Improving Geologic Data through Aerial Photography in the ACE Basin

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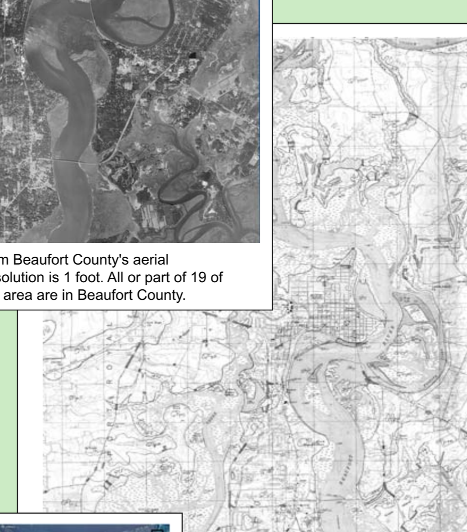
South Carolina Department of Natural Resources

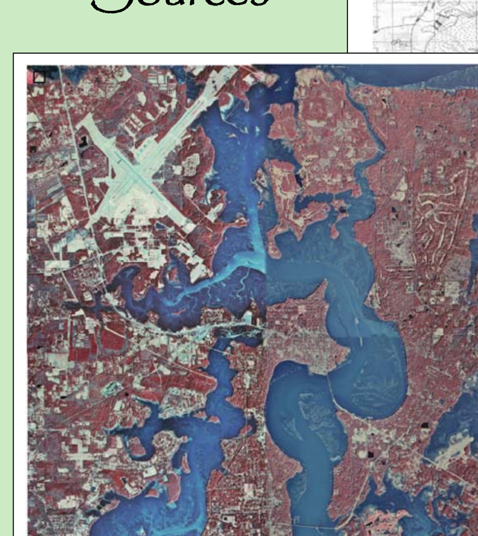
Geological Survey 1825

Data Sources

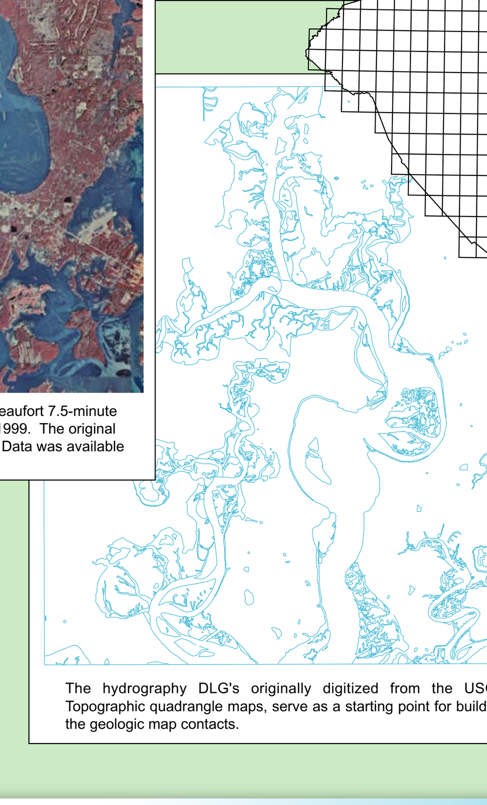
This is a sample quadrangle from Beaufort County's aerial photography from 2002. The resolution is 1 foot. All or part of 19 of the 23 quadrangles in this study area are in Beaufort County.



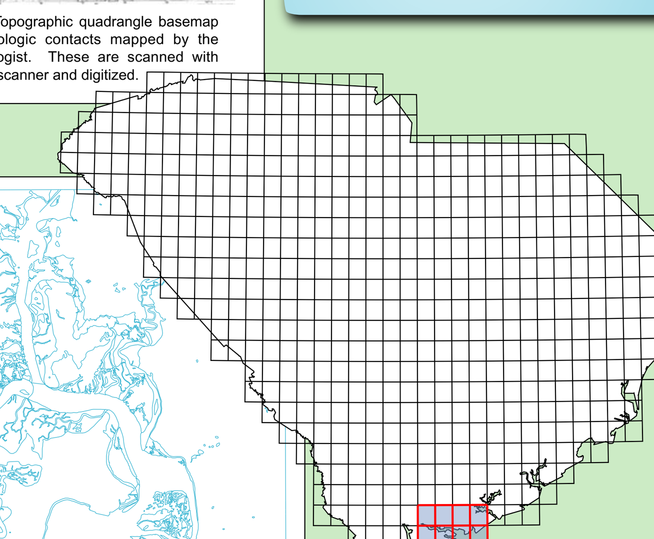
The USGS Topographic quadrangle basemap with the geologic contacts mapped by the project geologist. These are scanned with large format scanner and digitized.

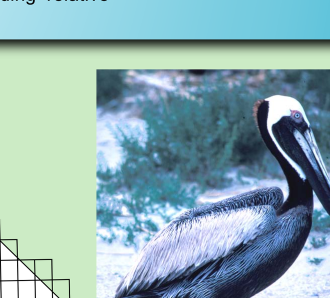


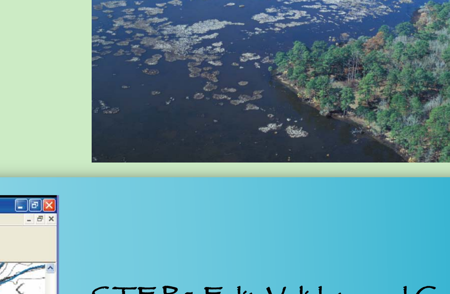
Digital Orthophoto Quarter Quadrangles of the Beaufort 7.5-minute quadrangle in Beaufort County, South Carolina, 1999. The original resolution is 1-meter but has been compressed. Data was available for all quadrangles in this study area.



The hydrography DLG's originally digitized from the USGS Topographic quadrangle maps, serve as a starting point for building the geologic map contacts.







Introduction

During a five-year period, the S. C. Geological Survey mapped 23 quadrangles in the Ashepoo-Combahee-Edisto River Basin and Hilton Head areas in South Carolina, funded by the USGS Statemap program. The ACE Basin is a rapidly changing coastal ecosystem at the convergence of these three rivers.

"Geology has a major part to play in coastal zone resource and hazard management. Understanding the physical environment of the coastal zone, in particular its geomorphological evolution, is essential for determining a strategy for land use and development that is both sustainable and sensitive to the rich wildlife of the ACE Basin. Geologic information also provides a long-term perspective on coastal zone issues. This perspective is important because it is largely unaffected by tidal or seasonal variability. Mapping provides information on tectonic processes that influence uplift or downwarp in the coastal zone. Such uplift or downwarp determines whether large estuaries will develop along any particular part of the coastline. Defining tectonic processes affecting the coastal zone also is important in understanding relative sea-level change. Sea levels have been rising since glacial ice began to retreat in the northern hemisphere 18,000 years ago. The location and age of depositional units within the coastal zone provide information on how the coastline developed. Integrating such information with offshore data will show how quickly the coastline has changed or can change during periods of rapid sea-level rise." [1]

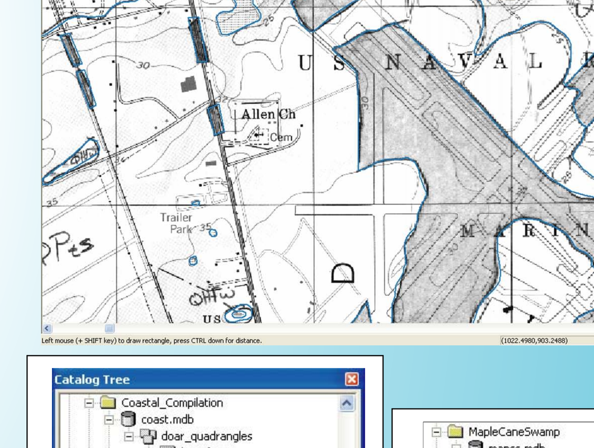
A basic tool of coastal mapping is to work with accurate base maps to help delineate geomorphic features throughout an area. While developing digital maps the Geological Survey realized that the USGS Topographic quadrangles, originally used by field geologists to delineate geologic contacts, were outdated. In some cases they were more than forty years old. The dynamic nature of this coastal environment and the availability of current aerial imagery led to the conclusion that a much better geologic data set of the area could be created.

1. Geology of the ACE Basin Area, Beaufort, Charleston, and Colleton, Counties, South Carolina, SCGS OFP-150, 2004

Procedure

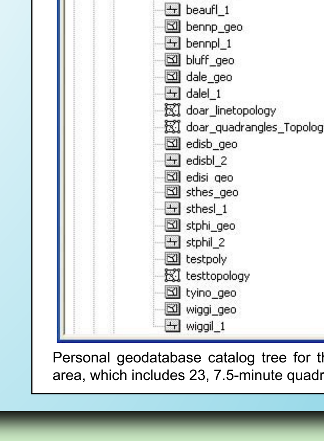
STEP 1 The Initial Digitization

The geologist's field maps are drawn on a 7.5-minute topographic base. Finished maps are scanned at 200-300 dpi depending on the complexity of the map, and saved as a TIFF image. The TIFF is then opened in R2V and control points are selected. Most often the four corners of a 7.5-minute quadrangle are suitable control points. The hydrography DLG is imported into the project, the geology contact lines are digitized, and these two are edited together. A line shapefile of the combination is exported. The bounding edge of the quadrangle is not included in the editing procedure in R2V, because the quadrangle border can inadvertently be pulled or snapped away from its correct position. The quadrangle boundary is merged with the geologic contact line file in ArcMap using the Geoprocessing tool. The result is a new complete line shapefile.

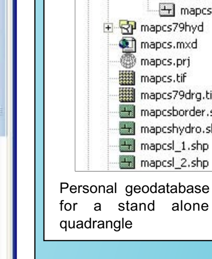


STEP 2 Creating a Geodatabase

In ArcCatalog, a personal geodatabase is set-up for the mapping area. A feature data set is created by importing the digitized polyline shapefiles as feature classes. Topology rules are assigned in order to validate the topology of the new line feature classes. Examples of line rules include: must not overlap, must not intersect, and must not have dangles. A first pass validation of these topology rules is performed in order to edit all the geology and hydrography lines that intersect the quadrangle boundary and snap them accordingly.



Personal geodatabase catalog tree for the study area, which includes 23, 7.5-minute quadrangles



Personal geodatabase catalog tree for a stand alone 7.5-minute quadrangle

STEP 3 Edit, Validate, and Code Lines

In ArcMap, the entire quadrangle is edited to ensure that all of the topology rules for lines are followed. After the lines are validated, they are coded for type and position. In lower coastal plain maps, the lines are coded as geology contacts or water boundaries. In the Piedmont or upper coastal plain of South Carolina the line coding process is more involved.

In most map projects, once the lines are coded, a new empty polygon feature class is brought in and features are constructed using the topology toolbar, which builds the polygon file.

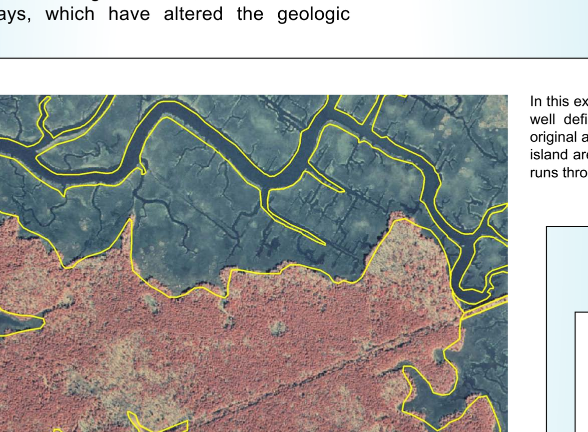
At this point, the accuracy and precision of geologic contacts needs to be evaluated. Because the coastal environment is constantly changing and the topographic base maps are typically 20 to 30-years old there are significant changes to the basemap that affect contact line accuracy. These changes can be natural or man-made. Natural changes are common on the active beach front by the addition and subtraction of deposits. Man-made changes are brought about by the intense development this area has experienced over the last 20 years. According to a recent U.S. Census Bureau report, Beaufort County had an estimated population growth rate of 11.2% for the years 2000-2004. The state average for the same period was around 4.3%.

During the ACE Basin project, available aerial photography was used to improve the accuracy of the geologic information delineated by the geologist on field maps.

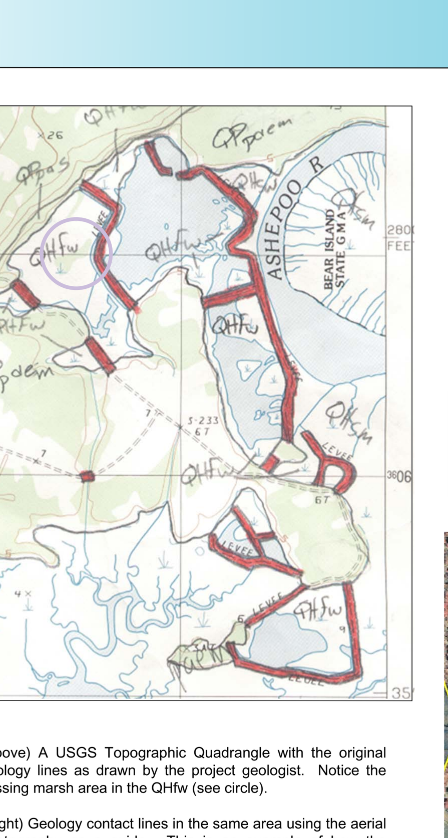
STEP 4 Editing the Geology

Interpretation of aerial photos was used to more precisely delimit geological features in the study area. Photos were loaded into the ArcMap project, and edits were made using the editing, snapping, and topology tools based on interpretations. The precision and smoothness of lines were corrected up to a scale of 1:5000. Items most often corrected included: moved earth or artificial fill; water bodies; islands, and salt-marsh features. This area has a large amount of new development, such as golf courses, residential areas, and roadways, which have altered the geologic landscape, since the most recent topographic map was printed. In fact, the most recent air photos (2-3 years old) can be out-of-date in some places.

Edge matching adjacent quadrangles was also a priority. Usually the editing process was done by the cartographer. When the geologic contacts were not clear, a marker was placed, and the geologist would carefully review and describe the proper edits for edge matching. The examples shown are common types of edits that were made.

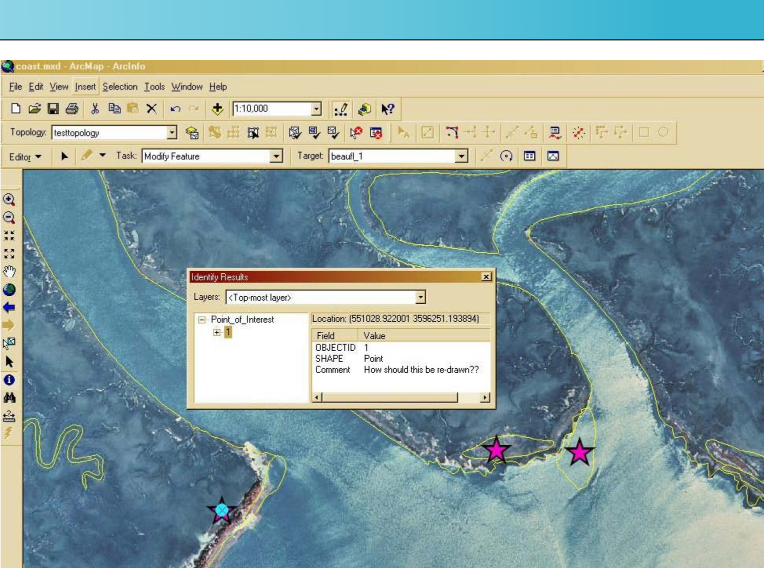


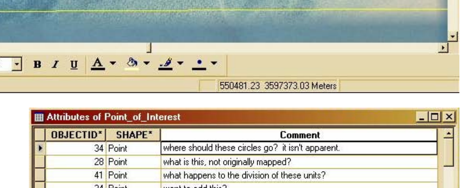
In this example, the original shape of the island was not very well defined on the USGS Topographic quadrangle. The original area of the island measured 1.64 km^2. The redefined island area now measures 1.69 km^2. The linear feature that runs through the middle is an old railroad grade.



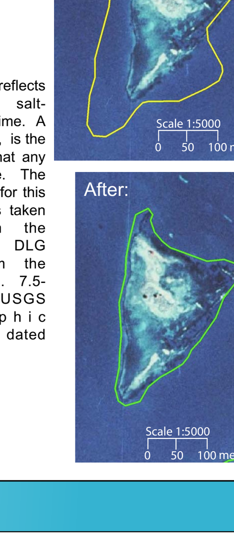
(Above) A USGS Topographic Quadrangle with the original geology lines as drawn by the project geologist. Notice the missing marsh area in the QHfw (see circle).

(Right) Geology contact lines in the same area using the aerial photography as a guide. This is an example of how the moved earth feature can be vastly improved using a DOQQ base. Digitizing from the DOQQ, the digitizer is able to call attention to possible errors or omissions. The geologist is also able to evaluate these changes for significance and accuracy. In this particular example, the inlier is know to be within the Princess Anne sequence, but remains undetermined.

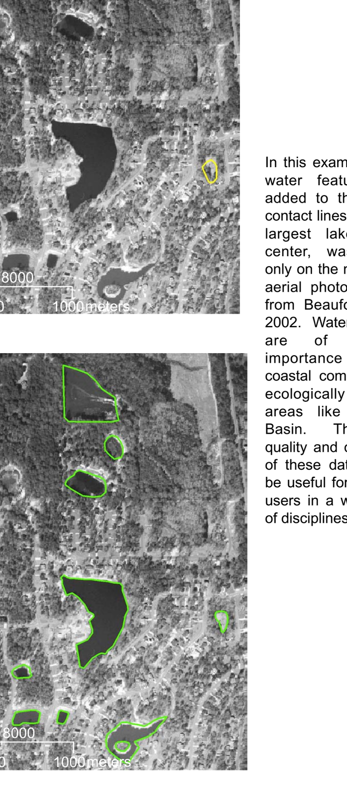




In some areas the original geologic contacts may not be edge-matched across quadrangles. In other locations contacts might be positioned incorrectly and/or cannot be determined by aerial photos.
A point shapefile was created to call attention to any areas which need specific attention from the geologist. Each point has a text field with a comment or question for the geologist.

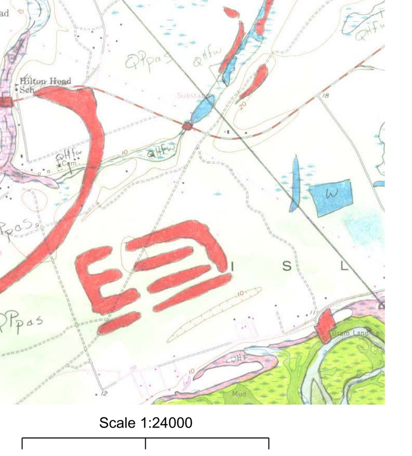


This example reflects a change in salt-marshes over time. A scale of 1:5000, is the largest scale that any edits are made. The original outline for this salt-marsh was taken directly from the hydrography DLG digitized from the Beaufort, S.C. 7.5-minute USGS Topographic Quadrangle dated 1979.



In this example, many water features were added to the geology contact lines layer. The largest lake, in the center, was present only on the most recent aerial photo available, from Beaufort County, 2002. Water resources are of particular importance to the coastal communities in ecologically sensitive areas like the ACE Basin. The level of quality and currentness of these data sets will be useful for many end users in a wide variety of disciplines.

Figure A.



Scale 1:24000

0 1000 2000 meters

Figure B.

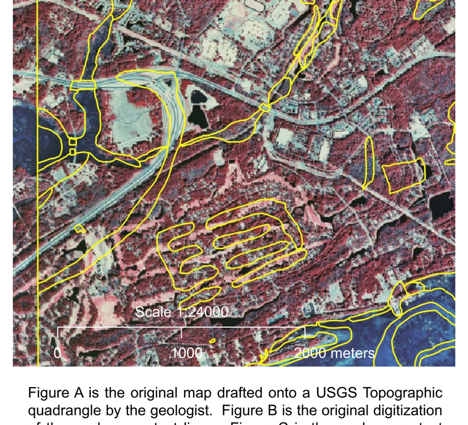


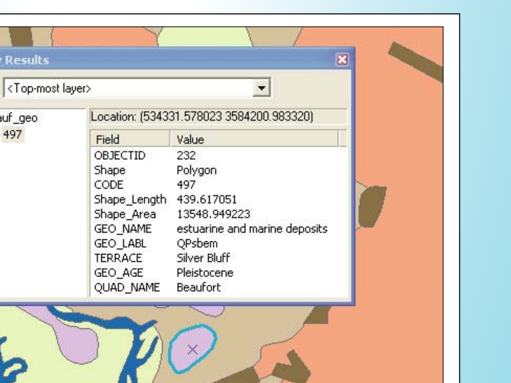
Figure C.

Figure A is the original map drafted onto a USGS Topographic quadrangle by the geologist. Figure B is the original digitization of the geology contact lines. Figure C is the geology contact lines after corrections were made using available aerial photography. In this example, dramatic changes were made to a large area of moved earth created by a road interchange on Hilton Head Island.

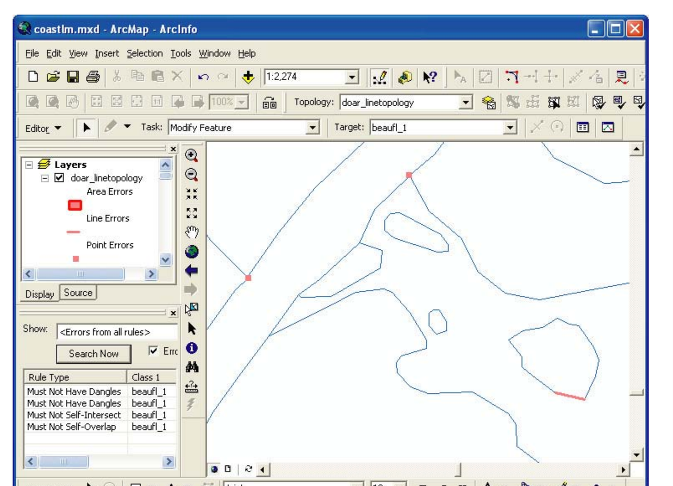
In addition, locations of water bodies and golf coarse fairways (moved earth) were significantly altered. All of the digitizing and aerial photography interpretation was done by a cartographer and later reviewed and accepted by the project geologist.

STEP 5 Final Validation and Coding Polygons

After all corrections are made to each quadrangle, a final validation is performed. At this point, an empty polygon feature class is brought in, all lines in the quadrangle are selected, and polygon features are constructed using the topology toolbar. Then the polygons are coded and attributes are assigned. In the ACE Basin and Hilton Head areas there are 40 geologic units across 7 terraces.



The polygon feature class is coded and attributed in the geodatabase.



The topology rules are being validated for the geology line file.

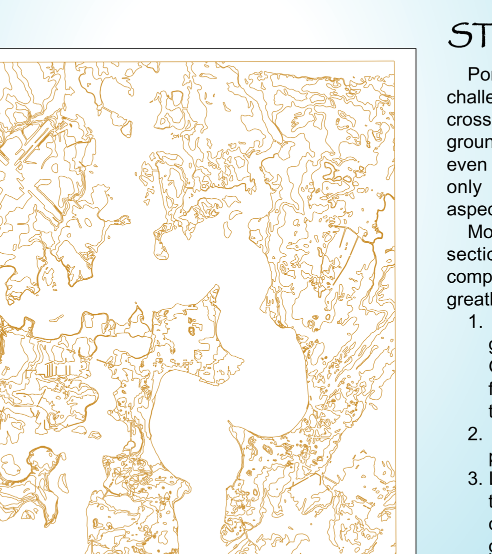
STEP 6 Creating Cross-sections

Portraying accurate digital cross sections has been a challenge for the digital mapping group. Often the final cross sections do not accurately match the map units or ground distances. Additional hours of corrections or even construction of a new cross section was often the only answer. Accordingly, we have adjusted some aspects of the process.

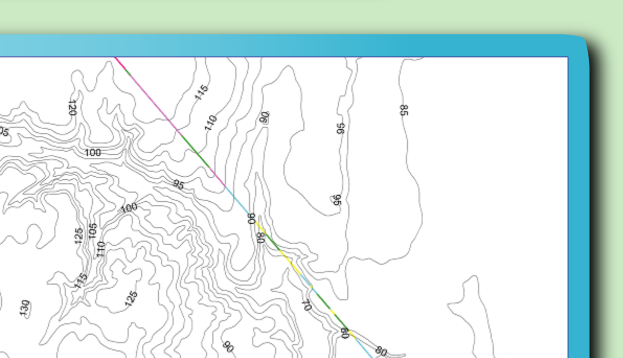
Most importantly, the construction of a digital cross section is delayed until the digital map layers are completely edited. Using the following procedure has greatly reduced errors.

1. Intersect the cross-section line with the final geologic map polygon layer using ArcMap - Geoprocessing Wizard (choose to keep attributes from polygon layer). Symbolize the new line with the value field for map units.
2. Import DLG hypsography (contour) data into the project and overlay the new cross-section line.
3. Label the contour elevations and plot the results at the horizontal scale that the cross-section will be drawn. The geologist then uses the plot as a guide under the graph paper when drawing the cross section.
4. Digitize, build, and code the resulting cross section.

We have found that distance errors and missed map units were greatly reduced when cross-sections were produced by this method.



Beaufort 7.5-minute quadrangle hypsography DLG contours are used to build cross sections.

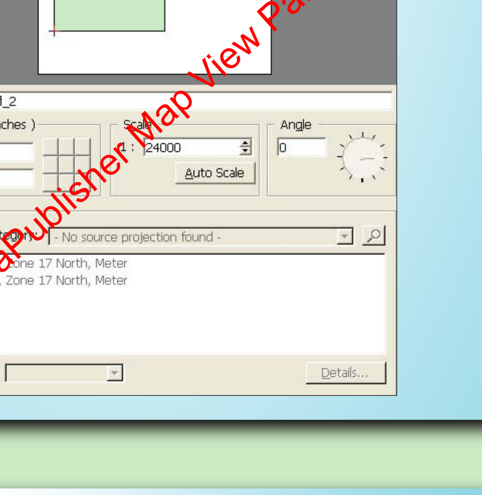


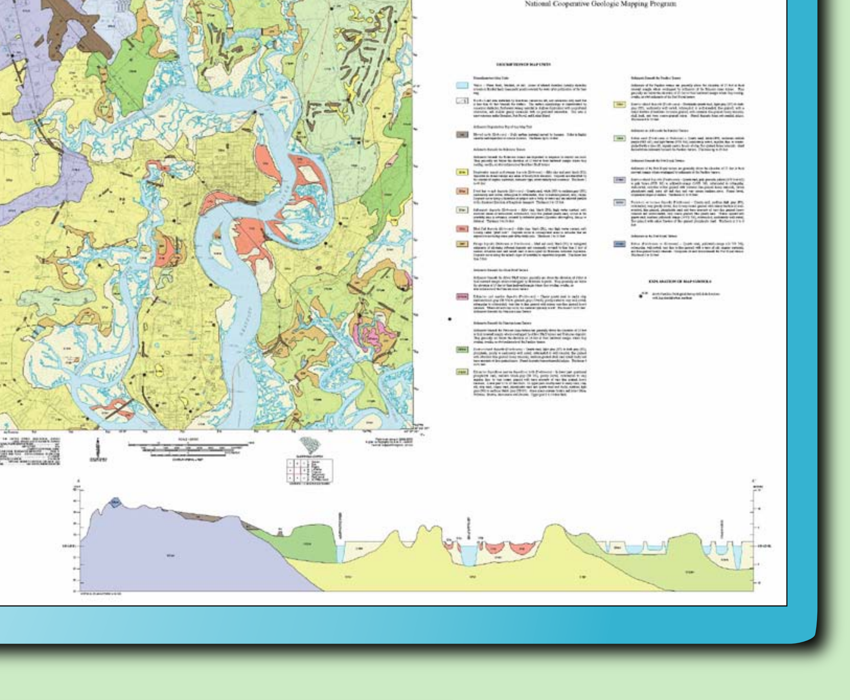
Quad	County	Field	Collar	Depth (ft)	EASTING	NORTHING	Data	Driller	Logger
Beaufort	7 - 290	Bf 6	12	70	3582514.511350	528370.922190	4/7/2003	Joe Koch	W.R.Doar
Beaufort	7 - 291	Bf 7	15	43	3582350.817290	529270.670220	4/7/2003	Joe Koch	W.R.Doar
Beaufort	7 - 292	Bf 11	16	50	3586880.251120	532917.904290	4/8/2003	Joe Koch	W.R.Doar
Beaufort	7 - 293	Bf 12	20	69	3587418.062650	533313.850280	4/8/2003	Joe Koch	W.R.Doar
Beaufort	7 - 294	Bf 15	21	38	3592855.828230	534803.085410	4/8/2003	Joe Koch	W.R.Doar
Beaufort	7 - 295	Bf 16	21	60	3593694.753370	533770.347910	4/8/2003	Joe Koch	W.R.Doar
Beaufort	7 - 297	Bf	12	50	3582151.338000	526485.855900	4/9/2003	Joe Koch	W.R.Doar
Beaufort	7 - 298	Bf 27	5	50	3585649.126340	535004.866680	4/9/2003	Joe Koch	W.R.Doar
Beaufort	7 - 299	Bf 13	18	44	3590300.801940	534497.070550	4/9/2003	Joe Koch	W.R.Doar
Beaufort	7 - 300	Bf 27	7	34.5	3590426.869920	531008.572520	4/9/2003	Joe Koch	W.R.Doar
Beaufort	7 - 301	Bf 9	15	50	3587495.078780	528826.029620	4/9/2003	Joe Koch	W.R.Doar

Drill hole data is converted directly from a DBF file into a point shapefile. Some point data has to be digitized into a point feature class in the geodatabase.

STEP 7 Final Cartography

Final cartography is accomplished using Adobe Illustrator 10 with Avenza's MAPublisher 6 plug-in. The plug-in supports the import of geographically referenced data into a graphics environment. An import tool along with style sheets and symbol sets allows us to update map products easily. Templates are used for most of the non-map features of the layout, saving more time.





Future Plans

The S.C. Geological Survey, upon completion of this digital compilation and metadata, intends to release the geology layers on the S.C. Department of Natural Resources, GIS Clearinghouse. Geographic data on the Clearinghouse is organized in 7.5-minute quadrangles. This 23-quadrangle compilation represents the first set of digital data layers made available by the S. C. Geological Survey.

Acknowledgements

W. R. Doar, III (SCGS geologist) mapped the ACE Basin and Hilton Head areas, assisted by drillers Joe Koch and Gary Taylor. Malynn Drescher assisted with the poster design.

Software

R2V 5.5 for Windows, Able Software; ArcGIS 8, ESRI; Adobe Illustrator 10.0.3; MAPublisher 6.1, Avenza

Hardware

Computer: Gateway Pentium 4 CPU 2.60 GHz, 1.0 GB of RAM
Microsoft Windows XP Professional
Scanner: Eagle SLI 3840 Plus
Plotter: HP Designjet 800ps 42 in plotter

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SCDNR Geological Survey Digital Geologic Mapping