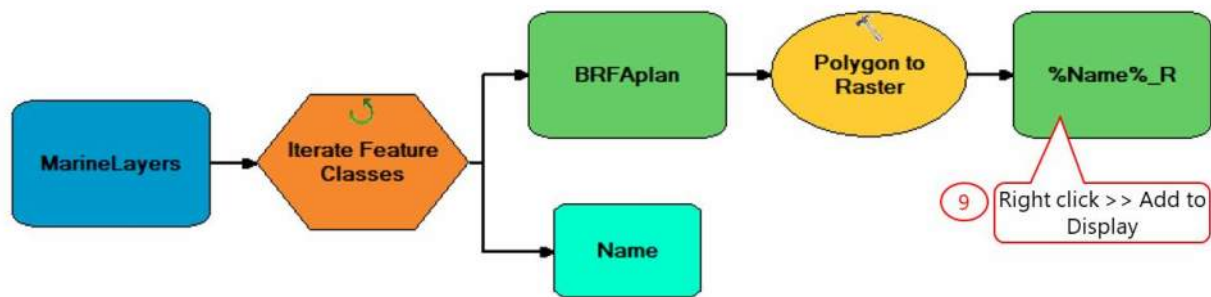
8. Double click Polygon to Raster tool to open it and set the following options
 - a. Input Features: leave default BRFAplan (this is just the 1st layer in iterator)
 - b. Value Field: Select RastCode (this is a field in the vector layer used to code the raster calls with values of 1 = BRFAplan or 0 = not BRFAplan)
 - c. Output Raster Dataset:
 - Click the Browse button and navigate to your working folder (e.g. STEPH) and create a new folder call, MarineRasters
 - For filename, type in %Name%_R (e.g. STEPH\MarineRasters\%Name%_R)

The %Name% is a 'replacement string' that will write the same output file name as the input file name. The _R will indicate the file is a raster layer (and keeps you from getting a file exists error. If you omit this step, you will end up with one output raster with the name of your first polygon file but the contents of the last one processed.

- d. Cell Assignment: leave as default CELL_CENTER
- e. Priority Field: leave as default NONE
- f. Cellsize: leave as default 10.895 (this is same as bathy10m_Rast set up earlier in Model properties)
- g. Click OK



9. Right click on the output, %Name%_R >> Add to Display

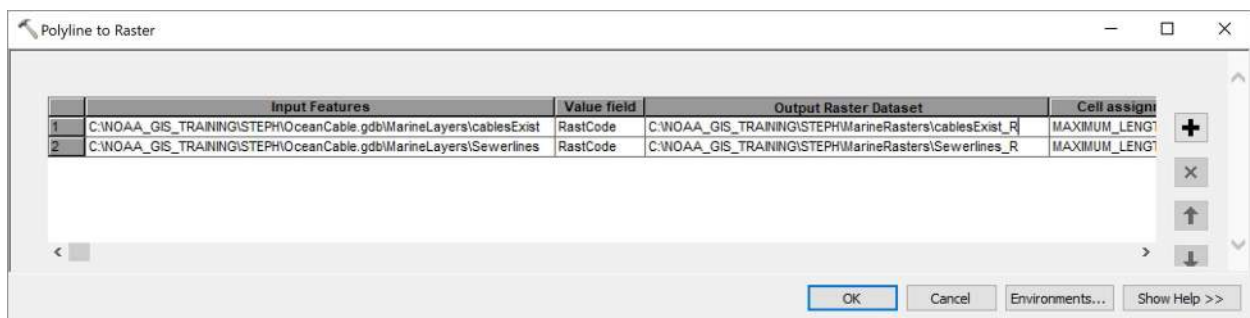
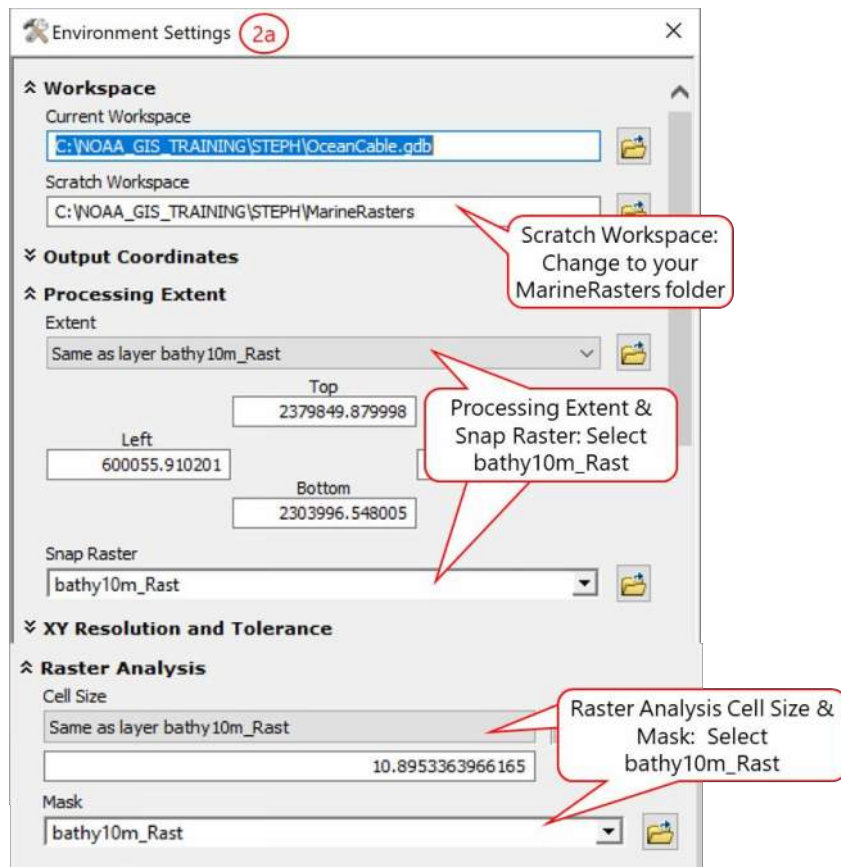


10. Save your Model and then validate and run the entire model
 - a. Go to Model Menu >> Validate Entire Model. If ok, run your model
 - b. Go to Model Menu >> Run Entire Model then close it when done

Polyline to Raster Batch Grid

The Convert Polygon to Raster Model you just created only works on the marine layers that are polygons. There are 2 marine layers (sewerlines and cablesExisting) that are line vectors. You will need to convert these into raster grids as well. But instead of creating a model to do this, you will instead use the Batch Grid method (another method if you don't want to use models with iterators).

1. In ArcToolbox, go to Conversion Tools >> To Raster >> Right click Polyline to Raster >> Batch
2. In the Batch window:
 - a. Setup Environments: Click Environments button
 - Expand Workspace and make sure this is your GDB
 - Expand Scratch Workspace: Change to your MarineRasters folder
 - Expand Processing Extent:
 - Extent: Select Same as layer bathy10m_Rast
 - Snap Raster: Select bathy10m_Rast
 - Expand Raster Analysis:
 - Cell Size: Select Same as layer bathy10m_Rast
 - Mask: Select bathy10m_Rast
 - Click OK
 - b. Input Features: Double click in the field and Browse to MarineLayers\cableExist (e.g. STEPH\OceanCable.gdb\MarineLayers\cablesExist)
 - c. Value Field: click in the field and select RastCode (from pick list)
 - d. Output Raster Dataset: Change Filename to cableExist_R (e.g. STEPH\MarineRasters\cablesExist_R)
 - e. Leave default values for: Cell Assignment Type, Priority Field, and Cell Size
 - f. Click the Add button to insert a new row
 - Input Features: MarineLayersr\sewerlines
 - Output Raster Dataset: MarineRasters\sewerlines_R
 - Leave default values for: Cell Assignment Type, Priority Field, and Cell Size
 - g. Click OK to Run the batch conversion



The Batch Grid will disappear after you run the tool. That's the disadvantage of this method as your workflow is not saved like when you create a model with ModelBuilder.

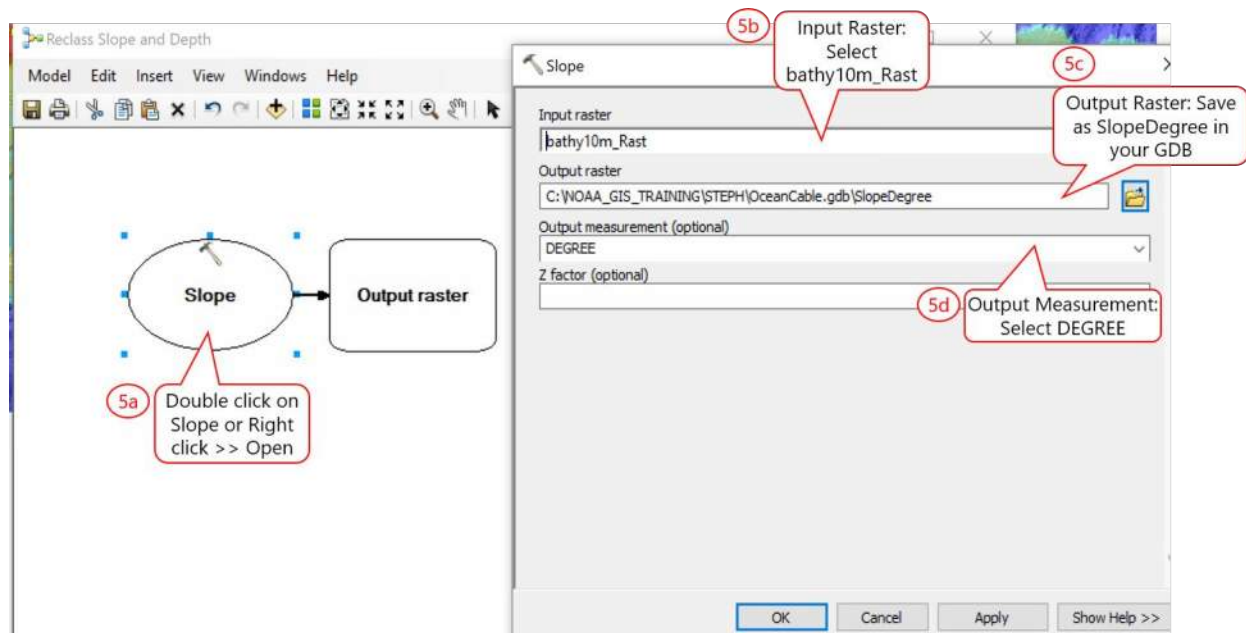
4.5 Deriving slope and reclassing slope categories

For this exercise, you will derive slope from the bathymetry grid. You're going to put the Slope Tool into your model and set up the parameters to run it. Note that the Slope Tool requires the Spatial Analyst Extension to be installed and a valid license to use.

After deriving the slope layer, you will reclassify the slope on a scale of 1-5, with 1 being the most optimum for cable laying and 5 being the worst. The scale is arbitrary – used only to create common categories with which different data can be compared. Remember that the cables can be laid on slopes up to 30 degrees and up to 45 degrees with anchoring. The assumption here is that flatter the areas the better for laying cables.

1. In OceanCable Tools >> Make a copy of the Empty Model (right click >> Copy >> Paste)

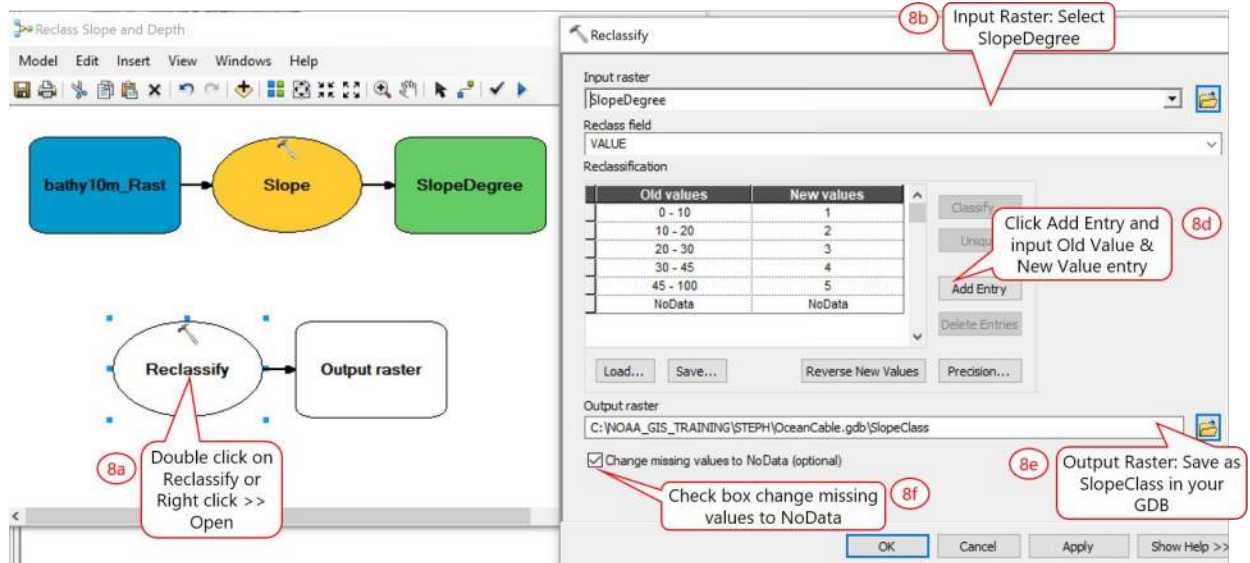
2. Right click on the copy of the Empty Model (2) >>Edit to open it
 - a. Click Model Menu >> Model Properties >> General Tab
 - b. Name: Type in "ReclassSlopeDepth" (this is the model filename)
 - c. Label: Type in "Reclass Slope and Depth" (this is what will be displayed in the toolbox)
3. Turn on the Spatial Analyst Extension. Go to Customize menu >> Extensions >> Check the box for Spatial Analyst
4. In ArcToolbox, go to Spatial Analyst Tools >> Surface Toolset >> Drag and drop Slope tool into the model window
5. In the model window:
 - a. Double click on Slope or Right click >> Open
 - b. Input raster: Select bathy10m_Rast
 - c. Output raster: save as SlopeDegree in your GDB (e.g. OceanCable.gdb\SlopeDegree)
 - d. Output measurement: Select DEGREE
 - e. Click OK
 - f. Click the Auto Layout button to rearrange your diagram
 - g. Save your Model (but don't close it)



6. Optional - Right click SlopeDegree >> Add To Display. This will automatically display the model output raster (SlopeDegree) to the TOC.
7. Reclass SlopeDegree into 5 categories (1= best, 5=worst). In ArcToolbox >> Reclass >> Drag and Drop Reclassify tool into the model Window
8. In the model window:
 - a. Double click Reclassify Tool
 - b. Input Raster: Select SlopeDegree
 - c. Reclass Field: Value (default)
 - d. Reclassification: Click Add Entry then input Old Value and New Value (add entry for each of the 5 categories below (NoData will be automatically added))

Old values	New values
0 - 10	1
10 - 20	2
20 - 30	3
30 - 45	4
45 - 100	5
NoData	NoData

- Output Raster: Save as SlopeClass in your GDB (e.g. OceanCable.gdb\SlopeClass)
- Check the box Change missing values to NoData
- Click OK
- Click the Auto Layout button to rearrange your diagram




- Right click SlopeClass >> Add To Display. This will automatically display the model output raster (SlopeClass) to the TOC
- Save your Model - but don't close it. You'll be adding to it

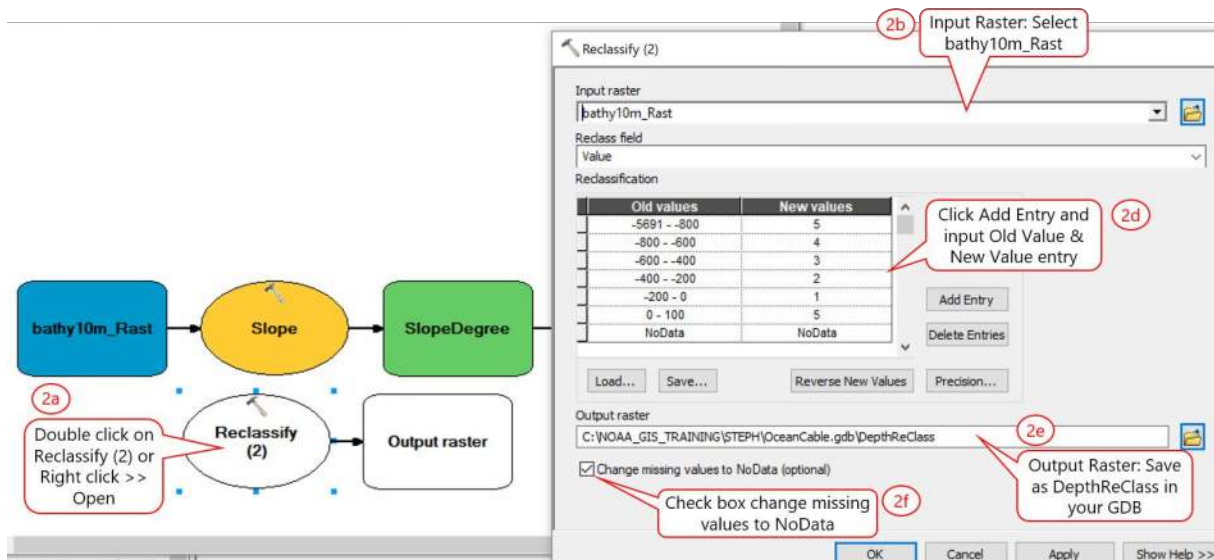
4.6 Reclassing depth categories

In this section you will reclassify the bathymetry layer using a scale of 1-5 (1=best, 5=worst). Remember that the depth should be kept above 800m for cable laying. The assumption is that between a certain depth range (0-800), shallower areas are better for cable laying.

- In ArcToolbox, go to Spatial Analyst Tools >> Reclass >> Drag and drop Reclassify tool into the model window
- In the model window:
 - Double click Reclassify (2) Tool
 - Input Raster: Select bathy10m_Rast
 - Reclass Field: Value (default)
 - Reclassification: Click Add Entry then input Old Value and New Value (add entry for each of the 5 categories below (NoData will be automatically added))

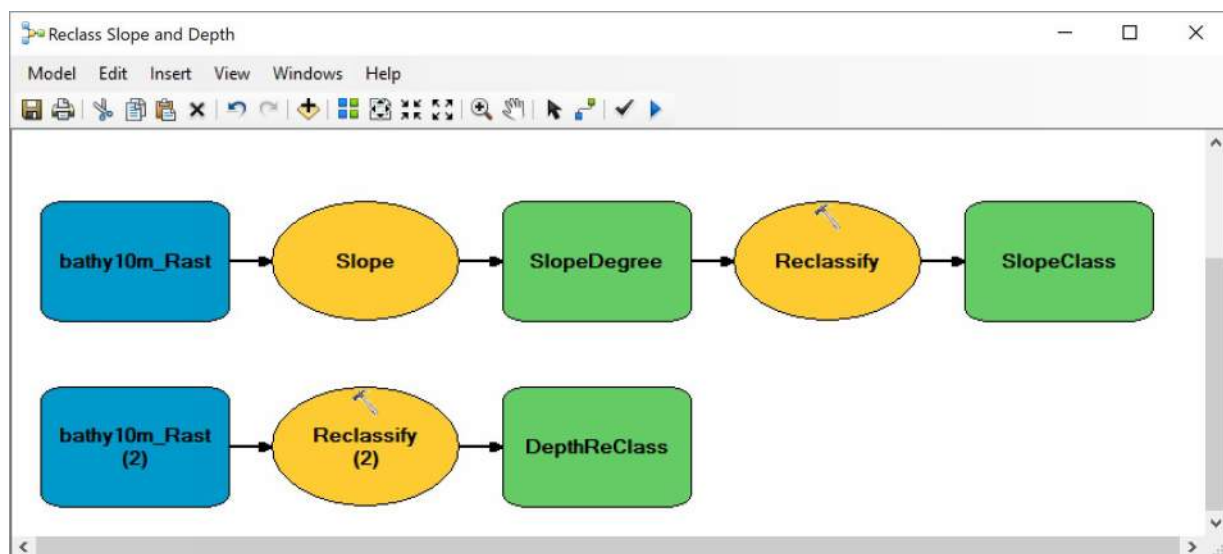
Old values	New values
-5691 - -800	5
-800 - -600	4
-600 - -400	3
-400 - -200	2
-200 - 0	1
0 - 100	5
NoData	NoData

- e. Output Raster: Save as DepthReClass in your GDB (e.g. OceanCable.gdb\DepthReClass)
- f. Check the box Change missing values to NoData
- g. Click OK
- h. Click the Auto Layout button  to rearrange your diagram



3. Right click on DepthReClass >> Add To Display

Your model should look something like the image below



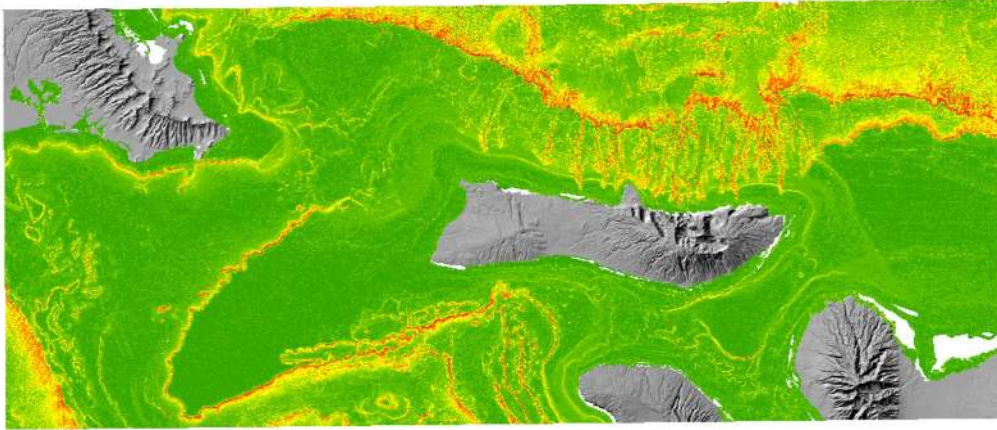
4. Validate your entire model, go to Model Menu >> Validate Entire Model. If no errors, run it.

5. Go to Model Menu >> Run Entire Model. Close the completed geoprocessing window when done

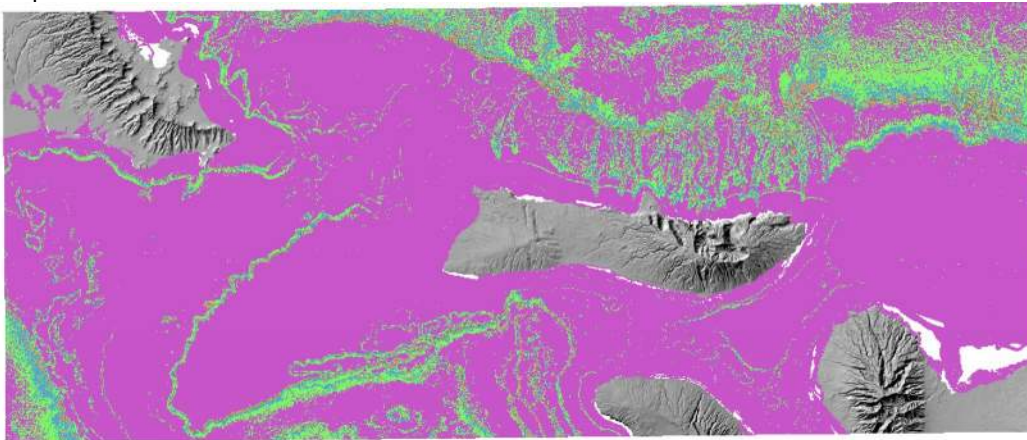
6. Save and close the Model

Your output raster grids should be added to the TOC. The layers should look similar to the ones shown here, although your color scheme may be different.

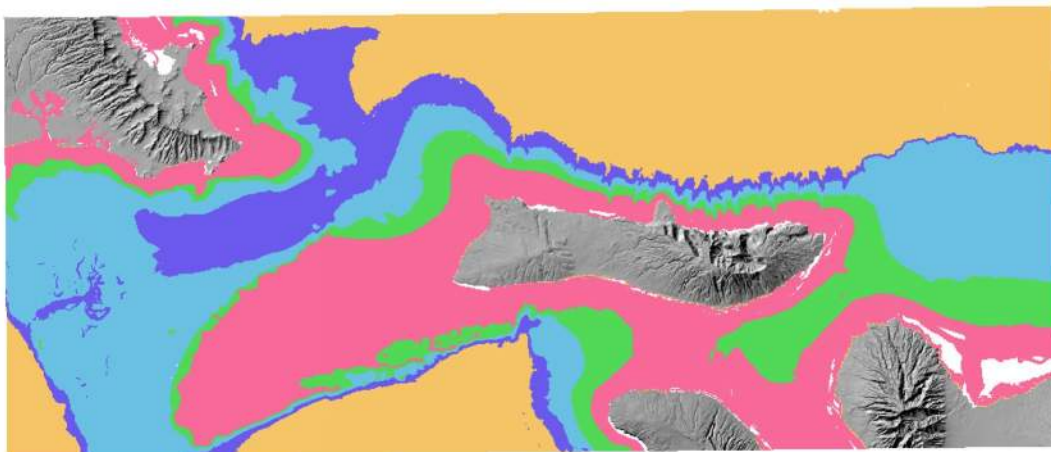
SlopeDegree Raster



SlopeClass Raster



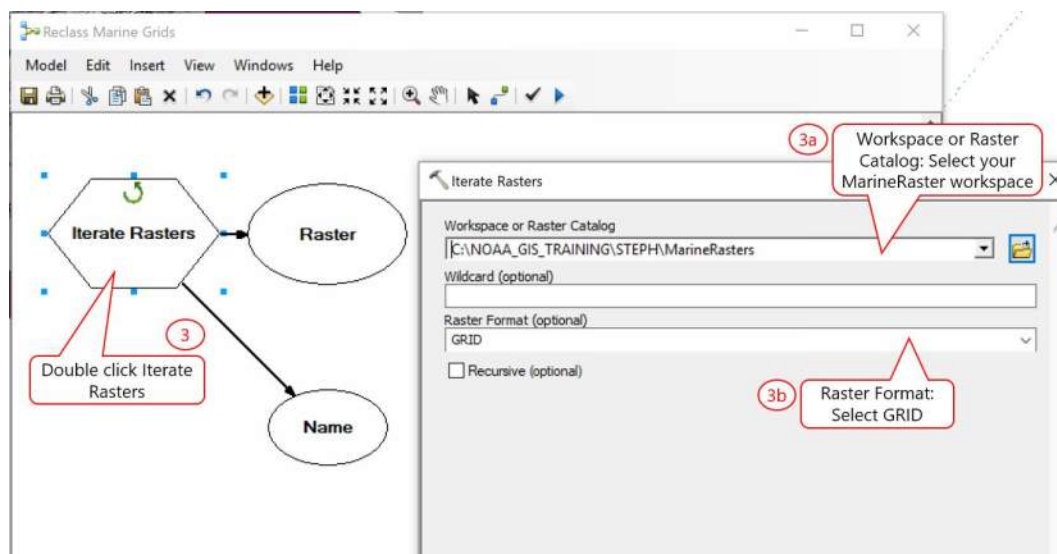
DepthReClass Raster





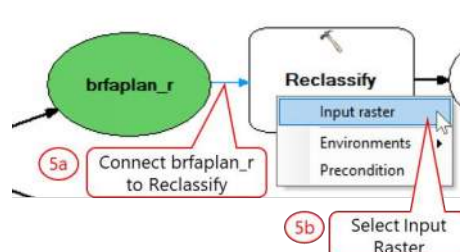
4.7 Reclassifying marine raster grids

For this exercise, you will also reclassify the raster grids of the marine layers to values of 1s and 5s using the same scaling as for slope and depth. (e.g. 1 = not whale sanctuary, good for cables; 5 = whale sanctuary, not good for cables).

1. In ArcToolbox, go to your custom tool OceanCableTools >> Make a copy of the Empty Model and change the following parameters:
 - a. Name: ReclassMarineGrid
 - b. Label: Reclass Marine Grids
2. In the Model window, go to Insert Menu >> Iterators >> Drag and drop Rasters into the model
3. Double click Iterate Rasters
 - a. Workspace or Raster Catalog: Select your MarineRasters workspace (e.g. STEPH\MarineRasters)
 - b. Raster Format: Select GRID
 - c. Click OK



4. In ArcCatalog, go to Spatial Analyst Tools >> Reclass >> Drag and drop Reclassify tool into your model
5. Click the Connect button  and connect the feature class to the tool
 - a. Click on brfaplan_r (green square output) then click on Reclassify Tool.
 - b. Select Input Feature from the popup menu
 - c. Click Select button 
 - d. Save your model



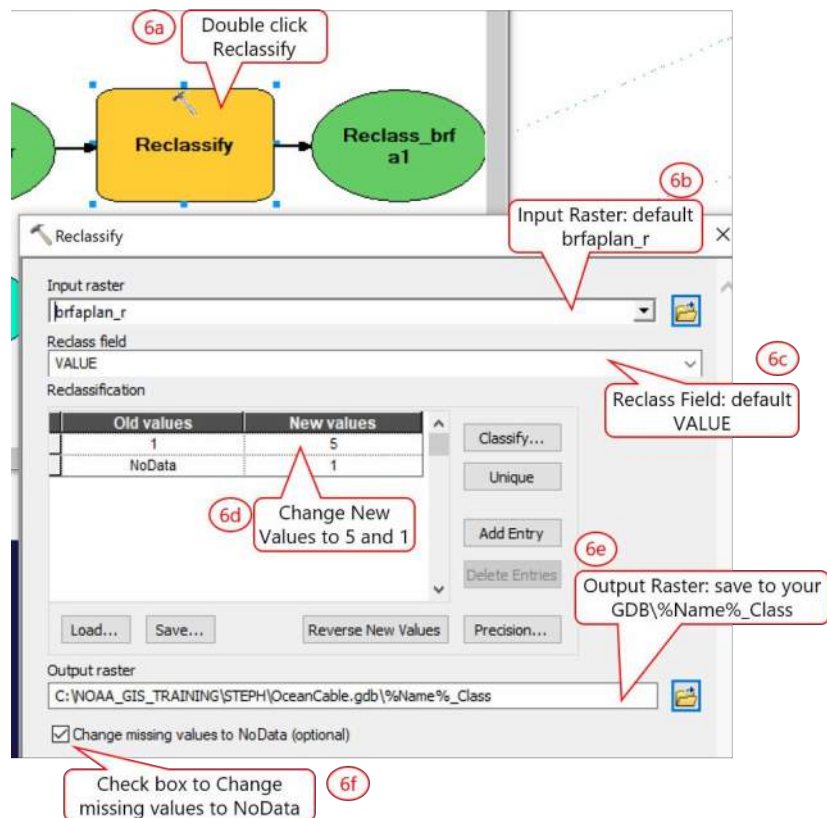
6. In the model window:

- Double click Reclassify tool
- Input Raster: leave default brfaplan_r
- Reclass Field: Value (default)
- Reclassification: Change the New Values to 5 (1) and 1 (NoData)

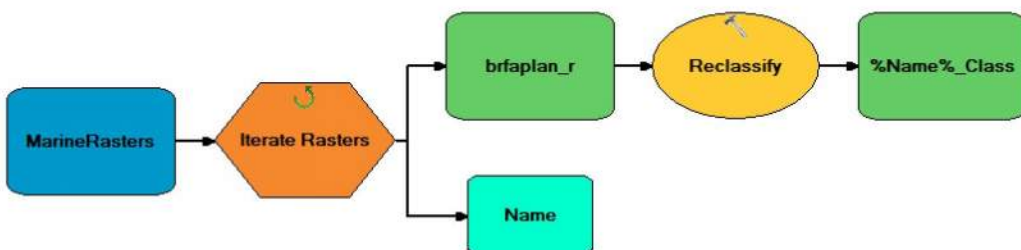
Old values	New values
1	5
NoData	1

Note this reclassification scheme works for the raster iterator because all the marine raster grids contain the same values of 1 or No Data.

- Output Raster: Save to your GDB and input filename as %Name%_Class (e.g. OceanCable.gdb\%Name%_Class)
- Check the box to Change missing values to NoData
- Click OK
- Click the Auto Layout button to rearrange your diagram



Your Reclass Marine Grids Model should look like this:



- Right click on the output, %Name%_Class >> Add to Display

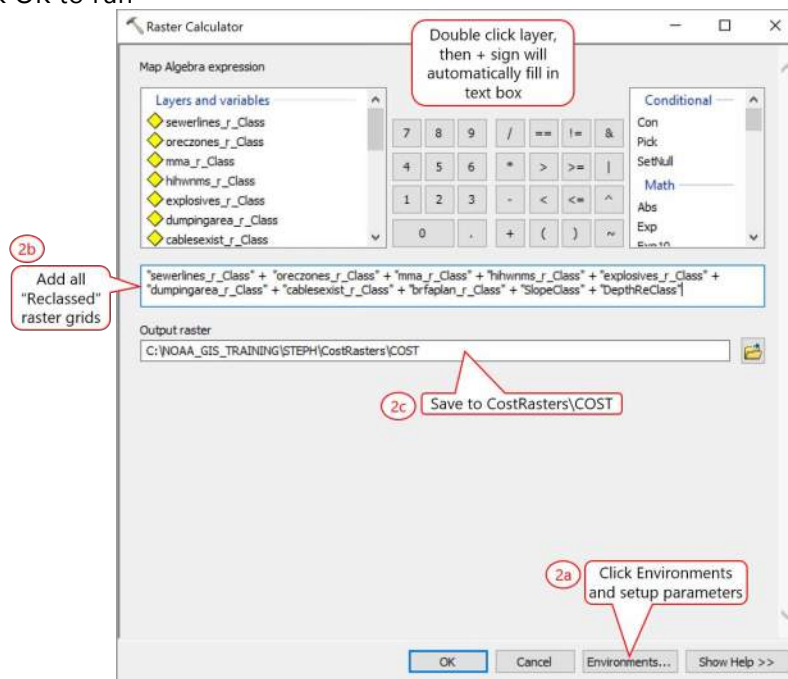
8. Save your Model and then validate and run the entire model
 - a. Go to Model Menu >> Validate Entire Model. If ok, run your model
 - b. Go to Model Menu >> Run Entire Model then close it when done

4.8 Deriving a total cost layer using raster calculator

Once all your raster layers are in a common scale, you can combine them to create a total cost layer. Here you will use the Raster Calculator tool in the Spatial Analyst extension toolbar to combine the raster layers. This simple method assumes that all the layers have equal influence on the cost of laying the cables. For example, if you have 10 criteria or layers then each layer would have a 10% influence on the overall cost.

IMPORTANT NOTE: Analyses related to Cost requires the input and output raster grids to be in a folder not a GDB. If you run the analyses it will just hang or keep going for a very long time – and if you cancel you'll get errors about VAT (Value Attribute Table) not found or accessible.

1. In ArcToolbox, go to Spatial Analyst Tools >> Map Algebra >> Double click Raster Calculator
2. In Raster Calculator window:
 - a. Setup Environments: Click Environments button
 - Expand Workspace and make sure this is your GDB
 - Expand Scratch Workspace: Browse to your working folder and create a new folder call CostRasters
 - Expand Processing Extent: Set Extent and Snap Raster to bathy10m_Rast
 - Expand Raster Analysis: Set Cell Size and Mask to bathy10m_Rast
 - Click OK
 - b. Add all the reclassified marine raster grids, slopeClass, and DepthReClass (10 rasters)
 - c. Output Raster: Browse to your working folder and create a new folder call CostRasters and save output as COST (e.g CostRasters\COST)
 - d. Click OK to run



The COST output should be added to your TOC and should have values of 10-27.

DIY: Create a total weighted Cost layer using Raster Calculator, where SlopeClass and DepthReClass have 30% influence each and the rest of the reclassified marine layers have 5% influence on the total cost. How would you do this? Hint: Reclassified Layer * influence factor

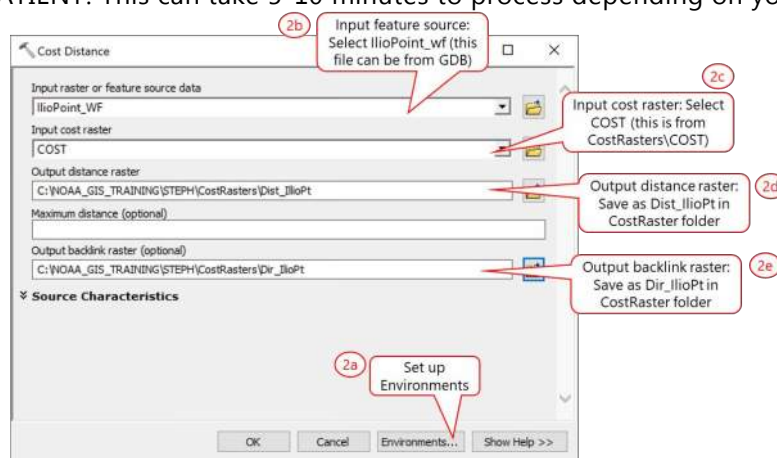
4.9 Cost distance and direction analysis

In this section you will use the Cost Distance tool with the cost layer you just created and the source layers (IlioPoint_wf and KaenaPoin_wf) to create a distance raster where the value of each cell is the accumulated cost of traveling from each cell back to the source. You will also create a direction layer giving the direction of the least-cost path from each cell back to the source. A direction raster is needed for the least-cost path analysis in section 3.10. This method assumes that all criteria have equal influence on cost.

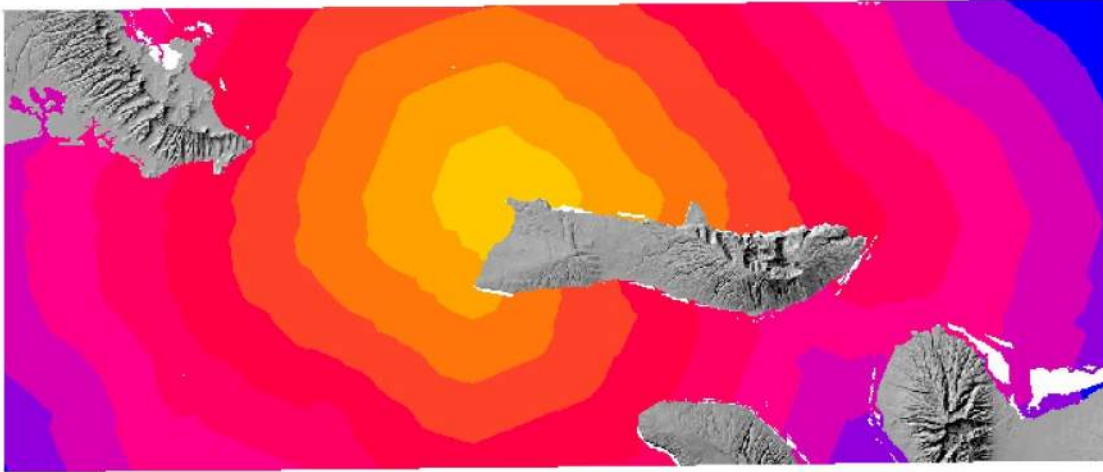
Note: You can choose to do this portion in a Batch mode or you can do run the Cost Distance twice, once for Ilio Point and then again for Kaena Point. Remember that that batch mode may take up to 20 minutes to run for both wind farms. Here, the analyses are done in two separate processes.

1. In ArcToolbox, go to Spatial Analyst Tools >> Distance >> Double click Cost Distance
2. In Cost Distance window:
 - a. Setup Environments: Click Environments button
 - Expand Workspace and make sure this is your GDB
 - Expand Scratch Workspace: Set to your CostRasters folder
 - Expand Processing Extent: Set Extent and Snap Raster to bathy10m_Rast
 - Expand Raster Analysis: Set Cell Size and Mask to bathy10m_Rast
 - Click OK
 - b. Input feature source data: Select IlioPoint_wf (this file can be from your GDB)
 - c. Input cost raster: Select COST (this must be from CostRasters\COST)
 - d. Output distance raster: Save as Dist_IlioPt in CostRasters folder (cannot be in GDB and filename <= 13 characters)
 - e. Output backlink raster: Save as Dir_IlioPt in CostRasters folder (this is your direction raster)
 - f. Click OK to run

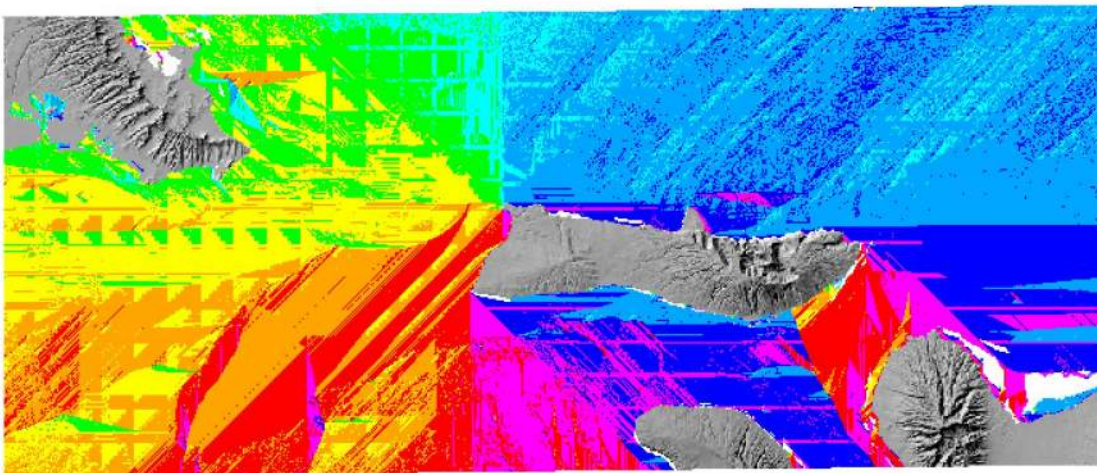
BE PATIENT! This can take 5-10 minutes to process depending on your computer.



Dist_IlioPt should look like this:



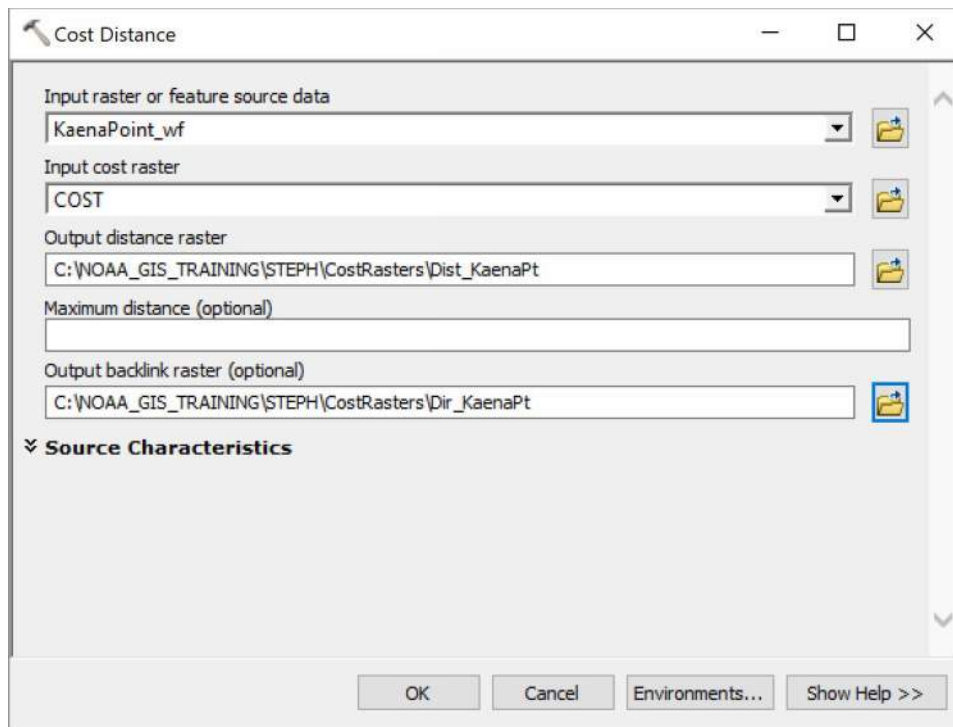
Dir_IlioPt should look like this:



3. Follow the steps above and create a Cost Distance and Cost Direction for Kaena Point (Lanai Wind Farm) using the parameters below

In Cost Distance window:

- a. Setup Environments: Click Environments button
 - Expand Workspace and make sure this is your GDB
 - Expand Scratch Workspace: Set to your CostRasters folder
 - Expand Processing Extent: Set Extent and Snap Raster to bathy10m_Rast
 - Expand Raster Analysis: Set Cell Size and Mask to bathy10m_Rast
 - Click OK
- b. Input feature source data: Select IlioPoint_wf (this file can be from your GDB)
- c. Input cost raster: Select COST (this must be from CostRasters\COST)
- d. Output distance raster: Save as Dist_KaenaPt in CostRasters folder (cannot be in GDB, filename <= 13 characters)
- e. Output backlink raster: Save as Dir_KaenaPt in CostRasters folder (this is your direction raster)
- f. Click OK to run



Your output rasters for Kaena Point should look very similar to the ones for Ilio Point.

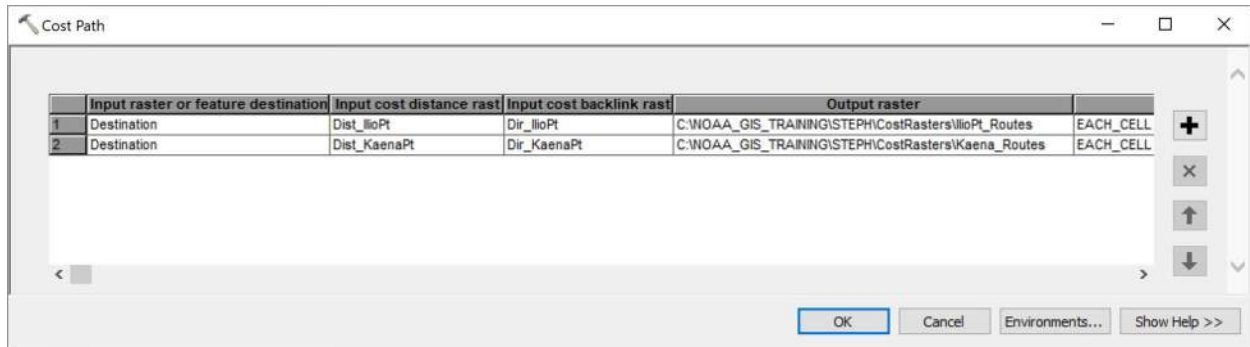
4.10 Least cost path analysis (Finding the shortest cable routes)

In this section, you will use the Least Cost Path (a.k.a. Shortest Path) tool to find the least cost path for laying undersea cables from wind farms on Molokai and Lanai to the Kaneohe and Pearl/Honolulu Harbor substations on Oahu. The path generated by the tool represent the least cost path – least cost meaning the path should avoid steep slopes, kept at a depth above 800m, and avoiding marine protected/restricted areas and existing telecom cables for laying undersea cables from the wind farms to the substations.

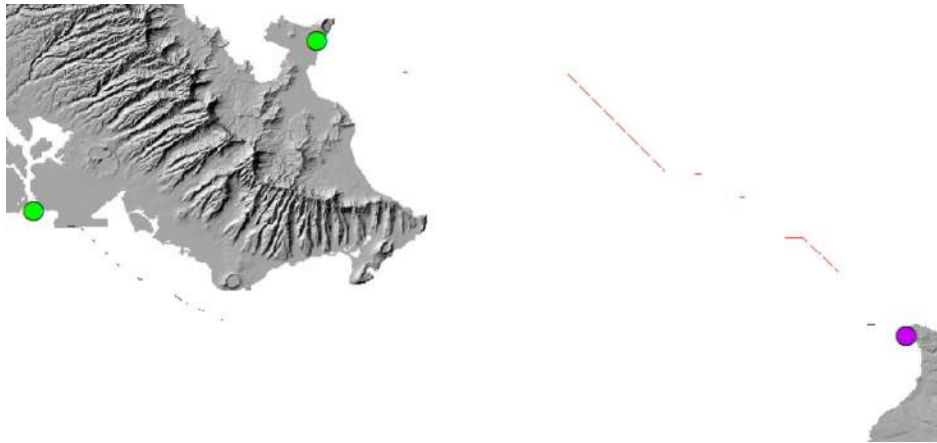
Least Cost Path (Shortest Routes) – Batch Mode

1. In ArcToolbox, go to Spatial Analyst Tools >> Distance >> Right click Cost Path >> Batch
2. In Cost Path Batch Grid window:
 - a. Setup Environments: Click Environments button
 - Expand Workspace and make sure this is your GDB
 - Expand Scratch Workspace: Set to your CostRasters folder
 - Expand Processing Extent: Set Extent and Snap Raster to bathy10m_Rast
 - Expand Raster Analysis: Set Cell Size and Mask to bathy10m_Rast
 - Click OK
 - b. Input feature source data: Select Destination (this file can be from your GDB)
 - c. Input cost distance raster: Select Dist_Ilio (generated earlier and should be in CostRasters folder)
 - d. Input cost backlink raster: Select Dir_IlioPt (generated earlier and should be in CostRasters folder)
 - e. Output raster: Save as IlioPt_Routes in CostRasters folder
 - f. Path type: Select EACH_CELL
 - g. Add another row and input the corresponding files for Kaena Point
 - h. Input feature source data: Select Destination (this file can be from your GDB)

- i. Input cost distance raster: Select Dist_KaenaPt (from CostRasters folder)
- j. Input cost backlink raster: Select Dir_KaenaPt (from CostRasters folder)
- k. Output raster: Save as Kaena_Routes in CostRasters folder
- l. Path type: Select EACH_CELL
- m. Click OK to run



Notice the raster outputs didn't produce lines or routes as you would expect – it's very hard to see anything on the map. You will need to convert the raster output to a vector.

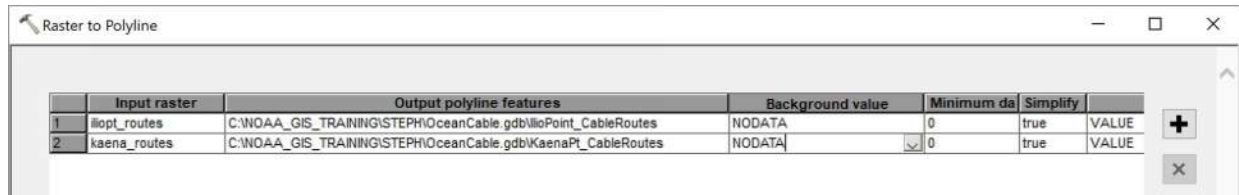


Note: If using the Batch mode – only the last output file will be automatically display in the TOC. Just add in the other output files.

Convert Raster to Polyline – Batch Mode

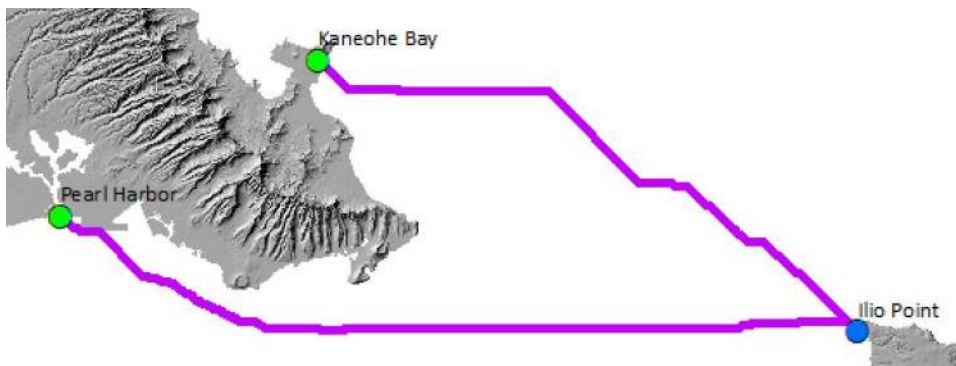
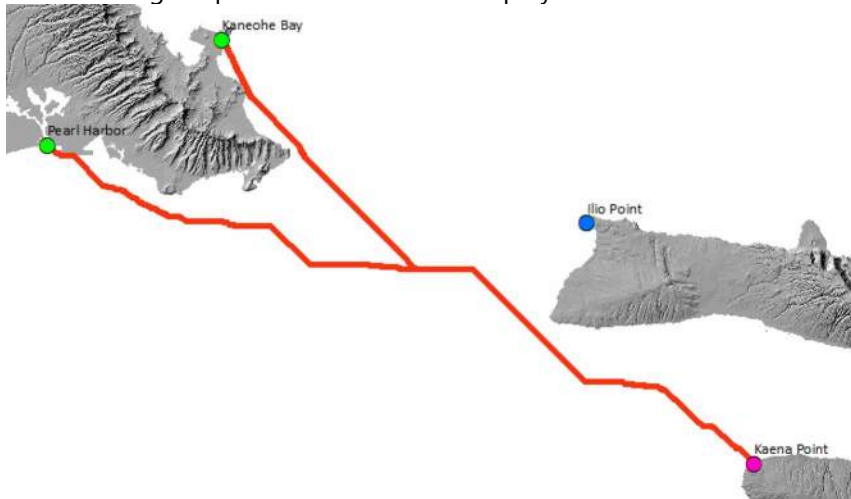
1. In ArcToolbox, go to Conversion Tools >> From Raster >> Right click on Raster to Polyline >> Batch
2. In the Raster to Polyline Batch Grid window:
 - a. Setup Environments: Click Environments button
 - Expand Workspace and make sure this is your GDB
 - Expand Scratch Workspace: Make sure this is your GDB
 - Expand Processing Extent: Set Extent and Snap Raster to bathy10m_Rast
 - Expand Raster Analysis: Set Cell Size and Mask to bathy10m_Rast
 - Click OK
 - b. Input raster: Select IlioPt_Routes
 - c. Output polyline features: Save as IlioPoint_CableRoutes in your GDB (e.g. OceanCable.gdb\IlioPoint_CableRoutes)
 - d. Background value: Select NODATA

- e. Add another row and input the corresponding files for Kaena Point
- f. Output polyline features: Save as KaenaPoint_CableRoutes in your GDB (e.g. OceanCable.gdb\KaenaPoint_CableRoutes)
- g. Background value: Select NODATA
- h. Click OK to run



Note: If using the Batch mode – only the last output file will be automatically display in the TOC. Just add in the other output files.

The resulting output cable routes are displayed below:



Exercise 5: Suitable Cable Route - Weighted Overlay Method

In exercise 4, you produced potential cable routes based on the assumption that all the inputs have an equal influence on the overall cost of laying the undersea cables. What if the layers you used to generate the cost layer do not all have equal influence in the overall cost of laying the cables? What if slope and depth have more influence on the overall cost? In this section, you will use the Weighted Overlay tool in the Spatial Analyst toolbox to apply weights to the datasets used to calculate overall cost. The procedures will be done in a model, which you've already learned how to create and add elements to. For the sake of time only the routes from Ilio Point, Molokai to the Oahu substations will be done.

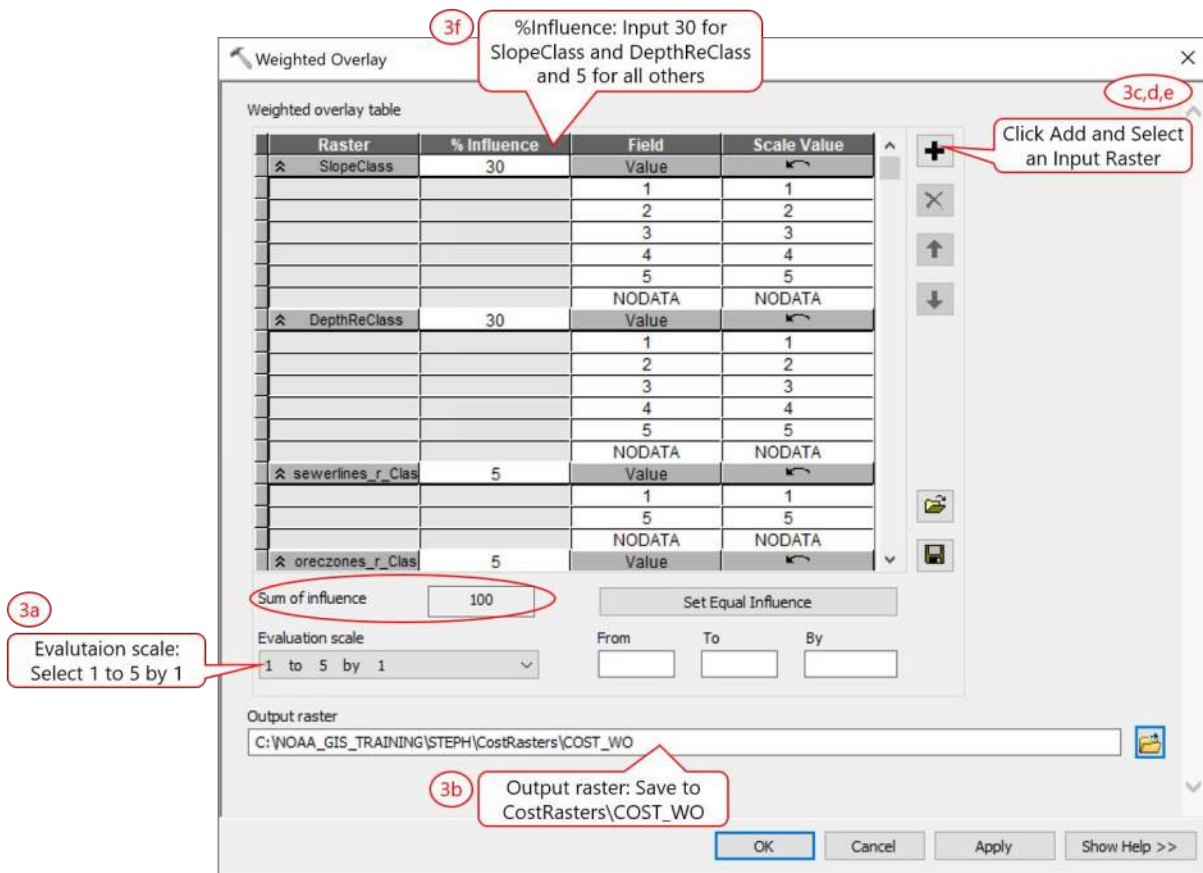
1. In ArcToolbox, go to your OceanCableTools >> Make a copy of the EmptyModel and change the name and label to WeightedOverlay and Cable Routes – Weighted Overlay respectively
2. In ArcToolbox, go to Spatial Analyst Tools >> Overlay >> Drag and drop Weighted Overlay tool into your model
3. In Weighted Overlay window:
 - a. Evaluation Scale: Select 1 to 5 by 1
 - b. Output Raster: Save as COST_WO in CostRasters folder (e.g. STEP\CostRasters\COST_WO)
 - c. Click the Add Raster Row button (plus sign)
 - Input raster: Select SlopeClass
 - Input field: Value (default)
 - Click OK
 - d. Add another raster row
 - Input raster: Select DepthReClass
 - Input field: Value (default)
 - Click OK
 - e. Continue to Add Raster Rows for all the marine raster grids that you reclassified earlier. The input field for all the rasters should be Value
 - sewerlines_r_Class
 - oreczones_r_Class
 - mma_r_Class
 - hihwnms_r_Class
 - explosives_r_Class
 - dumpingarea_r_Class
 - brfaplan_r_Class
 - cablesexist_r_Class
 - f. In the % Influence Column, input the following for each raster, so the sum equals 100% influence
 - SlopeClass = 30%
 - DepthReClass = 30%
 - All others = 5% each



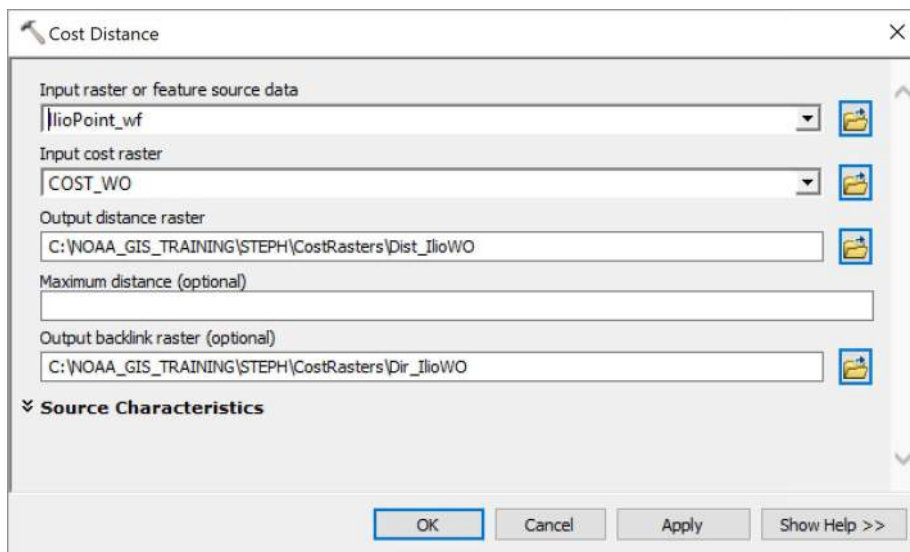
With Weighed Overlay you can change the evaluation scale of each raster grid as well as setting them all to equal or different influence



The Raster Calculator could also be used to create a weighted overall cost layer by multiplying the layer/criteria by its influence factor. For example: $\text{weighted cost} = \text{SlopeClass} * 0.30 + \text{DepthClass} * 0.30 + \text{mma_r_class} * 0.05$ and so on



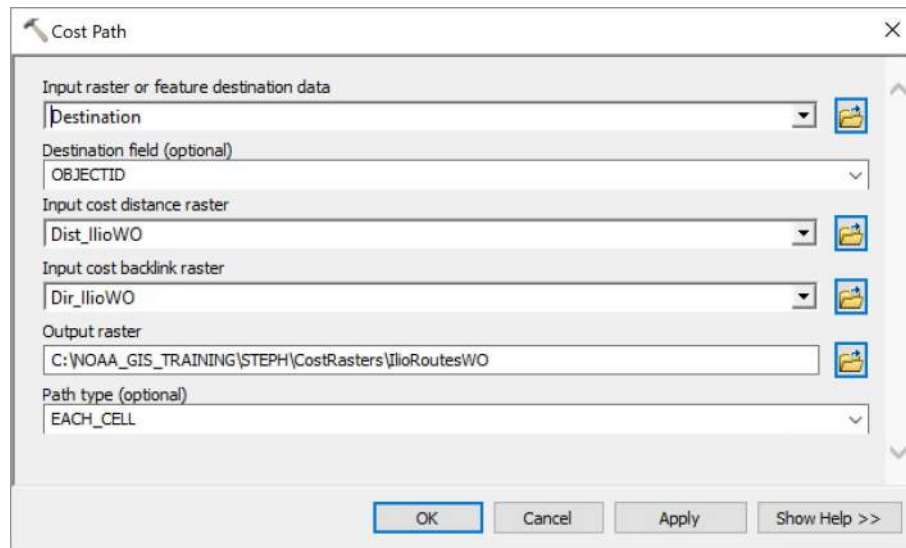
4. In ArcToolbox, go to Spatial Analyst Tools >> Distance >> Drag and drop Cost Distance into your model
5. In Cost Distance window:
 - a. Input feature source data: Select IlioPoint_wf (this file can be from your GDB)
 - b. Input cost raster: Select COST_WO (this must be from CostRasters\COST_WO)
 - c. Output distance raster: Save as Dist_IlioWO in CostRasters folder
 - d. Output backlink raster: Save as Dir_IlioWO in CostRasters folder (this is your direction raster)
 - e. Click OK



6. In ArcToolbox, go to Spatial Analyst Tools >> Distance >> Double click Cost Path

7. In Cost Path window:

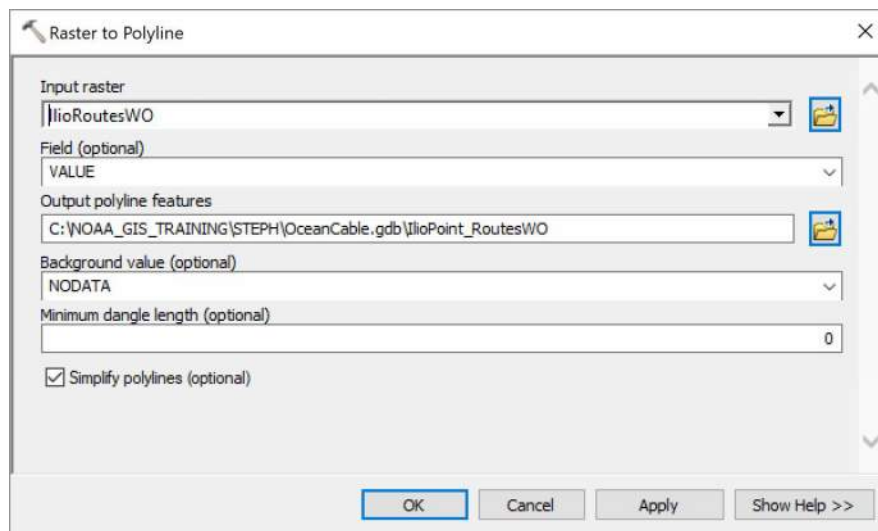
- a. Input feature source data: Select Destination (this file can be from your GDB)
- b. Input cost distance raster: Select Dist_IlioWO (from CostRasters folder)
- c. Input cost backlink raster: Select Dir_IlioWO (from CostRasters folder)
- d. Output raster: Save as IlioRoutesWO in CostRasters folder
- e. Path type: Select EACH_CELL
- f. Click OK



8. In ArcToolbox, go to Conversion Tools >> From Raster >> Drag and drop Raster to Polyline into your Model

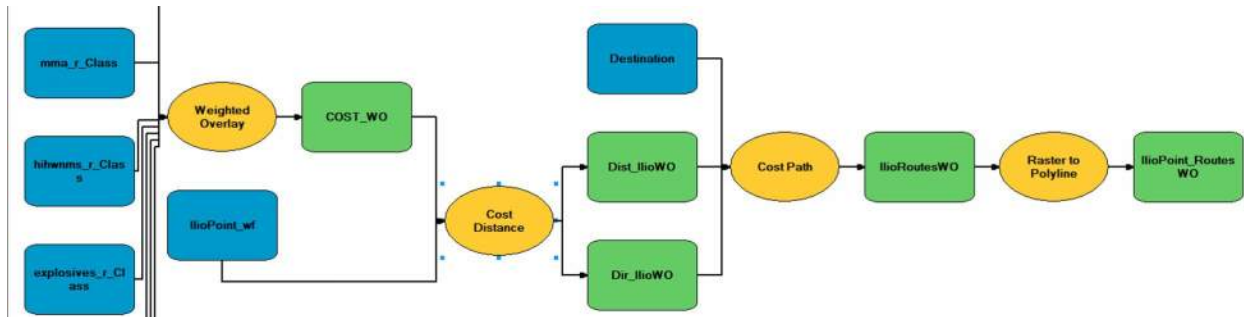
9. In the Raster to Polyline window:

- a. Input raster: Select IlioRoutesWO
- b. Output polyline features: Save as IlioPoint_RoutesWO in your GDB (e.g. OceanCable.gdb\IlioPoint_RoutesWO)
- c. Background value: Select NODATA
- d. Click OK



10. Add the last output, IlioPoint_RoutesWO to your display (Right click >>Add to Display)

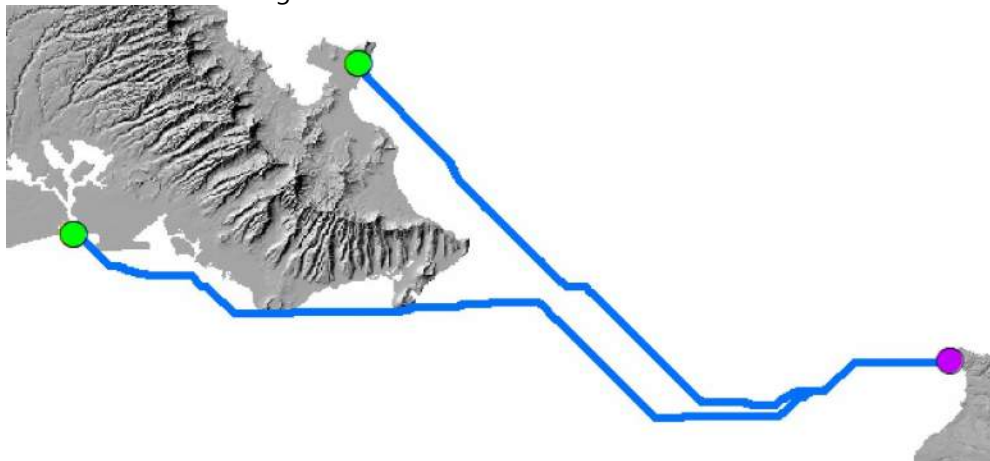
11. Click the Auto Layout button then save your model



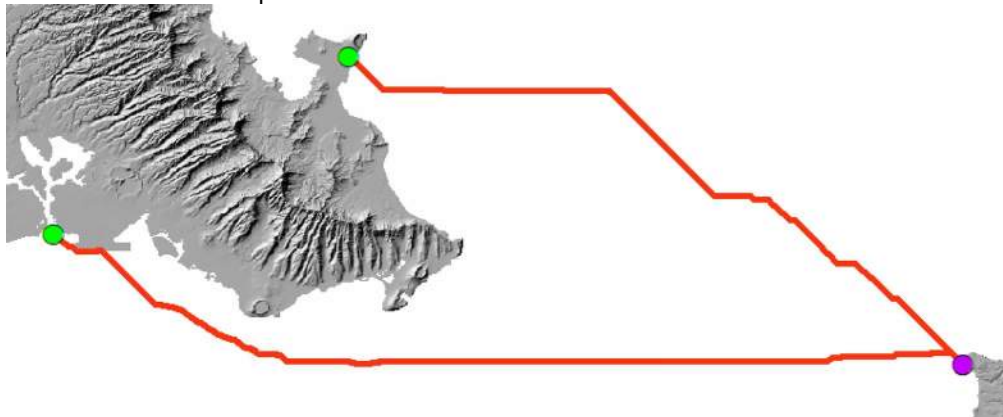
12. Go to Model Menu >> Validate Entire Model

13. Go to Model Menu >> Run Entire Model

Cable Routes with weighted influence:



Cable Routes with equal influence:



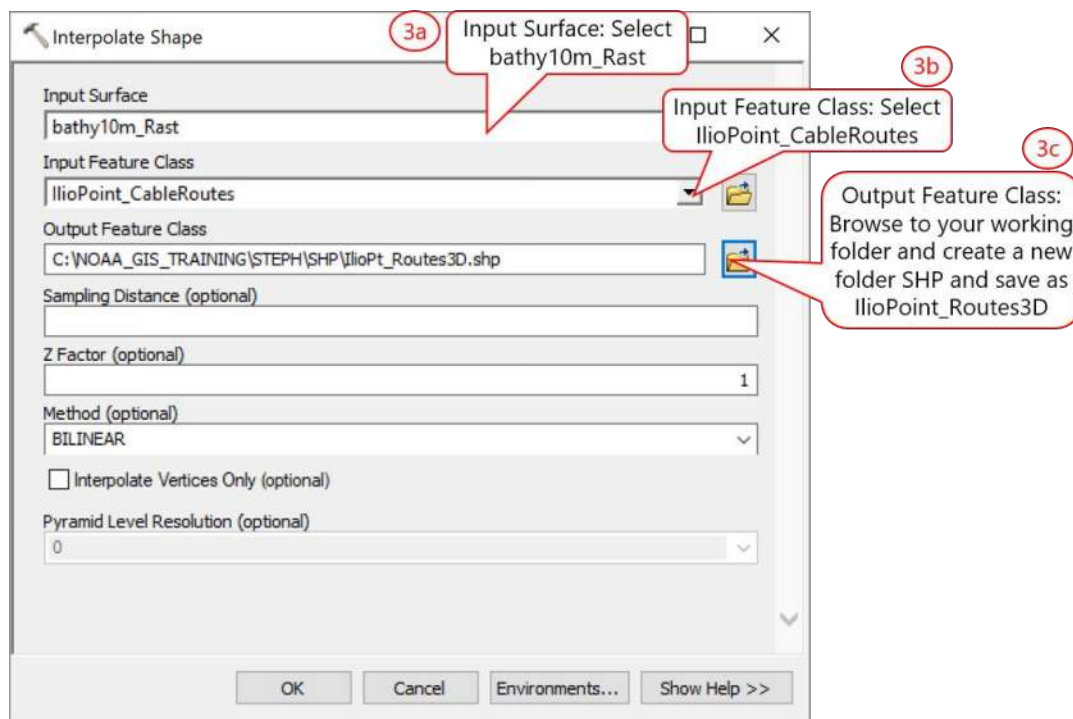
DIY: Create a model using the same Weighted Overlay method as you just did in this exercise for finding suitable cable routes from Kaena Point, Lanai to the Oahu substations.

Exercise 6: Creating Profile Graph

Flat 2D features can be converted to 3D features by deriving the height value from a surface (e.g. DEM, TIN, Terrain dataset). You can do this with the Interpolate Shape Tool. A profile graph can then be created from the 3D features and added to your map. Note this tool requires a valid 3D Analyst extension license.

IMPORTANT NOTE: Output file must be saved as a shapefile. Saving the output file as a feature class in a GDB, produces an error "The coordinates or measures are out of bounds."


1. Turn on 3D Analyst Extension. Go to Customize Menu >> Extensions >> Check 3D Analyst
2. In ArcToolbox, go to 3D Analyst Tools >> Functional Surface >> Double click Interpolate to Shape tool to open it
3. In Interpolate Shape window:
 - a. Input Feature Class: Select IlioPt_CableRoutes
 - b. Input Surface: Select bathy10m_Rast
 - c. Output Feature Class: Browse to your working folder and create a new folder, named SHP and save as IlioPt_Routes3D.shp (must be a shapefile)
 - d. Leave all other default options
 - e. Click OK to run

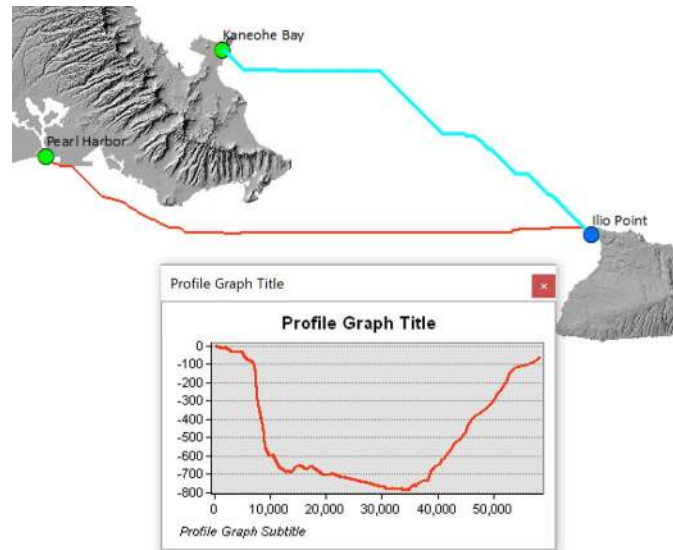


4. Turn on 3D Analyst Toolbar, go to Customize Menu >> Toolbars >> 3D Analyst

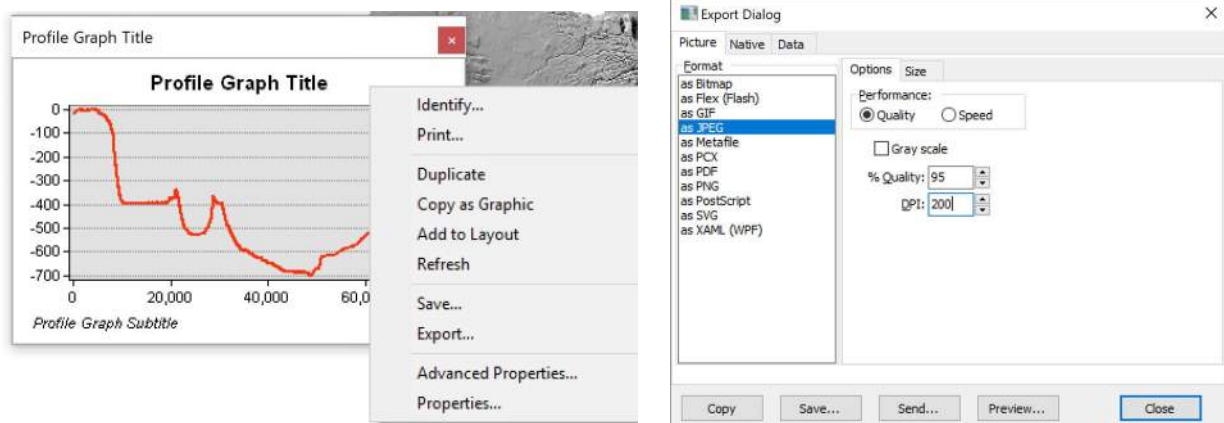


5. On the Tools Toolbar, click the Select Features button and click on one the 3D cable routes to select it (will be highlighted in blue)

6. On the 3D Analyst Toolbar, click the Profile Graph button . You should get another window showing the profile of the 3D line. By default, the unit on the graph is based on the coordinate system of your data – in this example both depth and distance are in meters.

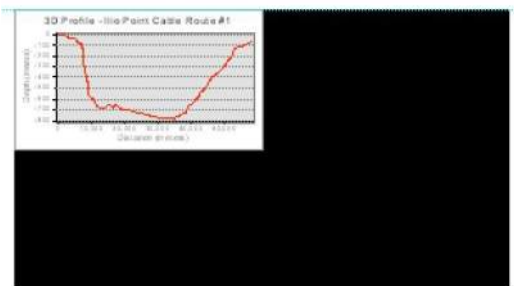


7. You can customize the profile graph by accessing its Properties or Advanced Properties windows by right clicking on the graph window >> Properties or Advance Properties. Explore these settings if you like.

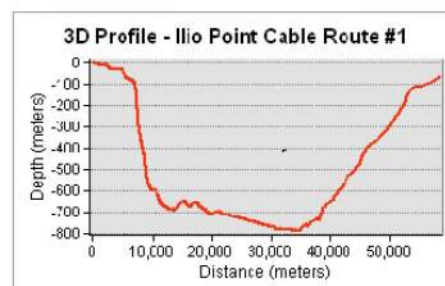


8. To add the profile graph to the map layout, use the Export option to export it to a PNG or JPG then insert into the map layout. The Export option also allows you to export the data points and use it in Excel. The Add to Layout option produces a weird results (see example below)

Add to Layout option:



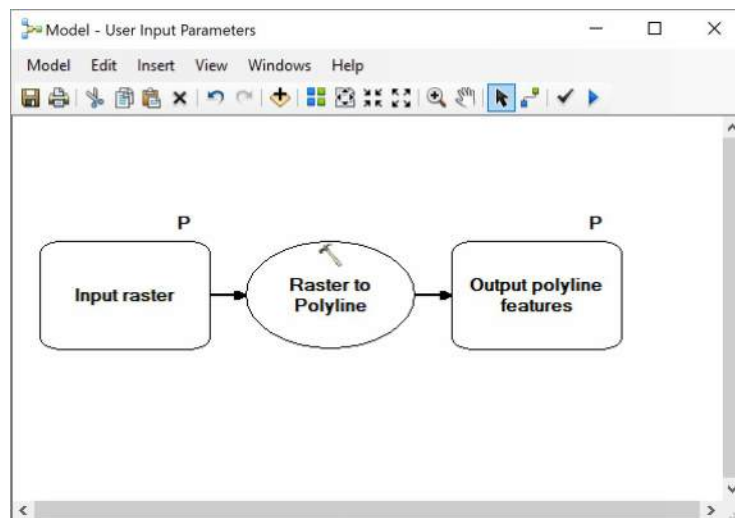
Exported as PNG & inserted as graphic:



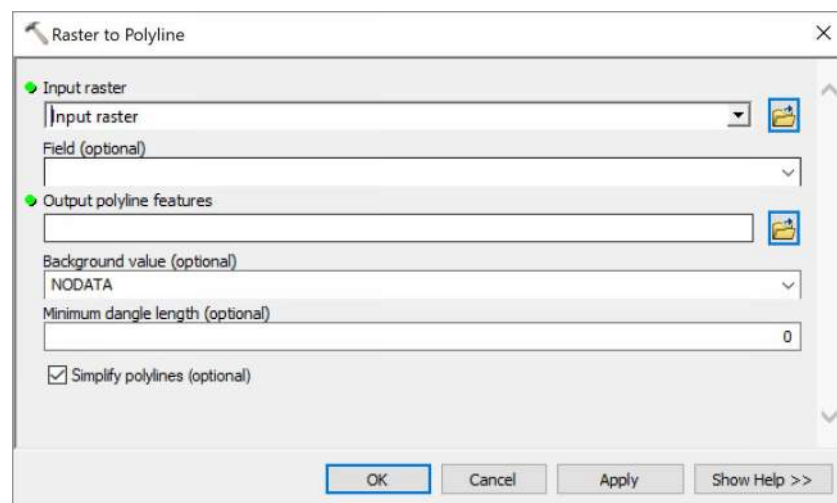
Exercise 7: Adding Model Parameters - Optional

Let's say you want to share a model and have others be able to input their own datasets. To do this you need to include the tools or functions in your model as model parameters.

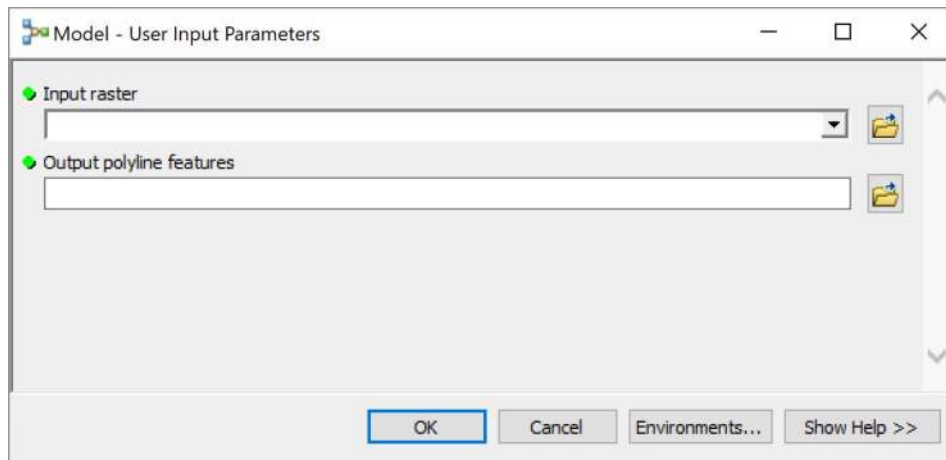
1. In ArcToolbox, go to OceanCable Tools >> Make a copy of the Empty Model and change the Name and Label to ModelUserInput and Model – User Input Parameters, respectively
2. In ArcToolbox, go to Conversion Tools >> From Raster >> Drag and drop Raster to Polyline Tool to your model window
3. In the Model window, right click on Raster to Polyline Tool >> Make Variable >> From Parameters >> Input Raster
4. Right click on Input Raster >> Model Parameter
5. Right click on Output Polyline Features >> Model Parameter



6. In the tool, any parameters with a default value can also be changed. Double click on Raster to Polyline tool to open it and make your changes (e.g. Background value's default is ZERO, this can be set to NODATA).



7. Save and close Model
8. Double click on the Model to open it. You should be able to specify an input raster and an output file.



Exercise 8: Hyperlinking, Adding Attachments and Geotagging Photos

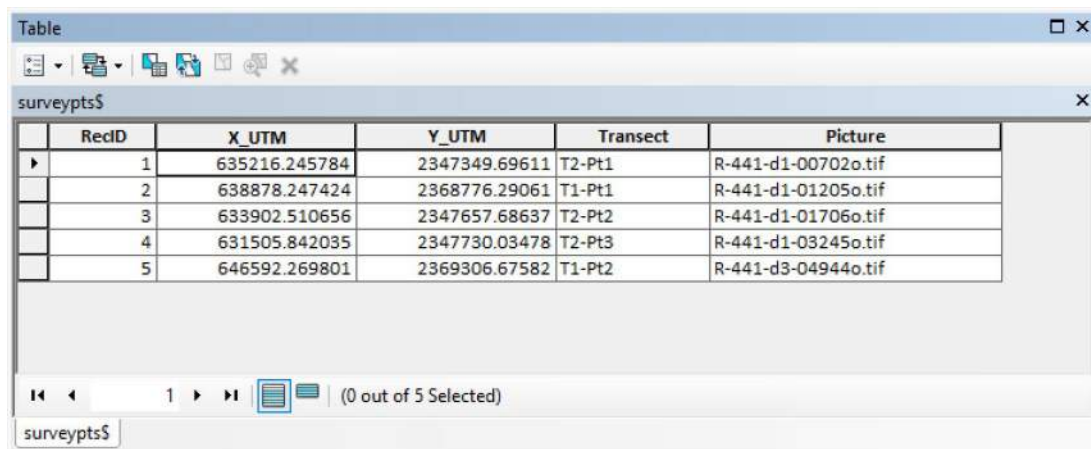
Suppose you did some dive surveys around where the potential cables routes are, and for each location that you surveyed, you took a picture. This information is stored in an Excel file and you want to plot out the survey points and hyperlink the pictures to the points on a map.

You can access documents (e.g. pdfs or images) or web pages related to features using the Hyperlink button on the Tools toolbar. But you need to create the hyperlink for the feature first by either defining it as a dynamic hyperlink or using a field-based hyperlink. Dynamic hyperlinks can be added after you've used the Identify button on the Tools toolbar on a feature – you then access the Add Hyperlink dialog box from the identified feature's context menu. A field-based hyperlink uses a field in the layer's attribute table, which is the method shown in this exercise.

This exercise goes over how to add and view attachments to features in layer, and how to create a point layer from geotagged photos. For creating a point layer from geotagged photos, you will use some sample photos taken in the downtown Honolulu area. Note there is also an option to add attachments in batch using the Add Attachments geoprocessing tool, which is not covered in this tutorial.

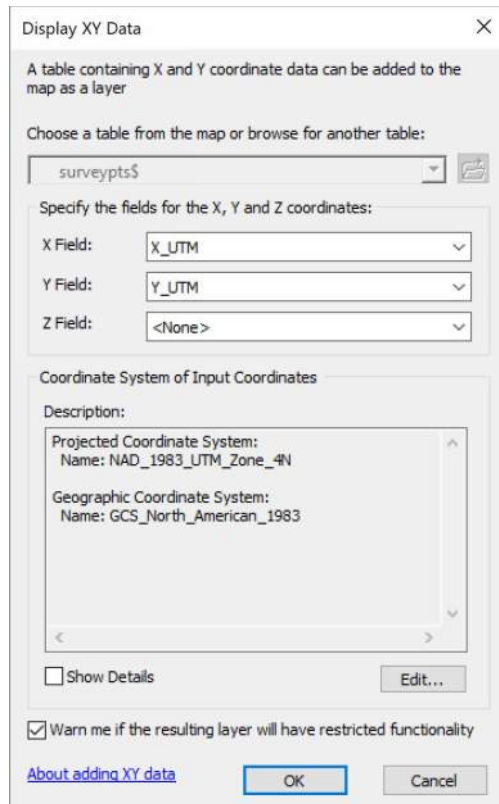
Convert survey locations to point layer

1. Add the Excel file surveypts.xls to the TOC.
 - a. Click Add data button. Navigate to the *OceanCableProj* folder Double click on SurveyPts.xls then click on surveypts\$ sheet.
 - b. Open the surveypts sheet (right click on surveypts\$ >> Open) and make sure it contains the information as in the image below

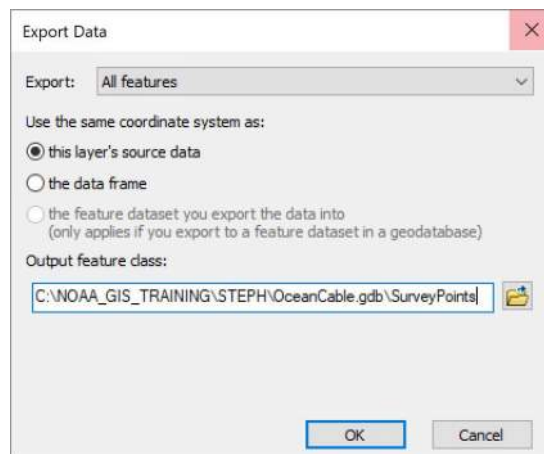


RedID	X_UTM	Y_UTM	Transect	Picture
1	635216.245784	2347349.69611	T2-Pt1	R-441-d1-00702o.tif
2	638878.247424	2368776.29061	T1-Pt1	R-441-d1-01205o.tif
3	633902.510656	2347657.68637	T2-Pt2	R-441-d1-01706o.tif
4	631505.842035	2347730.03478	T2-Pt3	R-441-d1-03245o.tif
5	646592.269801	2369306.67582	T1-Pt2	R-441-d3-04944o.tif

2. Plot out the points. Right click on the surveypts\$ >> Display XY Data.
 - a. In the dialog box: X Field = X_UTM; Y Field = Y_UTM.
 - b. For coordinate system, click the Edit button then select NAD 1983 UTM Zone 4N from Favorites folder.
 - c. Click OK.



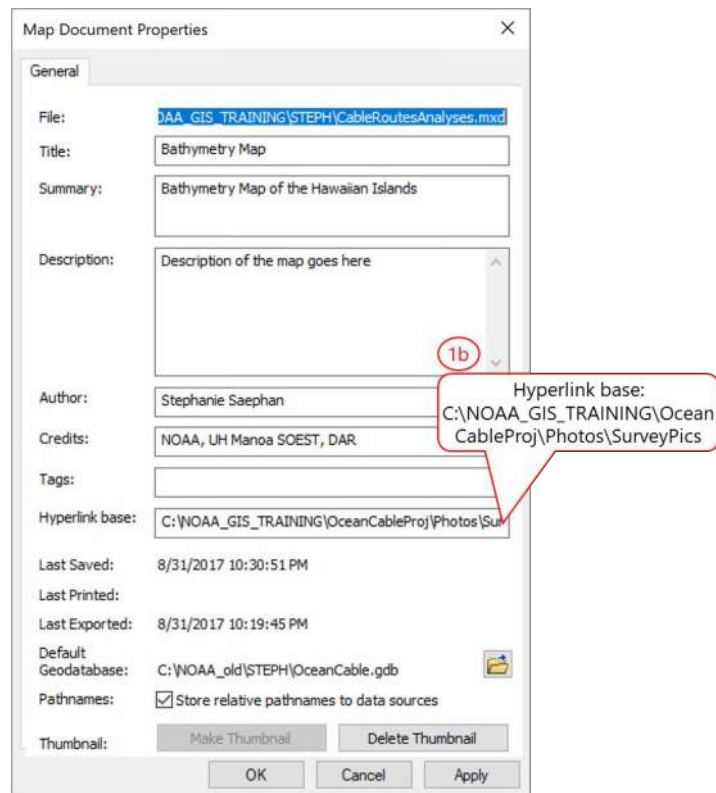
3. Convert the survey points events layer into a feature class in your geodatabase.
 - a. In the TOC, right click on surveypts\$ Events >> Data >> Export Data.
 - b. In the dialog box: export all features using this layer's coordinate system, and save output as SurveyPoints to your OceanCable.gdb.
 - c. Click OK.
 - d. Remove the events layer from your TOC.



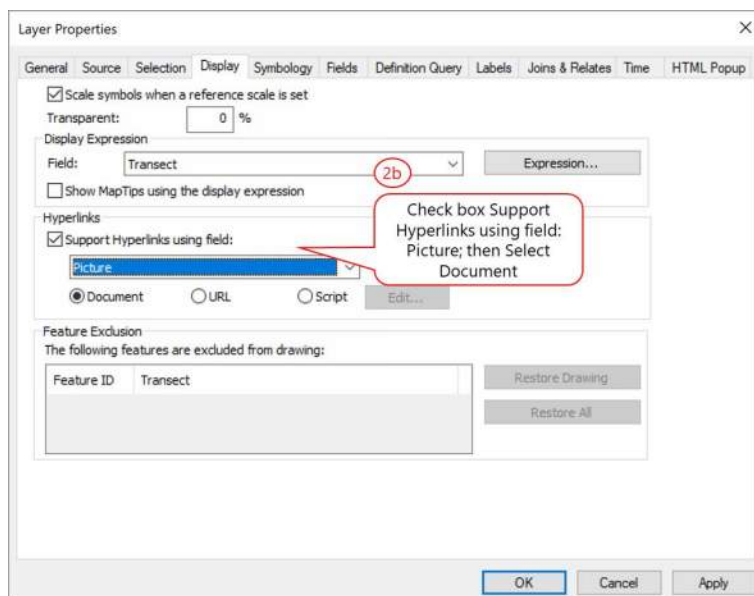
8.2 Hyperlinking images to survey point layer


1. Creating hyperlinks using relative pathnames. There are two ways to do this; one is to just have the folder structure to traverse in the field; the other is to set the hyperlink base property in the map document. Because the survey points table contains only the filenames of the pictures which are all store in one folder, you will use the latter method.
 - a. Go to File menu >> Map Document Properties
 - b. In Map Document Properties window:

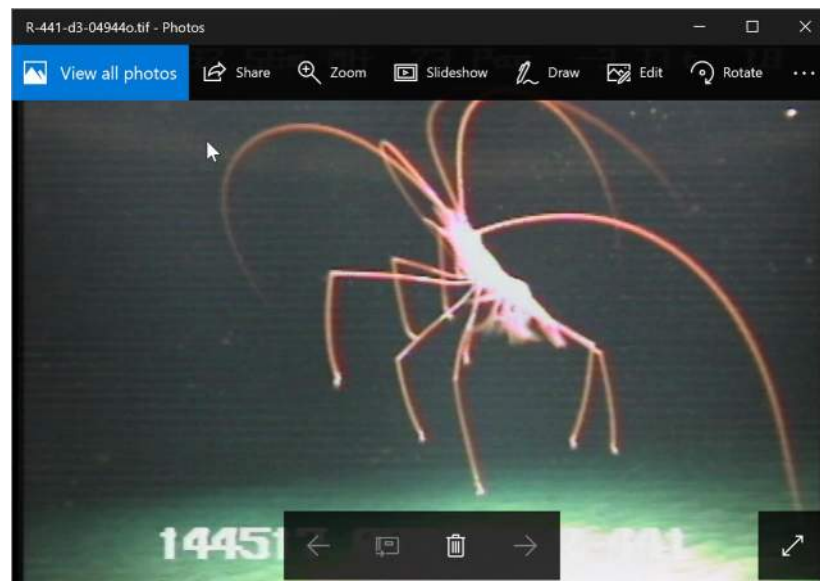
- Hyperlink base: type in the path to the photos folder
C:\NOAA_GIS_TRAINING\OceanCableProj\Photos\SurveyPics
- c. Click OK.



2. In the TOC, right click on SurveyPoints layer >> Properties
 - a. In Layer Properties window: Click the Display tab.
 - b. In the Display tab:
 - Under Hyperlinks: Check the box Support Hyperlinks Using field, then select Picture as the field to use.
 - Make sure the radio button Document is checked. Click OK



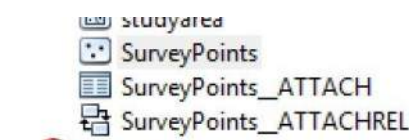
3. Test out your hyperlinks. On the Tools toolbar, click the Hyperlink  button. Click on a survey point on your map. The tif image that correspond to that particular point should open up in whatever software that is set up to open a tif file on your computer.




8.3 Adding images as attachments to survey point layer

Adding attachments requires a Standard or Advanced license, and the output feature class must be in geodatabase version 10 or higher.

1. Go back into the SurveyPoints Layer Properties window >> Display Tab and uncheck the Hyperlink box.
2. In the Catalog window: Right click on SurveyPoints) >> Manage >> Create Attachments. ArcGIS adds a new table to contain the attached files and a relationship class to manage the links between the features and their attachments.





 Attachment files cannot be created while in an edit session. Make sure you are outside of an edit session.

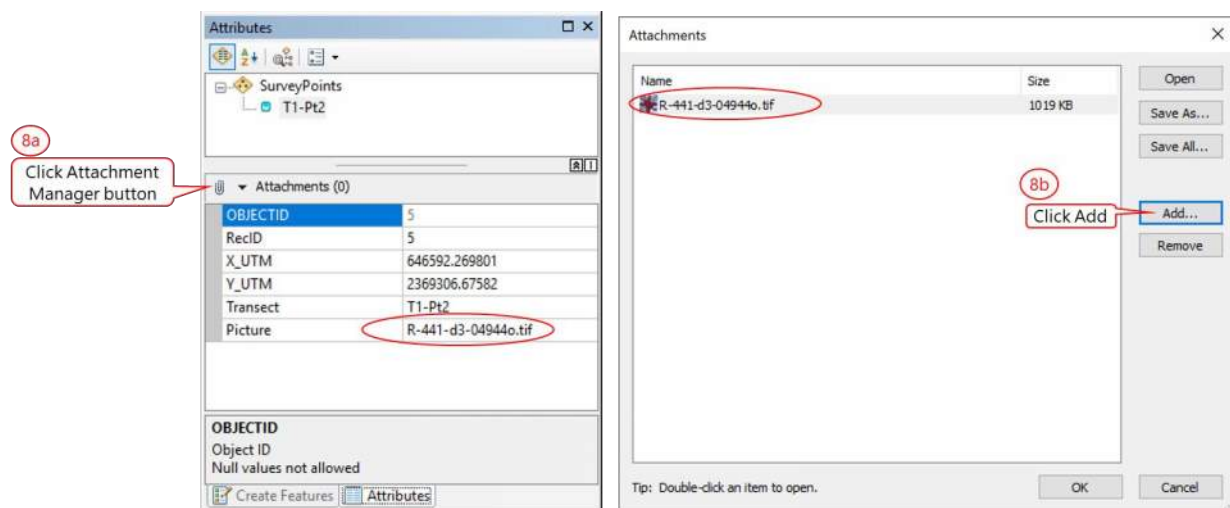
3. Start an edit session for SurveyPoints layer. Right click on the layer name >>Edit Features >> Start Editing)

4. Optional – right click on SurveyPoints layername >> Selection >> Make this the only selectable layer. This will prevent our features in other layers from being selected
5. Turn on the Editor Toolbar if not already shown. Go to Customize Menu >> Toolbars >> Select Editor





6. Using the Edit button  on the Editor toolbar, select a survey point feature on your map
7. With the feature selected, open the Attribute dialog by clicking the Attributes button  on Editor toolbar. Take note of the Picture field (this is the corresponding picture you will attach)

8. In the Attributes window:
 - a. Click the Attachment Manager button
 - b. In the Attachments window:
 - Click the Add button
 - Navigate to C:\NOAA_GIS_TRAINING\OceanCableProj\Photos\SurveyPics and select the appropriate photo for the point;
 - Click Add
 - c. Click OK




9. Add the appropriate photos to the other 4 points in the SurveyPoints layer, following the same steps 6-8 above.
10. Save your edits and stop editing when done (Editor drop down arrow >> Save Edits)

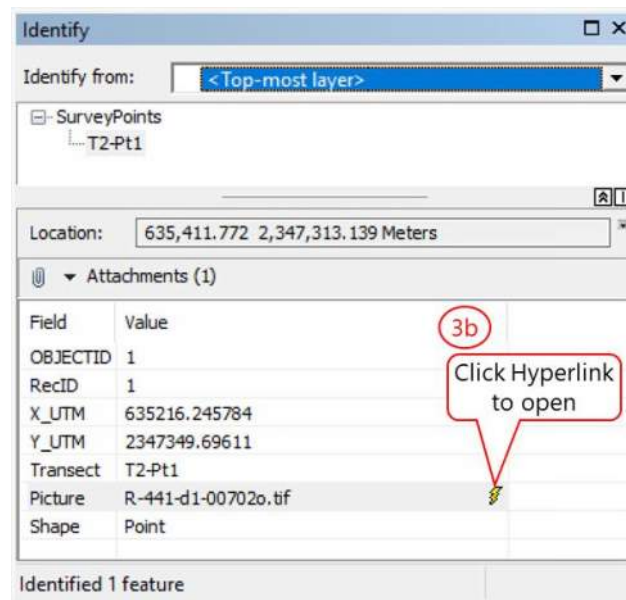
 Attachments can be any type of file (e.g. word doc, excel sheet, pdf, etc.).
 To remove all the attached files and delete the table and relationship class that ArcGIS created when you enabled attachment functionality, click Delete Attachments.

8.4 Viewing attachment(s) of a feature


To view or open attachments, you can either use the Identify window or table window or, when editing, use the Attachment Manager drop down arrow in the Attributes window. The attachments open in whatever default application you have set up on your computer for that file type.

Option 1: Identify button

1. Click the Identify button  on the Tools toolbar.
2. On the map, click a point of interest. If you're unable to select a point, try changing the selection tolerance size. Go to Selection menu >> Selection Options >> Input a higher number for selection tolerance (e.g. 10 pixels).
3. In the Identify window:
 - a. Make sure you are identifying from the correct layer (e.g. SurveyPoints)
 - b. Click the yellow Hyperlink icon - photo should open up on your computer with whatever default program you have set up to open images.



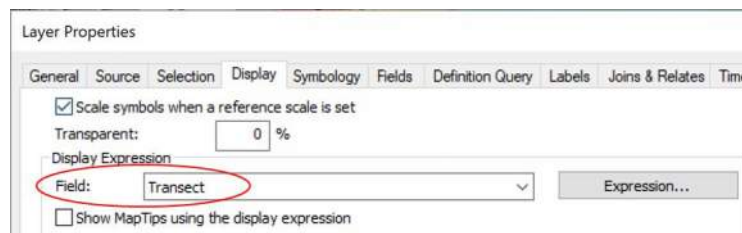
Option 2: HTML Pop Up

1. Click the HTML Popup button  on the Tools toolbar
2. On the map, click on a point feature of interest. An HTML pop up box will be displayed with the attached photo.

Notes: Also note that you'll have to close the pop up box manually (red X box), however, clicking another button on the Tools toolbar will automatically close the HTML popup boxes.



- Optional – The “Title” of the image can be changed in the Display Tab of the Layer Properties window

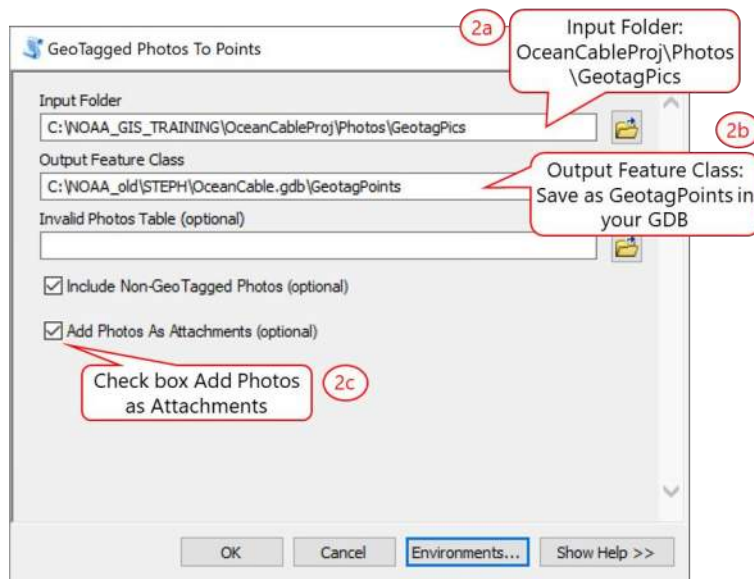


8.5 Creating point features from geotagged photos

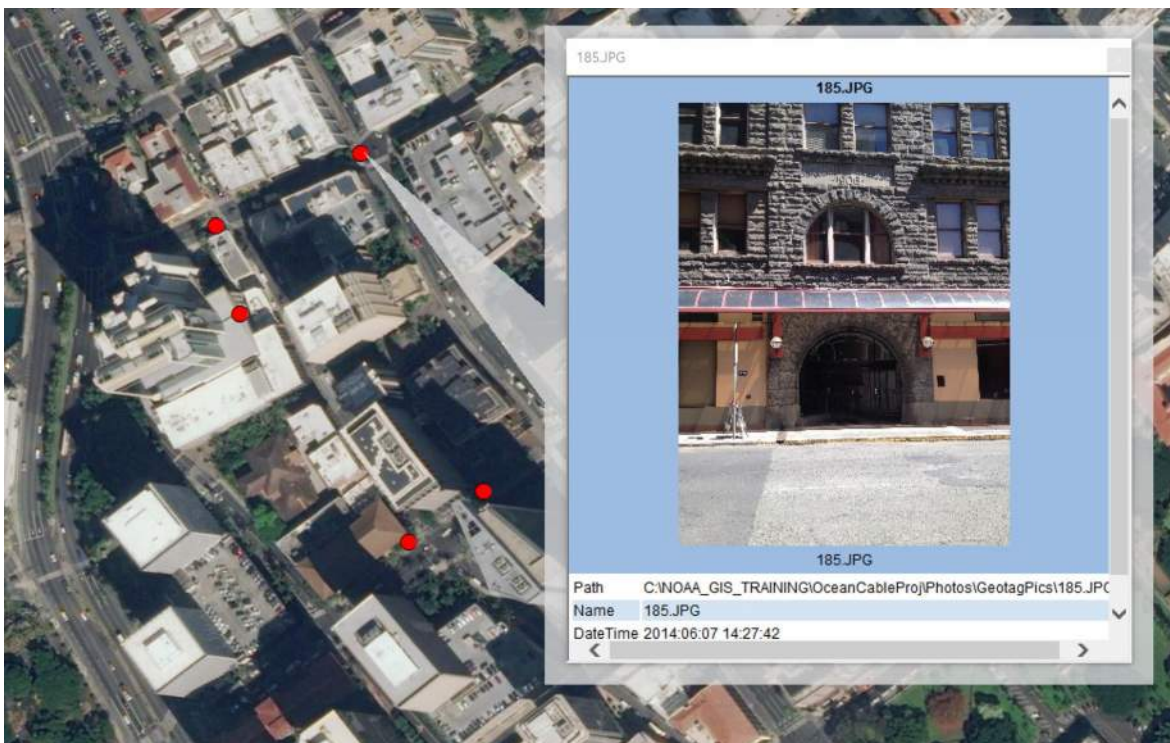
This exercise goes over how to create a point layer from geotagged photos. The photos must have geospatial coordinates embedded in the image files – photos must be taken with a device (e.g. iPhone or smart camera) that has geolocation capability.


- In the ArcToolbox window, go to Data Management Tools >> Photos >> Double click Geo Tagged Photos to Points tool.
- In the GeoTagged Photos to Points window:
 - Input Folder: C:\NOAA_GIS_TRAINING\OceanCableProj\Photos\GeotagPics
 - Output Feature Class: save as new feature class to your GDB (e.g. GeotagPhotosPts)
 - Check box to Add Photos as Attachments
 - Click OK to run

Note: you may get a warning that the output is in a different datum than your map or data frame. This is ok – photos taken with an iPhone for example are most likely in lat/long coordinates (e.g. WGS 84) which the project data and data frame is in NAD 83.



3. When the geoprocessing tool finishes running, it will automatically add the newly created point layer to the map.
 - a. In the TOC, right click on GeotagPoints) >> Zoom to layer. These points are very close together so you may need to zoom out to get a better view. The points in this example are in the downtown Honolulu area.
 - b. Change the symbol of the layer if you'd like to help you see the points better.
 - c. Use the HTML button on the Tools toolbar and click on a point of interest to see the geotagged photo.



 The point layer created from the geotagged photos can be edited to input addition attributes.

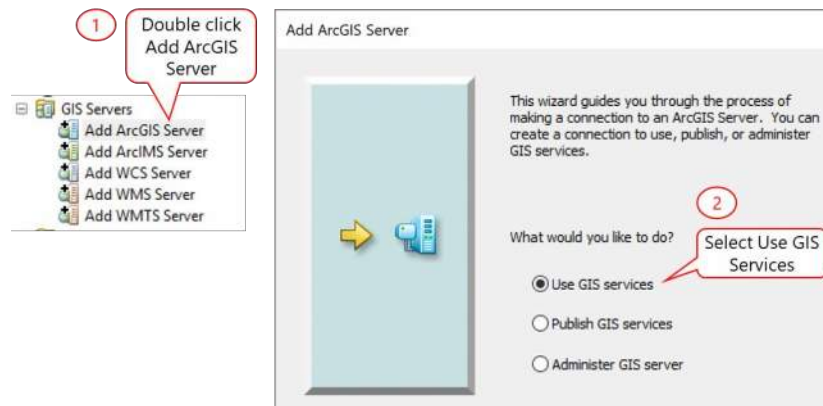
Exercise 9: Connecting to and Using Public GIS Server

This exercise goes over how to add/connect to public GIS web services. There are several different types of GIS servers/services that you can add or connect to. You will be adding 2 of the more common GIS server types, ArcGIS Server and a WMS (Web Map Services), using the Hawaii State GIS Program's GIS ArcGIS Rest web service and the U.S. Fish and Wildlife Service's National Wetlands Inventory Web Map Services as examples. After you connect to these public GIS servers you can then use them in ArcMap. Internet access is required

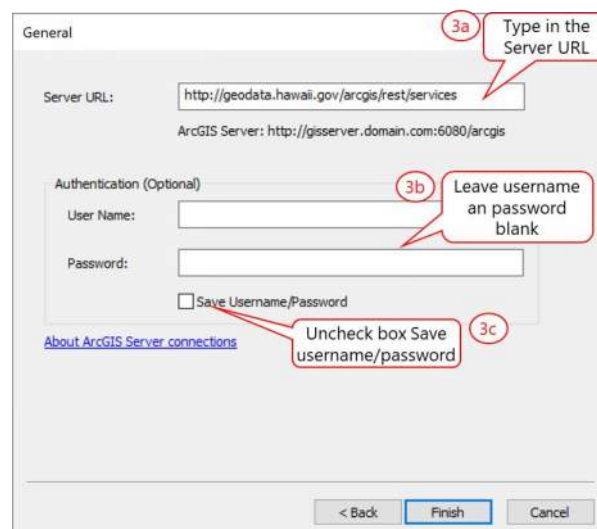
Note: State agency participants can directly connect to the Hawaii State GIS geodatabases. See Appendix B.

Connecting to Hawaii Statewide GIS Program web service – ArcGIS Rest Service

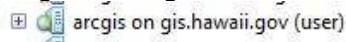
1. In ArcCatalog or the Catalog window (ArcMap), expand GIS Servers folder and double click on Add ArcGIS Server to open it.
2. In the Add ArcGIS Server window: make sure that the option to Use GIS services is selected >> Click Next.



3. In General window:
 - a. Service URL: <http://geodata.hawaii.gov/arcgis/rest/services>
 - b. User name and password: leave blank
 - c. Uncheck Save Username/Password
 - d. Click Finish



In the Catalog tree, you should now see the State's GIS web service added as a GIS server, arcgis on gis.hawaii.gov (user).



4. Rename the added GIS services to something more logical. Right click on the GIS server, arcgis on gis.hawaii.gov (user) >> Rename >> Enter a name (e.g. StateGIS).

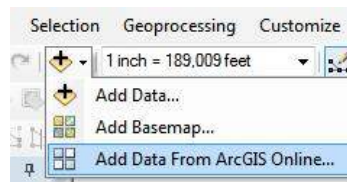


- Added GIS servers can be renamed (e.g. StateGIS)
- To add the City and Country of Honolulu's GIS server, use URL: <http://gis.hicentral.com/arcgis/rest/services>
- There may be more than one type of GIS servers available from an organization. You can check the organization's website.
- More information for the National Wetlands Inventory can be found at: <https://www.fws.gov/wetlands/data/web-map-services.html> (last accessed 8/20/2017)

Connecting to Hawaii Statewide GIS Program web service – ArcGIS Online

An alternative way to connect to and use Hawaii State GIS Program's data.

1. In ArcMap, click the Add Data dropdown menu >> Add Data From ArcGIS Online...



2. In ArcGIS Online window:
 - a. Search for HawaiiStateGIS
 - b. Add data of interest to ArcMap



Connecting to National Wetlands Inventory web service – WMS Server

1. In ArcCatalog or the Catalog window (ArcMap): Double click Add WMS Server to open it.
2. In the Add WMS Server window:
 - a. URL: <https://www.fws.gov/wetlands/arcgis/services/Wetlands/MapServer/WMServer?>
 - b. Version: Default version
 - c. Server Layers: Click Get Layers button
 - d. Leave user name and password blank
 - e. Uncheck the box Save Password
 - f. Click OK

The screenshot shows the 'Add WMS Server' dialog box. Annotations include: '2a' pointing to the URL field with the text 'Type in the Server URL'; '2b' pointing to the 'Version: Default version' dropdown; '2c' pointing to the 'Get Layers' button with the text 'Click Get Layers'; '2d' pointing to the 'User' and 'Password' fields with the text 'Leave username and password blank'; and '2e' pointing to the 'Save Password' checkbox with the text 'Uncheck box Save username/password'.

In the Catalog tree, you should now see the Wetlands WMS service added as a GIS server.

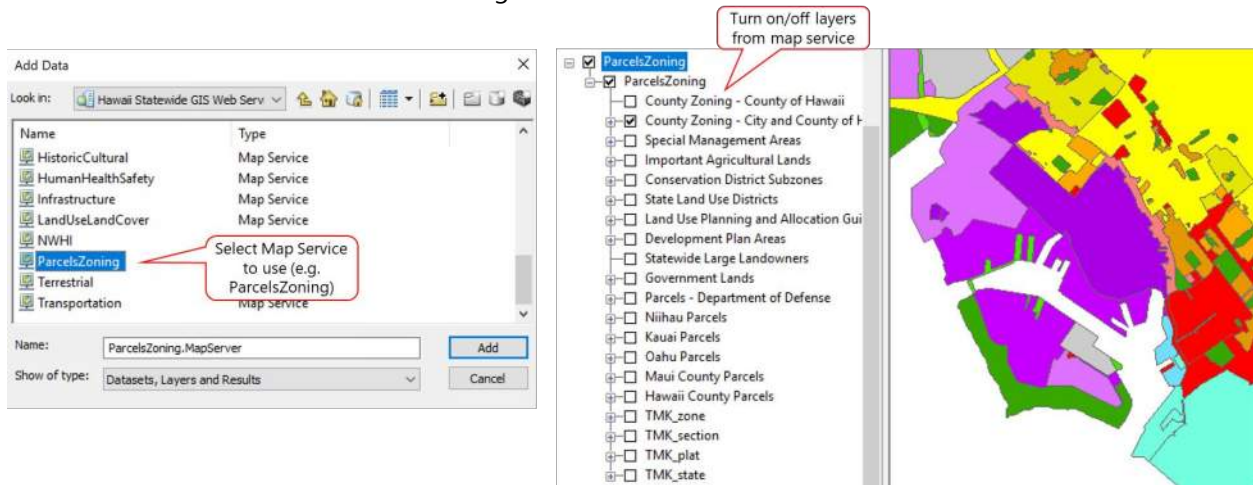
3. Rename the added WMS services to something more logical. Right click on the WMS server > > Rename > > Enter a name (e.g. National Wetlands Inventory).



Using data from public GIS servers

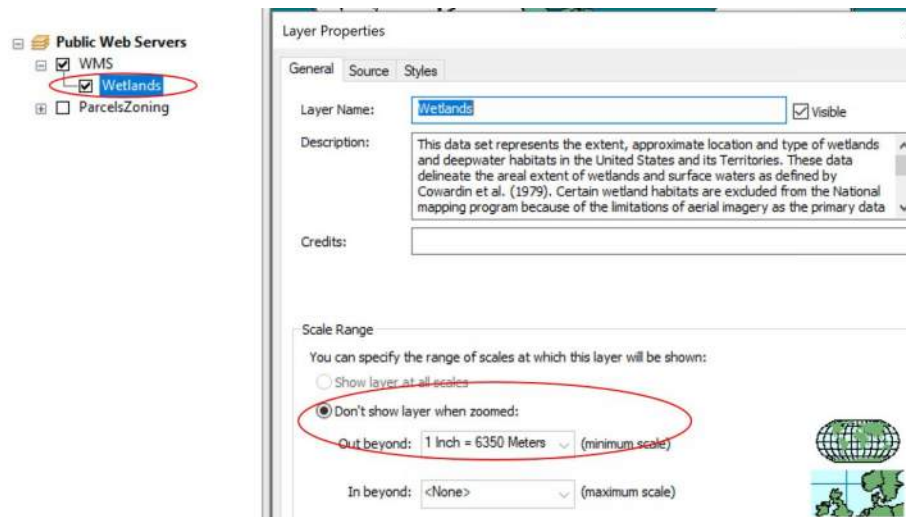
1. In ArcMap, click the Add Data button.
2. In the Add Data window:
 - a. Look in: click the drop down arrow and select GIS Servers
 - b. Double click on the Hawaii State GIS Web Service
 - c. Select a map service to add to the map (e.g. ParcelZoning)

- d. A Geographic Coordinate Systems Warning may pop up. This says that the coordinate system of the layer being added is different from the data frame. ArcMap will project or re-project the data on the fly to match the data frame so this warning can be ignored. Click OK to close the warning box.



4. Add the Wetlands layer from the National Wetlands Inventory WMS server.
 - a. Click Add Data button
 - b. Look in GIS Servers
 - c. Double click on National Wetlands Inventory Server and continue drilling down to wetlands layer
 - Double click Wetlands
 - Double click Layers
 - Double click Wetlands

Note: Some layers may have a map scale applied to them. For example, the wetlands layer has a set minimum scale beyond which the layer will not be displayed.

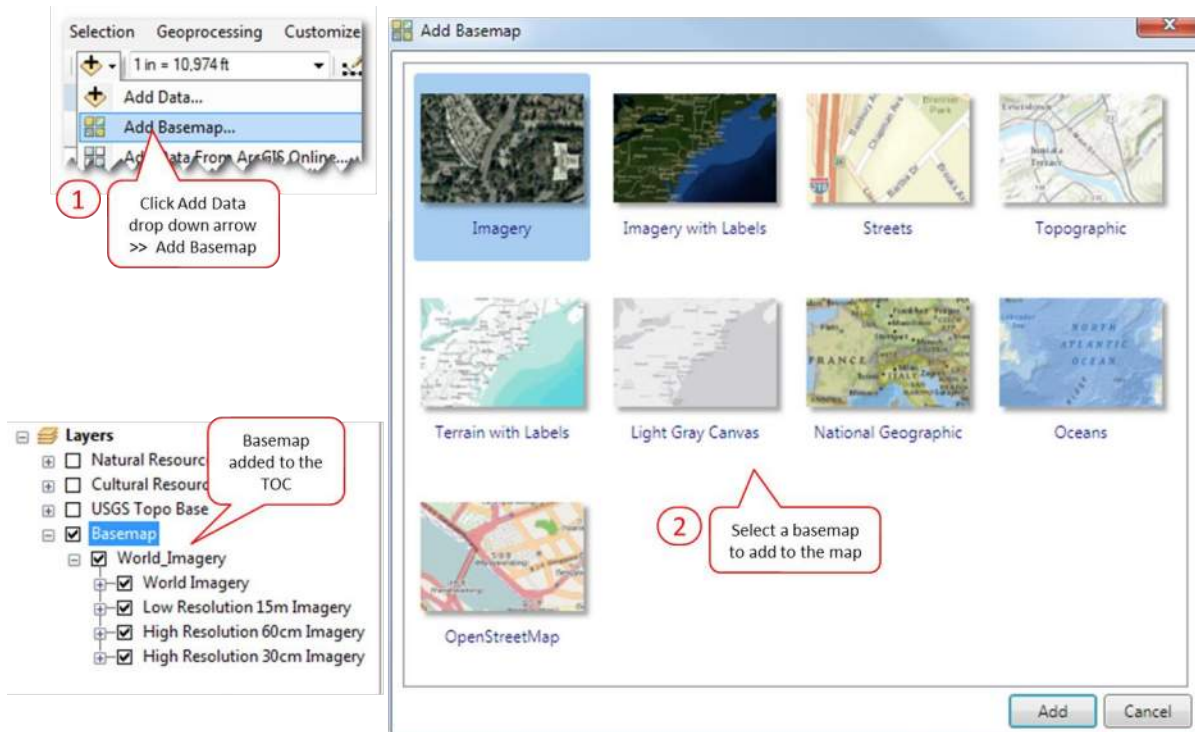


Sometimes you will see 2 different types of services (Map Service and Features Service) – most public GIS servers will only have map services available. Data that are available as Feature Services allow you direct access to individual features/objects within a data layer, and more control over how those features are display

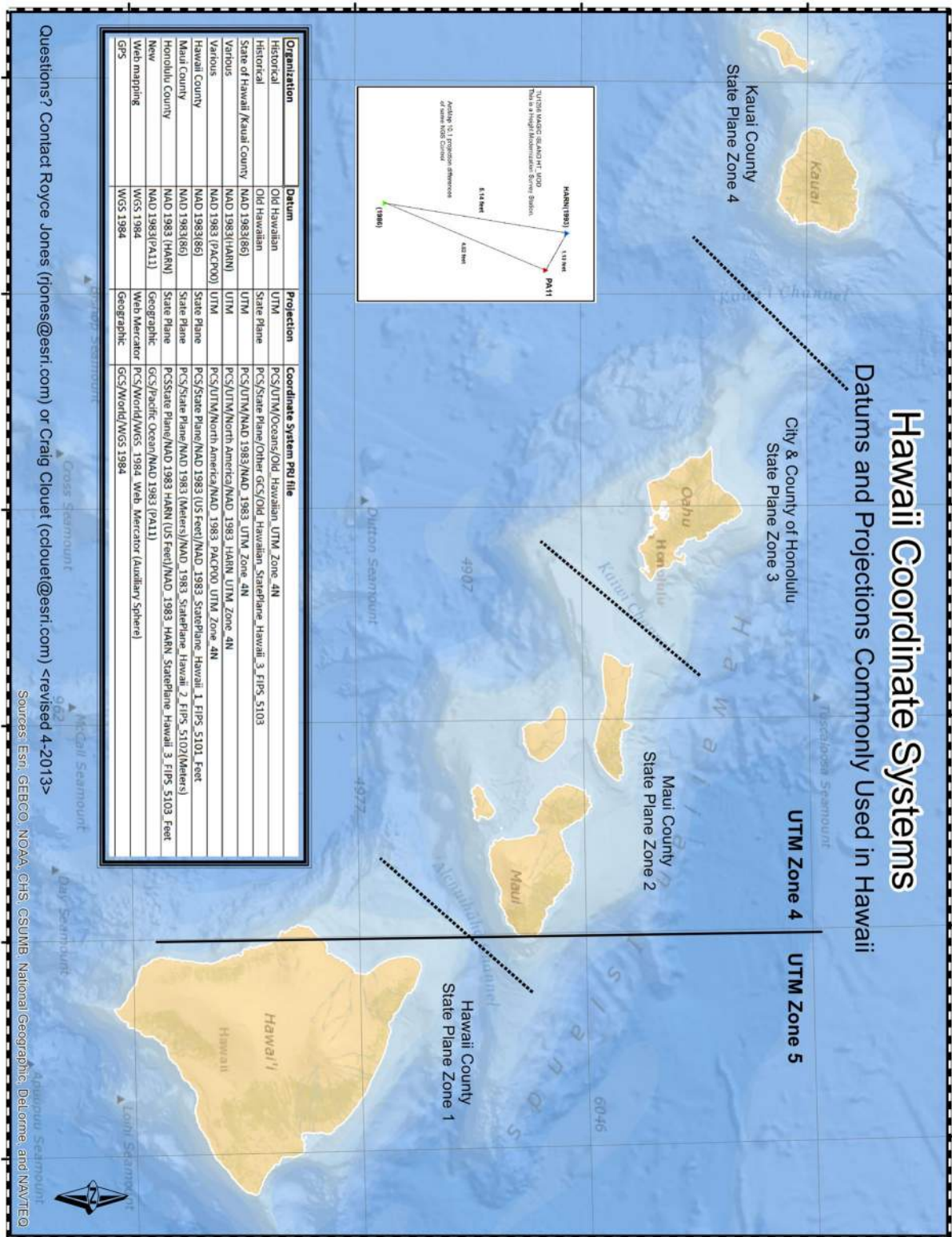
Exercise 10: Adding ESRI Online Basemaps

This exercise shows you how to add a basemap from the ESRI Online server. An internet connection is required.

1. To add a basemap from ESRI Online, click the Add Data drop down arrow > > Add Basemap.
2. In the Add Basemap window select a basemap then click Add button to add to the map (*e.g.* Imagery).



APPENDIX A – HAWAII COORDINATE SYSTEMS



APPENDIX B – ACCESSING HAWAII STATE GIS DATABASES AND WEB SERVICES

Information contained in Appendix B is provided by Hawaii Statewide GIS Program.