IMPROVING 3D SPATIAL VISUALIZATION OF STREAM CHANNEL MORPHOLOGY: A GEOMORPHIC APPLICATION OF ARCVIEW 3D ANALYST EXTENSION:

GREEN MOUNTAIN COLLEGE

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BACKGROUND

Spatial visualization is an essential skill for students to acquire to be successful in future geologic endeavors. The ability to create and manipulate mental "pictures" of geologic systems and structures is not an inherent skill that many students possess when they begin upper-level coursework. Previous research on spatial visualization evaluates the relationship between spatial ability and academic instruction (Shepard and Metzler, 1971; Burnett and Lane, 1980; Eley, 1993; and Schofield and Kirby, 1994). These studies suggest that continued exposure and application of spatial skills leads to improved spatial ability. In response to these studies, a number of tools that incorporate spatial visualization techniques have been developed to help instructors challenge and instruct students (Frodeman, 1996; Kali and Orion, 1997; Orion et al., 1997; Orion et al., 2000; Gerson et al., 2001; and Kali, 2002). However, few learning tools are available that specifically target spatial skills relating to geomorphology and terrain analysis.

The ability to predict future landform morphology and landscape response to changing climate, vegetation, and anthropogenic activities relies heavily on a students ability to visualize landforms in 3-dimensions. Traditional geomorphology and hydrology exercises require students to plot stream channels, either by hand or using a graphing program. To facilitate both an understanding of stream channel characteristics and help students strengthen their spatial visualization abilities, this exercise bridges the gap between data collection, manipulation (both 2D and 3D), and prediction.

The exercise is carried out along the Poultney River on the campus of Green Mountain College located in west-central Vermont (Figure 1). The close proximity of the river allows each student to construct their own stream profile and develop a sense of "ownership" of the data, and are therefore more vested in evaluating the effects on "their" profile.

METHODOLOGY

This two-week laboratory exercise incorporates traditional field based stream surveying with computer based GIS visualization of the survey data. Audet and Abegg (1996) discuss the merits of GIS in problem-based learning. Students spend one laboratory session collecting topographic data along stream channel cross-sections (Figure 2). They are asked to construct 2-dimensional cross sections in Microsoft Excel and presented with simple hypotheses to evaluate between laboratory sessions. However it is still often difficult for them to visualize stream morphology in 3-dimensional space. Therefore, during the second laboratory session they create and manipulate 3-dimensional models of the stream channel using their survey data. Finally, they are presented with the same hypotheses and asked to re-evaluate their findings.

Figure 2: Two students taking survey measurements on the Poultney River located on the grounds of Green Mountain College.

Figure 1: Location of Green Mountain College and a satellite photo of the campus and surrounding Poultney area.

LEARNING GOALS

The learning goals of this exercise include:

(1) collecting survey data using a total station
(2) constructing cross-sections using a graphing program
(3) a basic understanding of a geographic information system GIS
(4) developing an understanding of geomorphic responses to urbanization and associated changes in stream velocity, discharge, and morphometry.

2D DATA VISUALIZATION

Students are asked to construct stream profiles from survey data (Table 1) using traditional graphing techniques (graph paper) and Microsoft Excel. Both stream channel morphology and water levels are recorded and plotted for each site (Figures 3 and 4). In order to create 3D models, the y-increment must be arbitrarily assigned.

Point	Measured H_2O Level	X-increment	Y-increment	Height	H_2O Height
1	0	0	1	98.9	0
2	0	0.5	1	99.17	0
3	0	1	1	99.08	0
4	0.38	1.5	1	97.56	97.94
5	0.43	2	1	97.47	97.90

Table 1: Sample survey data collected in the field.

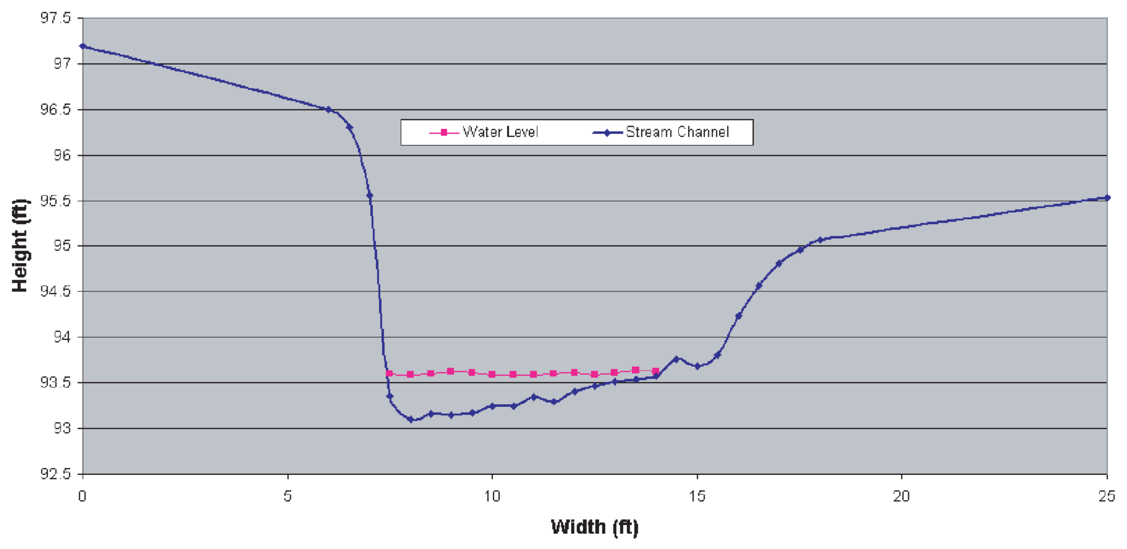

Figure 3: Characteristic stream morphology plot illustrating both stream topography and water level at site A.

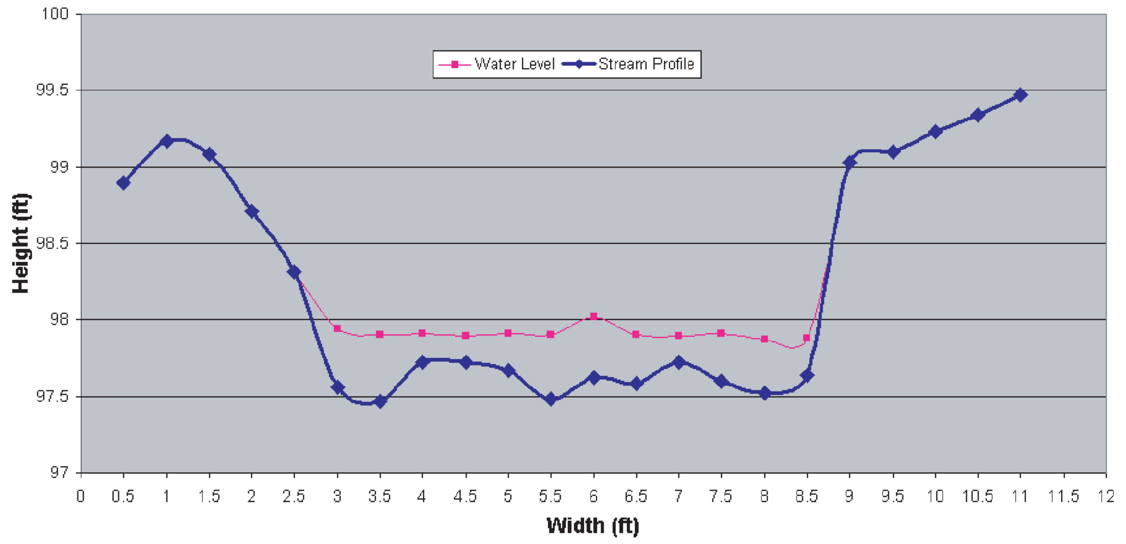

Figure 4: Characteristic stream morphology plot illustrating both stream topography and water level at site B.

3D DATA VISUALIZATION

Students are then asked to export data tables that can be imported into ArcView. For those students unfamiliar with ArcView explicit instructions are provided to facilitate the process. The raw data isn't very useful for visualizing the cross-section morphology (Figure 5). So triangular-integrated-networks are interpolated from this data (Figure 6), which inherently represent topography and allow for easy visualization using the 3D scene viewer provided with the 3D Analyst.

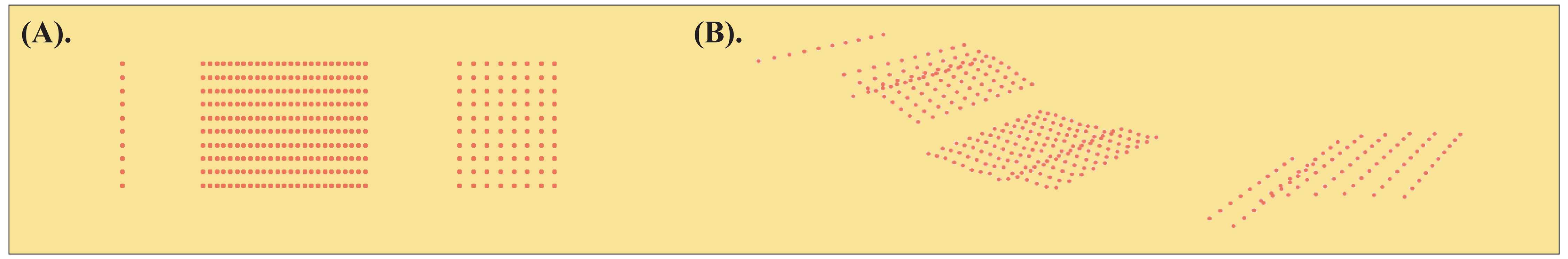

Figure 5: Intermediate data visualization of stream survey data. (a) 2D representation of point data over the surface of the stream channel and (b) a 3D representation of the same point data extruded by the underlying elevation values in the TIN surface. Although 3D, this representation of the stream channel is still difficult for students to visualize.

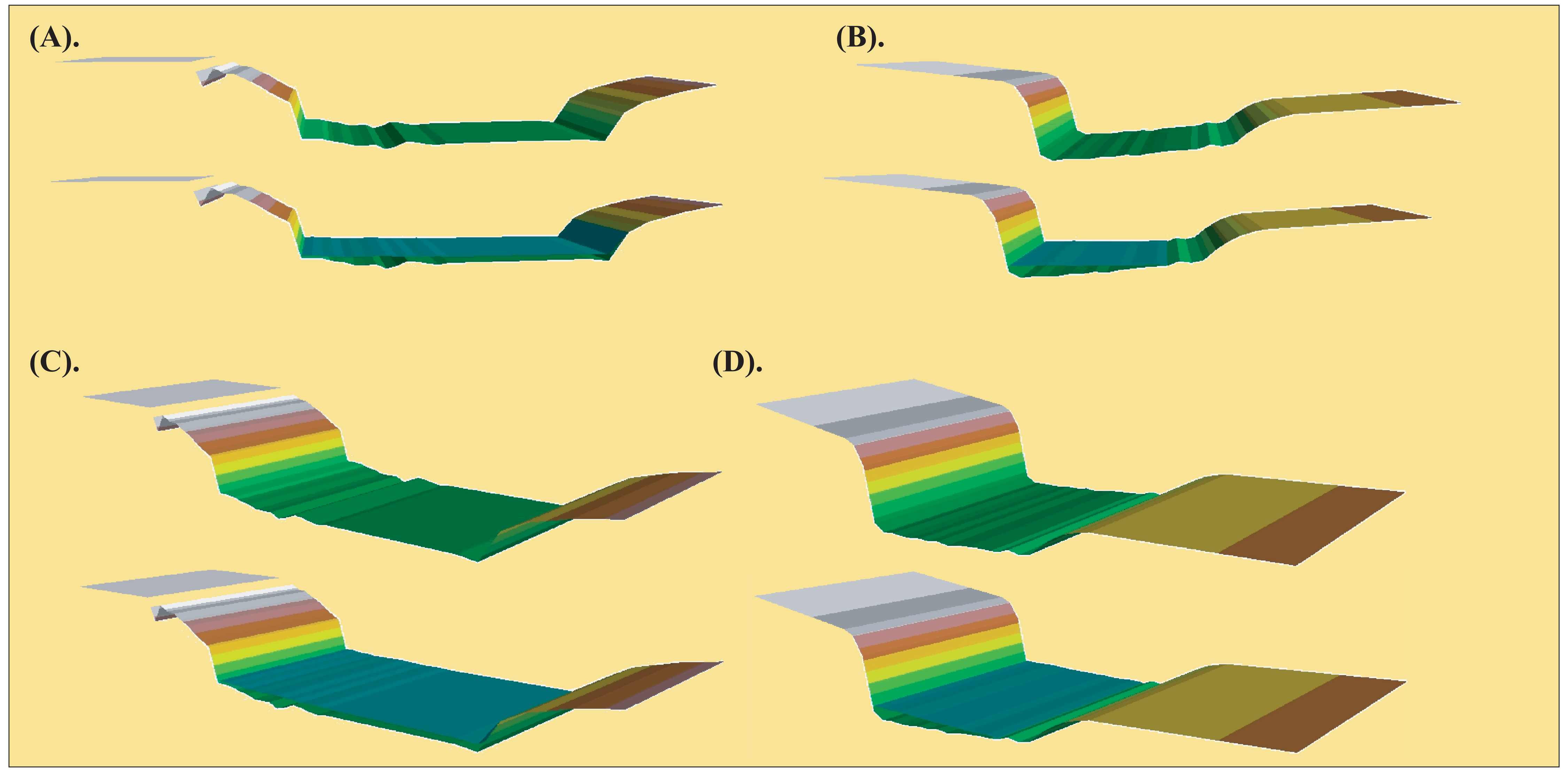

Figure 6: TIN surfaces created from survey data. (a) 3D profile of site B without water, (b) 3D profile of site A with water, (c) 3D profile of site A without water, (d) 3D profile of site A with water, (e) oblique 3D surface of site B, and (d) oblique 3D surface of site A.

ASSESSMENT

Once students have constructed cross-sections in Excel, they are asked to predict (and sketch) the morphology of the stream channel after:

(1) Urbanization
(2) Declining base level
(3) Disturbance of vegetation along the banks

A similar exercise is conducted once they have constructed 3D surfaces in ArcView and can rotate and manipulate the data.

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