VISUALIZING ENVIRONMENTAL HAZARD THROUGH INTERACTIVE AND ANIMATED CARTOGRAPHIC TECHNIQUES[1]

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ABSTRACT

The growing vulnerability to environmental hazards and the increasing magnitude of socioeconomic impacts in relation to disasters have resulted in numerous research efforts to assess and manage hazards. To what degree that visualization and cartography can contribute to this assessment is an important but neglected area. This study has the purpose of exploring the feasibility and applicability of interactive and animated cartographic techniques for visualizing environmental hazard with the Great 1993 Mississippi Flooding as a case study. The 1993 Mississippi Flood is notably remembered as the most destructive flood ever recorded in the United States, in which 150 primary and secondary levees failed, 12 billion dollars in damages, 48 deaths, and 9 states involved. The data used in this study include satellite images, thematic maps, photos, statistic tables, and relevant text-format literatures. Three types of data processing techniques were performed in consideration of data quality and nature: image enhancement, map editing and refinement, and image morphing using linear interpolation technique. Then, all the images, maps, and photos were imported as case members into a full-featured animation software package. The subsequent administrative operations, frame editing, and effects editing were performed to generate the final animation product. The adding of interactivity was realized through a script programming. The final product is organized into four sections: (1) introduction of the Mississippi River and the floods dated as early as in 1844; (2) description of the 1993 flood with a virtual trip to the flooded area; (3) simulation of the St. Louis flooding development with a series of morphed satellite images; and (4) impacts as represented in a series of thematic maps showing different categories of damages. The study demonstrates that interactive and animated cartographic techniques are quite effective for visualizing environmental hazards, which should be a valuable asset for hazard assessment and management.

INTRODUCTION

The adverse impact of natural hazards to global environment has been intensifying over the past decades (Verstappen, 1997). The environmental hazards that have been sources of disasters range from floods, earthquakes, and landslides to coastal storms, wildfire, and volcano eruptions. Because of a number of factors such as population growth and technological developments, the risk of environmental hazards has been increased during recent years, along with the frequency and magnitude of disasters. Such growing vulnerability to environmental hazards and the increasing magnitude of their socioeconomic

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impacts have resulted in numerous research efforts to assess and manage hazards. Central to these research efforts is the role of geographic information technologies (Emani, 1996).

Cartographers have long-time tradition studying environment and hazards mainly through the production of static maps. In recent years, animation and interactivity as two core areas in scientific visualization have witnessed a rapid development and have been applied into such diversifying fields as presentation, kiosks, advertising, games, information retrieval, training, and education (Vaughan and Vanghan, 1996). Those innovative technologies have also demonstrated a great potential in freely mapping from the expediency of static images and fully engaging cartographic treatments of geography and environmental sciences (Peterson, 1993 and 1995; Torguson, 1993). However, in contrast to other core geographic information technologies such as remote sensing and GIS, which have proven their usefulness in hazard assessment and management, the role of cartography and visualization in such research and practices has not been fully revealed. To bridge this gap, the current study has the objective of exploring the feasibility and applicability of interactive and animated cartographic techniques for visualizing environmental hazards with the Great 1993 Mississippi Flooding as a case study. The 1993 Mississippi Flood is notably remembered as the most destructive flood ever recorded in the United States, in which 150 primary and secondary levees failed, 12 billion dollars in damages, 48 deaths, and 9 states involved.

METHODOLOGY

To address the research objective, a digital "textbook" illustrating the great 1993 Mississippi flooding has been produced. Four sections were initially designed for this virtual "textbook: 1) introduction of the Mississippi River and the floods dated as early as in 1844; 2) description of the 1993 flood with a virtual trip to the flood area; 3) simulation of the St. Louis flood area with a series of morphed images; and 4) impacts as represented in a series of thematic maps showing different categories of damages.

After this structural design, an animation tool was chosen to produce the above virtual textbook. Both temporal animation and non-temporal animation were attempted. The former depicts change through time while the latter shows change that is caused by factors other than time. The interaction, mainly attribute-type, was also incorporated with two-dimensional cast-based animation in this project. The project was carried out under a fully-featured animation environment provided by MacroMedia Director. The program integrates a combined graphics-editing, scripting, and audio environment. The program can create animated sequences and complete animated presentations that run by themselves or from internet browsers equipped with a MacroMedia plug, or distributed to be run on computers that do not have the Director program installed. The program integrates the stage window that contains what the viewer of the movie will eventually see, the cast members and the cast window for organizing and displaying case for all the components (graphics, sounds, text, etc.), the sprites and score window that controls the appearance of the Stage while a movie is playing and a powerful Lingo scripting language for adding any sort of interactive capability (Figure 1). In addition, this program also provides a Painting window for creating artwork from scratch or modifying imported artwork, and a control panel consisting of icons representing standard VCR controls and the ability to dynamically change the tempo and the background color of the screen.

The sprites and score window is the single most important window. Information regarding what set of sprites are on the Stage in any form of the movie is represented in this window. Figure 1 is a close look of the window. Multimedia materials can be effectively integrated with different channels of tempo, palette, transition, sound, and scripting, which are available in the score window.

Finally, a complete working procedure is designed and illustrated in Figure 2, which will be described in next section.

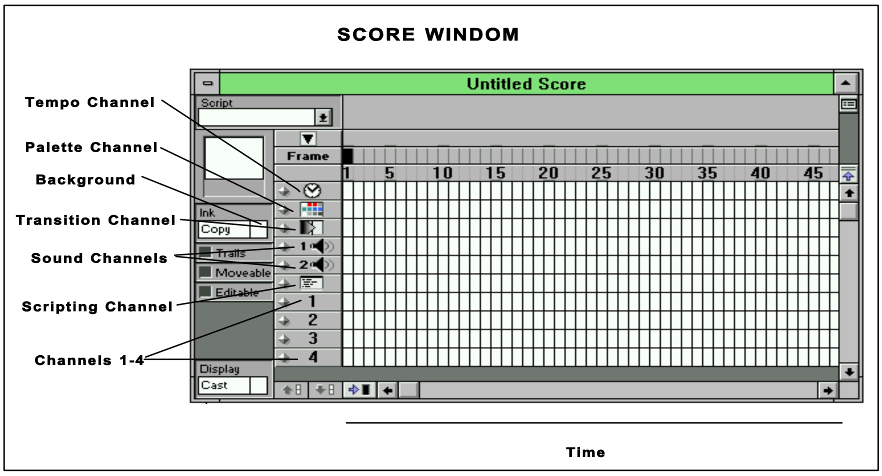

Figure 1 Sprites and score window from MacroMedia Director. The window is used to integrate multimedia material.

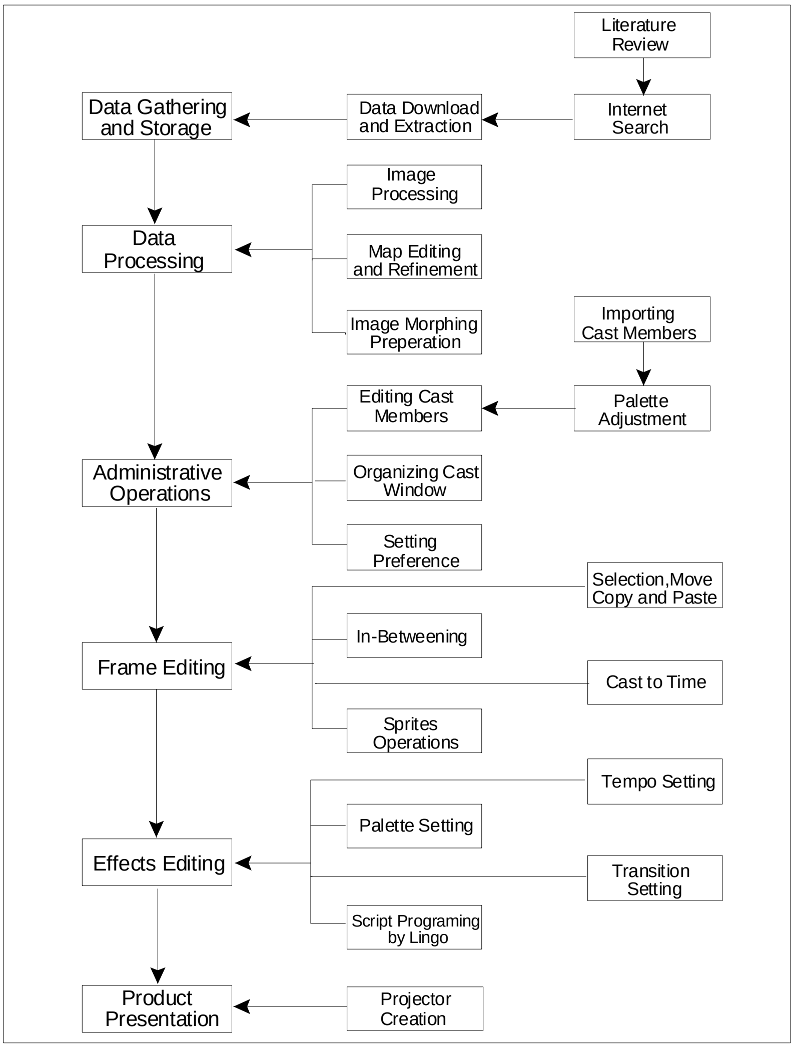

Figure 2 Flowchart of working procedural route.

MOVIE PRODUCTION

The movie was produced through the following steps (Figure 2).

Data Gathering and Storage

This work started from literature review, which served as the fundamental consideration for guiding and implementing the project. Two important facts were found from this review: 1) Aerospace technology has been actively applied in monitoring and evaluating the 1993 Mississippi River Flood developments (for example, Patrie et al. 1994 and Welker et al., 1994) and 2) A number of Web sites have been established for the Mississippi River including the 1993 Flood. A subsequent web search was carried out and a large amount of useful data in the format of image, graph, and text were downloaded from several web sites (see the references). The data downloaded from the

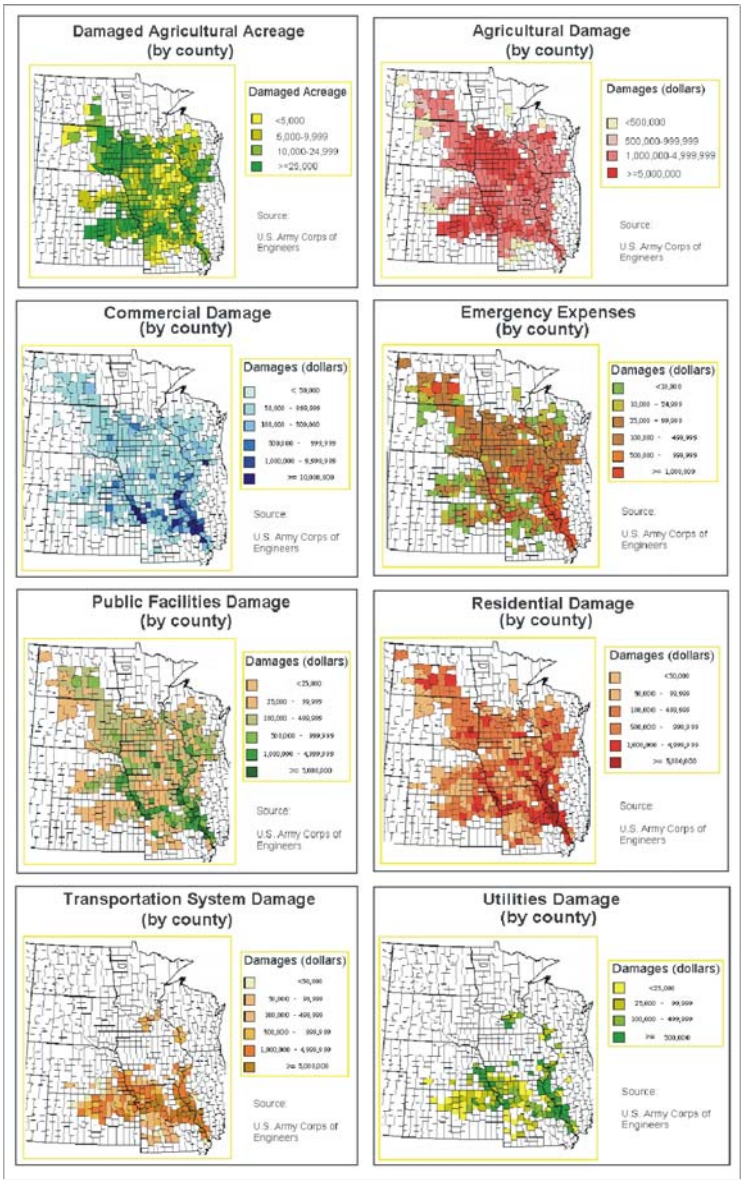

Figure 3 1993 Mississippi Flood damages (Source: U.S. Army Corps of Engineers, 1993).

Web must be processed before exporting into Director software package.

Data Processing

Three types of data processing were performed according to data quality and nature: image processing, map editing and refinement, and image morphing preparation.

Image processing was designed to process image data, particularly for satellite imagery and photo images. These photos or images vary in quality. A common problem is with the color component which otherwise degrades the usefulness of the photos/images as the cast candidates. This work was mainly performed with Corel PHOTO-PAINT by using several color commands under the effects menu:

- Brightness and contrast filter. It can be used to lighten/darken an image (brightness), or alters the distinction between light and dark areas (contrast). Intensity effects the brighter areas of an image by making them brighter or darker;
- Gamma filter. It can be used to enhance detail by adjusting middle grayscale values (mid tones). This will not effect shadow areas (darkest black areas), or highlight areas (lightest white areas);
- Hue and Saturation filter. It can be used to adjust Hue (a particular color) and Saturation (amount of that color) without effecting brightness.
- Tone map. It can be used to load or create gradation curves for image correction. The tone map can be edited by using the Curve Edit Style, the Freehand Edit Style, the Gamma Edit Style, or the Linear Edit Style.

Map editing and refinements was used to deal with graphic data downloaded from the Web. Since those graphs originally serve as various purposes, they must be edited and refined to optimize the visual effects. Generally, the map contents are maintained while the legend, the map title and subtitle, and the dimension of the map are subject to change in terms of its size (and font for text) and placement. The explanatory information represented in text format (such as the map makers, organization, etc.) has been substantially simplified. Map scale bar and north arrow are generally removed due to the space limitation (Figure 3).

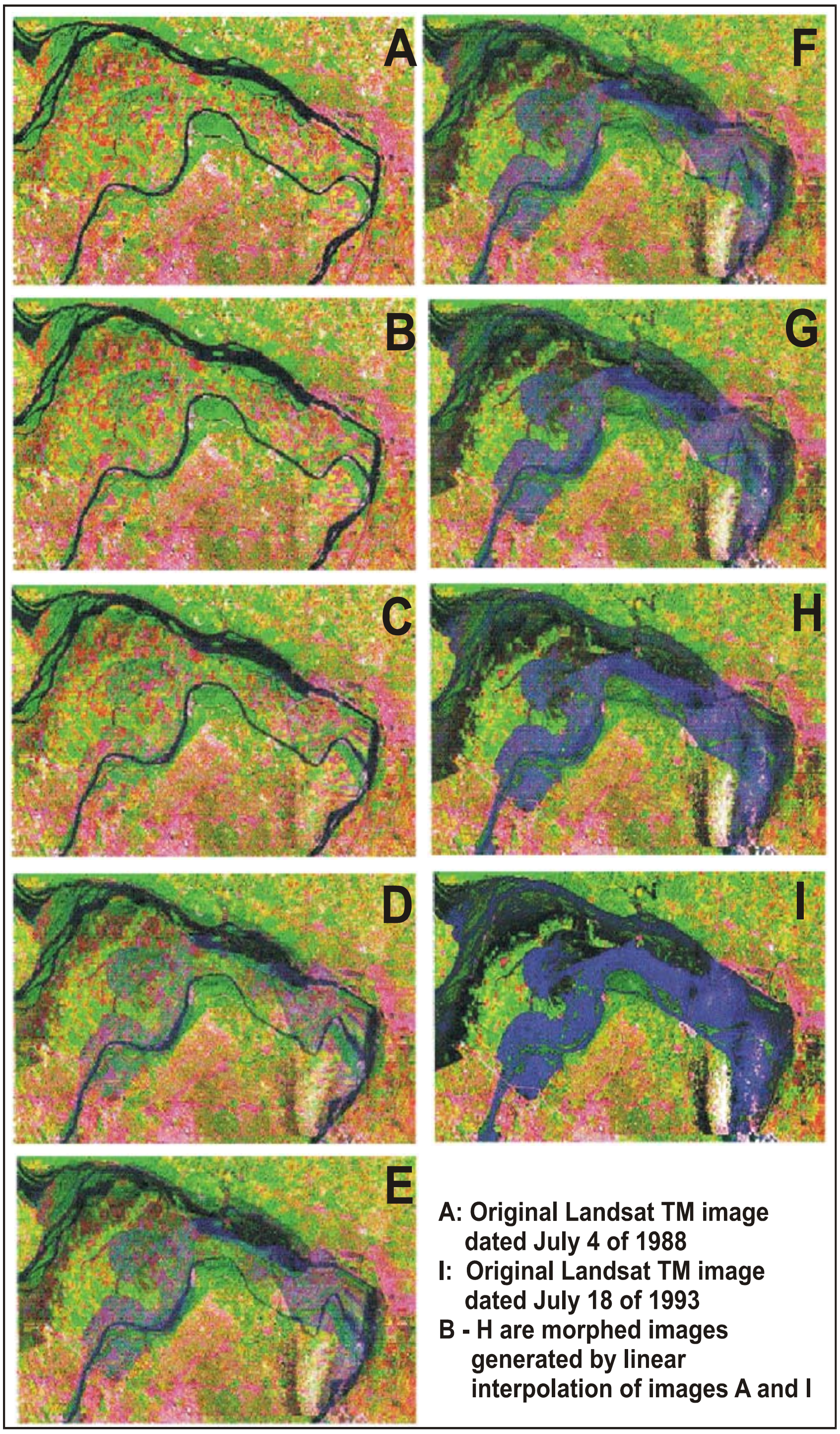

Figure 4 Morphed images used to simulate the Flood development.

Image morphing was performed by using CorelMOVE software package. One section in the project was to simulate the flood area at St. Louis, based on two satellite images acquired before flooding and during flooding. This work is actually a mini-animation A linear interpolation approach is employed by this package. Detailed explanation on the principal of linear interpolation is given elsewhere (e.g. Gomes, 1995). In CorelMove, choose Morph Cell from Effects menu of Paint Edit Window to create the illusion of a transformation between two existing cells in a multiple-cell actor. A two-step procedure has to be followed. Firstly, a number of matched pairs of control points were chosen from the two fields. They determine how the morphing will proceed. During the morphing, the intermediate image stages created will show changes in relation and with respect to these points. When the images are morphed, the point pairs are used to control the change from one form to another, taking color, size, shape and spatial location into account. The more points one, the greater will be the control one has over the way the morphing proceeds. In total about 200 points were chosen. After a set of morphing points were chosen, one has to specify the number of cells used to perform the morphing in the Cells to Create field. Seven intermediate images were generated (Figure 4). These images were further exported into Window bmp format.

Administrative Operations

Administrative operations are needed for logical organizations of a Director movie. They were performed under Director program. In the preference setting, one has to use the Preferences command (Control-Alt-U) to modify some of Director's default settings, including stage size, stage location, save settings, and other options. The stage size was set as 640X480. The Cast window is the most important tool for organizing the elements that make up a Director movie because it provides a visual interface for accessing all the various cast members in the movie.

Importing Cast Members: All the image and graph data were imported into the Cast Window while the palette associated with the casts must be remapped by color translation. These cast members can be selected, moved, duplicated, and sorted in the Cast Window if necessary.

Editing Cast Members: Both Open Script and Edit Cast Member were used to edit some selected cast members. Open Script is to open a Lingo Script window for the cast member. Edit Cast Member starts the suitable editing environment for a cast member, such as the Paint window to edit a bitmap cast member. Some new cast members, mainly in text format, were also created if necessary.

Organizing Cast Window: Since the cast is large (around 200), the cast members were named as much as possible, particularly for the graph and image member. The cast window was organized for facilitating locating of the members.

Frame Editing

Frame editing was the most important and most time-consuming activity in the animation production. Before that, a storybroad was created for creating a story. Then the frame editing was performed, which includes several useful techniques such as cast to time, in-betweening, frame-by-frame, etc. Selecting, copying, moving, and grouping are the most important sprite operations often used in the frame editing. Appropriate placement of the sprites on Stage is also very important, particularly for the bar-graph animation (as shown in the movies). In-betweening is the best method for animating sprites because it combines a high level of precision with high efficiency. It was frequently used to create a sequence of sprites as uniformly spaced positions along a straight-line path between a starting sprite and an ending sprite. Cast to Time animation technique is a way to create sprites on the Stage from a series of cast members. It has been used to create a section of animation for the morphing images generated from CorelMOVE (as shown in the movie). In addition, a number of markers were made for different sections of story.

Effects Editing

Effects editing were performed among three of the five effects channels: tempo, palette, and transition (see Figure 1). Tempo channel in combination with the Control Panel is used for setting the movie speed and timing. The tempo varied during different stages in the movie. There are no "thumb rules" for guiding the tempo setting. Experience seems to be vital. However, setting a tempo does not necessarily mean that the movie will actually play at the specific speed. It is subject to other factors such as processor speed and amount of memory. This is particularly true for the stage of "Extent" (see Flood in the movie). At that stage, the tempo was set as 29fps. The movie was designed for Pentium PC with at least 333 MHz CPU. Transitions were set at places where there is a significant change in the scene. They can be set on the transition dialog box under score menu (Figure 5). The transition takes place in the cell where the new scene begins. There are over 50 setting schemes of transition. Since no sounds were playing in this movie, the effect of adding transitions can be neglected.

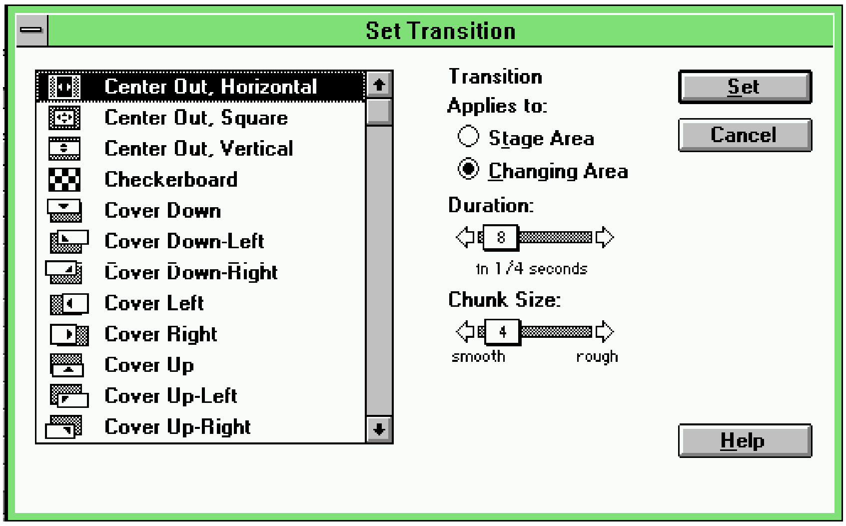

Figure 5 Score menu: transition dialog box.

Figure 6 Main content menu of the digital "textbook ".

Scripting programming by Lingo was used to create interactive function as mouseclicks. Only basic Lingo language was applied in this project, such as go to frame "effect", pause. etc.

RESULT AND CONCLUSION

The complete animated product can be run by Director itself or from any internet browsers with a MacroMedia plug in, or distributed to be run on computers that do not have the Director program installed. A project was created and an executable file (.exe) was compiled. It can be run without using Director Program. Interested readers may email me (xyang@uwf.edu) for a digital copy of this movie. Figure 6 is the content menu of this digital “textbook”, which contains four major “Chapters”. The first part, Introduction, gives a general description of the Mississippi River, its drainage basin, and flooding history dated back to 1844. This part contains a bar graph animation showing the flooding history for Cape Girardeau, Missouri. The second part, 1993 Flooding, documents the spatio-temporal characteristics of the Great Flood, the major reasons, and a virtual field trip to the flooded area. Users can choose any of the five major flooded sites for a virtual field trip with photos as the major media. This part has been designed quite nicely. The third part, Simulation, presents the results of linear interpolation of two satellite images acquired before flooding and during flooding. These morphed images, along with two original satellite images, have been organized by using temporal animation techniques (case to time). These images show the progressive development of the flooding around the St. Louis metropolitan area quite nicely. The last part, Flooding Effects, documents the impacts as represented in a series of thematic maps showing different categories of damages such as agriculture, transportation, public utilities, residential, commercial, etc. (see Figure 4). These data are organized by using non-temporal animation technique.

Overall, the project has demonstrated that animated and interactive cartography is quite effective for visualizing environmental hazards, which should be a valuable asset for hazard assessment and management.

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Henry Bosse Photos. Http://www.oldmanriver.com/bosse/

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