Reconstruction of Prehistoric Lake Cahuilla in the Salton Sea Basin Using GIS and GPS

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Abstract

During prehistoric times, the Colorado River occasionally meandered into and filled the Salton Sea Basin, creating several huge inland lakes, variously called Lake LeConte and Lake Cahuilla. Previous researchers have identified high stands of these ancient lakes using standard survey methods. The objective of this investigation was to further delineate the prehistoric shorelines using satellite imagery, global positioning system (GPS) and geographic information system (GIS) technologies. Using one-meter digital orthophotographs, points were selected in the laboratory and were located in the field using a GPS. Point data were integrated with a digital elevation model (DEM) and elevation contours were plotted on Landsat-TM images, generating a range of Prehistoric shorelines. Contours were then correlated with archaeological site data, geomorphic features, and other factors to reconstruct Early American settlement patterns for Lake Cahuilla. The combined GIS coverages of ancient Lake Cahuilla and cultural resources may be used together as a model for cultural resource constraints, identifying areas of high cultural resource sensitivity for evaluation of potential impacts as a result of implementation of Salton Sea restoration project alternatives.

Introduction

The Salton Trough is a northwestern landward continuation of the Gulf of California rift, formed by gradual subsidence coincident with the uplift of the surrounding mountains during the Miocene, Pliocene, and Pleistocene eras (Dibblee 1954; Hamilton 1961). During mid-Pleistocene time, sediments eroded from the Colorado Plateau were deposited in the Colorado River Delta to form a natural sediment dam across the trough (Downs and Woodward 1961). Over time the same actions that formed the dam also altered the course of the Colorado River to flow north, creating periodic stands of water in the Salton Basin.

Based upon travertine deposits, lake-related cultural resources and other geomorphic evidence, Waters and Wilke estimated there were three or four possible lacustral intervals in Salton Basin. The highest stand obtained an elevation of 12m (39ft) above sea level (asl) between 100 B.C. and 1580 A.D. (Waters 1981; Wilke 1978). At its climax, Lake Cahuilla encompassed over 5700km^2 and reached depths of 95m. Wilke identified three lacustral intervals for Lake Cahuilla, but Waters concluded that there were four lacustral intervals from 695 A.D. to 1580 A.D. (Waters 1981).

Wilke reported that Lake Cahuilla could reach a maximum height of 12m asl. For this to occur, flows from the Colorado River would have to continually fill the Salton Basin for a period of 12 to 20 years (Wilke op. cit.). At a height of 12m asl, Lake Cahuilla would begin to spill over the drainage divide at Cerro Prieto, Mexico, draining to the Sea of Cortez. When the Colorado River would resume its course directly to the Gulf of California, it would take approximately 53 years for the basin to dry at an evaporation rate of 1.8m per year.

Materials and Methods

The fieldwork and research were primarily used to search for undeniable evidence of shoreline features. Up against time and limited resources, Remote Sensing was the most valuable tool in discerning possible shorelines observable from LANDSAT-TM images. Global Positioning Units were then needed to store possible locations of features and used to navigate within close proximity of the features. The collected data is expected to be within the previous calculations made by Wilke and Waters as to the maximum elevation of the ancient lake.

The Lake Cahuilla shoreline reconstruction project has brought forth a model of ancient hydrology of the Salton Basin. The first phase of the reconstruction has identified the maximum elevation that Lake Cahuilla could have occupied during the past 2000 years. This was accomplished through the research of literature, interviews with authors, image analysis using one-meter resolution Digital Orthographic Quarter Quads (DOQQs), 30-meter resolution LANDSAT TM Images, field surveys accompanied by global positioning system receivers (GPS), and finally post processing the data within a Geographic Information System (GIS).

Fourteen control points were identified on one-meter digital orthophoto quarter quadrangles (DOQQs) in the laboratory. Many of these points were clearly visible on the

DOQQs, as evidenced by tufa deposits, differences in lake sediments, or other geomorphic features. One of the most clearly visible areas of the lakeshore can be viewed from Highway 86 along the northwest shore of present day Salton Sea at Travertine Rock, where the Lake Cahuilla shoreline is clearly visible nearly 30m above the highway.

Geographic location data for the control points were programmed into global positioning system (GPS) receivers. These data were used to navigate as closely as possible to the control points in the field. Upon arriving at the approximate location, shoreline field evidence was used to precisely locate a field-verified control point. Using the GPS receiver, clusters of 180 geographic positions were collected for post-processing in the laboratory.

Post-processing was performed in the laboratory by differential correction and determination of a centroid within the point cluster. The control points were then plotted on 7.5-minute digital raster graphics (DRGs). Elevations of the control points were correlated with a digital elevation model (DEM) to produce a shoreline delineation at 11.9m asl.

Results

Of the fourteen control points taken, three were eliminated due to inconsistencies with GPS satellite telemetry. By differential correction, the remaining 11 control points achieved 95% locational accuracy. This process eliminates 95% of the error introduced by the Department of Defense on the GPS system and distortion from the ionosphere.

The 11.9m-contour was plotted on a LANDSAT-TM base image. The shoreline delineation for Mexico was not obtainable due to pending acquisition of digital elevation data for this region. To supplement this a 10m contour was interpolated with the 11.9m contour used for the California side of Lake Cahuilla (Figure 1). The 11.9m-contour is consistent with the approximated shoreline elevation of Wilke and Waters (op. cit.).

Discussion

Wilke identified lake-related cultural resources along the northwest shore of Lake Cahuilla. These include rock fish weirs, shell middens, fish remains, and other cultural artifacts. Wilke, Waters, and others obtained carbon dates for Lake Cahuilla from tufa and organic cultural remains. Based upon these carbon dates, four possible high stands of Lake Cahuilla were determined to exist approximately between 100 B.C. and 1580 A.D.

Lake related cultural resources are not yet catalogued separately from non-lake related sites. Therefore, a more empirical correlation between the Lake Cahuilla contour and cultural resources was not possible.

Conclusion

Although a direct correlation between Lake Cahuilla contours and cultural resources is not yet possible, there is abundant archaeological evidence of a relationship to early American settlements and the prehistoric lake. For this reason the Lake Cahuilla contour may be used as an indicator of cultural resource potential. In this way, the Lake Cahuilla model may be used to identify cultural resource areas potentially affected by Salton Sea restoration alternatives.

Development of a cultural resources database of lake-related sites would greatly enhance our understanding of early American settlement patterns around the ancient Lake Cahuilla and further refine the cultural resource constraints model.

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